AGAINST THE CURRENT

The story of westslope cutthroat trout in Alberta's headwater ecosystems

TEACHER'S GUIDE

Biology. Threats. Recovery. Case Study.

Prepared by
GHOST WATERSHED ALLIANCE SOCIETY
www.ghostwatershed.ca

Developed for the

Ghost Watershed Alliance Society

www.ghostwatershed.ca

By Sourcewater Communications

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- Alberta Conservation Association
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- Cochrane Environmental Action Committee
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- TD Friends of the Environment Foundation

TEACHER'S GUIDE

Thank you for taking an interest in the westslope cutthroat trout! Along with other native trout, their presence in Alberta is a symbol of our biodiversity and an indicator of healthy aquatic ecosystems.

The Ghost Watershed Alliance Society offers you a teaching resource that supports the *Grade 7 Science Unit A: Interactions and Ecosystems* and looks at the following focusing questions:

- How do human activities affect ecosystems?
- What methods can we use to observe and monitor changes in ecosystems, and assess the impacts of our actions?

To address curriculum knowledge, skill, and attitude outcomes, this study of westslope cutthroat trout has been broken down into four main themes:

- Biology
- Threats
- Recovery
- Ghost Watershed Case Study

This teaching resource comes in two parts:

1. A slide deck (found at www.ghostwatershed.ca)
2. An accompanying teacher's guide including lesson plans and student activities

The slide show is a self-contained instructional package and this teacher's guide contains corresponding lesson plans with student activities. Whether you are teaching in-person or online, this resource can be used in multiple ways. You can "flip the classroom" by having students work through a section of the slides on their own and then spend class time working on the discussion and activities. Alternatively, you can guide the students through the slides, using the lesson plans and activities to support their learning.

PowerPoint Slides (accessed at www.ghostwatershed.ca)

Contents

LESSONS & ACTIVITIES

*each lesson requires approximately 45-60 minutes

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Against the Current covers all four of the STS and Knowledge Outcomes in the Grade 7 Unit A: Interactions and Ecosystems.

1. Investigate and describe relationships between humans and their environments, and identify related issues and scientific questions
2. Trace and interpret the flow of energy and materials within an ecosystem
3. Monitor a local environment, and assess the impacts of environmental factors on the growth, health and reproduction of organisms in their environment
4. Describe the relationships among knowledge, decisions and actions in maintaining life-supporting environments

The specific Knowledge/STS, Skills, and Attitudes for each lesson are listed here:

LESSON	KNOWLEDGE/STS	SKILLS	ATTITUDES
1 – Quest & morphology	• Identify examples of human impacts on ecosystems	Perform and record	Interest in science
2 – Life cycle & diet	• Illustrate how life-supporting environments meet the needs of living things for nutrients, energy sources, moisture, suitable habitat, and exchange of gases	Communica-tion and teamwork	Interest in science
3 – Habitat	• Investigate a variety of habitats, and describe and interpret distribution patterns of living things found in those habitats • Describe examples of interaction and interdependency within an ecosystem	Perform and record Analyze and interpret	Interest in science
4 – Ecosystem Factors	• Analyze an ecosystem to identify biotic and abiotic components and describe interactions among these components	Perform and record Analyze and interpret	Interest in science
5 – Food webs	• Analyze ecosystems to identify producers, consumers and decomposers; and describe how energy is supplied to and flows through a food web • Describe the process of cycling carbon through an ecosystem	Perform and record Analyze and interpret	Interest in science
6 – Threats	• Identify examples of human impacts on ecosystems, and investigate and analyze the link between these impacts and the human wants and needs that give rise to them • Identify intended and unintended consequences of human activities within local and global environments • Investigate and interpret evidence of interaction and change	Initiate and plan Analyze and interpret	Stewardship
7 – Recovery	• Describe and interpret examples of scientific investigations that serve to inform environmental decision making • Analyze personal and public decisions that involve consideration of environmental impacts, and identify needs for scientific knowledge that can inform those decisions	Analyze and interpret	Scientific inquiry
8 – Ghost Watershed Case Study	• Analyze a local environmental issue or problem based on evidence from a variety of sources, and identify possible actions and consequences • Identify signs of ecological succession in local ecosystems	Communica-tion and teamwork	Stewardship Mutual respect Collaboration

Lesson 1 – Quest & Morphology

Overview

Students will be introduced to the quest and morphology of westslope cutthroat trout.

Objectives

Students will gain a general understanding that westslope cutthroat trout are fighting for their survival. Students will define distribution and abundance of a species. Students will be able to identify 3 trout species based on their distinct physical features.

Materials and Background Information

PowerPoint slides #1-14
Student Activities – *Field Guide*

Procedure

1. Have students follow slides #1-14, either individually or together as a class.
2. Introduce the plight of the westslope cutthroat trout and emphasize the decrease in its distribution and abundance. Begin the biology section by identifying three trout species that interact in headwater ecosystems in Alberta.
3. Give students time to work on their *Field Guide*.

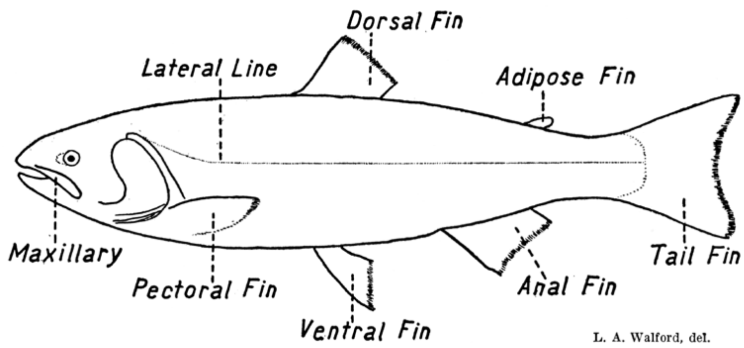
Extension

- Investigate other fish species:
  - What are other native trout species in Alberta? Which ones are also threatened? (e.g., bull trout, Athabasca rainbow trout)
  - What are other sport fishing species in Alberta?
  - Visit https://talkaep.alberta.ca/go-fish/ to find more resources.
- Create a "HedBanz" game with the field guide. Cut out each fish. Working in pairs and alternating roles, have one student ask questions about the unseen fish on their forehead and the other student answer until the correct fish species is given.
- Why are they called westslope cutthroat trout but live along the Eastern Slopes of the Rocky Mountains?

FIELD GUIDE

Create a **fish identification chart** by drawing and colouring the unique features of each trout species. Which one is native to Alberta?

Westslope cutthroat trout



L. A. Walford, del.

FIG. 3. Example of a fish with an adipose fin.

Rainbow trout

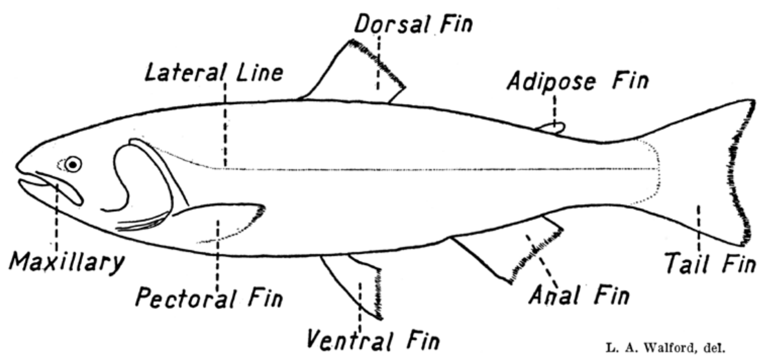


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FIG. 3. Example of a fish with an adipose fin.

Brook trout

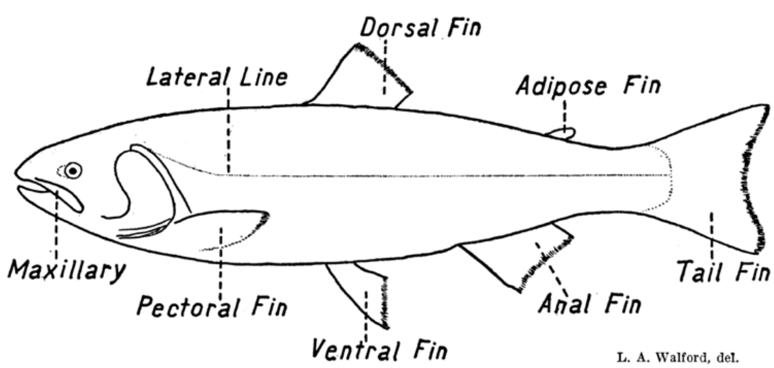

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FIG. 3. Example of a fish with an adipose fin.

Suggested key:

Westslope cutthroat trout (native to Alberta)

- Silver to yellowish body
- Bright red-orange streak in the fold under the mouth
- Small scales and black spots without haloes, mainly on upper part of body and increasing towards the tail

https://www.alberta.ca/cutthroat-trout.aspx

Rainbow trout

- Olive green colour with heavy black spotting over the length of the body
- Adult fish has a red coloured strip along the lateral line, from the gills to the tail

https://www.alberta.ca/rainbow-trout.aspx

Brook trout

- Back is dark green with pale, wavy lines, sides have a purple sheen with blue-haloed red spots
- Lower fins have a black strip behind a pale leading edge

https://www.alberta.ca/brook-trout.aspx

Suggested links and extensions:

https://talkaep.alberta.ca/go-fish/

http://www.nlft.org/2018/03/09/fish-identification-quiz/

Lesson 2 – Life Cycle & Diet

Overview

Students will be introduced to the life cycle and diet of the westslope cutthroat trout.

Objectives

Students will be able to identify and describe the main stages of the trout life cycle. Students will be able to identify the main food sources for westslope cutthroat trout throughout their life cycle.

Materials and Background Information

PowerPoint slides #15-23
Student Activity – *Survive to Spawn!* (template, dice, pawns)

Procedure

1. Have students follow slides #15-23, either individually or together as a class.
2. Discuss the main components of their life cycle. Emphasize that the required food sources for trout change throughout their life cycle.
3. Give students the opportunity to create and play their *Survive to Spawn!* life cycle game. Note: this activity can be repeated after students learn about human threats in Lesson 6

Extension

Investigate the following:

- Life cycles of aquatic invertebrates- when are they in or on the water? On land?
- Aquatic invertebrate functional feeding groups such as shredders and collectors
- Ephemeroptera, Plecoptera, and Trichoptera ratios (EPT ratios) as indicators of water quality
- Canadian Aquatic Biomonitoring Network (CABiN) https://www.canada.ca/en/environment-climate-change/services/canadian-aquatic-biomonitoring-network/science.html

SURVIVE TO SPAWN! Create a board game where players start out as a trout egg and win the game by surviving to become a spawning adult.

Instructions:

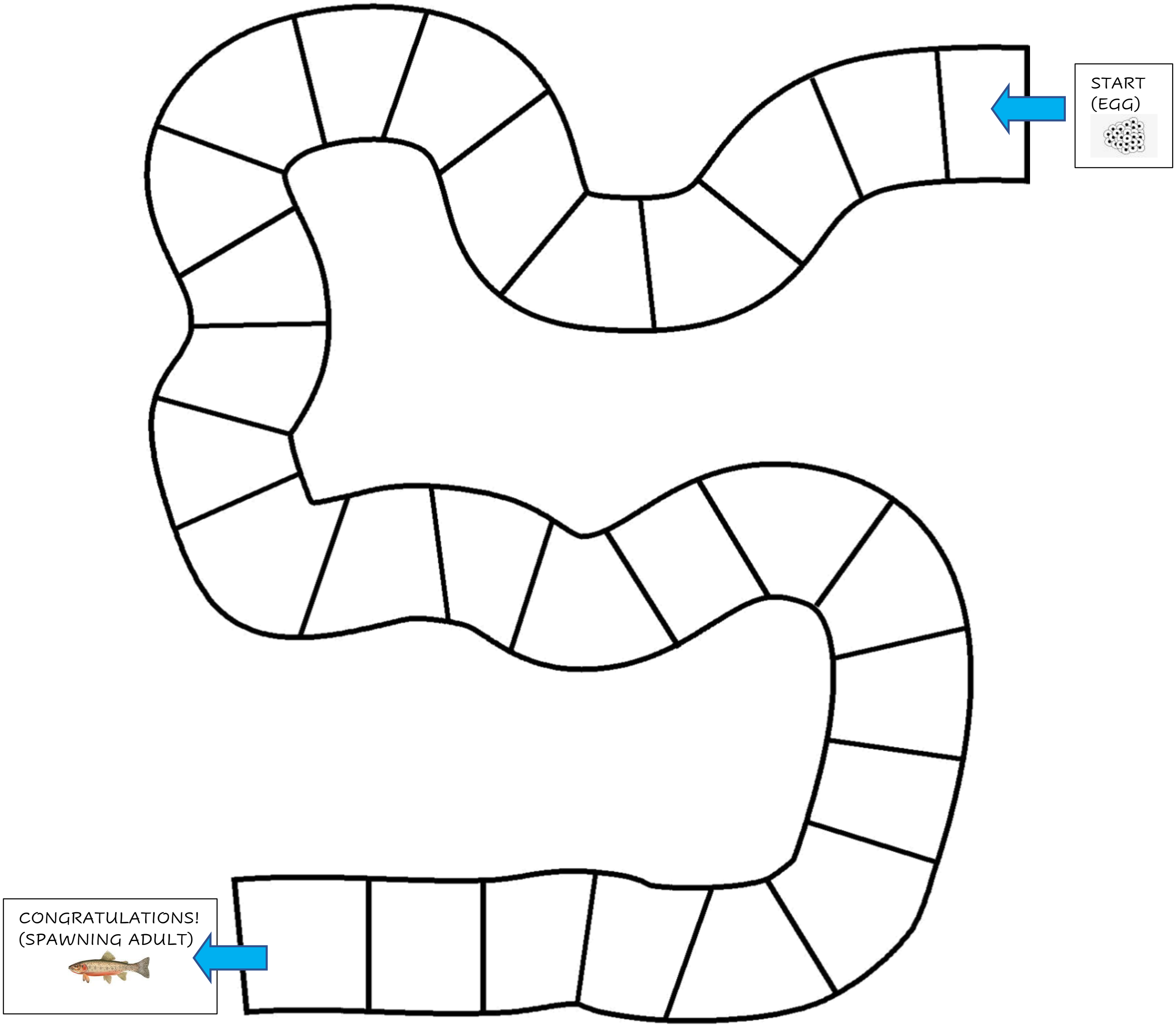
1. Use the stream template on the following page and fill in each section to advance the life cycle. Remember the correct order is **egg**, **alevin**, **fry**, **juvenile**, and **adult**. Make it interesting! Add drawings & colour to the stream sections and blank spaces.
2. Find small items (e.g., coin, paper clip) to represent each player. Take turns to roll the dice and advance. Play!

Sample stream sections:

- Live in shallow gravels as an **egg** to incubate - safe
- Temperature just right to incubate - safe
- Gravels are too compacted – go back to the beginning
- No floods- you can hatch into an **alevin**! - safe
- Large spring flood washes away your redd – go back to the beginning
- Move to slower part of stream - safe
- Rely on yolk sac for energy - safe
- You are eaten by a brook trout - go back to the beginning
- Yolk sac is used up – you made it to the **fry** level! - safe
- Eat chironomid larvae – grow to become a **juvenile**! - safe
- You found a deep pool and survived the winter! - jump forward one space
- You discover a mayfly hatch and eat a lot! - jump forward one space
- Spring flooding washes large amounts of sediment into stream – move back one space
- You survived another winter! - safe
- Warm summer temperatures decrease the available oxygen- miss a turn
- A bird pulls you out of the water to eat you – go back to the beginning
- You found cover underneath a sunken log- safe
- Eating lots of stonefly nymphs turns you into an **adult**! – jump forward one space
- Bug populations are low this year – move back one space
- An early freeze in the fall takes away your energy – move back one space

Extension: add human threats to this game

WESTSLOPE CUTTHROAT TROUT LIFE CYCLE GAME



Lesson 3 - Habitat

Overview

Students will be introduced to the key elements of westslope cutthroat trout habitat.

Objectives

Students will be able to describe the components of headwater habitats. Students will be able to define a riparian area and list the reasons why it is an important part of westslope cutthroat trout habitat. Students will understand how sediment impacts spawning.

Materials and Background Information
PowerPoint slides #24-30
Student Activity – *Habitat Hunt*

Procedure
1. Have students follow slides #24-30, either individually or together as a class.
2. Emphasize that westslope cutthroat trout outcompete other trout species in headwater habitats. They can live elsewhere but have retreated to higher elevation streams for survival.
3. Discuss the four main components of WSCT healthy habitat: cold, clean, covered, and connected.
4. Describe sediment as foe and riparian area as friend.
5. Give students time to complete *Habitat Hunt*.

Extension
Have students investigate the following:
- Common riparian vegetation in Alberta– plant ID trees, shrubs, grasses and sedges, and broad-leafed plants https://cowsandfish.org/
- Invasive plants and noxious weeds and their effects on riparian areas
- What is the difference between fluvial and adfluvial fish? Which type needs the most connected water networks?

HABITAT HUNT

You have been hired to work as a fisheries biologist. One of your first tasks is to create a **habitat checklist** for current distribution of westslope cutthroat trout. This chart can help you assess real stream conditions as you hunt for suitable habitat later on. Circle the best field assessment word for each habitat feature.

HABITAT FEATURE	FIELD ASSESSMENT		
• stream gradient	steep	moderate	flat
• water temperature	warm	moderate	cold
• deep pools or groundwater input	none	some	many
• water quality	good	moderate	poor
• amount of sediment in gravels	low	moderate	high
• dissolved oxygen level	low	moderate	high
• overhanging riparian plants	none	some	many
• boulders or large woody debris in water	none	some	many
• spawning areas	none	some	many
• amount of change in water flow	low	moderate	high
• abundance of aquatic invertebrates	low	moderate	high
• stabilizing riparian plants	none	some	many
• amount of fragmentation	low	moderate	high

Bonus: What are the four "Cs" of good habitat for westslope cutthroat trout?

HABITAT HUNT **Key**

HABITAT FEATURE	FIELD ASSESSMENT		
• stream gradient	steep	moderate	flat
• water temperature	warm	moderate	cold
• deep pools or groundwater input	none	some	many
• water quality	good	moderate	poor
• amount of sediment in gravels	low	moderate	high
• dissolved oxygen level	low	moderate	high
• overhanging riparian plants	none	some	many
• boulders or large woody debris in water	none	some	many
• spawning areas	none	some	many
• amount of change in water flow	low	moderate	high
• abundance of aquatic invertebrates	low	moderate	high
• stabilizing riparian plants	none	some	many
• amount of fragmentation	low	moderate	high

Bonus: What are the four "Cs" of good habitat for westslope cutthroat trout?

cold, clean, covered, and connected

Lesson 4 – Ecosystem Factors

Overview

Students will be introduced to aquatic ecosystems and their associated living and non-living elements.

Objectives

Students will be able to identify the main abiotic and biotic factors in aquatic ecosystems and explore how they interact.

Materials and Background Information

PowerPoint slides #31-39
Student Activity – *Find the Factors*

Procedure

1. Have students follow slides #31-39, either individually or together as a class.
2. Spend time making sure students understand that ecosystems are made up of the interactions between living and non-living parts. Highlight the main abiotic and biotic factors in aquatic ecosystems. Build on the previous learning about life cycle, diet, and habitat. Discuss what is meant by low or high productivity.
3. Have the students complete *Find the Factors* to reinforce their learning.

Extension

- Investigate further:
  -Abiotic factors
    What is the ideal range of temperature for trout?
    What is their preferred level of dissolved oxygen?
    Research these water quality parameters: temperature, pH, turbidity, phosphate and nitrates
    Trout Unlimited Water-Edu Kit
  -Biotic factors
    What are macro invertebrates, aquatic macrophytes and periphytons? What are some common types of algae in Alberta?

FIND THE FACTORS

INSTRUCTIONS: Read the following and complete Part 1 and Part 2.

Native plants in the riparian areas anchor soil in the bank, which keeps the channel shape stable and helps to maintain consistent water flow. Riparian plants also provide shade, which keeps water cooler in the summer months. When water temperatures are lower, there is more dissolved oxygen available for the fish. Riparian plants also filter out sediment and prevent too much from reaching the water. This helps spawning trout because they need clean, sediment-free gravels.

Fish depend on aquatic invertebrates for energy and nutrients. Many aquatic invertebrates need both riparian plants and clean water to complete their life cycles. When trout and aquatic invertebrates die, bacteria work to decompose them. This process returns nutrients back to the shores and beds of the streams, helping plants and other producers to grow.

Part 1: Identify the biotic and abiotic factors above.

Biotic Factors (4)	Abiotic Factors (8)

Part 2: Using the information in Part 1, create a list of 5 possible interactions (think verbs) in this ecosystem.

Factor	Interaction (verb)	Factor
E.g. riparian plants	filter	sediment

FIND THE FACTORS **Key**

Part 1: Identify the biotic and abiotic factors above.

Biotic Factors	Abiotic Factors
riparian plants	soil
trout	channel shape
aquatic invertebrates	water flow
bacteria	shade
	water temperature
	dissolved oxygen
	gravels
	sediment

Part 2: Using the information in Part 1, create a list of 5 possible interactions (think verbs) in this ecosystem. *may vary

Factor	Interaction	Factor
E.g. riparian plants	filter	sediment
riparian plants	shade	water
riparian plants	anchor	soil
channel shape	affects	water flow
water temperature	affects	dissolved oxygen
fish	need	dissolved oxygen
fish	eat	aquatic invertebrates
bacteria	decompose	fish
bacteria	decompose	aquatic invertebrates
aquatic invertebrates	live in or on	water
aquatic invertebrates	need	riparian plants
fish	spawn in	clean gravels

Lesson 5 – Food Webs

Overview

Students will be introduced to aquatic ecosystems and their associated food webs. The concept of an indicator species is addressed.

Objectives

Students will identify common producers, consumers, and decomposers in ecosystems containing trout. Students will understand the relationships between these energy capture categories. Students will understand that WSCT are an indicator species.

Materials and Background Information

PowerPoint slides #40-44
Student Activity – *Work the Web*

Procedure

1. Have students follow slides #40-44, either individually or together as a class.
2. Describe a food web as a map of ecosystem interactions that trace energy movement along specific pathways. Emphasize that the arrow direction is important to show energy transfer from one organism to another. Discuss energy capture categories and examples in ecosystems containing WSCT.
3. Have students work in pairs to verbally answer the questions on "Tug at the web" (slide 43).
4. Give students time to complete *Work the Web*.

Extension

- Investigate further:
  - -Look up the advanced biological vocabulary in these slides: particulate organic matter, dissolved organic matter, epilithic algae, hyphomycete fungi, allochthonous organics, detritus, seston, primary autochthonous producers
  - -Discover the functional feeding groups of aquatic invertebrates (shredder, collector, scraper, and predator)
  - - Research another indicator species in Alberta

WORK THE WEB

Given this sample food web, answer the questions on the next page. Please note that this food web does not contain WSCT, but it represents a very similar ecosystem.

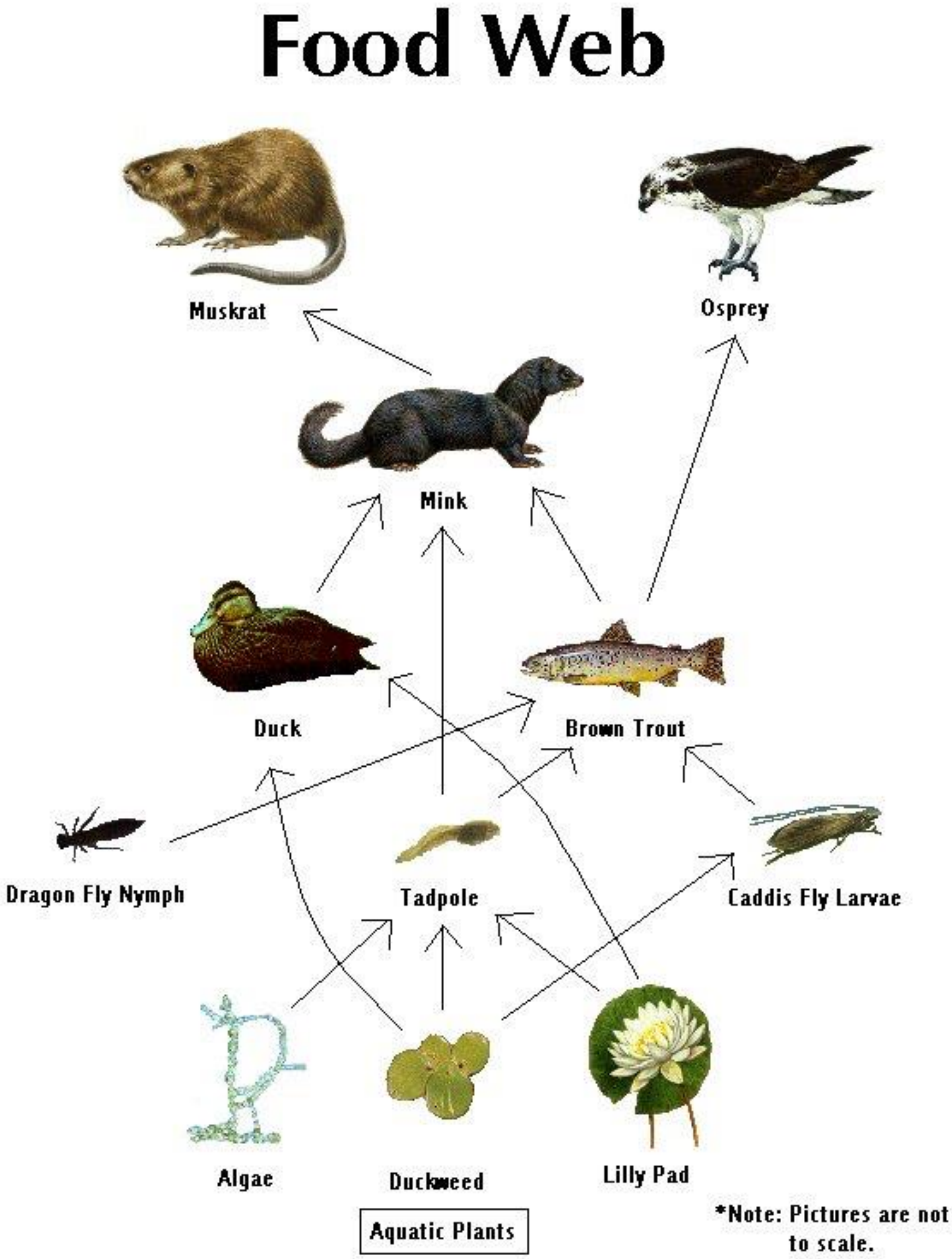


Image source: https://socratic.org/questions/how-can-you-trace-an-animal-s-trophic-level-on-a-food-web

Answer the following questions about the food web above.

1. Can you spot which forms of life give the trout energy?

2. Which forms of life use the energy stored in the trout?

3. What organisms are producers? Consumers?

4. Can you give an example of a primary consumer, a secondary consumer, and a tertiary consumer?

5. Where could you place the sun? What organisms would receive arrows (energy) from the sun?

6. What would happen if the caddis fly larvae disappeared?

7. What part of the food web is missing from this diagram? Hint: a large category

8. Name one tertiary consumer. Predict the effects on the food web if there was a sudden and large population increase of this organism.

9. A food web shows many different energy connections between organisms whereas a food chain traces only one path of energy transfer. An example of a food chain within this food web is duckweed > tadpole > mink > muskrat. List another food chain.

10. In this diagram, what organism does not have an energy source shown?

WORK THE WEB **Key**

1. Dragonfly nymph, tadpole, and caddis fly larvae

2. Mink and osprey

3. Producers: Algae, duckweed, lilypad
   Consumers: All other organisms

4. Primary consumers: tadpole, caddis fly larvae, duck
   Secondary consumers: brown trout, mink
   Tertiary consumers: muskrat, osprey

5. Anywhere, but at the bottom would be simplest. Algae, duckweed, and the lily pad all receive energy from the sun.

6. The trout will lose a food source and the duckweed could become more abundant.

7. Decomposers (e.g., bacteria)

8. Muskrat or osprey. A sudden population increase of either of these tertiary consumers would decrease the populations of their prey (e.g., mink and brown trout).

9. Examples include:
   algae > tadpole > brown trout > osprey
   algae > tadpole > brown trout > mink > muskrat
   duckweed > tadpole > mink > muskrat
   duckweed > duck > mink > muskrat
   duckweed > caddis fly larvae > brown trout > osprey
   duckweed > caddis fly larvae > brown trout > mink > muskrat
   lily pad > tadpole > mink > muskrat
   lily pad > duck > mink > muskrat

10. Dragonfly nymph (they are actually secondary consumers and eat other insects

Lesson 6 - Threats

Overview

Students will be introduced to the idea that an increase in human population can increase threats to species.

Objectives

Students will understand that an increase in human population leads to increased threats to native species. Students will be able to identify the intended and unintended consequences of human needs and wants. Students will be able to list and describe the 3 main human-caused threats (habitat loss, hybridization, and harvest) and the 2 main natural threats (floods and predation) to the survival of WSCT.

Materials and Background Information

PowerPoint slides #45-62
Student Activity – *Predictive Powers*

Procedure

1. Have students follow slides #45-62, either individually or together as a class.
2. Discuss the visual impact of slide #46. What are students' responses? Differentiate between intended and unintended consequences of various human activities. Summarize the threats of hybridization, harvest, and habitat loss. Discuss slide #58.
3. Divide the class into groups and assign them one (or more) scenarios from *Predictive Powers*. Give them time to identify the threat and make a prediction about how this will affect WSCT. Students can verbally present these scenarios to the class in a brief round table format or respond individually.

Extension

Investigate further

- How do scientists do genetic testing? What physical features change in hybridized fish?
- Research another species at risk in Alberta
- What is whirling disease? Research its presence in Alberta. https://www.alberta.ca/whirling-disease.aspx

PREDICTIVE POWERS

Write or discuss your predictions about the effect on westslope cutthroat trout (WSCT) in the following scenarios. Explain how a specific threat has been removed or added. Remember the three main human threats (hybridization, harvest, and habitat loss) and the two main natural threats (flooding and predation).

1. Banff National Park fisheries biologists are successful in removing all non-native trout species from a mountain lake and stream. They plan to reintroduce WSCT here.

2. An unusual combination of a heavy spring rain and a deep winter snowpack creates a large flood. Many aquatic invertebrates are washed away, and their populations remain low in the summer. Sediment washed into spawning gravels.

3. WSCT spawn along a certain reach of stream. For years, a riparian area just upstream of this important habitat had been damaged by motorized vehicles crossing through the water. The government installed a bridge. A local watershed stewardship group worked with a group of motorized recreationalists to plant willows and repair the shoreline.

4. Fishing regulations have changed in a certain stream. In previous years, anglers were allowed to catch and keep WSCT. Now, they must catch and release these native trout.

5. Fisheries biologists have located a pure-strain WSCT population in a headwaters stream. They've also identified critical habitat in another tributary of the watershed that has very similar abiotic and biotic factors. To introduce alevin into this tributary, they want to experiment with a new in-stream incubator and hopefully establish a healthy WSCT population there.

6. A forestry company wants to harvest trees near a stretch of creek known to have a healthy WSCT population. They construct a bridge to access the site. They also install sediment fences and keep a buffer of trees and shrubs beside the creek.

7. Since WSCT live in headwater streams with low productivity, they snatch any available invertebrate and can be easily caught by anglers. Fishing regulations require the use of barbless hooks.

8. A young angler, new to the sport, is told she can catch and keep as many brook trout as she can. She makes sure she knows the difference between brook trout and WSCT before she goes out.

9. A barrier is placed between populations of brook trout and WSCT. (hint: this action removes and adds a threat)

PREDICTIVE POWERS **Key**

1. Banff National Park fisheries biologists are successful in removing all non-native trout species from a mountain lake and stream that once contained WSCT. They plan to reintroduce WSCT here.
   WSCT have a chance to be re-established. The threat of hybridization and competition has been removed.

2. An unusual combination of a heavy spring rain and a deep winter snowpack creates a large flood. Many aquatic invertebrates are washed away, and their populations remain low in the summer. Sediment washed into spawning gravels.
   Flooding is the threat. Since the main food source of the WSCT is low and some spawning areas are damaged, they will struggle to complete their life cycle this year.

3. WSCT spawn along a certain reach of stream. For years, a riparian area just downstream of this important habitat had been damaged by motorized vehicles crossing through the water. The government installed a bridge. A local watershed stewardship group worked with a group of motorized recreationalists to plant willows and repair the shoreline.
   The bridge and riparian repair will improve WSCT habitat by decreasing sediment inputs and fragmentation.

4. Fishing regulations have changed in a certain stream. In previous years, anglers were allowed to catch and keep WSCT. Now, they must catch and release these native trout.
   This action addresses the threat of harvest. More WSCT have a chance to complete their life cycle, which will increase their population.

5. Provincial fisheries biologists have located a pure-strain WSCT population in a headwaters stream. They've also identified critical habitat in another tributary of the watershed that has very similar abiotic and biotic factors. To introduce alevin into this tributary, they want to experiment with a new in-stream incubator and establish a healthy WSCT population there.
   These actions will overcome habitat loss, giving the native trout a chance for greater distribution.

6. A forestry company wants to harvest trees near a stretch of creek known to have a healthy WSCT population. They construct a bridge to access the site. They also install sediment fences and keep a buffer of trees beside the creek.
   By preventing sediment from entering the creek and by maintaining a buffer of riparian vegetation, this forestry company is preventing habitat loss.

7. Since WSCT live in headwater streams with low productivity, they snatch any available invertebrate and can be easily caught by anglers. Fishing regulations require the use of barbless hooks.
   This action prevents harm from harvest (sport fishing).

8. A young angler, new to the sport, is told she can catch and keep as many brook trout as she can. She makes sure she knows the difference between brook trout and WSCT before she goes out.
   By learning how to identify different fish species, this angler is preventing the threat of harvest. The regulations are addressing the threat of competition.

9. A barrier is placed between populations of brook trout and WSCT. (hint: this action removes and adds a threat)
   This barrier will prevent hybridization but may block the WSCT from accessing different reaches of the stream they need to complete their life cycle (habitat loss).

Lesson 7 - Recovery

Overview

Students will be asked to think about why we should care about WSCT. Recovery of species is complicated: it requires knowledge, decisions, and actions from many groups including the federal and provincial governments. Students will be introduced to the existing legal and policy framework used to recover WSCT today, including how science plays a role in acquiring knowledge, making personal and public decisions, and acting on those decisions.

Objectives

Students will examine the question: Why care about WSCT? Students will be able to see the many reasons why wildlife are important and have meaning. Students will be able to identify examples of personal and public decisions that can help WSCT. Students will get an overview of the basic federal and provincial laws and policies that are concerned with protecting species (i.e., COSEWIC, SARA, Recovery Strategy and Action Plan, Critical Habitat Order, FISHES program).

Materials and Background Information

PowerPoint slides #63-75
Student Activities – *Why Care?*

Procedure

1. Have students follow slides #63-75, either individually or together as a class.
2. Focusing on slide #64, have students complete the activity *Why Care?*
3. This section has a social studies component. Federal and provincial governments have to work together for the recovery of WSCT. There are also personal and public decisions that people can make to help WSCT. Highlight the two main goals of the Recovery Strategy and Action Plan (slide #72), which are basically to prevent further loss in distribution and abundance of WSCT and then to bring WSCT back to self-sustaining levels. Emphasize the role of knowledge in decision making and action.

Extension

- Indigenous people – What was their relationship with WSCT? What is it like today?
- Government cooperation – how do federal and provincial governments work together when it comes to protecting species at risk?
- Alberta's Native Trout Recovery Program: https://www.alberta.ca/native-trout-recovery-program.aspx - toc-2
- What is the Fish Sustainability index? https://www.alberta.ca/fish-sustainability-index-overview.aspx
- What other scientific research and technologies have advanced our understanding of WSCT and our ability to recover them?
- To see an example of recovery efforts in a mountain lake in Banff National Park, click here.
  "*Parks Canada aquatics team working to restore native trout in Banff National Park*" Kevin Fleming, CTV News. September 16, 2020
  Fisheries biologists worked at removing a non-native trout species for 6 years by using various catching techniques. Despite their hard work, these non-native trout persisted. An advancement in scientific knowledge and the technical application allowed these biologists and Parks staff to remove the non-native trout in one day. This clears the path for the re-introduction of WSCT.

WHY CARE?

Question:

"Why would we, why should we care about cutthroat trout?"

Answer:

"Cutthroat trout are a part, a feature of a watershed and an indicator of landscape health…having cutthroat occupy these watersheds is the ***gold seal of water quality***. The ripples that extend outward from a pebble dropped in a stream containing cutthroat inevitably find us."

"It may well be that our own species will need these healthy watersheds with natural expressions of ***biodiversity and ecosystem services***. It truly needs them now!"

Author: Lorne Fitch, P. Biol.
Source: Alberta WSCT Recovery Plan 2012-2017

1. Can you put the thoughts of Mr. Fitch into your own words? What is he saying?

2. What do you think Mr. Fitch means when he says that streams containing westslope cutthroat trout have, "the **gold seal of water quality**"?

3. Explain how this relates to the idea of an indicator species.

4. What is **biodiversity**? What are **ecosystem services**?

5. Talk to someone in your family or neighbourhood. Do they think we should care about making sure WSCT survive in Alberta? Why or why not?

6. If a person cares about WSCT, what can they do to help this native fish?

7. When we protect WSCT, what else are we protecting?

Suggested Key (answers will vary)

1. Can you put the thoughts of Mr. Fitch into your own words? What is he saying?

He suggests that humans benefit when westslope cutthroat trout live in Alberta. He urges us to care because these fish represent healthy ecosystems that provide humans with clean drinking water.

2. What do you think Mr. Fitch means when he says that streams containing westslope cutthroat trout have, "the **gold seal of water quality**"?

Since westslope cutthroat trout need very clean water to survive, their presence tells us that the watersheds they live in are healthy and contain excellent water quality.

3. Explain how this relates to the idea of an indicator species.

An indicator species signals ecosystem conditions. WSCT are an indicator species and signal that the aquatic ecosystems they inhabit are healthy.

4. What is **biodiversity**? What are **ecosystem services**?

Biodiversity is the variety of life. Ecosystem services are the benefits that humans get from healthy ecosystems such as clean air, clean water, flood protection, and reduction of drought conditions.

5. Talk to someone in your family or neighbourhood. Do they think we should care about making sure WSCT survive in Alberta? Why or why not?

Various – good opportunity to discuss.

6. If a person cares about WSCT, what can they do to help this native fish?

If they sport fish, follow the regulations. If they use off highway vehicles, keep the wheels out of the water and use designated trails. People who care can also explain to others how important this species is. Individuals can make personal decisions to use less water and waste less materials such as paper products and timber. Groups can help with habitat repair and garbage clean-up.

7. When we protect WSCT, what else are we protecting?

Our headwater aquatic ecosystems, and ultimately ourselves.

Lesson 8 – Ghost Watershed Case Study

Overview

Students will be introduced to the basic geography and human activities in the Ghost Watershed. Cumulative effects will be discussed along with critical habitat, shrinking area, and reversing trends. Actions of watershed stewardship groups will be investigated.

Objectives

Students will learn about what a watershed is, where the Ghost Watershed is, how it connects to the Bow River Basin, and how land use activities affect water quality. Students will be able to identify the general areas where pure-strain WSCT are found in the Ghost Watershed and what people are doing to protect them.

Materials and Background Information

PowerPoint slides #76-97

Student Activities – *What Do the Numbers Mean?*
Play the Part

Procedure

1. Have students follow slides #76-97, either individually or together as a class. Note: Slides #78-82 give geographic context and describe watersheds within larger basins. These can be excluded from the lesson if time is limited.
2. Spend time discussing cumulative effects and linear footprint. These ideas are important when considering land use activities that affect WSCT.
3. Discuss how watershed stewardship groups are partners in local solutions to reverse habitat loss.
4. Give students time to complete *What Do the Numbers Mean?* In this activity, students will be led through a scientific investigation using hypothetical (but plausible and realistic) data.
5. As a summary activity, students can choose one project in *Play the Part*.

Extension

- Watch the video Source Water Stories and complete the passport to learn more about locations within the Ghost Watershed.
- Who is the Ghost Watershed Alliance Society? Visit their website www.ghostwatershed.ca When were they established? Why?
- Many watershed stewardship groups were created under the Alberta Water for Life Strategy. What year was this strategy created? Is it still going? What are its 3 main goals? https://www.alberta.ca/water-for-life-strategy.aspx

WHAT DO THE NUMBERS MEAN?

In this scientific investigation, you will analyze data and communicate plausible explanations for the research question:
Why have westslope cutthroat trout populations declined over time in a certain headwater creek?

Background Procedure for Fish Population Data

Fish inventories were conducted along a creek in the Ghost Watershed in 1978, 1995, and 2012, all in early September. Scientists used electrofishing to temporarily stun and catch the fish. Fish were handled gently to determine their species, length, and age before being released. To get an estimate of fish populations for the entire stream, they sampled five 100m segments spread out along its length. Sampling was done in these same spots in each year to get quantitative data (counts and measurements). Scientists also recorded qualitative data (descriptions of conditions).

Background on Linear Footprint Data

Human created lines on the landscape such as trails and roads can be called the linear footprint. This linear footprint can be represented by a calculation called linear disturbance density. It is simply the total number of human made lines divided by the total area where these lines are found. How do we know these lengths and areas? Today, satellite imagery and computer software can be used. Before these advances in technology, maps and air photos provided information.

Sample linear disturbance density calculation:

The added lengths of all the linear features (e.g., trails, roads) is placed in the numerator and the area where all these features are found is placed in the denominator. The higher the final number, the more linear features are present. Often more linear features mean more water crossings.

$$\frac{\text{Lengths of trails \& roads}}{\text{Area}} = \frac{10\text{ km} + 26\text{ km} + 17\text{ km}}{50\text{ km}^2} = 1.06\text{ km per km}^2$$

DATA

Quantitative data:

Year	Number of westslope cutthroat trout	Number of brook trout	Total number of trout	Linear density (km of trails and roads for every km^2)	Number of estimated anglers (June to October)
1978	41	39		0.15	45
1995	12	25		0.35	90
2012	3	16		1.48	160

Qualitative data: (1995 data unavailable)

1978	2012
no barriers	no barriers
streambanks are stable with lots of overhanging riparian plants	streambanks are mostly stable but riparian plants are missing at stream crossings (trails)
deep pools	deep pools
instream cover (woody debris)	instream cover (woody debris)
small to medium, clean gravel, very little silt	small to medium gravel, noticeable silt clogging the gravel
water flow was good	water flow was moderate
cool temperature	warm temperature
very little suspended material (clear)	suspended material present (mirky)
many aquatic invertebrates	few aquatic invertebrates

UNDERSTANDING THE DATA

1. In the chart above, fill in the total number of trout. (Assume there are no other trout species present other than WSCT and brook trout)
2. Suggest one piece of qualitative data that could be measured or counted.

3. For the fish inventories, scientists kept certain things constant. List them. Why would this be important?

ANALYSIS

Report these data as two graphs. For each graph, place the year on the x-axis (horizontal) and the other data along the y-axis (vertical). Please include a title and a label for each axis.

1. **Bar Graph:** Number of westslope cutthroat and brook trout for each sample year (two bars side-by-side for each year)

2. **Scatter plot (points):** Linear disturbance density (km/km^2) for each sample year

3. What are the changes in qualitative data between 1978 and 2012?

DISCUSSION

1. Why do you think brook trout numbers are higher than westslope cutthroat numbers in 1995 and 2012? Suggest one possible reason.

2. What is happening to both trout populations over these 34 years? What is the trend?

3. How has linear density changed from 1978 to 2012? What effect does this have on the qualitative data?

4. Sport fishing has increased over time in this study. Which piece of data might this be connected to? Why?

CONCLUSION

Based on this dataset, what do you think is causing the decline in the abundance of westslope cutthroat trout in this particular headwater creek?

EXTENSION

1. In the scientific method, the results of one investigation often lead to more questions. What is one question you have about this data? How could you design data collection to answer that question?

2. In June 2013, there was a major flood in the Bow River basin. What might have been the effect of that flood on trout populations? Give specific abiotic and biotic factors that might have changed in the flood.

3. If you want to increase the populations of WSCT, what would you recommend?

WHAT DO THE NUMBERS MEAN? KEY

DATA

Quantitative data:

Year	Number of westslope cutthroat trout	Number of brook trout	Total number of trout	Linear density (km of trails and roads for every km^2)	Number of estimated anglers (June to October)
1978	41	39	80	0.15	45
1995	12	25	37	0.35	90
2012	3	16	19	1.48	160

Qualitative data: (1995 data unavailable)

1978	2012
no barriers	no barriers
streambanks are stable with lots of riparian plants (overhanging)	streambanks are mostly stable with riparian plants missing at stream crossings (trails)
deep pools	deep pools
instream cover (woody debris)	instream cover (woody debris)
small to medium, clean gravel, very little silt	small to medium gravel, noticeable silt clogging gravel
water flow was good	water flow was moderate
cool temperature	warm temperature
very little suspended material (clear)	suspended material present (mirky)
many aquatic invertebrates	few aquatic invertebrates

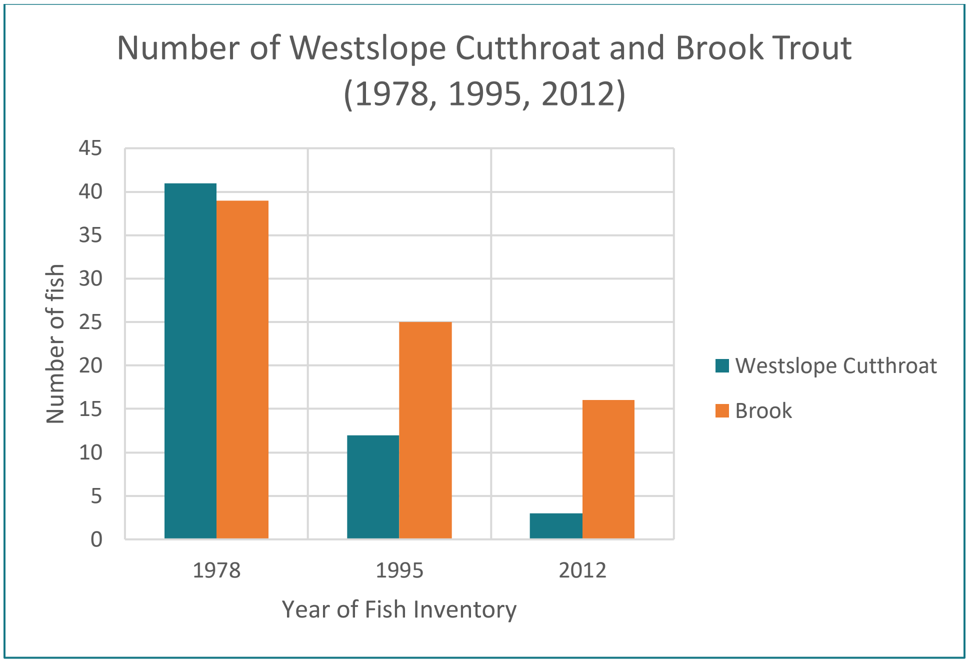
UNDERSTANDING THE DATA

1. Fill in the total number of trout (assuming no other trout species).
   1978 – 80 1994 – 37 2012 – 19
2. Suggest one piece of qualitative data that could be measured or counted. Any one item highlighted in yellow.
3. For the fish inventories, scientists kept certain things constant. List them. Why would this be important?
   1. time of year (early September)
   2. same places along stream (5 segments of 100 m each)
   3. same catching method (electrofishing)

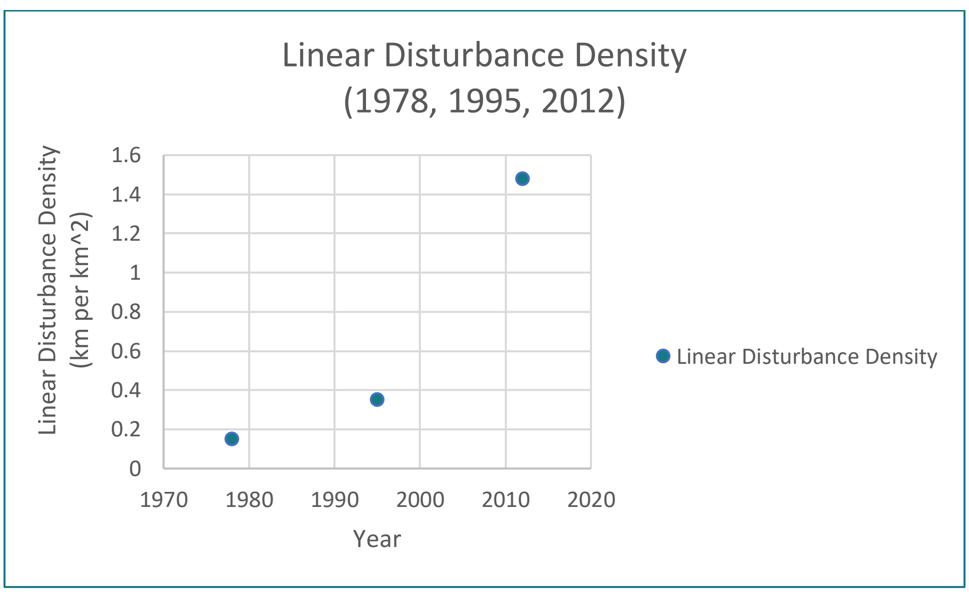
   Keeping these variables constant allows scientists to compare data over the years. It minimizes the interference of other variables when coming to conclusions.

ANALYSIS

1. **Bar Graph:** Number of westslope cutthroat and brook trout for each sample year



2. **Scatter plot (points):** Linear disturbance density (km/km^2) for each sample year.



3. What are the changes in qualitative data between 1978 and 2012? These are the changes in habitat for WSCT.
    - Streambanks and riparian vegetation are damaged at stream crossings
    - Silt is clogging the gravels
    - Water flow is not as good
    - Water temperature has increased
    - More suspended material
    - Less aquatic invertebrates

DISCUSSION

1. Why do you think brook trout numbers are higher than westslope cutthroat numbers in 1995 and 2012? Suggest one possible reason.

The brook trout are outcompeting the WSCT for food and habitat.

2. What is happening to both trout populations over these 34 years? What is the trend?

Both of these fish species are decreasing in abundance.

3. How has linear density changed from 1978 to 2012? What effect does this have on the qualitative data?

Linear density has increased from 1978 to 2012. More trails and roads have led to more stream crossings, which damage riparian plants and streambanks and contribute sediment to the water. This clogs the gravels with silt and makes the water murky or turbid.

4. Sport fishing has increased over time in this study. Which piece of data might this be connected to? Why?

More trails and roads mean more access to the creek. More access might mean more sport fishing. Also, an increase in harvest contributes to the decline in fish populations.

CONCLUSION

From this dataset, what do you think is causing the decline in the abundance of westslope cutthroat trout in this particular creek?
WSCT populations are declining because of competition from other trout (brook trout), an increase in harvesting, and an increase in human linear footprint that contributes to habitat loss.

EXTENSION

1. In the scientific method, the results of one investigation often lead to more questions. What is one question you have about this data? How could you design an investigation to answer that question?
   Answers will vary. Samples include: What was the abundance of WSCT in other creeks in the Ghost Watershed? What is happening to fish populations now?

2. In June 2013, there was a major flood in the Bow River Basin. What might have been the effects of that flood on trout populations? Give specific abiotic and biotic factors that might have changed in the flood.
   Trout populations might have declined as the flood changed the channel shapes and added silt to the gravels. In some areas, the riparian plants were washed away, leaving bare streambanks or gravel bars. Also, the abundance and distribution of aquatic invertebrates could have been affected.

3. If you want to increase the populations of WSCT, what would you recommend?
   Decrease brook trout populations by increasing catch limits in the fishing regulations. Decrease the number of water crossings by adding bridges or re-routing the trails away from the creek. Repair the damaged riparian areas by planting native vegetation.

The relationship between all of these factors is complicated. How do you think linear footprint and angling are related? Hint: more roads and trails increase access to streams

PLAY THE PART

Choose one role to play and complete the project.

GOOD NEWS STORY

You are a reporter for a local media outlet. You have decided to write an article about a recent bioengineering project completed in WSCT critical habitat. Using the “who, what, where, when, why, and how” approach, give your readers a good news story about this ecosystem repair.

STELLAR SIGNS

You work for a graphic design company that recently won a contract to make interpretive signs for off-highway vehicle bridge crossings. Illustrate a compelling sign informing people of why it’s important to drive over the bridge, not through the creek. Include a catchy message that talks about protecting WSCT habitat.

SCIENTIFIC METHOD

You are a government scientist. To answer the question: “Do improved trail networks and bridge crossings for motorized recreation help WSCT populations?”, you will design a scientific investigation including your hypothesis, materials, procedure, and data collection methods.

FISH PHOTOS

You are a photographer for a leading nature magazine. You are contributing to an article about WSCT in all their life cycle stages. Research and report on the specific techniques and equipment needed for underwater shots. If you are limited to contributing 6 photos, what would they be? Describe or draw each one.

TOURIST TAKE-AWAYS

You work for a tourist company that offers guided fishing trips. In a brochure, describe and show the beauty of the headwater ecosystems. Include what you will do as a guide to make sure sport fishing is sustainable for decades in these areas. Sell the idea of catch and release to your clients.

FANTASTIC FACILITATOR

You are a professional land-use planner. You would like to bring different groups together to talk about protecting critical habitat for WSCT. Who would you ask to come to the table? Why? Prepare a sample agenda.

GAME SHOW HOST

You have been hired to work for a popular game show. Create a Kahoot! game about WSCT **OR** create a Jeopardy style list of questions in the following categories: Biology; Threats; and Recovery; and the Ghost Watershed.

AWESOME ASSESSOR

You are a riparian health expert and have been hired by a local municipality to assess a creek with known populations of WSCT. Assume most of the shoreline is healthy, but there are a few places where human activity has damaged the plants and compacted the soil. Write your report describing the differences between healthy and unhealthy sites. Include the names of specific plant species found in Alberta riparian areas.

WATER QUALITY WONDER

You are an environmental consultant, specializing in water quality testing. You have been hired by a local forestry company to report on turbidity, pH, temperature, dissolved oxygen, phosphates and nitrates in a creek close to where they plan to harvest timber. Assume the water quality is good. Write the report and include realistic data.

GLOSSARY (alphabetical)

Abiotic factor (noun) – a non-living component of an ecosystem

Abundance (noun) – how many individuals of a species exist

Alevin (noun) – newly spawned trout containing egg yolk

Aquatic ecosystem (noun) – communities of life that exist in or on the water, either fresh or saltwater

Aquatic invertebrate (noun) – animals without backbones that live in, on, or near the water

Basin (noun) – a large river drainage that is made up of smaller watersheds

Biodiversity (noun) – variety of life

Biotic factor (noun) – a living component of an ecosystem

Common name (noun) – a name given and recognized by the general public

Confluence (noun) – where two or more flowing bodies of water join

Consumer (noun) – an organism that gets energy by eating other organisms. Primary consumers eat producers, secondary consumers eat primary consumers, and tertiary consumers eat primary and secondary consumers.

COSEWIC (acronym) - Committee on the Status of Endangered Wildlife in Canada

Critical habitat (noun) – the habitat necessary for the survival or recovery of a listed species (Section 2 of the Species at Risk Act)

Critical Habitat Order (noun) – a legal protection under SARA for areas designated as essential to the conservation of a listed species

Cumulative effects (noun) – changes in the environment that are caused by a combination of all of the past and present human actions

Decomposer (noun) – an organism that breaks down dead or decaying organisms for energy

Designated trail network – the allowable pathways for motorized recreation, set by the Government of Alberta

Dissolved oxygen (noun) – a measure of how much oxygen is dissolved in water; often measured in milligrams per litre (mg/L); high amounts of dissolved oxygen indicate good water quality

Distribution (noun) – the range of area where a species can be found

Ecosystem (noun) – a community of living organisms that interact with their environment

Ecosystem services (noun) – the benefits to humans coming from healthy ecosystems

Electrofishing (verb) – a scientific survey method that uses electricity to temporarily stun fish

Elevation (noun) – height above sea level

Erode (verb) – the process by which the surface of the earth is worn away by wind, rain, ice, and gravity

Extirpated (adjective) – locally extinct; a species no longer exists in one area

FISHES (acronym) – Fisheries Habitat Enhancement and Sustainability program; an Alberta program that focuses on fish habitat restoration

Fit (adjective) – in good health; suited for a purpose

Food web (noun) – a diagram showing energy relationships between life in an ecosystem. Arrows represent a pathway of energy transfer, all originating from the sun.

Fragment (verb) – the condition or process of breaking into smaller parts

Freshwater (noun) – water that does not contain significant amounts of salt

Fry (noun) – stage of trout life cycle after alevin stage

Genetically pure (adjective) – unique genes in a species are not altered or lost due to breeding with other species

Gradient (noun) – a measure of how steep or gentle a slope is; the degree of incline

Grazer/Scraper (noun) – an invertebrate functional feeding group defined by its behaviour of grazing or scraping algae off rocks and aquatic plants

GWAS (acronym) – Ghost Watershed Alliance Society; watershed stewardship group

Habitat (noun) – home or environment of a species

Harvest (verb) – to collect plants or animals that can be eaten or used

Headwaters (noun) – sources or beginnings of rivers

Hybridize (verb) – the process of producing fertile offspring from two different parent species resulting in young with blended traits

Incubate (verb) – keep conditions stable for development

Indicator species (noun) – a species that serves as a signal for ecosystem conditions

Intended consequence (noun) – a planned result

Invasive species (noun) – an introduced (non-native) species that causes ecological harm

Juvenile (noun) – stage of trout life cycle between newly spawned and mature adult

Linear footprint (noun) – a visible alteration of the natural environment in the form of a line. Examples include roads, trails, seismic lines, and utility corridors; each with varying width.

Morphology (noun) – the study of form

Native species (noun) – a species that originated in and adapted to a certain area

Outlet (noun) – a point where the water flows or pours out

Poach (verb) – to harvest or hunt illegally

Predator (noun) – kills and eats another organism called its prey

Producer (noun) – an organism that takes energy from the sun to make its own energy through the process of photosynthesis

Productivity (noun) – a measure of the amount of living organisms or the biomass. Highly productive ecosystems have a large quantity of biomass.

Public Land Use Zone or PLUZ (noun) - an area of public land designated by the Alberta Government to manage recreational activities. Each PLUZ has a map of designated trails and public recreation areas (PRAs) including rules for use.

Redd (noun) – spawning nest

Release mortality (noun) – when a fish is caught alive, but then dies when let go

Riparian area (noun) – the lands beside streams, rivers, lakes, and wetlands where the vegetation and soils are strongly influenced by the presence of water. These areas link water to land. They support rich biodiversity and are the most productive and valuable of all landscape types.

Saltwater (noun) - water that contains amounts of salt, such as oceans or lakes with no outlet

SARA (acronym) - Species at Risk Act; federal legislation

Scientific name (noun) – a name given based on rules of classification; includes genus and species; a formal name accepted by the scientific community

Seasonally abundant (adjective) – lots to be found at a certain time of year

Sediment (noun) – solid particles that move by the action of wind, water, ice, or gravity. Particles can be debris made of plant and animal material or rock and mineral pieces.

Silt (noun) – solid particles that are smaller than sand particles but larger than clay particles

Soil bioengineering (verb) - a technique or process to stabilize the soil and restore riparian areas by using living native plant materials such as willows and woody debris to re-establish plant communities

Spawn (verb) - produce young

Species at Risk (noun) – a naturally occurring species in danger of disappearing

Stock (verb) – artificially introducing or increasing fish populations

Temperature/elevation refugia (noun) – the theory that low temperature and high elevation habitats are a refuge for westslope cutthroat trout

Threatened (adjective) – likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction

Tributary (noun) – a stream or smaller watercourse that flows into a larger one

Unintended consequence (noun) – an unplanned result

Watershed (noun) – an area of land that drains precipitation to a common outlet

Watershed stewardship group (noun) – a community of people who take action to protect the environmental health of a watershed; usually made up largely of volunteers and partnerships working at a local level towards on-the-ground solutions

Zooplankton (noun) - microscopic animals that drift in water

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