Habitats & Biodiversity Lab

Future of Agriculture Curriculum for Teaching Sustainability

Name: _____ Hour_____Date: _____

Date Packet is due:_____ Why late? _____Score: _____
Day of Week Date If your project was late, describe why

Overview: in this unit, you will be investigating how biodiversity changes in different parts of a habitat near your school.

Main Questions

- How do scientists reliably answer questions about the natural world?
- How does biodiversity change in the edge of this habitat in comparison to the interior of this habitat?
- How can we collect data in a reliable fashion to answer this question?
- How can we analyze our data to reach a sound and valid conclusion?
- How can we be sure that our results are sound, valid, and representative?

Weekly Schedule

Monday:
- Introduction to the Habitats & Biodiversity Lab
- Introduction to Designing and Conducting Research

Tuesday & Wednesday:
- Option A: School Habitat Data Collection (Outside)
- Option B: Applications of Data Activity (Indoors)

Thursday:
- Data Analysis and Report Preparation

Friday:
- Delivery of Reports
- Career Connections/Make-up Day

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National Science Foundation WHERE DISCOVERIES BEGIN

KBS LTER Kellogg Biological Station Long-term Ecological Research

MICHIGAN STATE UNIVERSITY

Semester Schedule

Week 0: Introduction & Lab Safety

Atoms to Ecosystems

Week 1: Matter & Energy
Week 2: Cell Biology
Week 3: Biodiversity & Ecosystems
Week 4: Biodiversity & Habitats Lab
Week 5: Midterm Assessments

Causes of Extinction

Week 6: Extinction
Week 7: Habitat Loss
Week 8: Invasive Species
Week 9: Land & Water Pollution
Week 10: Atmospheric Pollution
Week 11: Overharvesting
Week 12: Midterm Assessments

Sustainable Societies

Week 13: Natural Resources Management
Week 14: Societies & Sustainability
Week 15: Individual Sustainability
Week 16: Personal Campaigns
Week 17: Personal Campaigns

Day 1: - Introduction to Conducting Research

Overview: the job of a scientist is to answer unknown questions about the world. To do so, scientists must

- Ask questions and clearly define the problem.
- Plan and carry out an investigation that reliably addresses their question.
- Collect, analyze, and interpret data from their investigation using mathematics and computational thinking.
- Construct explanations and design solutions to problems.
- Recognize patterns and trends in data in order to develop an explanatory model that helps to simplify and explain the natural phenomenon central to the investigation (and other similar natural phenomena).
- Engage in argumentation and debate based on the evidence and conclusions.
- Communicate the conclusions, data, and evidence from an investigation in order to help advance the work of all people in that field.

In this activity, you will be applying these practices as you measure the biodiversity of different parts of a habitat near your school (Option A). In teams, you will compare the levels of biodiversity on the edge of the habitat to the interior areas. Once you have collected your data, you will compile all of the data collected by your class, determine the average amount of biodiversity for each of the different locations that were sampled, and then develop a presentation that you will deliver either to your instructor or to the class as a whole.

If this is not an option, you will use data previously collected by other students and consider how these data relate to concepts we have addressed so far in this course (Option B).

Before you begin, you will do a brief activity to help you become more familiar with data collection and analysis. You will end today's class with an overview of the work that you will be doing later this week. If you go outside, be sure to dress appropriately. Be sure to bring appropriate clothing for the weather as well as close-toed shoes and a jacket if necessary.

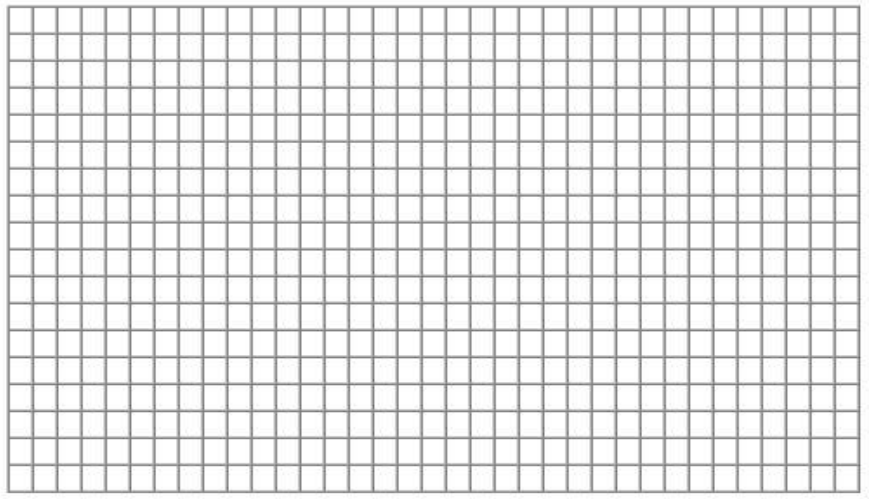
Day 1: - Intro Biodiversity Data Activity

Intro video: https://www.youtube.com/watch?v=C_35v4tuBpY

Introduction: in this activity, you will be provided with habitat biodiversity data from a previous class. Your group will be calculating the average biodiversity levels at different points in this habitat. You will also identify different components of the experiment based on the information provided to you.

Background: in this experiment, the student researchers in a school in southeastern Wisconsin sought to determine how biodiversity levels changed as they moved from the edge to the interior of their school forest. To determine this, students worked in six groups. Each group spread out evenly across the eastern edge of this forest and identified sampling locations at 1 meter from the edge, 25 meters, 50 meters, and 75 meters. Using PVC squares (1 m x 1 m), students determined the number of individuals and the number of species within that square at each sampling location. Students then divided the number of species by the number of individuals to calculate a biodiversity score (*the higher the score, the greater the biodiversity*). Their data is shown on the next page.

Site	1 m	25 m	50 m	75 m
Group 1	0.024	0.062	0.122	0.0047
Group 2	0.13	0.44	0.8	0.87
Group 3	0.35	0.3	0.3	0.18
Group 4	0.83	0.25	0.17	0.27
Group 5	0.21	0.0875	0.0833	0.142
Group 6	0.21	0.17	0.25	0.5



What is the average biodiversity for each sampling site - 1, 25, 50, & 75 m? (*Add up all of the values in each column and divide each sum by 6*).

1 m avg: _____ 25 m avg: _____ 50 m avg: _____ 75 m avg: _____

1. Calculate the average biodiversity score for each sampling location. List these values in the blanks above. In the graph paper grid above, create a bar graph showing the average biodiversity scores at each sampling location. Be sure to label your x-axis (horizontal) and y-axis (vertical).

2. What question was this experiment trying to address? _____

   _____

3. How did this experiment address this question? _____

   _____

4. An **independent variable** is the thing that is changed in an experiment to see what impact it has. What was the independent variable in this experiment? (*HINT: what were the students comparing or changing in this experiment?*)

   _____

5. A **dependent variable** is the thing that is measured to determine the impact of the independent variable. What was the dependent variable in this experiment?

   _____

6. What would be the most reasonable conclusion that could be reached from this experiment's data?

   _____

Be prepared to discuss your answers as a class.

Day 1: - Introduction to the Lab (Option A)

Overview: In this lab you will be performing quadrat sampling to gauge the level of biodiversity of different components of the same habitat. "Quadrat sampling" is a term for sampling portions of an ecosystem to indicate the health of the overall habitat. To perform this procedure, a series of squares (quadrats) of a certain size are placed at random or along a straight line in a habitat. The species within those quadrats are identified, counted, and recorded.

To conduct the sampling within your quadrat, simply count the number of species and the number of individuals. Our basic biodiversity score is calculated by dividing the number of species found by the square root of the number of individuals found. These scores from the whole class will be averaged for each section.

Directions: for this lab you will need your research team and a quadrat. A quadrat is simply a square; PVC pipe, meter sticks, or broomsticks can work as well as any piece of fancy equipment as long as they are consistent in size. Our quadrats are made from pieces of PVC pipe and nylon rope. It is important for you to ensure that your quadrat is evenly square; if it looks more kite-shaped, adjust it to make it perfectly square.

Each group will be assigned a portion of a nearby habitat. After receiving your assigned location, move one pace (roughly a meter or 3 feet) from the outside towards the interior of the habitat (step carefully! Do not damage any vegetation). Lay down your quadrat and begin counting all the plant species that have stems within your square. Using this sheet, each person should record the total number of species and the total number of individuals within the quadrat (overhanging vegetation with stems outside of the square DO NOT count; only count species with stems within the square). To determine the biodiversity score for that area, divide the total number of species by the square root of the total number of individuals. For example, if you counted 25 individuals and identified 10 species, you would perform the following calculation[1]:

$$(\#\text{ species} \div \sqrt{\#\text{ individuals}}) = 10/\sqrt{25} = 10/5 = 0.5$$

On the second day, move to a location in the interior of the habitat (as determined by your instructor) and repeat the procedure. On the third day, you will share your data with the class. You will compile the data for each of the sections in which you collected the biodiversity data, determine the average biodiversity score for the edge and interior sections, and then determine the difference in biodiversity between the edge and interior of the habitat. Using this information, you will compile a report that you will present on the following day using the questions in this packet as a guide. On the final day, you will present your report to either your instructor or to the whole class.

Use the remainder of the time in this class to listen to your instructor's specific instructions in regard to what to wear, what to bring, where to meet, and other important details. Remember to dress appropriately!

Lastly, you should have a **hypothesis** and **rationale** before beginning this lab. Complete the sections below:

1. Which do you think will have the greatest biodiversity, the edge or the interior? _____

2. Why do you think that this section will have greater biodiversity? _____

_____

[1] *Note: the formula used in the Wisconsin example was slightly different. This formula is more accurate.*

Day 2: Habitat Edge Assessment (Option A)

Directions: After receiving your assigned location, move one pace (roughly a meter or 3 feet) from the outside towards the interior of the habitat (step carefully! Do not damage any vegetation). Lay down your quadrat and begin counting all the plant species that have stems within your square. Using this sheet, each person should record the total number of species and the total number of individuals within the quadrat (overhanging vegetation with stems outside of the square DO NOT count; only count species with stems within the square). To determine the biodiversity score for that area, divide the total number of species by the square root of the total number of individuals. For today, only record the data for your group. If time is available, speak with your instructor to see if you can collect data for a second quadrat (more data = more accuracy).

Number of individual plants: _____ Number of different plant species: _____

Edge Biodiversity Score: _____ (# species ÷ √# individuals)

Day 3: Habitat Interior Assessment (Option A)

Directions: repeat the protocol from the previous day for your new assigned location in the center of the habitat.

Number of individual plants: _____ Number of different plant species: _____

Interior Biodiversity Score: _____ (# species ÷ √# individuals)

Day 4: Data Analysis & Reporting (Option A)

Overview: You will be working in teams to develop a paper or presentation about your data collection.

Directions: begin by reporting your biodiversity scores on a whiteboard, chalkboard, or wherever the whole class can see your data depending on your teacher's instructions. Then record the data from the rest of the class in the space below.

	Edge Biodiversity	Interior Biodiversity
Group 1		
Group 2		
Group 3		
Group 4		
Group 5		
Group 6		

Calculate the average biodiversity for each region of the habitat. To do so, add up all of the scores for each section and divide by the number of scores that you have.

E.g. if you have six scores that add up to 3, you would divide 3 by 6 to get an average score of 0.5

Edge Avg:____ Int. Avg:____

Next you will be compiling a report. This can be in an oral format, PowerPoint, poster, or paper. Your instructor will determine which format will be most appropriate for your situation.

In your report, you should address the following:

1. What was the question you were trying to answer?
2. What was your original hypothesis? What was your rationale for that hypothesis?
3. How did you conduct this experiment and collect your data?
4. What trends did you notice in your data?
5. What conclusions did you reach as a result of your data?
6. Does the data support or refute your hypothesis? Or is more data needed to reach a valid conclusion?
7. What are the limitations of this experiment? How much trust can we put in the results of this work?
8. What would be the best options for our next steps in regard to answering our original question? Is this enough to reach a sound conclusion about our question, or is more data necessary? If so, what would be the best option for getting the data needed to answer our question more accurately?

Day 5: Presentations (Options A & B)

Directions: You will be delivering your presentations on this day. Your instructor will use this rubric (or something similar) to grade your presentations.

Item	*Plus (100%)*	*Check (70-90%)*	*Redo (0%)*
Accuracy	No errors were detected in this presentation	This presentation contained a few errors, but overall was very accurate.	This presentation contained considerable errors.
Thoroughness	No important information was omitted.	A few more details would have enhance this work.	Major topics were omitted that should have been included.
Professionalism	This presentation's quality exceeds expectations for high school students.	This is acceptable work for high school students but room exists for improvement.	The professionalism of this group needs significant improvement.
Group Involvement	Every member was involved with the development of the presentation as well as its delivery.	At least one more group member could have been more involved than they were.	Multiple group members clearly could have been more involved.
Effort	Effort exceeds what would be expected of a high school student.	Effort is acceptable for a high school student but room exists for improvement.	Level of effort could have been much greater than what was presented.

Comments:

Day 1-3: Applications of Data Activity (Option B)

Overview: In this activity, you will use the biodiversity data that was previously collected (See *Day 1: Intro Biodiversity Data Activity*) to develop explanations that relate this data to the concepts you have addressed so far in this course.

Directions: Begin by reading the excerpt below, which will provide additional background information about this experiment. Then work in your assigned teams to address the questions on the next page. After your team has addressed these questions, your instructor will temporarily form new groups so that you can hear the conclusions reached by other teams (alternatively, your instructor may arrange for a gallery walk or use another option to have you share ideas across teams). After you have heard the ideas from different groups, meet again with your original team and revise your original responses based on any new ideas or information you may have gained. Your instructor will decide if you should record your answers using the space provided in this packet, a dry erase board, a digital document, or another option.

Additional Background Information: the data provided for you in the *Intro Biodiversity Data Activity* was collected by students in the WHS Agricultural Science Program in southeastern Wisconsin. Students collected this data in their school forest, a 20-acre wooded area on the edge of the high school campus (*an acre is roughly the size of a football field*). An oval-shaped trail runs just inside the entire perimeter of the forest; there is also a trail that runs down the center of the forest (shown in the image to the right).

The high school is east of this forest (*right side in this image*). There is a suburban housing development directly north of the forest, and an elementary school is directly south of the forest on the other side of Barnes Dr. A country road forms the western (*left*) edge of this forest, with farmland directly across the road.

Students collected data on the east (*right*) side of the forest, beginning 1 meter from the edge of the forest. They continued to collect their data at 25, 50, and 75 meters from the east edge of the forest (*75 meters is roughly at the center of this forest*). At each of these sites, students measured both the number of individual organisms as well as the number of species that they found. They calculated a biodiversity score for each site by dividing the number of species by the number of individuals. Their data is shown below.

Site	1 m	25 m	50 m	75 m
Group 1	0.024	0.062	0.122	0.0047
Group 2	0.13	0.44	0.8	0.87
Group 3	0.35	0.3	0.3	0.18
Group 4	0.83	0.25	0.17	0.27
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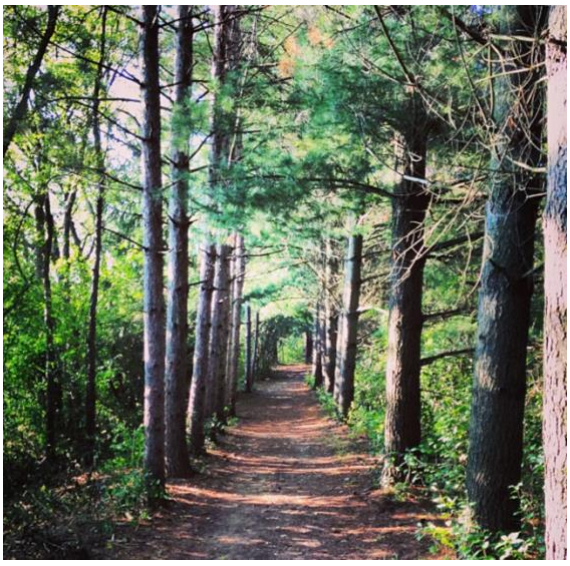
Group 6	0.21	0.17	0.25	0.5

Questions: In your groups, address each of the questions below. Your instructor will decide if you should record your answers using the space provided in this packet, a dry erase board, a digital document, or another option.

1. How did the biodiversity change between the edge and interior of this forest ecosystem? What explanations might help to explain these trends?
2. What is *biodiversity*? What does it mean that some parts of this forest are more biodiverse than others?
3. Why does biodiversity matter? How might changes to biodiversity at different points in this ecosystem affect the function of this ecosystem?
4. What is *ecosystem resiliency*? Which parts of this ecosystem are more likely to be resilient to disturbances? Why?
5. What are *ecosystem services*? Which parts of this ecosystem are more likely to produce more ecosystem services? Why?
6. What differences exist between the edge and interior of this ecosystem at the following scales that might help to explain the trends in this data?
    a. *Ecosystem* (interactions between living organisms and non-living components of a landscape).
    b. *Organismal* (processes that occur within individual living organisms)
    c. *Cellular* (processes that occur within cells, especially photosynthesis and respiration).
    d. *Atomic-Molecular* (changes in matter and energy among atoms and molecules).
7. How might the *10% rule* and rates of *biosynthesis* affect the measured differences in biodiversity between the edge and interior of this ecosystem? In your response, include a definition of the *10% rule*.
8. Suppose that the high school wants to maximize the biodiversity of this forest ecosystem to provide its students with a more enriching educational opportunity. The farmer across the street supports this, as he is hoping that this will increase his opportunities for hunting and birdwatching on his own property (assuming that the wildlife move back and forth between his property and the school forest).
    a. What are some ways in which this forest's biodiversity could be maximized?
    b. Why might these options be effective for this goal? What evidence or reasoning supports your conclusions?
    c. What are some initial steps that could be adopted to enact these options?
    d. What might be some potential drawbacks that might occur if these options are implemented?



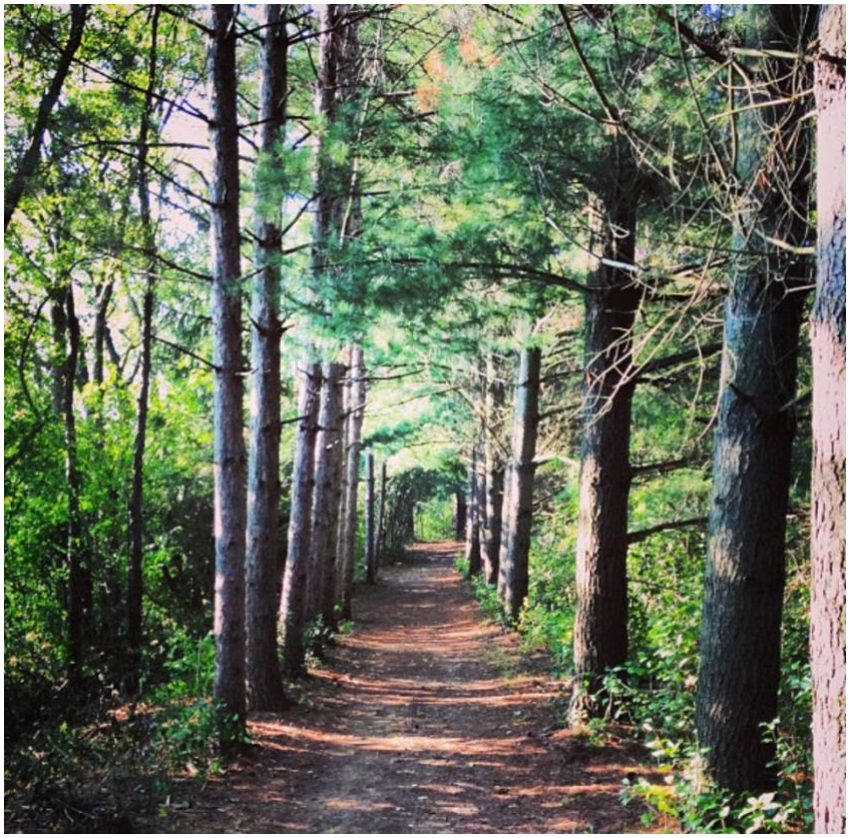
Day 4: Data Analysis & Reporting (Option B)

Overview: You will be working in teams to develop a paper or presentation about the WHS School Forest Data and how it relates to the concepts addressed so far in this course.

Directions: Begin by meeting with your team to discuss the original 8 questions. You will use these questions to create a report. This can be in an oral format, PowerPoint, poster, or paper. Your instructor will determine which format will be most appropriate for your situation.

In your report, you should address the following:

1. How did biodiversity differ between the edge and interior of this forest?
2. Why do you think these differences occurred?
3. Why do these differences matter? What is biodiversity, and how does biodiversity affect the resiliency and function of this ecosystem?
4. What might be the cause and/or impact of these differences in biodiversity at each of the following levels?
    a. Ecosystem
    b. Organismal
    c. Cellular
    d. Atomic-Molecular
5. If our goal was to maximize biodiversity in this ecosystem, what would be your recommendations? Summarize the evidence and reasoning that would support your recommendations.



Day 5: Presentations (Options A & B)

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Group Involvement	Every member was involved with the development of the presentation as well as its delivery.	At least one more group member could have been more involved than they were.	Multiple group members clearly could have been more involved.
Effort	Effort exceeds what would be expected of a high school student.	Effort is acceptable for a high school student but room exists for improvement.	Level of effort could have been much greater than what was presented.

Comments:

Appendix: Setting up the Biodiv. & Habitats Lab

Introduction: In this activity, students will be assessing the biodiversity of the edge and interior portions of a habitat near your school. School forests or prairies can work well for this. As long as you have a natural habitat within walking distance of your classroom that you have permission to use, it would be a suitable candidate for this activity. If this is not an option, consider using Option B in this packet as an alternative (see directions within the text of this packet for more details, as well as "Presentations" below).

Outdoor Data Collection: It is best to assign students to equally-separated areas within sight of each other (for purposes of supervision). Quadrats can be assembled from four equally-sized sections of PVC pipe and rope. The size of the quadrats depends somewhat on the amount of vegetation and your available time. For example, if you have a dense prairie, 24-inch sections of PVC pipe would provide plenty of plants to count and identify in the available time. If you have a forest with minimal understory, you would probably want quadrats that are at least 1x1 meter.

Students should count every stem of every living plant that exists inside the quadrat. It is not important that they identify the exact species (although this is an option for more advanced students). Rather, it is only necessary that they identify the total number of different species in addition to the total number of living individuals.

It may be helpful to have a satellite image (such as those available on Google Maps) of your habitat so that you can point out exactly where you will be collecting data on each day prior to the start of the activity. It also would be recommended to have students meet in your classroom first and then move to the habitat rather than have students leave the school building without supervision. It would also be recommended to check with your administration and to send letters home to parents in advance informing them that class will be meeting outside. This is especially important for students with medical needs (particularly stinging insect allergies) as medical precautions may need to be taken prior to the lab.

Data Analysis: Depending on the mathematics abilities of your students, they may need assistance with calculating averages. Similarly, students may need help developing their presentations. While a PowerPoint or Google Slides presentation would be ideal, students with limited abilities may find that an oral presentation may be sufficiently challenging.

Presentations: While students can present to the whole class, you may find that this will lead to classroom management problems after they have heard the same presentation for the 5th or 6th time. What may work best is to have students deliver their presentations to the instructor while the rest of the class finalizes their preparation and/or works on other assignments. This may be an especially valuable time to inform students of missing work and have them complete this missing work after they have completed their presentation.

The order of presentations can be assigned or determined at random. It may be encouraging to offer a rounded-up score to the first or second group that volunteers as a means of encouragement.

Be sure to ask questions of different group members as they present as a means of checking the level of engagement of each group member. Similarly, be sure to float among groups as they are working to check to make sure all members are equally involved. Pointing out that full group involvement is part of the rubric may be helpful in encouraging less engaged members to pull their weight (ditto for offering to have unengaged students work alone instead of in a group unless they can become more involved).

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Group 4	0.83	0.25	0.17	0.27
Group 5	0.21	0.0875	0.0833	0.142
Group 6	0.21	0.17	0.25	0.5
Avg Biodi	0.292333	0.21825	0.28755	0.327783
Std Dev	0.284367	0.141916	0.263481	0.312325
Std Error	0.116092	0.057937	0.107565	0.127506
Error Bars	0.232184	0.115874	0.215131	0.255012