FIELD ENHANCEMENT 3
Forest Diversity

NUTSHELL

In this lesson, students study and collect data on three components of diversity found within a forest: species, structural, and functional diversity. After comparing two types of forests, students discuss the value of diversity and the role it plays in a forest.

OBJECTIVES

Upon completion of this lesson, students will be able to:

- Define forest diversity.
- Identify and measure components of three types of diversity.
- Compare and contrast different types of forests with respect to diversity.

SUBJECT AREAS

Science

LESSON/ACTIVITY TIME

- Total Lesson Time: 70 minutes
- Time Breakdown:

Introduction .....5 minutes
Activity, Part A.....20 minutes
Activity, Part B.....20 minutes
Activity, Part C .....20 minutes
Conclusion .....5 minutes

TEACHING SITE

This lesson can be done in any forested area. Ideally, there are a variety of tree species, sizes, and ages. It is recommended that the lesson be done at two contrasting sites, such as a pine plantation and a mixed forest.

CLASSROOM LESSON CONNECTIONS

This lesson ties closely with Classroom Lesson 2, *Biodiversity and the Forest Connection*.

BACKGROUND INFORMATION

Wisconsin has many different types of forests, including coniferous, deciduous, and mixed. Some specific examples include, pine, aspen/birch, spruce/fir, maple/basswood, oak/hickory, and urban. These different forests show diversity in a variety of ways. This lesson explores species, structural, and functional diversity.

Biodiversity encompasses the variety and variability of all life on earth. It is important to maintaining the natural systems that support life. Wisconsin's forests contain biodiversity and contribute to the overall biodiversity on the planet. Biodiversity is generally measured in three areas: species diversity, genetic diversity, and ecological diversity. This lesson explores species diversity in a forest ecosystem, as well as structural and functional diversity, which are components of ecological diversity.

SPECIES DIVERSITY

Species diversity can be assessed by measuring the **richness** and **evenness** of the forest tree composition. Richness is the number of different tree species present in the forest. Evenness is a comparison of the number of individuals of each of those species. In order to have an even distribution, the number of individuals in each tree species needs to be close to even, not necessarily perfectly even. To help explain richness and evenness, refer to the example on page 212.

MATERIALS LIST

FOR EACH GROUP (8 TOTAL)

- Copy of Student Pages **1A-B**, *Forest Diversity Data Sheets*
- Copy of Student Pages **2A-B**, *Forest Diversity Data Sheet – Pine Plantation* OR Student Pages **3A-B**, *Forest Diversity Data Sheet – Mixed Forest*. (Dependent upon the type of forest your students are collecting data from [see Teacher preparation].)
- Forest Floor Sampling Square
- Ruler
- Tree ID book or dichotomous key
- Clipboard

FOR THE TEACHER

- Nutrient Cycling poster (optional)
- Plot markers (flagging, ribbon, stakes, etc.)
- Tape measure (preferably 50' or 100')

TEACHER PREPARATION

- Create eight plots at your teaching site. If time permits, students can help prepare the plots as part of the lesson. The same plots used in Field Enhancement 2, *Forest Mapping* can be used for this lesson.
- Each plot should be 33' by 33' (which is equivalent to 1/40th of an acre).
- Mark the corners of the plots with flagging, cones, or stakes.
- Mark the center of the plots with a stake containing a number, letter, color, etc.
- If you have only one type of forest for your students to collect data in, make copies of Student Pages **2A-B**, *Forest Diversity Data Sheet – Pine Plantation* OR Student Pages **3A-B**, *Forest Diversity Data Sheet – Mixed Forest* for each of the eight groups. Use the *Data Sheet* from the forest that is most different from the one your students are working in to represent the missing forest.
- Make or gather eight Forest Floor Sampling Squares. They can be 12" X 12" squares with an open center like a picture frame. Sampling squares should be the same for all students.

SAFETY PRECAUTIONS

Visit the teaching site ahead of time to locate any hazards such as holes, hanging branches, protruding tree roots, poison ivy, etc. Consider these:

- Are you in sight or earshot of students?
- Are boundaries for students marked?
- Have you set expectations for being out of the classroom?
- Do you have a whistle, first aid kit, insect repellent, and sunscreen?
- Is everyone dressed appropriately?

VOCABULARY

Duff Layer: Layer of the forest containing partially decomposed organic material. Found beneath the litter layer on the forest floor.

Evenness: A comparison of the number of individuals of each species in a forest.

Forb Layer: Layer of the understory containing non-woody plants.

Forest Functions: Processes in a forest ecosystem. These include nutrient cycling, photosynthesis, providing animal habitat, etc.

Forest Services: The benefits that a forest provides for humans. These may include recreation, products, aesthetics, etc.

Functional Diversity: The variety of functions in a forest. Functions include nutrient cycling, photosynthesis, providing animal habitat, etc.

Horizontal Structure: The distribution of forest layers across the landscape.

Litter Layer: Surface layer of the forest floor composed of leaves, twigs, needles, etc. with minimal decomposition.

Microhabitat: A specific combination of habitat elements in an area that are needed by a particular organism.

Overstory: The uppermost trees in a forest.

Richness: A measure of the number of different species in a forest.

Scat: A scientific term for animal feces.

Shrub Layer: Layer of the understory containing woody plants with multiple stems.

Species Diversity: The variety of species present in a given area.

Structural Diversity: The variety in the physical organization of a forest. It has both vertical and horizontal components.

Structure: The horizontal and vertical distribution of layers in a forest, including height, diameter, and species present.

Understory: Forest vegetation present under the overstory which can include trees, shrubs, and forbs.

Vertical Structure: The distribution of forest layers from top to bottom.

Number of Species	Total Number of that Species	Richness	Evenness
1	100	1	Even
4	25, 25, 25, 25	4	Even
4	22, 21, 26, 28	4	Even
3	70, 28, 2	3	Uneven

NOTE: The measurements for richness and evenness may be affected by sampling techniques. Imagine a forest with 100 trees. Of those 100, 98 are red pine and two are white pine. This forest would have a richness level of two and an uneven composition. However, a sample may miss those white pines and lend a richness of one and an even composition.

Richness is a measure of the biodiversity that exists in a forest. Evenness qualifies that value. One value without the other would be useless when attempting to measure the true biodiversity of a forest. For example, a Wisconsin forest with a richness value of 5 might be a mixed hardwood stand containing maple, ash, hickory, oak, and elm. This forest might be considered a natural forest containing a variety of native animal and plant species. Yet, without the evenness value to further clarify the richness value of 5, the forest could actually be a red pine plantation that only has one or two trees of each of the other species mixed in with a large number of red pine trees. The evenness value helps measure the abundance and distribution of tree species, allowing a more complete understanding of the forest's biodiversity.

STRUCTURAL DIVERSITY

The structural diversity of a forest includes both below and aboveground, **vertical structure** and **horizontal structure**. This lesson deals only with above ground diversity. A diverse vertical structure includes an **overstory** and an **understory**, containing a tree, **shrub**, and **forb** layer. A diverse horizontal structure includes variety in layers across the landscape. For example, two different types of forests with different vertical layers adjacent to one another would contribute to horizontal diversity.

The structural diversity of a forest has a direct effect on the diversity of animals within the forest. The more **microhabitats** a forest has, the greater the variety of animals the forest can support. The presence of standing dead trees and climbing vines in a forest can enrich the forest's structural diversity by providing additional habitats and pathways between the structural layers.

FUNCTIONAL DIVERSITY

The **function** of a forest refers to the processes that occur within a forest ecosystem. A forest has many functions. These include cycling nutrients, producing oxygen, forming carbon-based products (leaves, twigs, stems, bark, etc.), and providing animal habitat. Forests also provide **services**. Services are benefits that humans get from forests. They include things like recreational opportunities, products, aesthetic value, etc. It is important to differentiate between forest functions and forest services.

Some forests are productive (grow very fast) while others are less productive. Some cycle nutrients quickly, while others are slow. Some contain a variety of animal habitats, and some have relatively few. All of these are examples of how forests differ in their relative functions. It would be impossible for us to measure all of the many forest functions in one lesson. Instead, this lesson looks at the characteristics of the forest floor to determine the relative rate at which nutrients cycle.

FUNCTIONAL DIVERSITY – NUTRIENT CYCLING

The forest floor is made up of fallen plant and tree material that has yet to be fully decomposed or broken down into soil. The **litter layer** of the forest floor begins where fallen material meets the air. Items in this layer are easily recognizable and have not begun to decompose. Just below the litter layer is the **duff layer**. In this layer is the litter that is partially decomposed. It ends at the first soil layer. The first soil layer is much more compacted than the loose forest floor and contains some mineral particles. The visual appearance of this layer is much like salt and pepper. The "salt" is the sand (mineral) particles, while the "pepper" is the organic part of the soil.

When trees lose their leaves, needles, or fruits, or when a tree itself dies and falls to the ground, small soil organisms (henceforth known as critters) begin breaking those complex structures down into more simple ones. It is not easy for critters to break down these complex carbon structures. Wood, nuts, and cones are generally more complex than leaves. It makes sense when you think about what you see on a forest floor. You can identify the same downed tree year after year, but thousands of leaves shed in the fall seem to disappear each year. The more complex a structure, the longer it will remain on the forest floor before being fully decomposed.

So we know what the forest floor is, but how can we use the forest floor as an indicator of how quickly nutrients are cycled through a forest? The plant material that falls from a tree is decomposed by the critters in the soil. This step is very important because plants cannot use nutrients directly from the fallen material of other plants. The critters break these compounds down and make the nutrients re-available to plants. The faster the critters break the compounds down, the faster they will be re-available to plants.

The rate of nutrient cycling can be compared between two forest types based on the depth of the forest floor. A deep, homogeneous (made up mostly of the same thing) forest floor indicates slower decomposition, smaller critter populations, and slower nutrient cycling. A shallow, diverse forest floor indicates faster decomposition rates, larger critter populations, and faster nutrient cycling.

PINE PLANTATION VS. MIXED FOREST

In Wisconsin, most of the plantation forests are red or white pine. Of the 46 percent of the state covered in forests, 4.5 percent of that is plantations. In general, a plantation forest will have lower levels of **species diversity** than a mixed forest. The richness will be low because usually one species of tree is planted. The evenness will be high if there is only one tree species. The structural diversity in a plantation will also be lower than in a mixed forest. All the trees are usually the same age and similar height. There might be forbs growing in areas where sunlight reaches the ground, but there are not likely to be other understory layers. The functional diversity in a plantation is generally lower than that in a mixed forest because there are fewer organisms to cycle nutrients, provide habitat and food, and photosynthesize.

Having lower levels of diversity than mixed forests does not mean plantations have less value. Plantations produce more wood in a smaller area than mixed forests because the trees have less competition in a plantation and can grow bigger faster. Management and harvesting are also easier in a plantation because there are fewer variables (such as understory plants) to account for. Ecologically, pine plantations may have fewer insects, which is great if you are looking for a nice open area to camp and hike in. Some wildlife, such as predatory birds that need open areas to hunt, may prefer plantations. Plantations also add to the overall diversity of the landscape.

EARTHWORM INVADERS

Recent research has highlighted the problems caused for forest diversity by the non-native, invasive earthworms brought into the forest by humans. These accidental residents are so good at decompsition, that they break down the duff layer too quickly for many native plants to reproduce. This can be a cause of reduced biodiversity in some forests.
For more information and classroom activities, go to the Great Lakes Worm Watch website. This organization focuses on citizen science and can provide an interesting research opportunity for students.

SUMMARY

We have discussed three different types of forest diversity, but what does it all mean? It is generally thought that more diverse systems are more stable against disturbances. They also host a greater variety of plants and animals. Many people believe that a more diverse ecosystem is a better one, but better how? More beautiful? More wildlife? More natural? It is important that instead of categorizing all ecosystems as good or bad, it is wiser to determine the value in diversity of each ecosystem individually. The diversity measures that we have discussed are all indicators of ecosystem health. These indicators are specific to each type of forest. Different forest types have different levels of biological diversity. Healthy systems are expected to maintain the levels of diversity expected for that particular type of system. For example, in Wisconsin, jack pine barrens and oak savannahs are naturally occurring, resilient ecosystems that have very low diversity. They provide habitat for a variety of animals such as the sharp-tailed grouse. Yet, they have an even-age structure, one species composition, and slower nutrient cycling. It is important in this lesson that students understand that some ecosystems only have the ability to achieve a certain level of diversity.

PROCEDURE

INTRODUCTION - STUDENT DIVERSITY

1. Introduce the concept of the day – forest diversity. Ask someone to define what diversity means. *(Different, variety.)* Explain that studying diversity in a forest means looking at how many different parts a forest has. These parts can be the tree species, structural layers, animals, or forest processes.
2. Tell the students that you are going to use them to demonstrate some principles of diversity. Tell them that together they make up the class, just like trees make up a forest. Ask them to form groups based on eye color. Each group must have the same eye color. After they form these groups tell them that they have just separated the class into groups of students because of one of their characteristics, just as trees are separated into different tree species by their individual characteristics. The different groups represent the composition of the class based on eye color.

   The diversity of their composition can be determined with two measurements: richness and evenness. Tell the students that richness is the number of different groups of things there are. What is their richness? *(It will be however many eye color groups the class has.)* Evenness is measured by looking at the number of people or things in each group and how the groups are distributed. For example, two groups of three and one group of 12 would not make an even distribution. A group of five, a group of six, and a group of seven would represent evenness. Remember that "even" does not mean exactly equal. It means pretty equal. The more rich and more even the composition, the more diverse it is. Is your class diverse?

   Tell the students that the richness and evenness of the forest composition measures the tree species diversity of the forest. Measuring the species diversity in the forest is only one way of measuring diversity. They will be collecting data on species, structural, and functional diversity. With their results, they will compare the diversity of two different types of forests.

ACTIVITY - FOREST DIVERSITY DATA COLLECTION

Divide the class into eight groups. Hand out a clipboard and Student Pages **1A-B**, *Forest Diversity Data Sheets* to each group. Explain that each group will work separately to complete the worksheets. Each group will also be assigned to work in a different plot.

Part A - Species Diversity

1. Tell students that the first type of diversity they will be studying is species diversity. Have students look at the top of Student Page **1A**, *Forest Diversity Data Sheet 1A – Species Diversity*.

   - Tell students that first they will be looking at richness and evenness to determine species diversity. It is very similar to what they just did by dividing the class by eye color. First they locate all the trees that are bigger than four inches in diameter and determine the species. (Four inches is used as a minimum diameter to conserve time. It eliminates the seedlings and reduces the number of trees students have to count. If your forest only contains young trees, you may want to lower the minimum diameter to ensure there are enough trees for students to count.) Explain that if they fold a piece of paper in half the long way it is approximately four inches wide. They can use this as a reference to measure diameter. Each group should have a tree identification book or dichotomous key to identify the tree species.

   - Once students collect their data, they should add the totals for each species and the total for all the species combined. Then, they should decide the richness and evenness of their forest area. Richness is measured on a scale of 1 to 5 based on the number of species in the plot, and evenness is measured by comparing the number of trees there are of each species. "Even" composition is about equal numbers of individuals of each species. What if there is only one species? We would consider this even, since there is nothing for it to be uneven with.

2. Have students come back together as one large group. Compare results from different groups. Was the species richness the same from group to group? Was the evenness the same from group to group? Discuss that even though there might have been minor differences from plot to plot, overall the forest is probably fairly consistent.

   - Tell students that they will now have the opportunity to examine data from another forest that is different from the one they sampled. If you will not be gathering data from a second type of forest (see Part D, page 220), hand out either Student Pages **2A-B**, *Forest Diversity Data Sheet – Pine Plantation* OR Student Pages **3A-B**, *Forest Diversity Data Sheet – Mixed Forest*. If you are gathering data from another type of forest, save this discussion until after data has been collected.

   - Have students read the description of the forest so they can visualize what it looks like and then compare their data on species diversity to the data given.

   - Ask students which of the two forests had more richness. *(Mixed.)* Ask students which of the two forests was more even. *(Pine Plantation.)* Tell them that is likely because there is only one species of tree in the plantation, so there is nothing to be uneven with. Ask students which forest has more species diversity. *(Likely they will say the mixed.)*

Part B - Structural diversity

1. The next type of diversity that students will study is structural diversity. Direct students to the bottom of Student Page **1A**, *Forest Diversity Data Sheet 1A – Structural Diversity*.

   - Discuss with students what the structure of a forest is. *(The horizontal and vertical distribution of layers in a forest, including height and species present.)* Review the layers: **Litter/Duff Layer:** Litter is the surface layer of the forest floor composed of leaves, twigs, needles, etc. The duff layer is the partially decomposed layer of the forest floor just below the litter. **Overstory:** The uppermost trees in the forest. **Understory:** The vegetation below the overstory, including trees, shrubs, and forbs. Trees are differentiated from shrubs by having one stem. Shrubs have multiple woody stems. Forbs are non-woody plants.

   - Point out some different forest layers to the students. Be sure that they understand that a layer consists of a fairly continuous mass of things. Think about a peanut butter and jelly sandwich. It has a layer of bread, a layer of jelly, a layer of peanut butter, and a layer of bread. If there were only a few drops of jelly between the peanut butter and the bread, would it really be a "layer"of jelly? No, we'd probably call it a peanut butter and drop of jelly sandwich. The same thing is true with forest layers. Just because there are a few plants in the first two feet of the forest, it does not mean there is a forb layer. In the same token, if there is just a hole in the jelly, we would still call it a layer.

   - Tell students that next they will be studying the structural diversity of a forest. On the bottom half of *Forest Diversity Data Sheet 1A*, they need to circle "Yes" or "No" for the presence of each layer. The litter layer will be studied separately, so it is not present in this portion of the *Data Sheet*. Next, tell students that they have to list any wildlife, signs of wildlife, areas of habitat, and foodsources they see in each layer. Remind them that if they do not have a layer, they may still have signs of wildlife at that level of the forest. For example, a spiderweb found on the base of a tree in the overstory would be listed at the forb layer. You can also introduce your students to the term scat, a scientific term for animal feces.

2. Once students have gathered their data, have them come together as a large group. Go over the results of the *Data Sheet*. Were the same layers present in all the plots? What types of wildlife, signs of wildlife, habitat, or food sources did they find? Were these consistent from plot to plot?

   - Explain that the first data set they collected was on vertical structure. This tells how many layers there are in the forest. Ask students if they think more layers mean there is more diversity. *(Yes, but it is not always that simple. Some animals need open layers to hunt or nest in. If there are not openings in the forest, these animals might not be found there. For example, many predatory birds use the open area under the forest overstory to spot and catch their prey.)*

- The second data set they collected was to help them assess horizontal structure of a forest. This is a measure of the diversity of layers across the landscape. Ask students what they think would happen to the wildlife they identified in their forest if one of the forest layers disappeared. *(Some of them might lose their food or habitat and need to relocate to survive.)* Ask if all animals use the same forest layers. *(No.)* Ask what the implication of this is for different kinds of forests with different layers. *(Different forests with different layers support different kinds of wildlife. It is necessary to have a variety of ecosystems and forests.)* Explain that part of structural diversity is looking at a wider area than just within one forest area like the one where their plots are located. It is important to study the forest layers of many adjoining forests and ecosystems.

- If you will not be gathering data from a second type of forest, have students look at the structural diversity section of Student Pages **2A-B**, *Forest Diversity Data Sheet – Pine Plantation* or Student Pages **3A-B**, *Forest Diversity Data Sheet – Mixed Forest*. If you are gathering data from another type of forest, save this discussion until after data have been collected.

- Have students compare their data on structural diversity to the data given.

- Ask students which forest has more layers. *(Mixed.)* Ask students which forest has more signs of wildlife. *(Likely the mixed.)*

Part C - Functional diversity

1. Next have students look at Student Page **1B**, *Forest Diversity Data Sheet – Functional Diversity*. Explain that this is the third and final type of diversity they will be studying.

- Ask the students if they know what a function is. Try to get them to figure it out by using the word in context. Ask them what a function of a school is. They will probably say to teach us things. Keep them brainstorming. There are many functions of school. *(Making new friends, playing games, sports, keeping you out of trouble, lets whoever takes care of you do other things during the day, feeds you hot lunch, etc.)* Prompt them with questions such as what function does school have for your teachers, janitors, and cooks? *(Jobs.)* Let them brainstorm for a while. Forests are a lot like schools. They both have many functions. Have the students brainstorm some functions of a forest. *(They provide homes for plants and animals, release oxygen and use carbon dioxide, cycle nutrients, retain water, etc.)* Tell students that the last type of diversity they are going to study is functional diversity.

- Show the class where the forest floor begins and where it ends. It starts at the very top of the litter and continues down to the top of the soil. The material that is partially decomposed is called duff. Show students how to measure the depth by pushing the ruler through the litter and duff until it touches the soil. Remember, the first soil layer has minerals, like sand, in it. They may have to estimate the depth if the depth within their sample square is uneven. **NOTE:** If this activity is done in a deciduous forest after leaves have fallen in the fall, have students remove the freshly fallen leaves from the litter layer before taking measurements. A pile of freshly fallen leaves will misrepresent the amount of decomposition that is actually occurring in the forest.

Show students the Forest Floor Sampling Square. Tell them to stand at one corner of their plot and toss the square inside the plot. Remind them that this is a Forest Floor Sampling Square; it does not work well if it is tossed onto a tree or shrub, especially if they cannot retrieve it. Therefore, they should throw it like a frisbee and keep it low to the ground. Each member should take a turn gently tossing it into the plot starting from a different corner. Wherever the square falls is where they will take their measurement. They need to do this four times, once from each corner.

- The next data they need to collect on Student Page **1B**, *Forest Diversity Data Sheet* is the composition of what is inside their sample. Show the students some of the different things they could find in the layer – pine needles, deciduous leaves, pine cones, acorns, whatever happens to be on the ground around you. They then need to determine the evenness of the composition. Does each type of material cover the same amount of surface area? *(If yes, the composition is even.)* **NOTE:** When measuring evenness students should compare the overall surface area taken up by an item, not the number of each item. They also need to determine the decomposition level. Point out the definitions at the bottom of *Forest Diversity Data Sheet 1B* and explain them. Explain that they need to select the level of decomposition present and mark it on their sheet.

- Remind students to only disturb the forest floor inside of the sampler. When they are finished, they must put all the material back inside the sample box and make it look as if it had never been touched.

2. Ask the class to look around and above them at all the trees and shrubs. If they all lose needles, leaves, twigs, etc., why isn't there more stuff on the forest floor? *(It is being decomposed and returned to the soil.)* Ask what would happen without decomposition? *(The material on the forest floor would continue to build up endlessly.)* Ask if they know what a nutrient cycle is. Use a Nutrient Cycling Poster to demonstrate the nutrient cycle, if you have one. Basically, critters (decomposers) break down the material that falls to the forest floor and it returns to the soil. Trees and other plants use these nutrients to survive. Without the continuous cycle, the trees would not get the nutrients they need to live.

- If you will not be gathering data from a second type of forest, have students look at the functional diversity section of Student Pages **2A-B**, *Forest Diversity Data Sheet – Pine Plantation* or Student Pages **3A-B**, *Forest Diversity Data Sheet – Mixed Forest*. If you are gathering data from another type of forest, save this discussion until after data have been collected.

- Have students compare their data on functional diversity to the data given.

- Ask students which forest has the deeper forest floor. *(Likely the Pine Plantation.)* Have students compare the composition of each forest floor. Ask which has the higher level of decomposition. *(Mixed.)* The nutrient cycle is one part of functional diversity in the forest. Based on the data, have students assess the overall functional diversity of each forest. A thick forest floor usually indicates slower decomposition and therefore slower nutrient cycling. This can be an indicator of low functional diversity.

Part D - Additional Comparison

If you have the option of visiting another type of forest, give students another set of *Data Sheets* and have them collect data. Lead a discussion using the questions in each section above to compare and contrast the two types of forests and the level of diversity found in each.

EXTENSION:

Use the information on the Great Lakes Worm Watch website to conduct an earthworm inventory of your study plots. The inventory involves pouring a mixture of water and ground mustard on a defined area of your plot. The worms are irritated by the mixture and come to the surface. Once the worms are at the surface, students collect them, count them, and identify them by species. Use this as a great way to include citizen science into your lessons.

This can be an ongoing exercise at your forest site. Track data from year to year to see how the worm population is changing or spreading and compare that to the diversity.

CONCLUSION - REVIEWING DIVERSITY

1. Review the differences in diversity between the two forests with students. *(The pine plantation had lower species richness than the mixed forest but higher evenness. The pine plantation had fewer structural layers and, therefore, less structural diversity than the mixed forest. The pine plantation also likely showed fewer signs of wildlife than the mixed forest. The pine plantation had a thicker forest floor than the mixed forest, indicating slower nutrient cycling and therefore lower functional diversity.)* To pull it all together, ask students if they would like to have more mixed forests or more pine plantations. Why? *(Likely they will say mixed forests because of the higher levels of diversity, animals, etc.)*
2. Discuss the implications of having all mixed forests. Have students think of the role of plantations in the overall landscape (horizontal structural diversity). Ask which is more diverse, a state with all pine plantations or all mixed forests, or a state with both plantations and mixed forests. *(A state with both plantations and mixed forests.)* Ask students what benefits pine plantations might have over mixed forests. *(They produce more wood in a smaller area than mixed forests because the trees have less competition in a plantation and can grow bigger faster. Management and harvesting are also easier in a plantation because there are fewer variables [like understory plants] to account for. Ecologically, pine plantations may have fewer insects, which is great if you are looking for a nice open area to camp and hike in. Some wildlife, like predatory birds that need open areas to hunt, may prefer plantations.)* Explain that, because we use so many products that come from the forest, we need a lot of trees. If we did not have plantations to cut, we would have to cut more mixed forests.
3. Ask the class if they think that a more diverse ecosystem is a better ecosystem. Tell the class that many ecosystems exist naturally that would have a very low diversity in all of the measurements that we have taken. Ask the students if they have seen a pine barren, oak savanna, or if they have been to a forest in Canada or Alaska. Tell the students that these forests naturally often have only one species of tree. Many times all of the trees are the same age and height. Are these forests unhealthy or bad? No, they are just that way. They are best suited for that environment.

4. Ask the students if they can name some types of forests found in Wisconsin. *(Pine, aspen/birch, spruce/fir, maple/basswood, oak/hickory, urban.)* Tell the class that each type of forest has its own diversity level. An oak savanna with a scattering of oak trees in an open prairie would have a very different diversity than a coniferous forest full of pine trees. But the oak savannas of Wisconsin should all have diversity measurements similar to each other's. If we knew the diversity level of a certain type of forest, we could compare the diversity levels of individual forest samples to that accepted value. A healthy forest has the proper diversity level for its own forest type. Would a pine plantation be healthy if it had many layers, different species, and a high decomposition level? Probably not. The same goes for the mixed forest. If it showed an extremely low diversity level like a plantation, we could hypothesize that it was unhealthy.

5. Ask what the importance of forest diversity is. Why not have all one type of forest like pine plantations or mixed forests? Have the students brainstorm for a while. Remind them of the benefits of diverse forest and a variety of different types of forests. Many of the foods that we eat, the medicines we use, and the materials that we use for clothing, shelter, and other products came from the forest. People have discovered a wide variety of uses for our forests and many people believe that there are even more uses to be found. Plants and trees that we have not yet discovered may become important in the future for medicine, food, or materials. If we lose forest diversity, we will lose all of these possibilities before we ever have a chance to explore them.

SUMMATIVE ASSESSMENT

Have students do a diversity study of shopping centers or car lots in their town. Have them look at the stores/cars present in different locations. What is the richness? What is the evenness? How are they distributed across the landscape (town)? What is the level of functional diversity? This could be studied by measuring hours the businesses are open, parking availability, or relative numbers of salespeople. Have students be creative in coming up with questions to ask about the businesses to measure their level of diversity.

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1A

FOREST DIVERSITY DATA SHEET A

Which plot are you studying?_____

SPECIES DIVERSITY

Tree Species	Number of Trees More Than 4" in Diameter

Total Number of Trees_____

Richness: A measure of the number of tree species in an area.

More Tree Species = Greater Richness

How many species of trees?

1 2 3 4 5

Evenness: A comparison of the number of trees of each species.

Equal Numbers of Each Species = Greater Evenness

Even | | | | | | Uneven

STRUCTURAL DIVERSITY

Structural Layer	Is the layer present?	List wildlife, signs of wildlife, habitat, food sources.
1. Overstory	Yes No	
2. Understory		
A. Trees	Yes No	
B. Shrubs	Yes No	
C. Forbs	Yes No	

FOREST DIVERSITY DATA SHEET B

Which plot are you studying?_____

FUNCTIONAL DIVERSITY

Sample	Depth (cm)	Composition (Leaves, Twigs, Seeds, Pine Cones, Etc.)	Evenness of Decomposition	Level of Decomposition
1			Even Uneven	Low Medium High
2			Even Uneven	Low Medium High
3			Even Uneven	Low Medium High
4			Even Uneven	Low Medium High

LOW DECOMPOSITION: You can tell what **most**, **or all**, of the materials are made of.

MEDIUM DECOMPOSITION: You can tell what **some** of the materials are made of.

HIGH DECOMPOSITION: You **cannot tell** what most of the materials are made of.

Compare the amounts of material in each category. If there is more material of high decomposition than low decomposition, the overall level of decomposition is high. If there are about equal amounts of decomposed materials and non-decomposed materials, the level is medium.

2A

FOREST DIVERSITY DATA SHEET – PINE PLANTATION A

SITE DESCRIPTION

Envision tall red pine trees towering 30 feet above your head. You can hear the wind rushing through the needles in the tops of the trees swaying above you. All around you are straight tree trunks that are nearly all the same size. A chickadee sits on a short branch sticking out of one of the trees. You notice that there aren't many branches around you; most of them are high up in the trees. On the forest floor is a thick, soft layer of pine needles with cones and twigs scattered around. In patches of scattered sunlight, there are a few small pines growing. You are in a 25- to 35-year-old pine plantation.

SPECIES DIVERSITY

Tree Species	Number of Trees More Than 4" in Diameter
Red Pine	13

Total Number of Trees 13

Richness: A measure of the number of tree species in an area.

More Tree Species = Greater Richness

How many species of trees?

(1) 2 3 4 5

Evenness: A comparison of the number of trees of each species.

Equal Numbers of Each Species = Greater Evenness

(Even) | | | | | | Uneven

FOREST DIVERSITY DATA SHEET – PINE PLANTATION B

STRUCTURAL DIVERSITY

Structural Layer	Is the layer present?	List wildlife, signs of wildlife, habitat, food sources.
1. Overstory	(Yes) No	Bird
2. Understory		
A. Trees	Yes (No)	
B. Shrubs	Yes (No)	
C. Forbs	Yes (No)	Spider Web

FUNCTIONAL DIVERSITY

Sample	Depth (cm)	Composition (Leaves, Twigs, Seeds, Pine Cones, Etc.)	Evenness of Decomposition	Level of Decomposition
1	5.5	pine needles, bark, twigs, cones	Even (Uneven)	(Low) Medium High
2	4.5	pine needles, leaf, twigs, cones	Even (Uneven)	Low (Medium) High
3	7.0	pine needles, twigs, cones, bark	Even (Uneven)	(Low) Medium High
4	6.0	pine needles, twigs	Even (Uneven)	Low (Medium) High

3A

FOREST DIVERSITY DATA SHEET – MIXED FOREST A

SITE DESCRIPTION

All around you are plants of various heights. It is hard to see all the tree trunks clearly through the green leaves around you. High above your head are white pine and red maple trees. One of the maples is dead and still standing, providing a nesting area for wildlife. In one corner is a big, old hemlock tree. A breeze rustles the leaves of shrubs around you. They are about your height, and on some of them are sharp thorns. A few pine seedlings are growing on the forest floor among wild strawberries and other forbs. There are twigs, leaves, maple seeds, and pine cones on the ground around your feet.

SPECIES DIVERSITY

Tree Species	Number of Trees More Than 4" in Diameter
White pine	2
Red Maple	4
Hemlock	1

Total Number of Trees 7

Richness: A measure of the number of tree species in an area.

More Tree Species = Greater Richness

How many species of trees?

1 2 (3) 4 5

Evenness: A comparison of the number of trees of each species.

Equal Numbers of Each Species = Greater Evenness

Even | | | | | | (Uneven)

FOREST DIVERSITY DATA SHEET – MIXED FOREST B

STRUCTURAL DIVERSITY

Structural Layer	Is the layer present?	List wildlife, signs of wildlife, habitat, food sources.
1. Overstory	(Yes) No	Bird, nest in tree, seeds
2. Understory		
A. Trees	Yes (No)	
B. Shrubs	(Yes) No	Deer, Spider Web
C. Forbs	(Yes) No	Scat

FUNCTIONAL DIVERSITY

Sample	Depth (cm)	Composition (Leaves, Twigs, Seeds, Pine Cones, Etc.)	Evenness of Decomposition	Level of Decomposition
1	1.5	Dead grass, pine seeds, maple seeds, twigs	(Even) Uneven	Low (Medium) High
2	3.0	leaves, twigs, bark, pine cone, pine needles	(Even) Uneven	Low (Medium) High
3	2.0	pine needles, leaves, twigs	(Even) Uneven	Low Medium (High)
4	5.5	needles, leaves, twig, hemlock cones	Even (Uneven)	Low (Medium) High