PURDUE UNIVERSITY | Extension

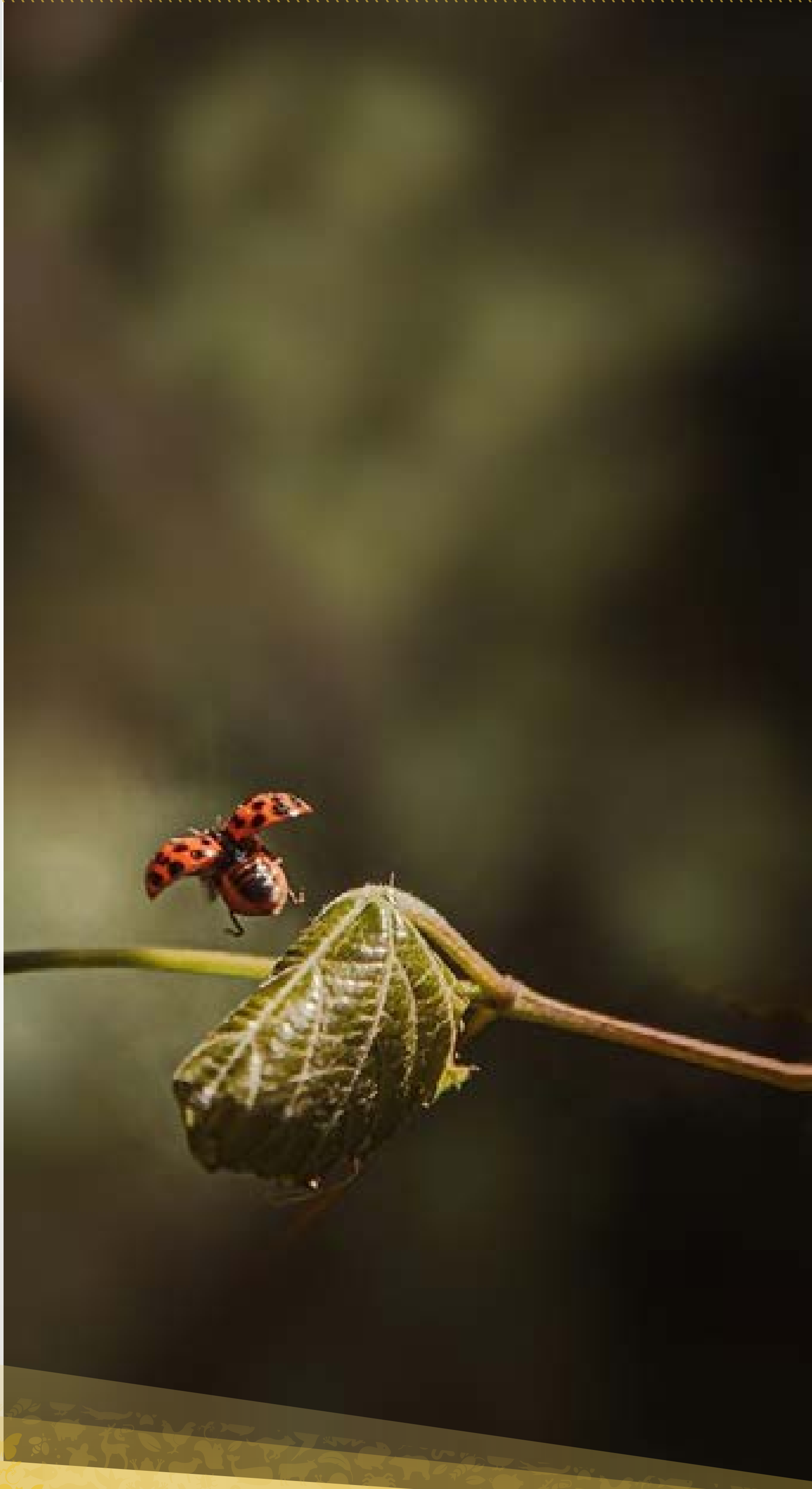
FNR-619-W

EXPERT REVIEWED

The NATURE OF TEACHING

WILDLIFE

How Humans Impact Gene Flow and Genetic Diversity



LESSON PLAN

This unit explores the effects of barriers and human assistance on wildlife gene flow.

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OVERVIEW

ESTIMATED TIME

2 class periods (90 minutes in class, plus 45 minutes lady beetle collection time)

VOCABULARY

- **genetic diversity**: the amount of variability in traits that can be inherited from one generation to the next (through information encoded in the genome).
- **heritability**: the degree to which an observable trait (phenotype) is passed on through genetic inheritance.
- **barrier**: a physical or behavioral obstacle that prevents or inhibits the movement of wildlife across a landscape, either directly or indirectly.
- **gene flow**: the movement of genes between populations via wildlife movement and reproduction.
- **translocation**: the movement of an individual from one place to another by humans, usually between wild habitats.
- **wildlife corridor**: a narrow strip of habitat connecting wildlife populations or suitable habitats.
- **local geography**: the layout of a local area including natural and human elements.

OBJECTIVES

i) Understand how wildlife genetic diversity is affected by barriers to gene flow.

ii) Discuss the effects of human-induced factors on wildlife movement and gene flow.

iii) Describe and evaluate the effectiveness of human interventions that promote gene flow among wildlife.

ACKNOWLEDGEMENTS:

Reviewers: Nicholas Burgmeier, Nancy Lillie, Shelby Royal, and Laurynn Thieme.

Editor: Brian MacGowan

Required Materials

- rubbing alcohol (> 70% isopropyl alcohol)
- liquid container (> 2 oz. plastic or glass jar)
- masking/labeling tape
- marker or pen for fieldwork
- tweezers
- (optional) microscope
- (optional) dissecting light
- calipers or measuring tape with millimeter accuracy
- downloaded local map (Google Earth)
- three trays with edges > 1 inch
- two stiff boards (cardboard or paperboard recommended) with a length equal to tray width
- 90-120 beans or large beads of 2-4 distinct colors
- Lady Beetle Collection Instructions
- Lady Beetle Data Sheet
- Genetic Diversity and Gene Flow Worksheet
- Gene Flow Class Discussion Worksheet
- Assisted Gene Flow Introduction
- Assisted Gene Flow Examples Resources
- Assisted Gene Flow Examples Table
- Assisted Gene Flow Examples Worksheet
- Assisted Gene Flow Class Discussion Worksheet

LESSON STANDARDS

Lesson One

8.LS.5; 8.LS.9; 8.LS.10; 6-8.LST.5.1

B.3.2; B.3.3; Env.1.2; Env.1.5; Env.1.7; Env.5.1; Env.5.6; Env.8.2; ESS3.C LS2.A

MS-LS4-4; MS-LS2-2; MS-LS2-4

Lesson Two

8.LS.5; 8.LS.9; 8.LS.10; 6-8.LST.4.2; 6-8.LST.5.1; 6-8.LST.6.2

B.3.2; B.3.3; Env.1.2; Env.1.7; Env.4.1; Env.4.2; Env.5.6; Env.8.2; ESS3.C; ETS1.B

MS-ESS3-3; MS-LS2-2; MS-LS2-4; MS-LS2-5

CONSERVATION GENETICS

Conservation genetics is a field with increasing importance in ecology, biology, and policy. This field is unique in that it applies genetics knowledge to assist conservation decisions, planning, and implementation. Knowledge of the genetic code and the structure of genomes has become an important tool to conserve Earth's biodiversity. Conservation managers, often government or non-profit employees who plan and oversee conservation projects, rely on genetic data to make decisions with lasting consequences. These projects can range from successful captive breeding programs (such as the California Condor or Giant Panda) to groups restoring wildlife populations (the Eastern Hellbender salamander.) In these lessons, we focus on the visible traits caused by genetic diversity, which students can use to conceptualize genetic effects on species viability and how human-introduced factors affect the genetic diversity of wildlife populations.

Lesson One: Genetic Diversity and Gene Flow—Vocabulary

- genetic diversity
- heritability
- barrier
- gene flow
- geography

Lesson One: Genetic Diversity and Gene Flow—Background

Genetic diversity is at the very core of wildlife conservation and management. **Genetic diversity** is a form of biodiversity described by the amount of variability in traits that can be inherited from one generation to the next and helps predict how well organisms survive and adapt in changing environments. Populations with higher genetic diversity have a higher likelihood that some individuals possess adaptive traits that help them to survive and reproduce in new and changing environments; populations with lower genetic diversity may lose important, adaptive traits. For future generations to survive, these important adaptive traits need to be passed on to offspring. Since it is difficult or impossible to know how or when environments will change, conservation managers may focus on increasing or maintaining genetic diversity as a whole rather than specific traits that may or may not be relevant when an environment changes. Genetic diversity is often estimated by averaging the frequency of alleles (different genetic mutations of the same gene) within a population. We can get an idea of the genetic diversity in a population by measuring traits (phenotypes; outwardly observable characteristics) caused by a single gene or group of genes.

Many factors can impact the level of genetic diversity found in a population including population size, selection pressure on different traits, the introduction of new mutations, and gene flow. This lesson will focus specifically on gene flow and barriers that prevent the movement of wildlife.

Gene flow is the movement of genes between populations via wildlife movement and reproduction. One possible factor slowing gene flow between populations is a **barrier**, a physical or behavioral obstacle that prevents or inhibits the movement of wildlife across a landscape, either directly or indirectly. Because DNA is passed to offspring through inheritance, wildlife must travel and breed in a new population to share and spread genes. When movement is easy, genes regularly spread between populations via gene flow, changing the genetic diversity. When barriers prevent gene flow, there can be strong negative effects on the genetic diversity of populations.

Barriers take different forms, from large, physical barriers (ex. highways, fences, dams) to less obvious barriers (ex. open farmland, where food is difficult to find). To make identifying barriers easier for instructors, we give advice, below, for how to think about barriers in your **local geography** (Identifying Barriers).

Gene Flow Simulation

A simulation involving colored beans or beads is one of the most effective ways to quickly express how gene flow spreads genetic diversity. You will need three trays with edges > 1 inch, two stiff boards (length = tray width), and beads or beans of at least two distinct colors. Each tray represents a landscape, the boards represent barriers to gene flow, and the colors of the beads represent different alleles (genetic diversity). This simulation can be done with a single tray by changing the barrier and resetting the beads.

Tray #1: open gene flow (without barriers).

In an empty tray, place the beads so that they are divided by color. To simulate gene flow, gently shake or sift so the beads travel across the surface of the tray, mixing into an approximately even spread of bead color (genetic diversity) across the whole tray.

Initial setup:

Final distribution:

Tray #2: no gene flow (hard barrier).

In an empty tray, divide the beads by color. Fasten a stiff board across the center of the tray. Gently sift or shake the tray and remark how the beads are unable to cross the barrier, maintaining constant genetic diversity in each.

Initial Setup:

Hard Barrier:

Final Distribution:

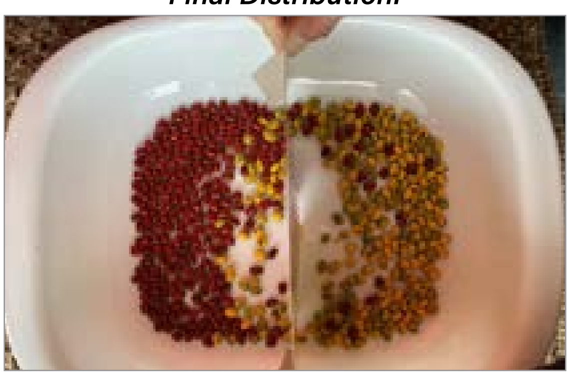
Tray #3: some gene flow (soft barrier).

Set up the tray like the second demonstration but cut doors large enough for 2-4 beads to pass through in the barrier. Make 1-4 of these doors, depending on the size of your tray and beads. Most of the beads should still have trouble crossing but some will pass through the doors as you shake. This demonstrates how some genetic diversity will be shared between populations.

Initial Setup:

Soft Barrier:

Final Distribution:



Once all three demonstrations have been completed, note differences in the genetic diversity of populations in each scenario.

Identifying Barriers

Download a local map of your area (from Google Earth, for example) to be projected for the whole class. You may find it helpful to also provide each student or team with a map printout for use at their station. Before class, try to determine what habitat attributes may serve as barriers to wildlife movement – and thus gene flow – so you can lead the class in discussion. The different barriers you and your class identify on your map will affect different species of wildlife in different ways, depending on their biology (ex. if they move via swimming, walking, flying, etc.), so consider i) different types of animal movement, ii) physical and behavioral limits on wildlife movement, iii) natural and human-made barriers, iv) hard versus soft barriers. As a class, mark barriers on the projected map corresponding to different types of animal movement with different colors on your map. Lastly, mark hard or soft barriers using thick or thin lines, respectively (hard barriers prevent nearly all movement, soft barriers allow more movement).

Depending on the time you have left in class, you may want to connect the subject material here to other coursework. For example, the Isthmus of Panama is a major geographic barrier that cut off aquatic animals in the Pacific and Caribbean when it was first formed. The Panama Canal, on the other hand, has split some land animals north and south of the canal, even isolating some populations on islands in the middle of the canal. Another example that has gained attention in national media is the US-Mexico Border Wall. These walls and the habitat removed on either side of the border has stopped many species from being able to cross. This has had strong negative effects on some species who have limited habitat on either side of the border.

Lesson Two: Assisted Gene Flow—Vocabulary

- translocation
- wildlife corridor

Lesson Two: Assisted Gene Flow—Background

In lesson two, students investigate how conservation managers create programs to improve genetic diversity when gene flow has become difficult or impossible. In order to spread genetic diversity, conservation managers will sometimes assist gene flow by reducing barriers or moving wildlife past barriers. There are many ways that conservation managers can assist gene flow. Lesson Two will discuss two common methods, translocations and wildlife corridors. **A translocation** is taking an animal(s) from one place and moving it to another place (transport to a new location = translocation) where managers hope it will breed with local animals, or establish a new population, and spread its genetic diversity. Translocations are difficult, expensive, and labor-intensive because animals must be trapped, kept calm and safe, transported, and released in an unfamiliar environment. **Wildlife corridors** are sections of habitat that connect two or more areas and help animals to move past barriers.

After translocations and corridors have been defined, students will research examples of human-assisted gene flow. These examples should consist of multiple species, barriers, conservation organizations and plans, and outcomes. To this end, students' presentations and discussions should highlight a diverse set of human interventions to maximize wildlife genetic diversity.

Identifying Assisted Gene Flow

Return to the map of your local area and determine where gene flow has been assisted in your community. To find instances of assisted gene flow, consider i) areas of natural habitat, ii) community events where groups of animals are released into the wild, and iii) corridors built into specific barriers. Natural habitats can be areas for human use, such as preserves, parks, and trail systems. Community events, such as butterfly releases or fish stocking, may be part of larger celebrations. Infrastructure can be built specifically to reduce its impact as a barrier (incorporating a fish ladder into a dam, or building a road with under- or overpasses.) As with barriers, mark types of assisted movement by color to help compare with barriers marked on the map in Lesson One.

Ideas for Assisting Gene Flow at Home

Think about how your students and their families can make gene flow easier in their own communities. When generating these ideas with your students, consider changes to i) behavior and ii) property. Behaviors such as following speed limits, picking up trash and not littering, and using less-destructive farming practices make a difference. Helpful changes to personal property can include growing native plants, designing unfenced yards, and growing corridor habitats between fields.

READING WRITING MATH SCIENCE STEM

GENETIC DIVERSITY AND GENE FLOW

This lesson allows students to measure genetic diversity, identify barriers, and predict how they influence patterns of genetic diversity.

Estimated Time

90 minutes (including lady beetle collection time)

Procedure

1. Have students complete Activity #1. Lady beetles (i.e., ladybugs) need to be collected from three different geographic locations per student (see collection protocol below). Samples can be stored indefinitely in a freezer, so Activity #1 can be done even in the winter.

2. Have students collect and analyze color and spot pattern data on lady beetles using the Lady Beetle Data Sheet. Students can work in pairs or teams to allow colorblind or visually impaired students to fully collect data.

3. Introduce genetic diversity as a concept. Have students work in groups or individually to measure genetic diversity in lady beetle samples and share the results with the class.

4. Introduce the concepts of gene flow and barriers. Follow up with a demonstration of Activity #2: Gene Flow Simulation with Beads. Allow students to complete discussion questions.

5. As a class, locate and mark barriers on a map of the local geography.

6 In groups or individually, have students look at the map of barriers and answer the remaining discussion questions.

Required Materials

- Lady Beetle Collection Instructions
- Lady Beetle Data Sheet
- rubbing alcohol (70% isopropyl alcohol)
- liquid container (> 2 oz. plastic or glass jar)
- masking/labeling tape
- marker or pen for fieldwork
- tweezers
- (optional) microscopes
- (optional) dissecting lights
- calipers or measuring tape with millimeter accuracy
- three trays with edges > 1 inch
- two stiff boards (cardboard or paperboard recommended) with a length equal to tray width
- 90-120 beans or large beads of 2-4 distinct colors
- Genetic Diversity and Gene Flow Worksheet
- downloaded local map (Google Earth) for projection
- Gene Flow Class Discussion Worksheet

Activity #1: Estimating Genetic Variation in Lady Beetles

Genetic diversity is the amount of variability in the genetic makeup of a group. Conservationists often measure genetic diversity in specific populations to get an idea of how flexibly the population might adapt to sudden changes in the environment or how well the population might thrive in the future. Conservation managers use information about genetic diversity to make decisions about which species or populations might need help surviving in changing environments and how best to give this help. To measure this diversity, geneticists will measure the variety of alleles (different genetic mutations) in the group to see how many different alleles are present, how common each allele is, and how similar or different these values are when we compare different populations.

Today, you will estimate genetic diversity (measured by color and patterns on lady beetles) sampled from different populations and compare these across the landscape. Follow the procedure here carefully and record the values you find for each population. Remember to keep your samples separate and record your values for each location separately so you know you are not combining populations.

Asian Lady Beetles (*Harmonia axyridis*, also called Harlequin Lady Beetles or Ladybugs) are an invasive species in many parts of the world. In North America, they are most commonly orange to red with black spots. Lady beetle variations in color and spots characteristics are caused by groups of genes. This means that the genetic diversity in the population will influence the diversity in color and spots. During their fall migration, they can be easily caught and preserved. Look for them on light-colored surfaces. Lady beetles in North America are recognizable by their white heads with four black dots that make an "M" shape.

Sample Collection

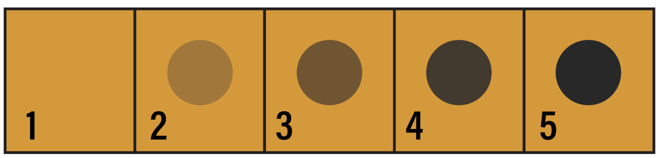
- Find a location where you have permission to collect beetles. (This could even be your backyard.)
- Bring a liquid container (at least 2 oz) that is filled at least 1 inch deep with rubbing alcohol (70% isopropanol). Label this container with your name, the date, and the location where you will be collecting. Try to be as specific with the location as possible (ex. "Ken-O-Sha Park, by the entrance to the middle baseball dugout")
- In your first location, catch ~10 lady beetles. Be careful not to damage or squish the beetles when you collect them. Place each beetle in your container, being sure to immerse it fully in the isopropyl alcohol to preserve it.
- Record the number of samples collected on your container and store your samples in a cool, dry, dark place (like a refrigerator) until you are ready to record the data from each sample.
- Repeat the above steps in two more locations that are at least a 10-minute drive away or about 5 miles from the first location. The goal here is to find locations that are far enough away that lady beetles cannot travel between them easily. If you want to be sure that you have three different populations, pick locations on the opposite sides of town.

Recording Data

- Look at each container of lady beetles you collected. Make sure that each container is clearly labeled and that you do not mix up samples from different locations.
- Use your tweezers to pull each beetle out and place it on a brightly lit surface. You can use a microscope to look more closely at each beetle if you are unable to clearly see the color and spot patterns, the traits you will be measuring.
- With each of the traits listed below (color and spot patterns), look at the elytra of the lady beetle. (This is the hard, colorful wing covering on the beetle's back.) Record your best estimate for each of these values on the Lady Beetle Data Sheet:
    - o Elytra color: use the color scale from red to yellow and record the color that most closely matches the beetle's elytra color.

1	2	3	4	5	6	7	8	9	10
CE2F09	CF3C0A	D0490C	D2560E	D36310	D57011	D67D13	D88A15	D99717	DBA419

    - o Spot visibility: record, on a scale from 1-5, the darkness of the spots (1: no spots, 5: fully dark, black spots)



    - o Number of spots: count and record the number of spots on the elytra of each lady beetle. Do not count spots on the lady beetle's white head.
    - o Spot size: record the diameter of the largest spot per lady beetle with calipers or a ruler that can measure millimeters. Mark any individuals with no spots as NA.

- After taking measurements, place each lady beetle on a separate paper so you do not measure a beetle more than once. When all lady beetles from a population have been measured, return all lady beetles to the labeled sample container.
- For each population, summarize your genetic diversity data (color and spot patterns): record the minimum, maximum, and mean (average) of all individuals from a population for each value you measured.
- Finally, share your summary statistics and location data for each population with the rest of the class. Do all the populations have the same genetic diversity or is there variation?

Lady Beetle Data Sheet

Sample Number	Location	Elytra color (1-10)	Spot Visibility (1-5)	Number of Spots	Spot Size (mm)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					
Minimum	Location 1				
Average	Location 1				
Maximum	Location 1				
Minimum	Location 2				
Average	Location 2				
Maximum	Location 2				
Minimum	Location 3				
Average	Location 3				
Maximum	Location 3				

Genetic Diversity and Gene Flow Worksheet

Gene Flow

Gene flow is the movement of genes (and hence genetic diversity) when wildlife move and reproduce between populations. In any environment, there are also **barriers** to gene flow that minimize or prevent wildlife from moving to new populations and passing genetic diversity. There are multiple types of barriers, each capable of impacting different species in different ways. Some barriers, such as predators or automobiles, can kill the animals; a dam in a river or a wall might only stop animals from moving further. Some barriers are more effective than others. For example, a fenced highway will stop more wildlife than a country road. Different barriers will also affect different types of wildlife based on animal behavior or type of movement.

When we measured traits in our lady beetle samples, we got an idea of the diversity in the genes that cause these traits. This let us estimate the genetic diversity for only specific traits. Answer the following questions:

How could we estimate the genetic diversity underlying other traits (such as antennae length)?

What about those traits that we cannot easily observe?

How could scientists look at diversity across the whole genome?

Use what you know about how genetic material is inherited, gene flow, and barriers to answer the following questions.

Why do all the sites where you sampled lady beetles not show the same genetic diversity?

What might be contributing to these differences?

Why does genetic diversity matter for wildlife conservation? How does genetic diversity benefit a population?

After you have measured genetic diversity in several wildlife populations, how would you use the data to find out if there might be gene flow between the populations?

Genetic Diversity and Gene Flow Answer Key

When we measured traits in our samples, we got an idea of the diversity in the genes that cause these traits. This let us estimate the genetic diversity for only specific traits. Answer the following questions:

How could we estimate the genetic diversity underlying other traits (such as antennae length)?
Other observable traits can be measured i n turn to estimate the genetic diversity underlying those specific traits. Measuring one trait does not necessarily tell us anything about the genetic diversity of another trait.

What about those traits that we cannot easily observe?
For traits that are not easily observable (ex. immune strength), we can sequence the DNA and look at the genetic code.

How could scientists look at diversity across the whole genome?
If we want to look at diversity across the whole genome, scientists can average the diversity at many different places in the genome.

Use what you know about how genetic material is inherited, gene flow, and barriers to answer the following questions.

Why do all the sites where you sampled lady beetles not show the same genetic diversity?
Samples from different sites may be from different populations. Individuals are more likely to be related to others within their population than to individuals from other populations. This will lead to differences in genetic diversity (and, therefore, expression of traits) between the sites.

What might be contributing to these differences?
Barriers may exist on the landscape preventing the genes of nearby populations from mixing.

Why does genetic diversity matter for wildlife conservation? How does genetic diversity benefit a population?
Potential answers may include: Genetic diversity is important for conservation because higher diversity will allow wildlife to adapt to changing environmental conditions.
More genetically diverse populations are more likely to have some individuals with traits that help them survive and reproduce when the environment changes.

After you have measured genetic diversity in several wildlife populations, how would you use the data to find out if there might be gene flow between the populations?

Potential answers may include:
There might be gene flow between populations if they have similar levels of genetic diversity. If the levels of genetic diversity are very different, then gene flow is unlikely.

Gene Flow Class Discussion Worksheet

Discuss the following prompts as a class. First, discuss types of barriers that can inhibit gene flow. Second, mark barriers on the map your teacher provides. Third, observe the overall patterns of barriers where you live. Fourth, make a hypothesis about how barriers are affecting patterns of genetic diversity. Last, place on the map the summary statistics for the lady beetle data collected by the class and revise your hypothesis.

Discuss: What are some examples of barriers for different species? Think about all the ways wildlife can move and how some wildlife can move in multiple ways (ex. walking and climbing). Consider natural and human-made barriers. Which barriers might be more effective at stopping gene flow than others? Why are some more effective than others? We sometimes use the term **hard barrier** to describe something that stops almost all gene flow and **soft barrier** to describe a barrier that makes wildlife gene flow harder but does not stop it completely. What are some notable barriers in your town? What are some famous barriers to gene flow in the world and in history?

Identify: Look at a map that shows your **local geography** (the layout of a local area including natural and human elements). Mark down local barriers on this map. Use different colors for barriers that will inhibit different types of animal movement. Use different types of lines (ex. bold or dashed) to indicate how difficult it is to cross a barrier. Do not forget to include a key with your map.

Observe: Look at the overall layout of the barriers on your map.

Are there any areas on your map that are isolated from each other?

Which barriers caused this isolation?

How do these barriers inhibit gene flow?

Create a hypothesis: How will the barriers in your local geography affect the patterns of genetic diversity? Keep this hypothesis in mind as you learn more and be prepared to revise and refine.

Revise: Compare the class measurements from earlier to your map of barriers. Do you see any patterns arise? How can you revise your hypothesis in light of the data you have collected?

Gene Flow Class Discussion Answer Key

Discuss the following prompts as a class. First, discuss types of barriers that can inhibit gene flow. Second, mark barriers on the map your teacher provides. Third, observe the overall patterns of barriers where you live. Fourth, make a hypothesis about how barriers are affecting patterns of genetic diversity. Last, place on the map the summary statistics for the lady beetle data collected by the class and revise your hypothesis.

Discuss: What are some examples of barriers for different species? Think about all the ways wildlife can move and how some wildlife can move in multiple ways (ex. walking and climbing). Consider natural and human-made barriers. Which barriers might be more effective at stopping gene flow than others? Why are some more effective than others? We sometimes use the term **hard barrier** to describe something that stops almost all gene flow and **soft barrier** to describe a barrier that makes wildlife gene flow harder but does not stop it completely. What are some notable barriers in your town? What are some famous barriers to gene flow in the world and in history?

See teacher notes, "Identifying barriers."

Identify: Look at a map that shows your **local geography** (the layout of a local area including natural and human elements). Mark down local barriers on this map. Use different colors for barriers that will inhibit different types of animal movement. Use different types of lines (ex. bold or dashed) to indicate how difficult it is to cross a barrier. Do not forget to include a key with your map.

You and your class will not be able to identify and label all of the barriers in your local setting. That is OK. Try to get a semi-complete picture of the most effective (hardest) barriers or barriers that hold particular importance in your town (i.e., landmarks). Try to aim for a variety of types of barriers. The goal of this exercise is to help students look at their local geography from the perspective of wildlife trying to navigate the landscape. Students will learn to look at the places they live with this new perspective and better understand how human activities and decisions affect wildlife..

Observe: Look at the overall layout of the barriers on your map.

Are there any areas on your map that are isolated from each other?
Which barriers caused this isolation?
How do these barriers inhibit gene flow?

Answers will vary but should identify areas that are surrounded by barriers blocking the same types of animal movement. Be careful not to mark areas on the edge of the map since wildlife do not know the map edge is there and could easily move around barriers we have marked if there are not barriers beyond the edge of the map. Most local places will have areas that have become isolated from others and answers should identify these, name the specific barriers that have enclosed each space, and explain why these barriers are preventing gene flow.

Create a hypothesis: How will the barriers in your local geography affect the patterns of genetic diversity? Keep this hypothesis in mind as you learn more and be prepared to revise and refine.

Hypotheses will vary here and there are no correct answers because this hypothesis will be revisited and revised moving forward.

Revise: Compare the class measurements from earlier to your map of barriers. Do you see any patterns arise? How can you revise your hypothesis in light of the data you have collected?

Answers here will vary according to the original hypothesis but should consider the patterns of genetic diversity measured from class samples and compare these to the hypothesis. Answers should discuss whether the patterns of diversity the class recorded are in agreement with the hypothesis or not – and revise the hypothesis if they are not.

LESSON 2

READING WRITING

ASSISTED GENE FLOW

This lesson allows students to research well-known examples of assisted gene flow, identify assisted gene flow, and revise hypotheses about patterns of genetic diversity.

Estimated Time

45 minutes

Procedure

1. Introduce the concept of assisted gene flow as it relates to conservation, specifically translocations and wildlife corridors.
2. In pairs or groups, research one real-world example from the Assisted Gene Flow Examples Worksheet to share and discuss with the class.
3. As a class, identify and mark examples of assisted gene flow on the local map used in Lesson One and answer the questions in Activity #2: Assisted Gene Flow Class Discussion Worksheet.

Required Materials

- Assisted Gene Flow Introduction
- Assisted Gene Flow Examples Resources
- Assisted Gene Flow Examples Table
- Assisted Gene Flow Examples Worksheet
- map from Lesson One
- Assisted Gene Flow Class Discussion Worksheet

Activity #1: Assisted Gene Flow Examples

Assisted Gene Flow Introduction

When barriers inhibit gene flow and reduce the ability to share genetic diversity between wildlife populations, conservation managers may take actions to improve gene flow. It is the job of conservation managers to conserve natural resources, such as water, land, and wildlife. Conservation managers often work for governments or nonprofits to come up with the best plan for each unique conservation problem. Translocations and corridors are two plans that conservation managers often work with governments and use to improve gene flow. **A translocation** takes an animal (or multiple animals) from one place and moves it to another place where managers hope it will breed with local animals and spread its genetic diversity. **Corridors** are sections of habitat that help animals to move past barriers. Corridors lower a barrier's resistance to gene flow.

When deciding how to best improve gene flow, conservation managers choose the plan that will maximize genetic diversity. Sometimes, translocations and corridors are both good options. Other times, only one is possible. Sometimes, conservation managers have to make difficult decisions and do not know what will work until after they have tried. Using the links provided in the Assisted Gene Flow Examples Resources, you will investigate one example where wildlife has problems with gene flow. Next, fill out your row on the Assisted Gene Flow Examples Table. Then, share your answers with the class and use their results to fill in the rest of the table and answer the questions on the Assisted Gene Flow Worksheet.

Assisted Gene Flow Examples Resources

General

https://www.nationalgeographic.org/article/wildlife-crossings/7th-grade/

Ocelots in Tamaulipas, MX and TX, USA

https://www.fws.gov/refuge/laguna_atascosa/science/ocelot_partners.html

https://www.conservationfund.org/projects/laguna-atascosa-national-wildlife-refuge

https://www.statesman.com/article/20180401/NEWS/304019978

Aplomado Falcon in the USA and Mexico

https://www.conservationfund.org/projects/laguna-atascosa-national-wildlife-refuge

https://peregrinefund.org/explore-raptors-species/falcons/aplomado-falcon

Eastern Collared Lizard in MO, USA

https://update-techline.squarespace.com/articles/2014/conservation-practice-enhances-habitat-for-eastern-collared-lizard

Florida scrub jay in USA

https://brevardzoo.org/conservation/conservation-programs/florida-scrub-jay-translocation/

https://assets.speakcdn.com/assets/2332/09-901_2011jan_smurl-translocationasatooltoreintroduceandsupplementfloridascrub-jay.pdf

https://fl.audubon.org/news/scientists-report-relocating-scrub-jays-shows-promise-and-new-hope-species

"management considerations":

https://www.fs.fed.us/database/feis/animals/bird/apco/all.html

Platypus on King Island, Australia—page 41, page 120:

https://www.kingislandnaturalresources.org/publications/KIFauna.pdf

https://www.abc.net.au/science/articles/2012/05/18/3505667.htm

Florida Panther in USA

https://wildlife.org/florida-panther-population-grows-but-gene-flow-still-a-concern/

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Assisted Gene Flow Examples Table

Species	**Barrier to gene flow**	**Barrier effect** (how did it affect your species)	**Conservation organization(s)**	**Actions taken**	**Conservation outcomes** (better, worse, or uncertain?)
Ocelots in Tamaulipas, MX and TX, USA					
Aplomado Falcon in the USA and Mexico					
Eastern collared lizard in MO, USA					
Florida scrub jay in USA					
Platypus on King Island, Australia					
Florida Panther in USA					
Black bears in the Interior Highlands of AK, USA					
African elephants in Kenya					
St. Francis satyr (butterfly) in NC, USA					

Assisted Gene Flow Examples Worksheet

After you have filled out the Assisted Gene Flow Table, answer the following questions.

Were all the conservation actions the same? Why might conservation managers have chosen different actions for specific barriers?

What sorts of organizations took part in these projects (government, nonprofit, business)?

If organizations were government organizations, were they state, national, or international governments?

If organizations were nonprofits or businesses, why do you think they helped with conservation work?

Did all the conservation actions improve gene flow?

Why might an action work in one situation but not another?

If conservation actions are not always successful, are they still important? Why or why not?

Assisted Gene Flow Examples Table (Answer Key)

Species	Barrier To Gene Flow	Barrier Effect (How did it affect your species)	Conservation Organization(S)	Actions Taken	Conservation Outcomes (Better, worse, or uncertain?)
Ocelots in Tamaulipas, MX and TX, USA	habitat destruction	isolated populations on either side of the border	Comisión Nacional de Áreas Naturales Protegidas, USFWS	translocations and corridors	uncertain
Aplomado Falcon in the USA and Mexico	1900s habitat conversion to farmland, towns, etc.	fragments open grassland habitats favored by Aplomado Falcons. Died out in USA, almost died out in MX	World Center for Birds of Prey	translocations (captive breeding and hacking)	better and uncertain (in different places)
Eastern collared lizard in MO, USA	habitat fragmentation due to fire suppression	reduced gene flow, increased drift	Missouri Department of Conservation, US Forest Service	translocations and controlled burns to make corridors	uncertain (translocations) better (corridors)
Florida scrub jay in USA	habitat fragmentation due to urbanization	urban areas cannot be settled, isolating populations	Michigan State University	translocations	uncertain
Platypus on King Island, Australia	open water, habitat fragmentation on King Island	isolation of population on King Island. no gene flow with other populations. Limited gene flow within King Island	University of Sydney	river/ streamside vegetation corridors not translocations	uncertain
Florida Panther in USA	Habitat loss	no migrants from previously continental range	Florida Fish and Wildlife Conservation Commission	translocations	better
Black bears in the Interior Highlands of AK, USA	urban development	human conflict, little habitat for movement	Arkansas Game and Fish Commission	translocations	better
African elephants in Kenya	lowland agriculture and poaching	prevent traditional elephant migrations between different populations	Lewa, Save the Elephants, Kenya Wildlife Service, Northern Rangelands Trust, Mount Kenya Trust	corridors	better
St. Francis satyr (butterfly) in Ft. Bragg, NC, USA	habitat loss	undisturbed habitats are unsuitable for this species	Department of Defense, North Carolina State University, Michigan State University, USFWS	corridors	uncertain

Assisted Gene Flow Examples Answer Key

After you have filled out the Assisted Gene Flow Table as a class, think about what you have found.
Examples given here are possible responses. There are many more good responses.
Were all the conservation actions the same? Why might conservation managers have chosen different actions for specific barriers?

No, conservation actions were varied. Different actions will create better outcomes for some barriers than others in different species.

What sorts of organizations took part in these projects (government, nonprofit, business)?

A mix of government, nonprofit, and university work. See Assisted Gene Flow Examples Table Answer Key

If organizations were government organizations, were they state, national, or international governments?

Government work is at both national and state levels.

If organizations were nonprofits or businesses, why do you think they helped with conservation work?

Possible answers include: Nonprofits and businesses often help because conservation is part of their mission, helps to further another goal, or is required by law.

Did all the conservation actions improve gene flow?

Not all conservation actions improved gene flow. In many places, the outcome is uncertain.

Why might an action work in one situation b ut not another?

Possible answers include: Factors that can affect the level of success include understanding species biology, cooperation of local people, available money, maintenance and upkeep, poaching, animal survival, etc.

If conservation actions are not always successful, are they still important? Why or why not?

Answers will vary. A conservationist's perspective: Yes. Uncertain outcomes and some failure do not outweigh the successes and are useful as learning opportunities. Conservation actions are important in part because they often are able to conserve biodiversity, which is an ethical imperative in many worldviews and has strong positive impacts in human wellbeing (economic, health, etc.).

Activity #2: Assisted Gene Flow Class Discussion Worksheet

As a class, return to your map of the local geography. Think about where assisted gene flow happens in your community. Look for strips of natural habitat or corridors that go under or over roads and other barriers. Are there events in your community that are translocations (ex. butterfly releases)? Like before, use colors to mark different types of animal movement. Do not forget to update your map key.

Step back: Look at the overall layout of the map.

What barriers can now be crossed because of translocations or corridors?

What areas looked isolated before but have gene flow because of translocations or corridors?

Revise: Look back at your hypothesis about patterns of genetic diversity and compare it to your new map additions.

How does the knowledge you have gained about assisted gene flow affect your hypothesis?

What is your revised hypothesis about how barriers in the local geography will affect patterns of genetic diversity?

Conservation managers are not the only people who can help reduce barriers and make gene flow easier for wildlife. Aside from volunteering to help conservation projects, there are many ways that any person can make barriers smaller for wildlife. Think about common barriers where you live. What about these barriers makes gene flow hard or dangerous? What are ways that you, your guardian(s), or your family can make gene flow across these barriers easier or safer?

Activity #2: Assisted Gene Flow Class Discussion Answer Key

As a class, return to your map of the local geography. Think about where assisted gene flow happens in your community. Look for strips of natural habitat or corridors that go under or over roads and other barriers. Are there events in your community that are translocations (ex. butterfly releases)? Like before, use colors to mark different types of animal movement. Do not forget to update your map key.

Discussion here will vary. See teacher notes.

Step back: Look at the overall layout of the map.

What barriers can now be crossed because of translocations or corridors?

What areas looked isolated before but have gene flow because of translocations or corridors?

Responses will vary but should reference observations in Lesson One and note some differences where translocations or corridors lessen or overcome barriers.

Revise: Look back at your hypothesis about patterns of genetic diversity and compare it to your new map additions.

How does the knowledge you have gained about assisted gene flow affect your hypothesis?

What is your revised hypothesis about how barriers in the local geography will affect patterns of genetic diversity?

Responses will vary but should re-evaluate the hypothesis from Lesson One in light of the corridors and translocations marked on the map. Propose a new hypothesis if needed.

Conservation managers are not the only people who can help reduce barriers and make gene flow easier for wildlife. Aside from volunteering to help conservation projects, there are many ways that any person can make barriers smaller for wildlife. Think about common barriers where you live.

What about these barriers makes gene flow hard or dangerous?

What are ways that you, your guardian(s), or your family can make gene flow across these barriers easier or safer?

Discussion will vary. See teacher notes.

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