Against the Current

Metamorph Films

Classroom Discussion Guide

High School Version (9-12)

Content created for **Schoolyard Films, Inc.** by Cypress Curriculum Services, LLC

Film Overview

For over 70 years, the upstream reach of Montana's North Fork Fridley Creek was severed from the Yellowstone River. To maintain productive grazing fields, ranchers constructed a canal to divert water from the creek for flood irrigation, resulting in the loss of spawning and rearing grounds for the Yellowstone cutthroat trout, Montana's state fish. But the valley did not just lose a fish; it lost the health of an entire stream ecosystem. Thankfully, there were those who noticed. The creek was reconnected in 2005 and through the flow of water—the lifeblood of the stream—the ecosystem is healing and the Yellowstone cutthroat trout has returned.

“Against the Current” tells the story of competing water interests between agriculture and wildlife, and how one group came together to find a sustainable solution for all. Set on the Ox Yoke Ranch in Paradise Valley, Montana, this 19-minute film highlights a successful collaboration between the Murphy Family, Trout Unlimited, the Gallatin Valley Land Trust, and the State of Montana, to restore the connection of Fridley Creek. As students learn about the restoration of this small creek, they will develop a broader understanding of connections between land, water, fish, and humans. As Montana biologist Pat Byorth eloquently states, "Our fate is tied to the fate of the rivers."

Teachers can use this guide to supplement study of the Montana Essential Learning Expectations and Florida Sunshine State Standards for Science, specifically on content standard topics such as scientific investigation, structure and function of living things, the processes and diversity of life, interactions between living organisms and their environments, and the impact of scientific knowledge and technology on communities, cultures and societies.

Key Terminology

Be sure that students are comfortable with these terms either before the film, or as part of discussion after the film. If the students are doing writing prompts, provide these terms as a "word bank" to help guide their writing.

abiotic, artesian well, biological evolution, biotic, carrying capacity, community, competition, ecology, ecosystem, food chain, food web, limiting factors, model, natural selection, parasitism, population, speciation, trophic level

National Standards Correlations

Discussion Guide Element	Unifying Concepts and Processes	Science in Personal and Social Perspectives	Life Science	Science and Technology
Discussion Question #1	●	●	●	
Discussion Question #2		●	●	●
Discussion Question #3		●	●	●
Discussion Question #4	●	●	●	
Discussion Question #5	●		●	
Discussion Question #6			●	
Discussion Question #7	●	●	●	
Activity #1: Construct a Food Web	●		●	
Activity #2: Modeling Interactions	●		●	

State Science Standards Correlations

Discussion Guide Element	Montana: Essential Learning Expectations for Science	Florida: Sunshine State Standards
Discussion Question #1	S5.3.gr9-12.B	SC.912.L.17.20
Discussion Question #2	S5.3.gr9-12.B S5.4.gr9-12.A	SC.912.N.4.1 SC.912.L.17.20
Discussion Question #3	S5.4.gr9-12.A	SC.912.N.4.1 SC.912.L.17.20
Discussion Question #4	S3.4.gr9-12.G , S3.4.gr9-12.H	SC.912.L.17.6 SC.912.L.17.9 SC.912.L.17.11
Discussion Question #5	S3.4.gr9-12.A, S3.4.gr9-12.B, S3.4.gr9-12.G	SC.912.L.17.7
Discussion Question #6	S3.4.gr9-12.B , S3.4.gr9-12.H	SC.912.L.17.6
Discussion Question #7	S3.4.gr9-12.L, S3.4.gr9-12.M, S3.4.gr9-12.N	SC.912.L.15.9
Activity #1: Construct a Food Web	S3.4.gr9-12.E	SC.912.L.17.9
Activity #2: Modeling Interactions	S3.4.gr9-12.H	SC.912.N.3.5 SC.912.L.17.5 SC.912.L.17.6 SC.912.L.17.1

Discussion Questions/Writing Prompts

Use the following questions as springboards—either to stimulate a classroom discussion or as writing prompts. Either way, the goal is to foster discussion on the level of synthesis and analysis. Below each question, you will find possible areas of discussion to guide the teacher.

1. Scientists estimate that the Yellowstone cutthroat trout currently occupies half of its historical range. This decline of Montana's state fish is largely due to impacts by humans. Can you give examples of human activities that may have contributed to the decline of the Yellowstone cutthroat trout?
   - *Students may identify disturbances to the population that fall into three main categories: habitat degradation, introduction of non-native fishes, and over fishing. Specific examples would include agricultural activities, livestock grazing, mining, timber harvest, introduction of non-native predators, and over fishing.*

2. What specific activities on the Murphy Family's ranch were causing harm to local trout populations?
   - *Make sure students understand that agriculture involves diversions of water from streams (for irrigation and water supply for livestock).*
   - *While not specifically addressed, other common impacts from ranching activities include shoreline disturbance (erosion) from livestock, and increased nutrient inputs to streams from animal waste and fertilizers.*

In the film, we learned that the Murphy Family and conservationists looked for a way to restore flows to Fridley Creek while preserving enough water to operate the Ox Yoke Ranch. They constructed a bypass that allowed water to flow past the irrigation canal and continue downstream. What was the new source of water for the ranch? What role did technology have in the solution?
   - *The film narrative explains that the ranchers constructed a deep artesian well, which harvests ground water rather than surface water from the creek.*
   - *A notable application of technology in this project was the use of specially designed irrigation sprinklers that efficiently supply water to the fields. These water-efficient sprinklers greatly reduce ranch water use and impacts on ground water supply.*
   - *Discuss the reliance of humans and the environment on technology. Point out that technology allows humans to get resources that would otherwise be very limited. Discuss the ever-increasing demand for water as human populations grow and what this might mean for the Fridley Creek ecosystem in the future.*

Can you give other examples of technologies that humans use to solve environmental problems? What are some current environmental issues in our area that science and technology are helping to solve?

- *Help students think of examples by first asking them to identify other environmental problems (e.g., oil spills, non-renewable resource depletion, water pollution). Then prompt students to consider machines, tools, electronics, and other technologies that humans use to minimize these problems.*

4. The introduction of non-native lake trout (and other fish species) has caused significant declines in the Yellowstone cutthroat trout. The lake trout is a relatively large trout species and, unlike the cutthroat trout, preys on other fishes. Lake trout also consume leeches, amphipods, and midges, all of which are part of the Yellowstone cutthroat trout diet. Why do you think these non-native fishes have had such an impact?
    - *Prompt students to consider the consequence of introducing a new, voracious predator that did not co-evolve with the Yellowstone cutthroat trout. Students should understand that migrating cutthroat trout are not adapted to the presence of large predator fish and become easy prey for the larger, longer-lived lake trout.*

    Besides predation, what other impacts on the Yellowstone cutthroat trout may be attributed to lake trout?
    - Students may identify the following: competition for food, reducing available habitat space, and exposure to new diseases brought by the lake trout. Hybridization is not known to occur between these two species.

    Unlike the cutthroat trout, the lake trout does not migrate upstream to spawn. What is the significance of this life cycle characteristic on the upstream ecosystems?
    - *Help students reason that if the adult cutthroat trout population is significantly reduced by lake trout predation and the lake trout do not migrate upstream to spawn, it follows that fewer and fewer trout will occupy the upper reaches of the stream. This will have a dramatic impact on the food webs of the upper reaches of the Yellowstone. Many species (grizzly bears, osprey, eagles, and otters) rely heavily on the Yellowstone cutthroat trout as prey.*
    - *Another predator will miss the cutthroat. Recreational trout fishing is very popular in Montana, bringing in over $30 million in revenues to the state.*

5. Can you identify common biotic and abiotic factors in Montana stream ecosystems? Describe how these biotic and abiotic factors influence Yellowstone cutthroat trout populations.

- *BIOTIC: Students may identify "living things" or name specific organisms common to stream ecosystems (e.g., dragonfly) as biotic factors. While these are biotic components of the ecosystem, ask students to consider interactions that a trout would have with its environment that involve other living things. Examples include competition with other organisms for food and space, both interspecific and intraspecific; predation; parasitism. Discuss predation both from native predators (e.g. grizzly bear, American white pelican) as well as from recently introduced species (e.g. lake trout). An important example of parasitism is Myxobolus cerebralis. Originally introduced from Europe, this non-native parasite causes whirling disease and seriously threatens cutthroat trout populations throughout the region.*
- *ABIOTIC: Students should identify a variety of factors including water temperature, water flow rates, water pH, substrate type (loose sediment, rocky bottom, etc), and nutrient levels. Facilitate discussion regarding the effects of changing these abiotic factors on trout population dynamics.*

As conservationists attempt to restore Yellowstone cutthroat trout fisheries, they must consider the factors that affect population growth. These factors can be dependent or independent of the population's density. In other words, the influence of density-dependent factors changes as the population density changes, but density-independent factors have the same influence regardless of population size. Can you give examples of each type of factor that are likely to affect cutthroat trout populations?

- *DENSITY-DEPENDENT: Competition for limited resources (e.g., food, nesting habitat), predation, disease outbreaks*
- *DENSITY-INDEPENDENT: Drought, extreme cold, environmental toxicants, fire. To explore indirect consequences in ecosystems, ask students to consider how fire would affect trout populations. By changing vegetation and soil conditions, fire (especially catastrophic fire) can affect forest hydrology in many ways: 1) reductions in vegetative cover reduces interception of rainfall, thereby increasing soil erosion and turbidity in streams; 2) reductions in surface organic matter reduces the water holding capacity of soil also leading to soil erosion 3) with increased erosion comes increased nutrient concentrations in stream water, potentially leading to eutrophication*
- *Ask students if they can observe a relationship between biotic/abiotic factors and density dependent/independent factors. They should see that most density dependent factors are biotic factors whereas most density-independent factors are generally abiotic factors.*

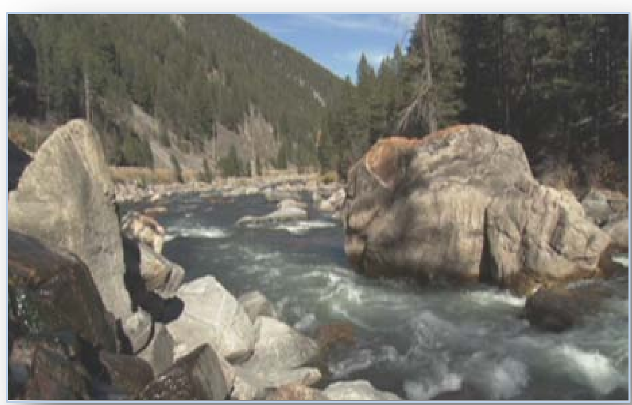
6. An indicator species is any species whose status characterizes the condition of the environment. If certain environmental conditions decline, the indicator species will also decline. The cutthroat trout is an indicator species for Montana's stream ecosystems. What can this species indicate about stream ecosystem health?
    - *The film identified several basic needs of the Yellowstone cutthroat trout. Prompt students to consider environmental conditions that must exist if cutthroat trout are present in an upper tributary stream. Students may identify several conditions, including 1) connectivity of the upper reaches with larger downstream water bodies (e.g. rivers, lakes); 2) good water quality with limited turbidity and excess nutrients, 3) ample water quantities*
7. The Yellowstone cutthroat trout (*Oncorhynchus clarkii bouvieri*) is one of many subspecies of the cutthroat trout (*O. clarkii*). What does it mean to be a subspecies? Why might subspecies have formed?
    - *Subspecies are groups of a species that are unique from each other, but are still capable of interbreeding. Individuals of two cutthroat subspecies can produce offspring. Members of a subspecies are commonly found in the same geographic region.*

    What factors do you think contributed to the formation of so many subspecies of cutthroat trout?
    - *During the last glacial retreat, populations of cutthroat trout became isolated. Mountain ridges and other land formations made it impossible for these isolated groups to interbreed. Over thousands of years, these isolated populations faced unique selective pressures and therefore evolved independently.*
    - *Discuss the concept of genetic drift as an important evolutionary mechanism in small, isolated populations. Explain how changes in allele frequency, random mating, and chance all contribute to genetic drift. Also, use the isolation of small cutthroat trout populations during the last glacial retreat as an example of the Founder Effect. Make sure students understand that small founder populations will significantly under-represent the allele frequency of the parent population and that this new genetic composition will carry on into future generations of the new population.*

Suggested Activities for Further Study

Activity One: Construct a Food Web for the North Fork Fridley Creek

In this classroom activity, students will construct a food web for a Montana stream ecosystem.

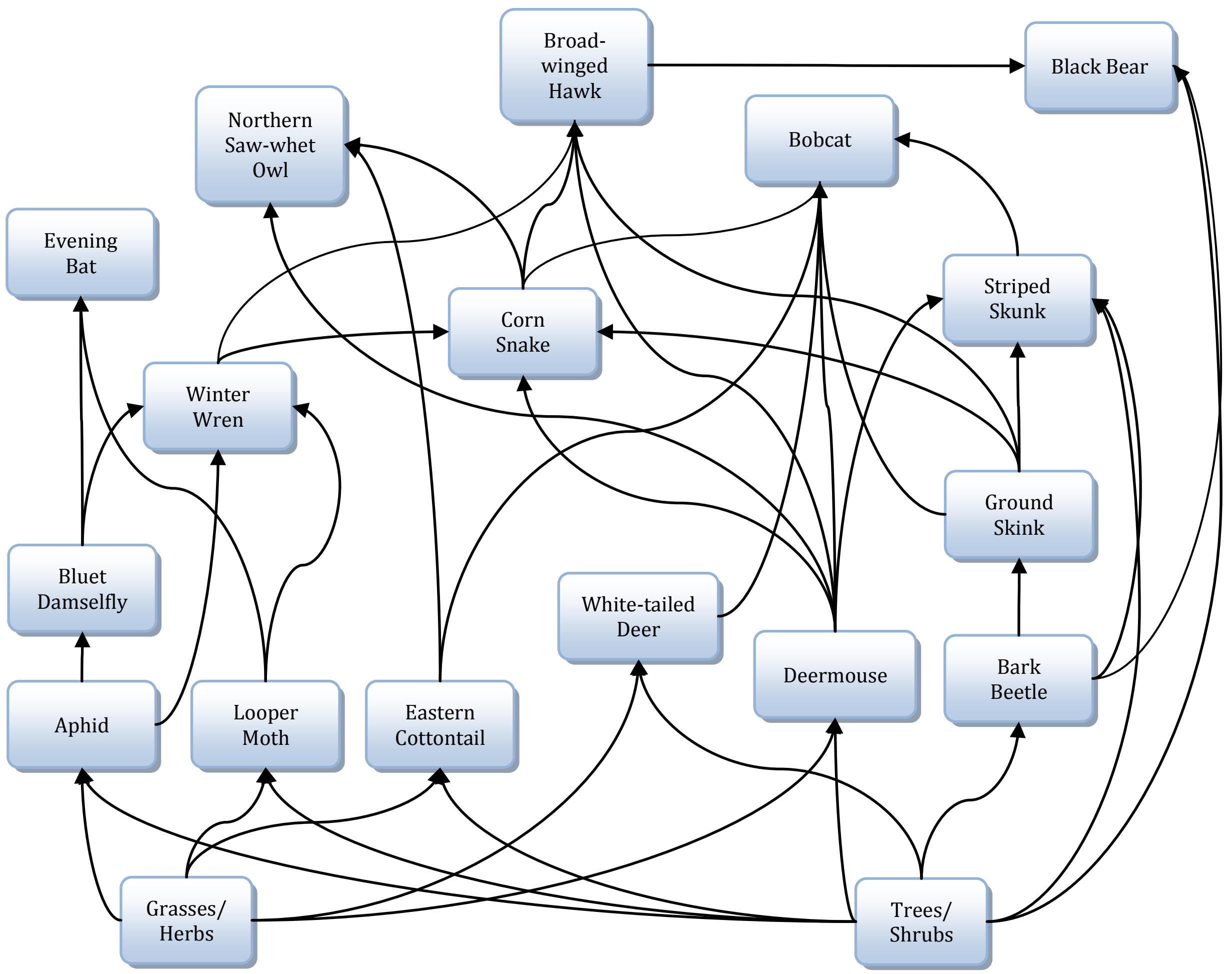


a) Begin by dividing the class into small groups. Using the species list provided below, assign equal numbers of animal species to each group. Instruct each group to utilize various reference resources to research the diet of their assigned animal species.

Note to the teacher: Adequate resources and time to do the research are key to the successful completion of this activity. In an ideal situation, there would be one or more class periods for library research alone. If this is not possible, you may wish to gather resources ahead of time for students to use in class.

b) After students have completed their research, use large group instruction to lead the class in creating a food web, preferably on a dry-erase board. Building the web is easier if species are added in the following trophic order: herbivores, omnivores, carnivores. Advanced classes may include scavengers and decomposers (fungi). It is not necessary to label the trophic groups on the board. Also, be sure to point arrows from prey to predator to show the direction of energy flow.

Here is an example of a simple food web for the Smoky Mountains:



Smoky Mountain Food Web

c) Once the food web is constructed, crosschecked, and neatened, ask students to copy the food web onto their own paper. Students should then group sections of the food web into trophic levels: producers, primary consumers, secondary consumers, higher order consumers, scavengers, and decomposers.
d) If there is access to presentation software, give students an additional class period to design the food web using graphic organizational software. Their presentations could then be offered to the rest of the school or community as an informative display or presentation, along with the film "Against the Current."

Common Animal Species of Fridley Creek

American Dipper - *Cinclus mexicanus*
American Rubyspot - *Hetaerina americana*
Arctic Grayling - *Thymallus arcticus*
Belted Kingfisher - *Megaceryle alcyon*
Brook Stickleback - *Culaea inconstans*
Brook Trout - *Salvelinus fontinalis*
Coeur d'Alene Salamander - *Plethodon idahoensis*
Common Stonefly - *Plecoptera*
Grizzly Bear - *Ursus arctos*
Harlequin Duck - *Histrionicus histrionicus*
Leech - *Helobdella stagnalis*
Mayfly - *Caudatella* spp.
Mottled Sculpin - *Cottus bairdii*
Mountain Marshsnail - *Stagnicola montanensis*
Mountain Whitefish - *Prosopium williamsoni*
Northern Leopard Frog - *Rana pipiens*
Pale Snaketail - *Ophiogomphus severus*
Pilose Crayfish - *Pacifastacus gambelii*
Raccoon - *Procyon lotor*
Rainbow Trout - *Oncorhynchus mykiss*
Rhyacophilan Caddisfly - *Rhyacophila angelita*
Rocky Mountain Duskysnail - *Colligyrus greggi*
Rocky Mountain Tailed Frog - *Ascaphus montanus*
Trout Perch - *Percopsis omiscomaycus*
Tule Bluet - *Enallagma carunculatum*
Virile Crayfish - *Orconectes virilis*
Water Shrew - *Sorex palustris*
Western Pearlshell - *Margaritifera falcata*
Wood Duck - *Aix sponsa*
Yellowstone Cutthroat Trout - *Oncorhynchus clarkii bouvieri*

Activity Two: Modeling Interactions between the Invasive Lake Trout and the Yellowstone Cutthroat trout

This activity utilizes a computer simulation model based on the ***Lotka-Volterra predator/prey equation****. The model uses equations to predict population changes of theoretical predators and prey as they interact. In this exercise, students can run simulations of population changes between the introduced lake trout and the native Yellowstone cutthroat trout. Whether conducted as a classroom activity or individually, students should evaluate and interpret model outputs for a variety of parameter scenarios.*

- *The model is included on the Excel® spreadsheet that accompanies this discussion guide. Open the spreadsheet and familiarize students with its elements. Point out that initial fish densities and several model parameters can be manipulated to automatically produce new outputs.*
- *Ask students to vary initial densities of predators and prey (X(t) and Y(t)), prey population increase (r), predation (a), reproduction of predators (b), and/or predator mortality (m). To focus the discussion, it is advisable to provide pre-determined values that best illustrate how these factors influence population dynamics.*
- *For each model simulation, the time series graph should be printed and attached to a brief interpretation of the model output.*

- *Ask students to articulate the general limitations of this type of model. After evaluating equation parameters, students should identify real world factors not incorporated in the model that would affect either population. Examples: competition with other predators/prey, large-scale disturbances like disease outbreak. Advanced students with introductory calculus may also evaluate specific limitations of the equation. Example: predation rate is constant at all prey population densities (i.e., if cutthroat trout tripled in population, would lake trout necessarily eat three times as many cutthroat trout?)*