Modeling Trophic Cascades: Educator Handout

OVERVIEW

This activity reviews the concept of trophic cascades. Trophic cascades occur when predators reduce the abundance or change the activity of their prey, thereby allowing species in the next trophic level to increase in number. These indirect effects by the predator can trickle down (or cascade) to many lower levels of the food chain. In a classic example, sea otters protect kelp forests, sea otters protect kelp forests by controlling the abundance of urchins that graze upon the kelp. In the absence of otters, urchins consume most of the kelp and negatively affect other organisms that live in the kelp forests.

Trophic cascades have been described in numerous ecosystems ranging from kelp forests of the Pacific Ocean to arctic islands, to Central American jungles, to salt marshes. In this activity student use organism cards to build examples of trophic cascades based in different ecosystems, including several in Wisconsin!

KEY CONCEPTS

- Organisms can have both direct and indirect effects on other members of the ecosystem.
- Indirect effects occur when an organisms' activity or behavior (e.g., feeding) affects other organisms within which they do not directly interact.
- When indirect effects are transmitted through a food chain, it is called a trophic cascade.
- Trophic cascades can be found in diverse types of ecosystems

LEARNING OBJECTIVES

Students will be able to:

- Arrange organisms according to trophic level in a variety of different ecosystems.
- Distinguish between direct and indirect effects of organisms in their environment.

CURRICULUM CONNECTIONS

Curriculum	**Standards**
NGSS	HS-LS2-6, HS-LS2-8
AP Biology (2013)	2.A.1, 4.A.5, 4.A.6, SP7
Wisconsin's Standards for Science	SCI.SEP2.B.m, SCI.SEP2.B.h, SCI.CC7.m, SCI.CC7.h SCI.LS2.A.m, SCI.LS2.A.h

KEY TERMS

Ecology, trophic cascade, species interactions, direct effect, indirect effect

TIME REQUIREMENTS

This activity can be done in less than one 50-minute class period. It can be done as a quick review of concepts, or it can be expanded with discussion.

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SUGGESTED AUDIENCE

This activity is appropriate for middle school through high school biology and environmental science.

PRIOR KNOWLEDGE

Students should be familiar with trophic levels and species interactions. The focus of this activity is to apply the logic of trophic cascades to a variety of different environments.

MATERIALS

- Habitat and organism cards
- Chart paper or while boards and magnets
- Markers
- Space to work
- Stopwatches if you opt to do it as a game/competition.

TEACHING TIPS

- Students can use their models to predict the effects of predator removal or other disturbance to the trophic chain.
- To use as a quick "check for understanding," give students the organism cards for a habitat already bundled.
- Cards can be laminated for repeated use.
- Apply magnets to the cards to use them on whiteboards.
- This activity is best completed in small groups

PROCEDURES

In this activity, students build models of trophic cascades in different environments. It is designed as a competitive game, but it can also be done by focusing on discussion instead of competition.

As an optional introduction to this activity, have students watch the video "How Wolves Change Rivers" from Sustainable Human on YouTube, this video gives a quick overview on the concept of trophic cascades, and gives a real-life example of the impact of wolves in Yellowstone National Park. We want to give caution that this video gives an overly simplified version of trophic cascades, and that increased pressure to hunt elk also had a significant impact on shaping the biodiversity within the park. (https://www.youtube.com/watch?v=ysa5OBhXz-Q). *Disclaimer: The subject of how wolves change rivers is controversial. Please keep this in mind and take the video with a grain of salt.*

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Print the organism and habitat cards from the included PDFs for each group. Habitats include: African Savanna, Great Lakes Forests, Arctic Island, Salt Marsh, Kelp Forest, Wisconsin Lakes, and Rocky Mountain Aspen Stands.

1. Separate the cards into two categories: habitat or organism. Please them face down on the table.
2. Students draw a card from the habitat pile.
3. Student then find all the organisms cards that correspond to that habitat. There are three or four cards for each habitat. If students need a hint, the border on each organism card is color coded according to the correct habitat
4. Arrange species according to trophic level with the top predator and producer on the bottom.
5. Draw solid arrows between each organism and the one below it and draw a "+" or "-" to indicate whether the effect is positive or negative. The direction of the arrow should be in the direction of the effect, not in the direction of the flow of energy. For example, an arrow from Arctic Fox → Puffin as the Arctic Fox is consuming the Puffin.
6. Finally, draw a dashed line from the top predator to the producer and draw a "+" or "-" to indicate whether the effect is positive or negative.

DISCUSSION QUESTIONS

1. Provide an example of an indirect effect of an organism on other members of your assigned ecosystem.

   Answers will vary by group, but students should provide an example of how a predator's activity or behavior affects another organism in their assigned ecosystem.

2. If the predator was removed from your assigned ecosystem, what impact would that have on the other species in your assigned ecosystem?

   Answers will vary by group, but students should predict effects on the next trophic level and on the lower levels. For example, removal of wolves in the Rocky Mountain Aspen Stands, may result herbivores spending time browsing in these habitats. This in turn decreases the prevalence of woody tree species.

3. What circumstances could result in predator removal from an ecosystem?

   Predators have been extirpated (extinct locally) or become extinct due to habitat loss, over hunting, poaching, or loss of genetic variation.

4. Think about what animals appear on your Snapshot Wisconsin camera. What are some potential food chains, or trophic cascades that could occur?

   Answers will vary depending on your trail camera site. See "Creating Food Chains and Webs to Model Ecological Relationships" exercise for a complete lesson plan on this topic!

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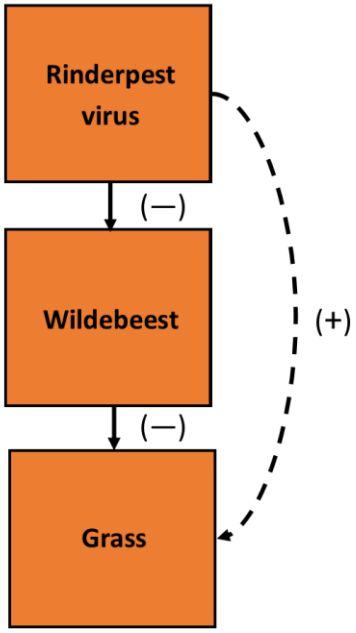
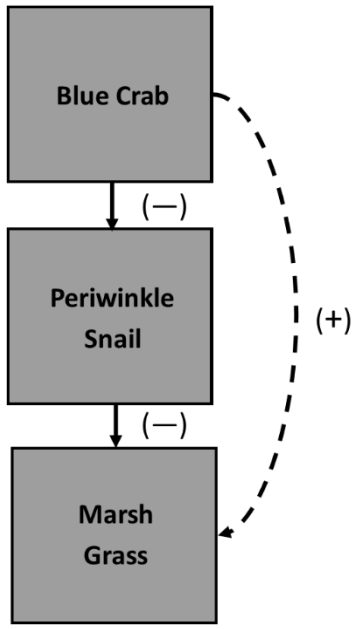
ANSWER KEY

African Savanna



Wildebeest consume grass as part of their herbivorous diet. When the Rinderpest virus infects Wildebeest it causes fever, oral erosions, diarrhea, lymphoid necrosis and eventually mortality. If Rinderpest virus infects a population of Wildebeest and decreases their overall numbers, this has a positive effect on grass because there is less consumption happening by the population and grass is able to flourish.

Salt Marsh



Periwinkle snails live in tidal marshes where they graze on algae living on the surface of marsh grass. While feeding, they cut holes in the marsh grass, and by spreading waste across the cuts, the snails allow grass fungal infections to thrive. These fungal infections negatively affect grass populations. Blue crabs consume the snails as a part of their diet. By decreasing the number of periwinkle snails, this has an overall positive effect on the marsh grass because there are fewer snails and fewer fungal infections.

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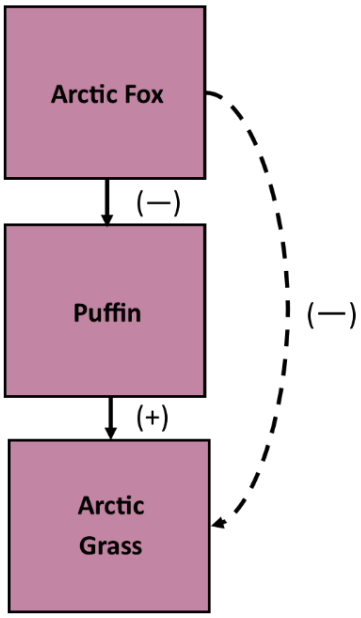
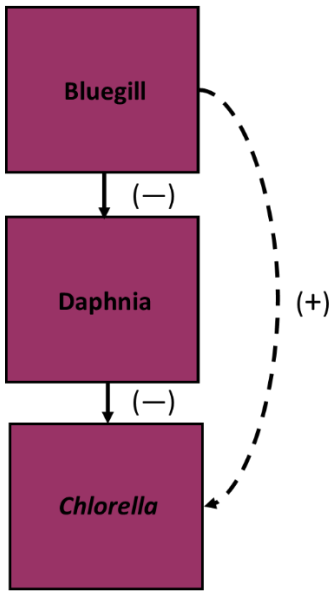
Arctic Island



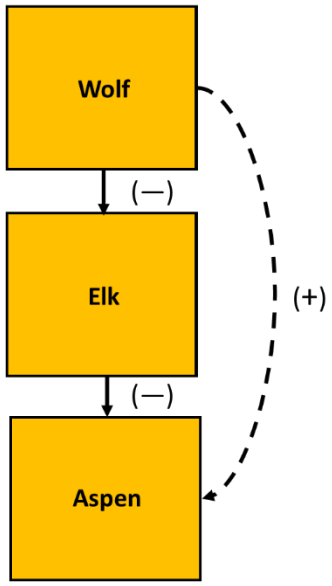
Puffins live in large colonies and build nests in rocky coastal areas. Their defecation fertilizes arctic grasses, helping the grasses to thrive. Arctic foxes eat small animals including lemmings, voles, rodents, and puffins. Arctic foxes can therefore have an overall negative effect on the arctic grasses, by reducing the number of puffins.

Wisconsin Lake



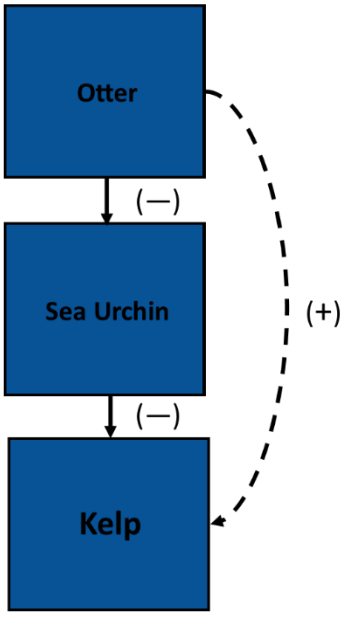
Daphnia are a small type of aquatic crustacean that live in freshwater lakes. Daphnia feed on green algae including Chlorella. Bluegills are also native to freshwater lakes in and consume Daphnia as a part of their diet. Bluegill can have a positive effect on the amount of Chlorella in the lake, by reducing the Daphnia population.

Aspen Stand



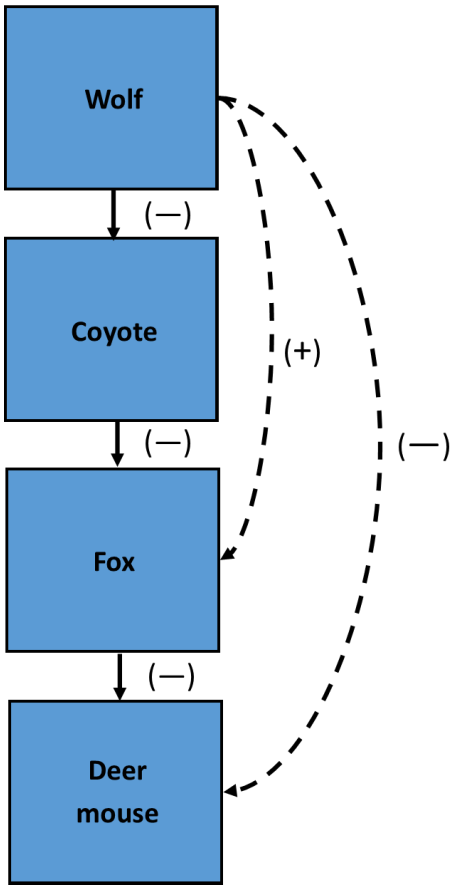
Elk graze on grasses and are also fond of aspen sprouts. In places like Yellowstone National Part, wolves consume elk as part of their diet. In areas where there are wolves, elk will spend less time browsing and more like looking out for wolves. As a result, wolves can have a positive effect on the Aspen population.

Kelp Forest



Sea urchins inhabit all oceans. Their diet consists of plant and animal matter including kelp, algae, and mussels. Sea urchins, in turn, are eaten by sea otters. By reducing the sea urchin population, otter can have a positive effect on kelp.

Great Lakes Forest



Wolves are territorial pack animals who defend their territory from competitors, including coyotes. As a result, coyotes avoid areas with wolves. Similarly, fox avoid areas with *their* competitors, coyotes. Fox populations tend to be higher in areas where there are high wolf populations. This causes deer mice populations to be lower in high wolf, high fox areas because mice are prey for foxes.

CITATIONS

Flagel, D. G., Belovsky, G. E., Cramer, M. J., Beyer Jr, D. E., & Robertson, K. E. (2016). Fear and loathing in a Great Lakes forest: cascading effects of competition between wolves and coyotes. *Journal of Mammalogy*, *98*(1), 77-84.

Beschta, R. L., & Ripple, W. J. (2009). Large predators and trophic cascades in terrestrial ecosystems of the western United States. Biological conservation, 142(11), 2401-2414.