Out of Sync

"When we try to pick out anything by itself, we find it hitched to everything else in the universe." –John Muir

Background Information:

Bin Information

In the previous two lessons in the phenology bin, students were exposed to the changes that occur in nature in cycles. In the migration game, students saw that what happens to one species in nature has a ripple effect; predators who are higher in the food chain will be affected by things that happen lower down even if there is not a direct link. In nature journaling, students became more aware of the timing of phenological events around them.

This lesson focuses on exploring how the timing of natural cycles is very important to the relationships between species, and how changes to the environment and climate can have ripple effect impacts.

Information for Instructors

The concept of phenological mismatch is used to describe when natural events start to fall out of sync with each other. This is something that will be occurring more and more as seasons change more quickly than evolution can account for.

One example of phenological mismatch can be seen in snowshoe hares. Snowshoe hares have a white winter coat and a brown summer coat. In years where there is an earlier spring, the hares stay white while their environment shifts to brown, and they are easy for predators to spot and are killed in higher numbers. Other events that are falling out of sync with each other include bird migrations falling out of sync with spring in their breeding grounds, causing possible issues with severe weather on migration routes if they leave too early, or missing the peak of spring food sources if they leave too late.

There tends to be a disconnect in spring as some events are timed based on the length of days, which is unaffected by climate change, and others are based on temperature, which has begun to shift.

The full extent of phenological mismatch or future ramifications are not yet known in their entirety.

Vocab

- **Phenological Mismatch:** Also known as phase effects, phenological mismatch is the phenomenon of life cycles falling out of sync with each other.

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Warm up activity is adapted from "Web of Life" from Project Learning Tree

Themes:

Phenology, Phenological Mismatch, Food Webs, Trophic Levels, Citizen Science

Estimated Duration:

55 minutes

Audience Identified:

6-10th grade

10-30 students

Location:

Classroom with open space or outdoors

Goal:

Students will gain awareness of the dangers of shifting timing for natural events and use observational skills from previous lessons to join citizen scientist efforts to track changes.

Objectives:

Students will be able to define trophic levels.

Students will be able to name connections between organisms and follow the effects of a change through a food web.

Students will extrapolate effects of phenological mismatch from information they have about food webs.

- **Green-Up:** The beginning of a new cycle of plant growth
- **Trophic levels**: The position an organism occupies in a food web, defined by its nutritional relationship with the primary energy source; the sun.
    - **Producer**: Plants and algae that use photosynthesis to get energy directly from the sun
    - **Primary Consumer**: Herbivores who get the energy from eating plants.
    - **Secondary Consumer:** Carnivores and omnivores who eat herbivores.
    - **Tertiary Consumer**: Carnivores and omnivores who eat secondary consumers.
    - **Apex predators**: animals at the top of the food chain because the have no natural predators.
    - **Decomposers:** organisms that consume dead plant and animal material.

Materials and Set-Up:

This kit includes:

- Minnesota ecosystem cards
- Ball of yarn

You will need:

- Scratch paper and writing utensils for students

Set-Up:

- If needed, rearrange a classroom so there is enough room for the class to stand in a circle.
- Make sure that all materials are ready and easily accessible and that the yarn is not tangled.

Introduction:

Estimated Duration: 15 minutes

Warm Up:

- Begin by gathering students in a circle. Ask students for a definition of a food chain (a simplified way to show energy relationships between plants and animals in an ecosystem in a line) and a food web (the interconnections of many food chains in an ecosystem) to access prior knowledge. Students can work together to assemble a definition.
- Hand out index cards with Minnesota plants and animals listed on them. Tell each student that you will be acting as a forest ecosystem to visualize a food web. Take out the ball of yarn and start with it. Hold one end as say that you represent the sun, since all energy on earth starts with the sun. Have students whose cards receive energy directly from the sun (plants) hold up their hands and choose one to pass the yarn to.
- Continue passing the yarn back and forth between organisms that interact with each other, naming what the interaction is each time (for example, a you may start with clover receiving energy from the sun, a rabbit eats the clover, a coyote eats the rabbit, a mosquito drinks from the coyote, is eaten by a dragonfly, etc. Interactions can also go backwards, i.e. a bumblebee pollinates a violet and pollinates a sunflower.) If needed, repeat some students so that they are holding on to the yarn at two points and go continue until everyone is holding on to at least one point.

- When everyone is connected, have students slowly pull back until the yarn is taut between everyone (make sure everyone is holding it, but that it is not wrapped around anyone's hand or fingers.) Tell students to hold the yarn still until they feel a tug, and then tug in response to it. Pull gently on the end of the string.
- Choose one students to drop the yarn. You may choose to include a narrative to why this is happening, such as a pesticide taking out a pollinator, or beavers being removed because they flooded private land. Have each organism who depends on the removed organism also drop the yarn and watch the ripple effect. Gather up the yarn, but have students hold on to the cards.
- Have students discuss briefly why removing species from an ecosystem has such widespread effects.

Content and Methods:

Estimated Duration: 20 minutes

After looking at the interdependence of species in an ecosystem, the next step is to look at phenological mismatch and discuss how species do not need to disappear entirely; if the timing of certain events in nature shifts, this also has ripple effects through nature, especially when there is disparity between trophic levels.

Some of the ecosystem cards are marked with stars on the back. For this next phase of the activity, those cards will be used. If needed, redistribute cards to match that for this phase.

Pollination

- Call up the students with the below cards and pass out the yarn to form a line in the following order:

Wood anemone -> clover -> big leaf aster -> goldenrod

- All of these are flowering plants that are interdependent with pollinators. Wood anemone are spring ephemerals that bloom early, clover blooms throughout much of the summer, and aster and goldenrod bloom through the end of summer into fall. Space the students several feet apart.
- Have the student with the bumblebee card come up and pass from flower to flower by taking only a single step between each.
- Have one of the flowers drop the yarn and step back. Can the bumblebee still make it to the end?
- Discuss the following: pollinators rely on having a variety of plant species. Early spring blooms and late fall blooms are especially important to provide food sources throughout the time that bees are active. What happens if species go missing?
- Have the students adjust so that all four plants are present, but have the wood anemone and clover move apart to create a gap. Have the bumblebee again jump from plant to plant. Discuss: if all of the species are present, but the timing is off, what effect does that have on pollinators? What effect does it have on the plants?
- If running the lesson with social distancing, have the cards set on the ground to mark the spots instead of held by the students.

- Another example of how pollination can be affected is the spider orchid, though this is not native to Minnesota. The spider orchid uses pseudocopulation for pollination by mimicking a female bee with the shape of its flower and releasing a pheromone to attract male bees. The plant used to bloom in a short window after male bees emerged, but before females emerged, but now with shifting spring, the female bees emerge earlier and reduce the window that the orchid can attract pollinators.

Camouflage

- Call up the student with the snowshoe hare card as well as an additional four students to also be snowshoe hares. Call up the Canada lynx and barred owl as well.
- Snowshoe hares have a brown coat in summer and a white coat in winter to help camouflage them from predators. Give the predators a die, or use a random number generator like this one.
- Have the predators roll the dice for each snowshoe hare. If they get a six, then they successfully 'catch' the hare. How many are left?
- When spring comes earlier, the snow melts before the hares have a chance to shed their white coats and they stand out against the brown background. When the hares are exposed like that, they are 7% more likely to be caught by a predator. Reset and have the predators roll the dice again, but this time have them 'catch' the hare with either a five or six. How many hares are left now?
- Currently, there is a small window of time of a week or two that the hares are discolored, and it does not currently pose a serious threat of extinction. However, by around 2050, this could become closer to two months. Snowshoe hares may be able to adapt faster than previously thought, which could be a source of hope for phenological mismatch in their case.

Conclusion:

Estimated Duration: 10 minutes

For the conclusion, collect the cards and yarn and reconfigure for a discussion and debrief. Start with the following questions and prompts:

- What are seasonal changes that plants and animals use as cues for timing of natural events? (temperature and length of day)
- What happens when natural events fall out of sync with each other?
- Introduce the term "phenological mismatch" as a name for the phenomena you have been describing.
- We looked at two ways that phenological mismatch can be detrimental. There are others as well. Many species that migrate are prone to instances of phenological mismatch. Ask students to brainstorm what might happen with migration and phenological mismatch. Use the following examples to help prompt if necessary.
    - The European pied flycatcher times its spring migration to time laying eggs with the emergence of winter moth caterpillars to ensure an ample food source for their chicks. Now, oak leaves are emerging sooner, which causes the caterpillars to come out earlier, and the flycatchers miss the window, which leads to a shortage of food, and less optimal food choices for chicks which can impede their growth.

- Caribou in Greenland migrate to follow food sources, eating lichen in the winter along the coast and moving inland in the spring to give birth to calves and eat artic plants, which are emerging earlier. The caribou migration has not shifted, and calf mortality rate has increased from reduced food sources.

Reflection and Evaluation:

Estimated Duration: 10 minutes

Reflection

Divide students into small groups and give each small group a piece of paper. Have each group choose a plant or animal that they are familiar with. It could be one from the previous activities, or something else. On the paper, have them make a timeline of important milestones that occur with seasonal changes (for example, migration, mating, birth, changing food sources, coat changing, etc. for animals and flowering, leafing, dormancy, pollination, etc. for plants.)

For at least three milestones, students should try to theorize if a) there are any environmental factors that could change and cause these milestones to fall out of sync with seasons and b) what might the effects of that seasonal change be? This is more of a thought exercise and does not need to be a complete list.

Once lists are done, students should find someone who was in a different group and compare answers.

Evaluation

Evaluation for this lesson takes place during the conclusion and reflection portion. Check for student understanding by their participation in the conversation. Ask prompting or follow up questions when needed.

Extensions:

Accessibility and Accommodation

Distance Learning: To adapt this lesson to distance learning, students can make a mobile of the organisms to demonstrate the interconnectedness. Using cards or scraps of with different organism names written on them and string to connect them in the same fashion as the food web warm up activity. Tugging on one part will cause the whole thing to move.

Warm Up

Instead of using cards that have been preprinted, the warm-up activity can be extended by having students choose their own plant or animal from Minnesota and research information prior to beginning to include where does it live, or where is it from, where does it get its nutrients, what eats it?

Citizen Science

A great way to get involved after this lesson and help come up with solutions to phenological mismatch is to help record data as citizen scientists. Several campaigns through the USA National Phenology Network are listed as extensions.

The USA National Phenology Network has several great citizen science programs where students can take what they have learned and use it to help in the real world. The phenology data that is collected is

used to help predict possible threats to the people and the environment to time decide timing of events like controlled burns, harvests, or irrigation. The guide to become an observer is located here.

Campaigns to join in Lakeville include:

Pesky Plant Trackers: Learn to identify and track wild parsnip and Japanese knotweed. Making observations throughout the seasons helps researchers learn how to best time control efforts.

Lilacs and Dogwoods: Either observe an established plant, or purchase a cloned lilac or dogwood to observe and record to help build data of when plants bloom across the US.

Nectar Connectors: Monitor nectar sources for monarchs and other pollinators.

Green Wave: Help observe flowering and leaf color for maples, oaks, and poplars to gather data about pollen activity and timing of fall colors.

Pest Control: Receive notifications of when to look for different life cycle stages of 13 species of pests that are harmful to forests and crop trees.

Public Speaking and Life Science

Have each student choose a specific example of phenological mismatch to research and prepare a short 2-5 minute presentation on for the next class period. This can also be used for additional evaluation of understanding and application of learning.

Reference Materials:

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