Lesson Three – Patch Size and Biodiversity

Biocompass

Where you've been

Lesson 2 introduced you to some key characteristics of the prairie, especially from the plant's point of view. You reviewed some important ideas in ecology, including net primary production (NPP) and its use in measuring energy flow in a system, and the way climatic factors determine dominant vegetation in a region. You also were introduced to some of the other ecosystem processes that take place in prairies (and grasslands all over the world) including migrations of birds and grazing animals.

Where you're going

This lesson introduces some basic ideas of landscape ecology, as a way to look at a landscape in process.

Introduction

Both natural and human-shaped landscapes are composed of patches — smaller or larger areas of different ecological types. Human activity, as well as nonhuman processes such as fire or wind-throw, create patches of different kinds. When a large patch, say of forest, is altered by clearing or road-building, patch-creation is termed "fragmentation." The fragmentation of ecosystems is a characteristic feature of urban and suburban landscapes. Moreover, natural processes, such as fires, floods, or windstorms, can create patches — as can animal activity, as when beavers create a pond in the midst of a forest. Fragmentation has an impact on biodiversity — more or less impact, depending on the process that created the fragment patches, and on the speed at which it takes place. In this investigation, you will identify two landscape patches of different sizes but of similar type (e.g. both meadow, both woods, etc.) near your school and collect arthropods (insects, spiders, crustaceans) in the patches. Next, you will identify at least three different ecosystems near your school and explore the possible links that might exist among these ecosystems.

This lesson explores these two basic questions:

1. What is the relationship between biodiversity and patch size?
2. How does the process of habitat fragmentation affect biodiversity?

Investigation - How are patch size and biodiversity related?

The basic unit landscape ecologists consider is a *patch*. In this context, a patch refers to a relatively uniform area, such as a patch of grass, or of asphalt, oak-hickory forest or pine forest. A landscape is made up of patches and the result usually resembles a patchwork quilt.

If you're interested in how Florida panthers move, you might talk about patches of forested wetlands, pine forests, or wet meadows across the landscape of the Everglades. But if you're more interested in how a cricket relates to its environment, you might talk about patches of certain kinds of flowering plants and patches of certain kinds of grasses or sedges in a meadow landscape. In one case a meadow is the patch and in another the meadow is the landscape. In any study, you would choose to define the patch vs. landscape carefully based on what you already knew about the organism.

This lesson introduces one way to investigate and compare the biodiversity in patches of varying size near your school by setting up traps to sample insects in the patches. In this class period you will set up pit fall traps that will sit out in the field for 24 hours. The next day you will collect and analyze the insects in the trap.

As a class, briefly discuss what you think the relationship between patch size and biodiversity might be. Consider the following questions in your discussion.

a. How do you think the total number of insects and other arthropods might compare between the small and large landscape patches? Why?
b. How do you think the total number of insects and other arthropod *species* might compare between the small and large landscape patches?
c. What do you think besides patch size might influence the biodiversity in a landscape patch?

Part A – Identify landscape patches

As a class, identify two different sized patches of the same terrestrial ecosystem near your school using Google Earth. Depending on where you live this might be a small and large patch of forest, desert, meadow or prairie. Ideally the small patch should be approximately 5-10 times smaller than the large patch.

Show me How: To find an initial starting point or location

There are several ways to do this.

One way is just to click on the general area you are interested in when the world map is displayed. You can then use the Hand tool to center your image and the slider on the right hand side of the screen to zoom in or out.

Another way is to use the Search box. Click on Fly To and type either the name of your location (i.e. your town, school name and address), or the exact latitude and longitude of the location. If you write in the latitude and longitude, do not use degree symbols. Instead, write the latitude and longitude using the following format to indicate the number of degrees, minutes, and seconds. Add the appropriate symbol for N or S after the latitude reading, and W or E after the longitude reading.

Example: To fly to Miami, FL = 25 43 36.98 N, 80 14 09.90 W

Show me How: To move from place to place

To zoom in, double click on a point in the image you are interested in. You will zoom in toward the object you clicked on. To zoom out, hold down the control button and double click. Or, you can grab the slider bar with your cursor and move it toward the top of the screen (+); to zoom out, move it downward (-).

To move from place to place, you can use the four arrowheads with the hand in the middle to move north, south, east, or west. Or, simply hold your mouse button down and use the hand cursor to move about the image.

Your current altitude (Eye alt) is given in the bar at the bottom of the screen.

Part B – Set up pit-fall traps

As a class, decide who will set up their pitfall traps in which of the identified landscape patches. (You may also want to decide the relative location of your pitfall trap in your assigned patch before going out into the field.) Then go set them up, using the protocol below.

INVESTIGATION PROTOCOL – PITFALL TRAPS

The color yellow attracts many insects, as well as other arthropods. Therefore, this investigation utilizes yellow bowls with water in the bottom to trap the arthropods attracted to the yellow color. Soap is added to the water to decrease the surface tension of the water and inhibit arthropods from crawling or swimming out. The added salt helps limits the amount of water absorbed by the dead arthropods, thus keeping them intact.

Preparation in the classroom

1) Measure the water and salt into the jar. Stir or shake the jar until the salt has dissolved.
2) Add dish detergent to the jar. Mix lightly to avoid creating lots of suds.
3) Put the lid on the jar securely so that it won't leak when you transport it out to the field site.

Setting up your pitfall trap in the field

4) Place the bowl down in your selected spot. Record the location and patch size.

5) Dig a small hole or hollow in the ground in which to place the bowl, with the rim more or less flush with the ground surface. See figure 3.1. (Check with your teacher before digging. There may be areas of your school grounds where hole digging might not be appreciated…)
6) Pour the water mixture into the bowl and leave it there for 24 hours.
7) Save the jar for the trapped insects once you've retrieved the bowl from the field.

Figure 3.1 – Pitfall trap secured in a hole in the ground.

2. Once you've set up your traps, make an estimate of approximately how many different plant species there are in the patch and record your estimate.

3. Measure the area and perimeter of the patches and record them.

Part C – Taking data

1. Pour the contents of the pitfall trap into your jar, screw on the lid and bring it and the bowl back to the classroom.

2. In pairs, record the number of different species collected from the pitfall trap (species richness), as well as the number of individuals in each identified species (species abundance), using the data sheet provided at the end of this lesson.

3. As a class compile all of the insect biodiversity data and relate it to the size of the patch and to the ratio of perimeter to area.

Part D - Analyze your data

1. How did patch size affect species richness (the number of different species), species abundance (the number of individuals within a species) and total numbers of individuals found in the patch?

2. How many of the species you collected were the same in both patches? How many were different?

3. What landscape patches bordered your chosen patches, both small and large?

4. How do you think the patches surrounding a given patch might influence the biodiversity of the patch?

Making Sense

In small groups, address the following questions:

1. On the basis of your data, can you demonstrate any relationship between patch size and biodiversity? Does this agree with your prediction, or not? If not, what might be some reasons for this discrepancy? Could you devise some way to test your conjectures?

2. In general, biodiversity declines as patches get smaller, and this is true at the Konza Prairie Research Area. Do your data also show this pattern?

3. If patches are more similar or less similar, how might this affect the flow of organisms across the landscape? How do the differences that you see interact with the size of the organisms, or their life histories?

Part E - Write up your investigation

Write up an investigation report, including your predictions, an analysis of the data and a summary of the Making Sense questions. If you tried to make use of Jaccard's Coefficient (in the last "Digging Deeper") describe what you did, and what your results were. Did the Jaccard's confirm your expectations, or surprise you?

📖Reading - Landscape ecology

Landscape ecology addresses a scale larger than the ecosystem. It focuses on larger blocks of country that contain many different ecosystems or in which the same ecosystem is divided into isolated patches. Landscape ecology draws on the knowledge of ecosystems for a specific applied purpose - to address large-scale issues of land use and land planning.

Landscape ecology focuses on three characteristics of landscapes that set it apart from other ecological disciplines. First, landscape ecologists are interested in the spatial arrangement of interacting elements, or patches, in a landscape. They are interested in identifying, for example, how green space is distributed in an urban or a suburban neighborhood, and they focus on patterns in this arrangement, for example how the green spaces might connect with one another. Take a look at the photograph below, and consider what kinds of patches are visible to you, and how they are arranged. Perhaps the most important kind of arrangement is the distance between two patches of the same type, since this arrangement will affect the flow of organisms among similar habitat patches.

Developing roads and neighborhoods creates a patchwork of different land uses and types.

Secondly, landscape ecologists look for relationships between this spatial arrangement and the social and ecological processes that occur in the landscape. They focus on what causes the relationships between spatial arrangement and processes, and what results from the relationships between spatial arrangement and processes. How did the landscape that we see today come about? What processes that shaped the landscape are still at work — are forests being cleared, or are they being allowed to come back, because agricultural lands are no longer in use? Is the population growing, and therefore building houses and roads, or are people moving away, or moving back to the town's center?

Third, they are interested in scale. How does the scale or size of a patch influence what goes on there? One of the primary reasons that landscape ecologists study patches, processes and scale is to understand land use and changes in land cover, and to conserve landscapes. How might the ecosystem processes in a small landscape patch compare to those in a large landscape patch? How might biodiversity relate to patch size?

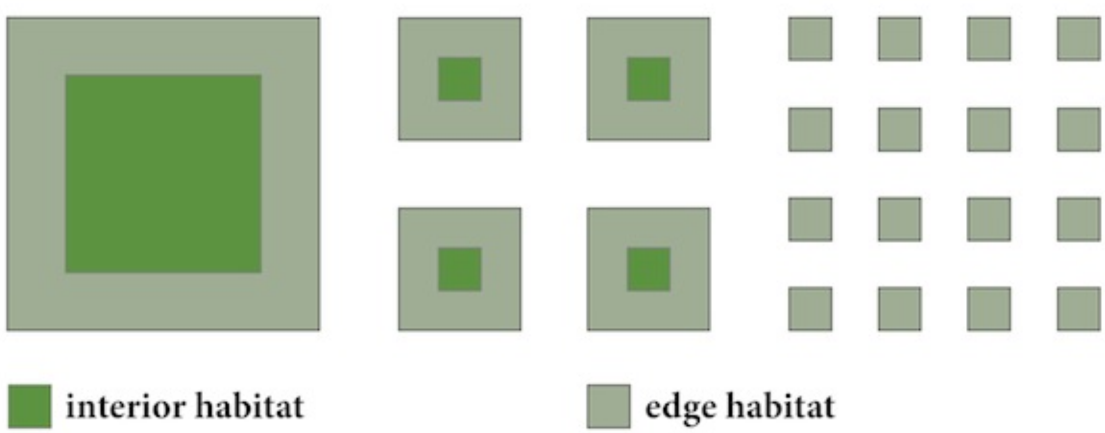
Check your thinking

What concepts set landscape ecology apart from other ecological disciplines? What patches do you see in the landscape through which you travel each day? What forces — human and nonhuman — are currently making changes in your landscape?

Interpreting your results: Reflections on patch size and biodiversity

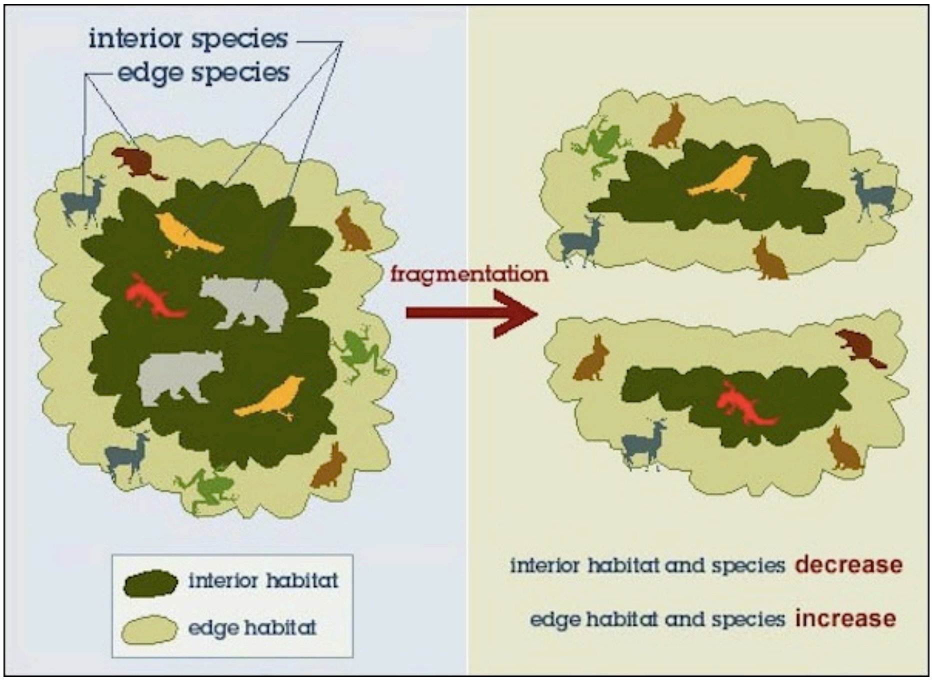
Larger patches support more species because they are more likely to contain a greater variety of habitats and microhabitats than smaller patches. Since organisms are connected and depend on one another for survival, large patch size helps ensure that each species will have what it requires over the long term. When a patch is fragmented, the number of species will start to decrease and continue to decrease over time. The loss of one species can, and often does, lead to the loss of another, and then another, as biodiversity shrinks. In fact, with all the fragmentation that has already occurred in most areas of suburban sprawl, species number is still decreasing in most patches of natural habitat in these areas. But there is something more at work than just size.

First, consider the relationship between the area of a patch that is "edge", and the area which is "interior" (which is most like the habitat before disturbance). Look at the figure below. How would you estimate the ratio between the edge of the largest patch on the left and the area of the interior habitat (green) of that patch? Compare that with the ratio for one of the smaller patches in the middle. What happens to interior habitat in the smallest patches? Also, notice that the overall area encompassing all the medium patches and the smallest patches is exactly the same as the large patch on the left.



Small patches have a higher edge to interior ratio than large ones do.

Now look at the diagram below that has patches more likely to occur in nature. How would you estimate the ratio between edge and interior area? Compare, for instance, the 100-hectare patch on the left with the two 50-hectare patches on the right.



Interior habitat decreases with fragmentation.

You can see that smaller patches have a higher edge to interior ratio than larger patches have. Smaller patches have more edge per unit area than large patches. (Note that the more curvy or zigzag the edge, the more the total edge length increases.) As an area becomes more and more fragmented, the area of edge habitat increases dramatically and the area of interior habitat decreases rapidly. Why does this matter?

Edge habitat differs from interior habitat in several important ways— this is especially true when the patch is very different from what surrounds it, for example a patch of forest surrounded by fields or housing developments. The edge zone is more exposed to wind and sun. This means that trees or other vegetation can be damaged by high winds, the temperatures can rise higher than in the interior, and the combination of more wind and higher temperatures leads to lower humidity, in the air and the soil. The edge zone is more accessible to some kinds of predators and "opportunistic" species which can thrive in a wide range of conditions. The edges are also more likely to be receptive to alien and invasive species. So the edge zone may not be hospitable for species that prefer interior-type habitats, not only because the microclimates are different, but also because the interior specialists will encounter new predators and competitors, and some organisms on which they depend may also not thrive in the edge zone.

Moreover, interior species may require larger ranges or territories than the newly created fragments provide, and the edge zones and the area surrounding the fragment (this surround is sometimes called the "matrix") may prevent movement of interior species to other patches of interior habitat (either because the journey crosses areas where the environmental conditions are hostile, or because the traveler is exposed to predators or other threats). This in turn may prevent organisms from finding mates or prevent offspring from finding suitable habitat in which to carry out their adult lives.

If the population of a species diminishes or dies out in one fragment, new recruits may not be able to reach the area, and the result is a local extinction. For a widespread, numerous species, extinction in one patch may not be too important, but the case of a rarer or threatened species, it could make all the difference between the species' survival or disappearance.

Patch size and prairie

Today only fractions of the once expansive prairie remain. In the tallgrass prairie, roughly one percent of the native prairie remains. The shortgrass prairie has been reduced to 18 percent of its original extent, while 25 percent of the mixed grass prairie remains. Prairie remnants can be found in places that were difficult to farm, along the edges of highways and railroads, and in the cemeteries of early settlers.

Because of their small size, these prairie patches do not function in the same way as intact prairie. For example, a study in Illinois found that 83% of the high quality prairie remnants were less than 10 acres (4 hectares) in size. This distribution of small prairie patches results in most of the remaining prairie in these areas being exposed to edge effects. This exposure may have negative effects on the living things found in the prairie patches.

Some species require a certain amount of interior habitat, the kind of habitat that only occurs greater than a certain distance from the habitat edge. Interior habitat protects interior species from the conditions and predators that occur at or near the edge. For example, predation on the eggs of ground nesting birds in prairie such as Henslow's sparrow is greater if they are situated near the edge of small patches. Why does predation increase as the size of patches decreases? This has to do with the ratio of edge to interior – predators living in edge habitats can more and more easily get access to interior species in smaller patches.

However, some species actually prefer the edge habitat, where conditions grade from one habitat into another. Such edge species tend to benefit from suburban development. They prosper from having access to two different habitats offering different resources. Conditions in the edge habitat can differ enormously from conditions in the interior habitat. Edges often have more sunlight, higher temperature, and faster wind speeds than interior forest areas. These changes favor plants that flourish under these conditions and the plant community changes. The animals living on and in the plants also change.

Common edge-loving species include raccoons, skunks and coyotes, which have increased with the expansion of suburban sprawl. They also exact a toll on native animal species, preying on nests and adults of all sorts of creatures.

Digging Deeper

How different is one patch from another?

Ecologists have developed or borrowed various methods with which to compare two samples or sites for similarity. One simple method which works usefully in comparing the species assemblage of one site with that of another is *Jaccard's Coefficient*.
This is computed as follows:

$$J=\frac{\text{Number of Species in common}}{\text{Number of Species only in A}+\text{Number of Species only in B}-\text{Number of Species in A and B}}$$

or

$$J=\frac{NC}{NA+NB-NC}$$

This produces a number between 0 and 1. What will it tell you?

Suppose we have found 10 species at A, and 10 species at site B.
If they're all found in both, the computation will work out this way:

$$J=\frac{10}{10+10-10}=1$$

So the equation tells us that their similiarity is 100% -- that makes sense.
But suppose the 10 A species are completely different from the 10 B species? then the calculation will go like this:

$$J=\frac{0}{10+10-0}=\frac{0}{20}=0$$

And if 3 species are found in both places, then:

$$J=\frac{3}{7+7-3}=\frac{3}{11}=0.27$$

What does using Jaccard's coefficient tell you about your patches that you didn't see before?

Check your thinking

1. How do shrinking interior areas due to fragmentation affect native animal species?

2. How does the size of a patch affect the number of species and size of populations of those species?