POLAR TREC
Learning Resources

Details

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Biodiversity of Ecosystems

Materials

- Calculator
- 2 parking lots with vehicles
- Images representing different ecosystems with differing species evenness and richness.

Overview:

Biodiversity is a central concept in understanding ecosystem functioning. Students explore how biodiversity is measured, impacted and can shift due to environmental changes to develop their understanding. Based off of the Microbial biogeography studies that Dr. Byron Crump is doing in the Arctic and around the world.

Objectives:

- Understand the role and importance of biodiversity in an ecosystem.
- Calculate and interpret quantifiable measurements of biodiversity.
- Explain how biodiversity impacts an ecosystem.
- Basic principles of classification of organisms.

Lesson Preparation:

Students should have learned about ecosystems. This lesson will introduce them to the importance of biodiversity on a population level (not genetic diversity), and how to measure and interpret the data to understand what is happening in an ecosystem.

Three measures of biodiversity are species richness, species evenness, and the Shannon diversity index, which is used in these lessons. It is important to have a healthy and robust ecosystem with a variety of different species because as changes occur there may be certain species that are better adapted and able to handle the changes than others. This will allow the ecosystem to flourish. Without a healthy diversity, major die offs can happen as environmental changes ensue. It is also important to have a good level of biodiversity to ensure that the different roles in the ecosystem are being filled. Each organism plays a different part, and if there are too

many, or not enough, of a certain species the effects can potentially be felt throughout the ecosystem.

Procedure:

Part 1:
Show these different pictures to students and ask them how many different species are found in each one.

"One picture with 10 different species" "One picture with 5 different species" "One picture with 2 different species"

Note that there are the same total number of individuals (10) in each image. These pictures illustrate that there are differences between these three areas in how many variety of species are found there. The first has 10 different species, the second has 5, and the third has two different species. This is called **species richness (R)**, and it is measured simply by counting up the total number of different species in the ecosystem.

Ask students would we want high or low species richness in an ecosystem? Why?

- Answers should include: high species richness to allow for greater diversity and balance of genetics, resilience to changes, and roles that each organism plays.

Now look at these pictures again. This time count how many of each of the different species is present in the image.

"One pic with 10 different species, 1 of each" "One pic of 5 different species, one with 5, and the other 4 with one" "One pic of 2 different species, 7 of one and 3 of the other"

These pictures illustrate that between these different areas the relative abundance differs. This is called **evenness (E)** and allows us to see if there is one species that is more dominant than another.

Ask students why we would want an ecosystem to have a greater evenness than dominance? Why?

- Answers should include: would like to have more evenness vs. dominance because more evenly distributed communities tend to have richer species diversity, and that is important for the reasons stated previously.

These two measurements species richness and evenness together allow us to consider species diversity of an ecosystem.

There is also the **Shannon Index (H),** which allows us to measure and consider the number of species and their relative distribution together.

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Part 2:
(adapted from http://goapes.wikispaces.com/file/view/schoolyard_ecology_lab.pdf)
Now to mathematically calculate these different indices:

Species Richness = R = number of different species in an ecosystem

Shannon Index = H = uncertainty of predicting species. Ranges from 0 if only a single species present, to over 7 for a very diverse community.

N = total number of individuals of all species
n_i = number of individuals that are in species i
P_i = relative abundance = n_i/N

$H = -\sum (P_i \ln [P_i])$

Species Evenness = E = H/ln (R)

This allows us to compare abundances of species, range is 1< E. Closer to 1 represents a more even distribution, higher represents more dissimilarity, high levels of dominance or rarity in the ecosystem.

Practice Calculations (put up on the board and work through with students, or assign to small groups):

Calculate R, H, and E for each community. Describe what each result means in terms of relative biodiversity to one another.

Community 1: 100 individuals, 10 species each with 10 individuals.
Community 2: 100 individuals, 5 species, each with 20 individuals.
Community 3: 100 individuals, 10 species, 80 in one species, and 2 in each of the remaining 9 species.
Community 4: 100 individuals, 5 species, species 1-50 individuals, species 2- 25 individuals, species 3- 15 individuals, species 4 and 5- 5 individuals each

Community 1:
R = 10

H = -10(10/100 ln [10/100]) = 2.30

E = 2.30/ln 10 = 1.00

Community 2:
R = 5

H = -5(20/100 ln [20/100]) = 1.61

E = 1.61/ln 5 = 1.00

Community 3:
R = 10

H = - [(80/100 ln [80/100]) + 9(2/100 ln [2/100])] = .88

E = H/ ln 10 = .38

Community 4:
R = 5

H = -[(50/100 ln [50/100] + (25/100 ln [25/100]) + (15/100 ln [15/100]) + 2(5/100 ln [5/100])] = -1.28

E = H/ ln 5 = .79

Part 3:
(adapted from: http://goapes.wikispaces.com/file/view/schoolyard_ecology_lab.pdf)

If your school has multiple parking lots consider each lot a separate community of species. If you only have one parking lot available, break the lot into two separate areas to count (Note with this method you may not see as much of a difference in the populations).

The different types of cars will represent different species (ex. truck, van, compact, SUV, etc.). Split the students into small groups, 2-4 students/group. Students should determine how they want to classify the cars and agree before proceeding to the parking lot so that they classify them in the same way. They should also identify how to deal with immigration and emigration of cars entering and leaving the parking lot. As students are ready, move out to the parking lots and begin the survey.

After students collect data from one lot, move to the other.

When finished they should calculate the richness, Shannon diversity index, and evenness for each of the communities. Show setup for calculations.

Consider the following questions:
1. Which community exhibits greater biodiversity? Why? What was the main contributing factor(s)?
2. Does either community have any particular species that is dominant? What might influence that type of species to dominate in the community?
3. Did either community have a high level of immigration or emigration? What may have

been a factor influencing these?

Part 4:
What would be roles of the organisms in that parking lot? Why drive one type of vehicle vs. another. Advantages disadvantages?

Possible answers may include:
- *Trucks- workers, carry things*
- *Vans- transporters*
- *SUV- can cover more terrain*
- *Compact car- good for smaller more dense areas of travel/parking*
- *Sports car – good for speed/fun*
  - Also could tie in economical cost and affordability of certain types of cars, or hand-me-down cars/used cars for students.

Can these roles also be applied to living ecosystems? Depending on your time and areas of focus, you could have students research and focus on an ecosystem for their comparisons.

Possible answers may include:
- *Producers, consumers, decomposers, different organisms are better at different functions.*
  - For example, in arctic tundra, there are producers: grasses, some shrubs, photosynthetic microbes. Primary consumers: voles, arctic ground squirrels, birds, caribou. Secondary consumers: foxes, wolverines, bears (could be tertiary depending on diet)

Now to bring in environmental changes. Compare winter (assuming there are seasonal differences in your area) to summer and the cars that might be present, how might the population of cars in the parking lot change? What would be possible reasons behind those changes?

Possible answers may include:
- *More trucks, SUVs better in the snow, perhaps more vans for carpooling, fewer overall number of cars because the presence of snow disturbed the population and made certain ones unable to drive to school.*

How might the seasonal change impact actual ecosystems? Think about why these changes might occur.

Possible answers may include:
- *Changes in amount of sunlight allow for more or less photosynthesis and productivity. An increased level of productivity often is reflected in greater species richness. Changes in temperatures cause for certain species to not be able to tolerate the climate. May migrate, or go into hibernation or dormancy.*
  - For example, in arctic tundra many species of birds migrate south to warmer climate.

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Plants die off or turn dormant over the winter. Arctic ground squirrels hibernate in their burrows. Level of activity is greatly reduced and impacted by both reduced daylight and temperatures.

Describe a disturbance (a wild fire, landslide, etc.) that might occur in an ecosystem, how might this disturbance impact the species found in that area?

Possible answers may include:

- *Disturbances will favor any species that remains adapted to the new conditions. Often generalists will thrive as specialists either have to relocate or die off. Depending on the type of disturbance there may be differences in length of time for recovery.*

Bringing it all together. Explain why a healthy ecosystem will have robust species diversity. Use an example of an ecosystem you research to describe roles that different species play, and responses to environmental changes and disturbances.

Extension:

In place of Part 3 you can also elect to do a plant survey if you have plant identification materials and have different areas you identify and identify as specific communities (riparian, meadow, forest etc.)

Have students examine how ecosystem diversity varies over the globe. Which ecosystems are the most diverse/least, what are contributing factors to their biodiversity?

Think about microbial biodiversity. How might this be measured, examined and classified?

Assessment:

Student responses should be evaluated to determine if they have met the stated objectives. They should demonstrate ability to calculate and defend the various measures of biodiversity and their relative importance as well as how they are impacted by changes.

Author / Credits:

This lesson was developed for the PolarTREC 2014 Microbial Changes in Arctic Freshwater by Lauren Watel <Lauren.Watel@gmail.com>.

Part 2/3: Parking Lot Biodiversity adapted from (http://goapes.wikispaces.com/file/view/schoolyard_ecology_lab.pdf)

File Attachments:
Attached drawing of first three communities described in Part 1 for comparison.

Science Standards:

This lesson has been used with AP Environmental Science classes following the curricular standards outlined by College Board for that particular course.

- It falls under Population Biology Concepts and Ecosystem Diversity and Change

National Science Education Standards

Content Standards, Grades 9-12

Content Standard C: Life Science

d. Interdependence of organisms

e. Matter, energy, and organization in living systems

Content Standard F: Science In Personal and Social Perspective

a. Personal and community health

d. Environmental quality