AMPHIBIAL Pursuits

FROGWATCH TEACHERS' GUIDE TO FROGS AS INDICATORS OF ECOSYSTEM HEALTH

ENVIRONMENTAL EDU-ACTION HELPS SCIENTISTS IDENTIFY THREATS TO AMPHIBIANS

A COMMUNITY EDUCATION PROGRAM OF NATURE CANADA

FrogWatch Nature Canada Environment Canada Environnement Canada Canada

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FrogWatch

INTRODUCTION

Chapter 1

Why are frogs and toads important?

"If you wait until the frogs and toads have croaked their last to take some action, you've missed the point."

Kermit the Frog (*Frogs* by David Badger)

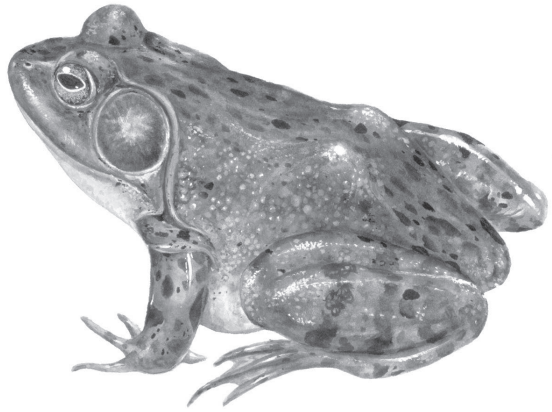
Frogs and toads—like the canaries in the coal mines of yesteryear—respond quickly to changes in their environment. This is important because we rely on the wetland ecosystems where they live for our clean water. Wetlands act as natural filters to keep Canada's water pure. Declines in frog populations may indicate ecological problems in an ecosystem that should be investigated for wider impacts on other species including humans.

Although small and often unseen, frogs are abundant and play an important role in ecosystems. Like conveyor belts, frogs—by their amphibious nature—move nutrients from water to land as part of both terrestrial and aquatic food chains. A single frog can lay thousands of eggs. If the eggs hatch, most will end up as critical prey for species of birds, mammals and reptiles. Frogs are also predators of invertebrates, including many insects considered pests by farmers and gardeners.

For thousands of years, Aboriginal people and ancient civilizations have used frog skin secretions for their medicinal properties. Modern science hopes to discover the science behind these traditional uses. Frogs are currently being researched to treat heart disease, cancer, high blood pressure, and for use as antibiotics and muscle relaxants.

Around the world, frogs are a part of folklore and mythology. In Japan, frogs are a sign of good luck. In Native American and Australian aborigine cultures the calling of frogs is a sign of coming rain.

Frogs are part of enjoying nature. The sound of frogs on warm spring nights is a sign that warm



weather is here to stay. They are the sounds of quiet summer evenings at camp or a cottage where bullfrogs call to each other in the dark.

Young people take a particular delight with frogs. Many of us can recall happy childhood days chasing frogs in muddy ditches and streams. The animals hold an innate fascination for youth. It's no surprise frogs are a large part of popular culture from Kermit the Frog, frog stickers, T-shirts, garden merchandise, jewellery, commercials, children's literature, and music.

It is this charismatic nature the *FrogWatch Teachers' Guide* hopes to build on. Almost anyone can relate to frogs. Building on this natural enthusiasm, teachers can introduce biology topics to their students in a way that is creative and fun. We hope you enjoy the guide and welcome your feedback.

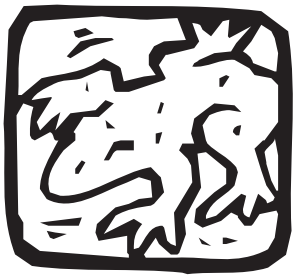
About Nature Canada

Since its founding in 1939, Nature Canada (formerly the Canadian Nature Federation) has been connecting Canadians to nature, instilling within each of us a respect for nature, an appreciation for its wonders, and a will to act in its defense.

Nature Canada's mission is to protect nature, its diversity and processes that sustain it. Our strategies are based on sound science, a passion for nature, and a belief that every Canadian should feel connected to the vast natural world that surrounds us. We are a member-supported, not-for-profit conservation organization whose network includes 40,000 supporters, nature lovers of all kinds – birders, gardeners, hikers, activists, parents, grandparents, volunteers and community groups.

PARTNERS IN EDUCATION

Nature Canada works with Environment Canada to host the NatureWatch (www.naturewatch.ca) volunteer monitoring surveys and education programs. This series of programs, which includes FrogWatch, seeks to create lifelong commitment to environmental awareness and protection among Canadians through backyard or schoolyard conservation. Through FrogWatch, people of all ages help identify ecological changes that may be affecting our environment. Volunteers in this program use scientific methods to discover how—and more importantly why—our natural environment is changing. The answers to these questions are used in recommendations to government leaders to help them create a better environment for us all.



"We do not inherit the earth from our parents—we borrow it from our children."

Native American philosophy

Note: it is not necessary to participate in FrogWatch to use this guide.

About this guide

The *FrogWatch Teachers' Guide* is written for Canadian teachers. Its purpose is:

- to fuel youth with a sense of curiosity about the natural world that could lead to lifelong environmental awareness and commitment; and
- meet teachers' needs for an engaging, curriculum-aligned program based on scientific validity, creative approaches and minimal preparation time.

The guide explores the world of frog and toad ecology, physiology and adaptation through classroom activities, visual demonstrations, critical thinking, and field trips. Designed for students in grades 7-12, background information and activities are easily adapted for all ages and settings, including visits to outdoor centres and family nature walks.

Note: Throughout this guide we sometimes only refer to frogs for convenience. In most cases, the information pertains to both frogs and toads.

The *FrogWatch Teachers' Guide* includes everything you need to teach about frog biology and their use as indicator species.

- matches to national, provincial, and territorial science curricula;
- necessary background information, simply described;
- step-by-step teacher instructions;
- masters of student worksheets for each activity;
- masters of teacher resources;
- a complete glossary of terms;
- species profiles.

The guide is composed of three lesson plan topics each culminating in at least one student activity. All topics are introduced and developed within the framework of how they affect frog populations. Activities vary and may include individual fill-in-the-blanks using worksheets and graphs, field trips, role playing or classroom debates. The topics are:

i) Natural factors: dispersal, carrying capacity, extinction
ii) Human factors: invasive species, ecosystem change, species interactions
iii) Food chains and pyramids: predator and prey, ecological niche, trophic level, biomass, taxonomy

Each topic includes introductory information and in some cases, preliminary discussion questions to generate student inquiry and teacher-guided class discussion. Where appropriate, general answers follow or are included in preliminary discussion material.

The activities can be used independently of one another and in any order. If taught as a suite, similar threads between activities allow students to build on their knowledge to deepen their understanding of amphibians and population biology.

FrogWatch is an activity-based program, which helps students practice skills of observation, identification, measurement, recording, and interpretation. The guide's activity topics and extensions develop classroom communication and teamwork.

The guide is national in scope and covers a range of Canadian anuran species. It includes detailed profiles for species from all parts of the country. Check the FrogWatch poster and FrogWatch website for species found in your province or territory.

Educational approach

The *FrogWatch Teachers' Guide* is linked to Canadian provincial and territorial science curricula. It reflects basic educational principles outlined in *Common Framework of Science Learning Outcomes: Pan-Canadian Protocol for Collaboration on School Curriculum*, specifically that:

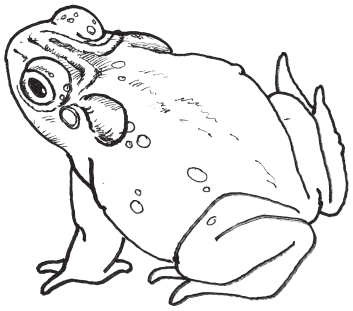
- Students learn most effectively when their study of science is rooted in concrete learning experiences, related to a particular context and applied to their world;
- Students should be engaged in active enquiry, problem solving, and decision making.

This guide has been created to place the students at the centre of the learning process and engage them in a diverse range of interesting activities, from role playing and debates to library and Internet research.

Objectives

The *FrogWatch Teachers' Guide* addresses how population biology can be used to identify threats to amphibian populations, and more generally, how amphibians can be used as indicator species to measure the health of Canadian ecosystems. This guide is interdisciplinary and covers material in Life Science, Earth and Space Science as well as Science and Society issues. The student learning outcomes below have been adapted from those identified by the organization Learning for a Sustainable Future. They outline specific objectives of the guide.

1. The nature of ecosystems; their health and interdependence within the biosphere.
2. The role of science and technology in the environment and their usefulness in measuring change.
3. Recognition of the development of human societies and land-use patterns and their impact on the natural environment.
4. Awareness of differing perspectives concerning humans and the environment, such as the relationships between ecological preservation and economic development.
5. Co-operative policy-making efforts to find solutions to common global environmental issues and to implement strategies for a more sustainable future.
6. A realistic appreciation of the urgency of the challenges facing the global community and the complexities that demand long-term planning for building a sustainable future.
7. A sense of hope and a positive personal and social perspective on the future.
8. An appreciation of the importance and worth of individual responsibility and action.



Curriculum links

Each activity is referenced to the *Common Framework of Science Learning Outcomes: Pan-Canadian Protocol for Collaboration on School Curriculum*, a document produced by the Canadian Council of Ministers of Education for use by provincial and territorial curriculum developers. We have attempted to reflect and support the Council's vision for creating scientific literacy in Canada, specifically:

"[To develop the] evolving combination of the science-related attitudes, skills, and knowledge students need to develop inquiry, problem-solving and decision-making abilities, to become lifelong learners, and to maintain a sense of wonder about the world around them."

Learning outcomes for each activity address three "foundations" described in the *Common Framework of Science Learning Outcomes: Pan-Canadian Protocol for Collaboration on School Curriculum*:

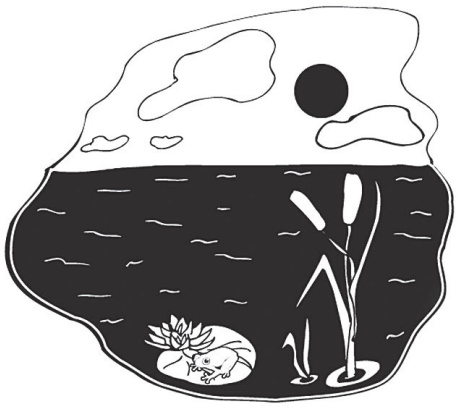
- science, technology, society and the environment (STSE)
- skills (initiating and planning, performing and recording, analyzing and interpreting, and communication and teamwork)
- knowledge (Earth and space science, and life science)

General learning outcomes for each activity appear at the beginning of each lesson plan. Specific learning outcomes are described in APPENDIX A.

How to use this guide

The guide and activities are organized to make it as easy as possible for you to use. We suggest you start by reading through the BACKGROUND information in CHAPTER 2 to become familiar with amphibian physiology and some terminology used in this guide. This information has been written with both teacher and student in mind. You may choose to photocopy this section and distribute it to your students.

When reviewing each activity, check the summary box at the beginning of the lesson plan. It contains essential information on grade levels, group size, materials and a vocabulary list. An activity overview, curriculum matches, introduction to the topic, preliminary discussion questions, teacher instructions, teacher debrief, and extension activities follow.



The STUDENT WORKSHEETS are designed to be easily photocopied for distribution. They direct students through the necessary steps to develop their problem-solving skills and apply their knowledge through various individual and team activities.

TEACHER RESOURCES are also designed so you can easily photocopy, cut out and distribute to students where required.

A GLOSSARY is provided for use by both teachers and students. You may wish to photocopy the glossary and distribute it to students.

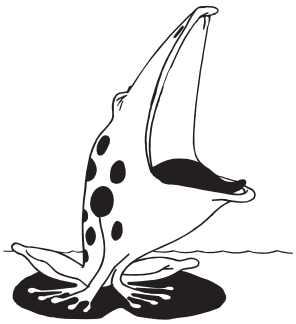
BACKGROUND

Chapter 2

Introduction to amphibians

There is an estimated 4,780 amphibian species in the world. The biodiversity of these vertebrates is phenomenal, exceeding the species richness of mammals, which is more than 4,600 species.

Despite the abundance of amphibians, even in urban areas, they may be elusive and therefore not as well known as other classes of animals. Around the world, new species of amphibians are still being discovered. In 2002, an astonishing 100 new frog species were discovered in Sri Lanka.



FROG FACT

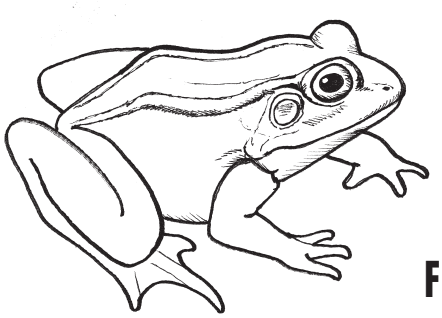
Frogs breathe with their lungs AND through their skin. This is called *COETANEOUS* respiration.

Amphibians should not be confused with reptiles. While both are cold-blooded vertebrates, swallow their food whole, and shed their skin, the similarities end there.

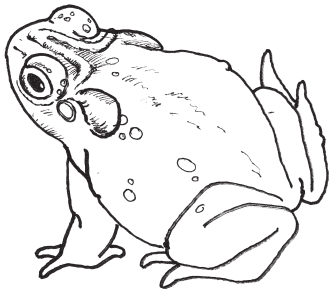
The class name, Amphibia, originating from the Greek words for "double" and "life," reflects the life cycle of most amphibians, which includes both a water and a land stage. Frogs and toads are a class of amphibians belonging to the order Anura. Toads are actually just one of the five families of frogs found in Canada. The other families include true frogs, treefrogs, tailed frogs and spadefoots.

AMPHIBIANS vs. REPTILES

	AMPHIBIANS include frogs and toads, salamanders and newts, and the worm-like caecilians, which are only found in the tropics.	**REPTILES** include lizards and snakes, alligators and crocodiles, turtles, and the lizard-like tuatara of New Zealand.
SKIN	smooth and slimy or warty; needs to stay moist for pore breathing.	completely covered in scales; impervious to water.
REPRODUCTION	some fertilize eggs externally, some internally; clusters of soft eggs are often laid in water.	all species fertilize eggs internally and either produce shelled eggs or bear live young.
LIFE-CYCLE	most have aquatic larval stage and terrestrial tailless adult stage.	no juvenile stage or metamorphosis; newly hatched young resemble small adults.
BREATHING	gills in tadpoles; some adults have simple lungs, used in conjunction with skin.	lungs; some turtle species have limited breathing through their skin; no gills at any part of their life cycle.
MOUTH	basic tongue projection for feeding; most have primitive vocal cords.	teeth used for grasping food, which is swallowed whole; limited vocalization, such as by crocodiles and alligators.
FEET	webbed feet for swimming or sucker-like toe pads for climbing.	often have clawed toes, the variety of foot shapes affects their mobility on land.



FROG



TOAD

CLASSIFICATION OF ANURANS

Kingdom: Animalia
Phylum: Chordata
Subphylum: Vertebrata
Class: Amphibia
Three orders:

Caudata, e.g. salamanders and newts;

Gymnophiona, e.g. caecilians;

Anura, e.g. frogs and toads

Anurans are ectotherms—their body temperature is dependant on the environment. Given Canada's extreme climate variations this is of special note. All amphibians in Canada exist at the northernmost limit of their species' distribution. Many herpetologists (scientists who study amphibians and reptiles) are interested in learning how these animals have adapted their physiology to survive Canada's severe winters and short summers.

Frogs and toads rely on aquatic ecosystems for breeding, hibernation and tadpole life stages. They require water for the successful development of their soft, unshelled eggs. As adults they are still dependent on moisture to "breathe" through their skin when they leave the water and head onto land to feed. This transitional lifestyle adds to their usefulness as key indicator species in determining the health of our environment.

WHAT IS AN INDICATOR SPECIES?

Species particularly sensitive to environmental change are called indicator species because any decline in their numbers "indicates" a potential concern in the local environment. Frogs and toads make exceptionally good indicator species because a variety of factors makes them more susceptible to environmental changes than many other groups of organisms. These factors include:

- **Amphibious life history** Since most frogs and toads spend part of their life in the water and part on land, changes to either habitat may affect them. In addition, their transformation from tailed, gill-breathing creatures into four-legged air breathers is a complex process. Some chemical pollutants can act as hormones, interfering with this metamorphosis and possibly causing deformities.
- **Permeable skin** Frogs and toads drink by absorbing water through their skin. This makes them prone to absorbing toxic chemicals or microorganisms through their skins as well.

- **UV sensitive** Typically, frog and toad eggs float in a jelly-like mass at or near the surface of the water. As ultraviolet levels increase around the world due to the thinning of the ozone layer, eggs are exposed to more harmful, and possibly lethal, radiation. Frog eggs can't move out of the sun or apply sunblock.
- **Climate sensitive** Many frogs and toads depend upon temporary wetlands, such as seasonal spring ponds or puddles. They must breed, the eggs must hatch and the tadpoles must grow and transform before these ponds dry up. In drought years, many populations will not breed successfully. Although amphibians are adapted to occasional dry spells, populations can be eliminated if droughts occur more frequently.

Furthermore, frogs and toads are ideal subjects for field study because males are easily identified by their springtime mating calls, and are thus easily monitored during a specific time period.

Canada's amphibians

Canada is home to 45 species of amphibians—21 salamanders and 24 anurans (frogs and toads). Seventy-five per cent of the global distribution of species of wood and mink frogs, and the aptly named Canadian toad, is in Canada.

Ten of Canada's anuran species have been designated Species at Risk by the Committee on the Status of Endangered Wildlife in Canada. Although no amphibian species are considered extinct in Canada, many scientists believe the northern cricket frog—represented in Canada by a subspecies called Blanchard's cricket frog—is endangered. The mating chorus of this tiny frog has not been heard in Canada since 1989. Although scientists and naturalists have been trying to find them in their last known habitat—Pelee Island in southwestern Ontario—not a single spring peep has since been heard.

FROGS vs. TOADS

SKIN
FROGS tend to be smooth, moist and a little slimy from mucous glands.
TOADS usually have dry skin and look warty because of glands, which often produce poison to ward off predators.

LOCOMOTION
FROGS can jump, swim and cling.
TOADS have short hind legs and are more upright, making them better at walking on all four legs.

REPRODUCTION
ALL Canadian species must lay their eggs in water.
FROGS lay eggs in clusters.

FROG FACT

Amphibian eyes come in all shapes and sizes with irises in a spectacular range of colours, including gold, silver, red, orange, yellow, and blue. Some amphibians even have square, triangular or heart-shaped pupils.

northern leopard frog

Endangered frogs in Canada include:

- northern leopard frog (Southern Mountain area of British Columbia)
- Oregon spotted frog (British Columbia)
- Rocky Mountain tailed frog (British Columbia)
- northern cricket frog (Ontario)

Great Basin spadefoot toad

Frogs listed as threatened in Canada include:

- Great Basin spadefoot toad (British Columbia)
- Fowler's toad (Ontario)

northern red-legged frog

Frogs designated a special concern in Canada include:

- coast tailed frog (British Columbia)
- northern red-legged frog (British Columbia)
- Great Plains toad (Alberta, Saskatchewan, Manitoba)
- northern leopard frog (Prairie population of the Northwest Territories, Alberta, Saskatchewan, Manitoba)

The national Species at Risk list is determined by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). They classify species according to the following risk designations:

Extinct: A species that no longer exists.
Extirpated: A species that no longer exists in the wild in Canada, but occurs elsewhere.
Endangered: A species facing imminent extirpation or extinction.
Threatened: A species that is likely to become endangered if limiting factors are not reversed.
Special concern: A species' characteristics make it particularly sensitive to human activities or natural events.
Not at risk: A species that has been evaluated and found to be not at risk.

Amphibian decline

In the 1980s, herpetologists noticed a disturbing trend: frog and toad populations were declining around the world. While scientists agree that amphibians are disappearing, they don't have enough long-term data to discover the reasons for the decline. Given the global nature of the problem, it's likely amphibians are being affected by a variety of factors, such as ultraviolet radiation, global warming and chemical pollutants.

In Canada, habitat loss and modification are likely the greatest threats to frogs. More than half of the wetlands in southern Canada have been drained, but the actual loss of breeding habitat may be even greater. Frogs often depend upon small ponds and temporary flooded meadows—the kind of sites that are filled in or drained.

Just as important are the changes that have been made to the habitat between wetlands. Many frogs migrate every spring from a wintering site to their breeding pond. If a road gets built between the two areas, an entire population can be wiped out attempting to cross it.

Another threat is introduced species. Many lakes have been stocked for sport fishing, introducing hungry predators which feed on the amphibians that already live there. Frogs also can face threats from their own kin. For example, in southern BC, where the bullfrog has been introduced, large adults will eat the juveniles of many other species of frogs.

The FrogWatch program mimics the investigative process, used by scientists, in trying to discover why amphibian numbers are decreasing. Through Nature Canada and Environment Canada, students and teachers are becoming schoolyard detectives to address this issue.

BACKGROUND RESOURCES

Frog and toad identification by Canadian region www.frogwatch.ca

Introduction to amphibians; morphology and reproduction; ecology and evolution; amphibian families.
www.aquatic.uoguelph.ca/amphibians
(CyberNatural Software Group, University of Guelph)

Guide for identifying amphibians based on distinguishing characteristics
http://www.carcnet.ca/english/amphibians/key/AmphKey.html
(Canadian Amphibian and Reptile Conservation Network)

Profiles of Canadian freshwater amphibians by common name or species name
www.aquatic.uoguelph.ca/amphibians/amphib/amphib_frame.htm
(CyberNatural Software Group, University of Guelph)
http://www.carcnet.ca/english/amphibians/tour/amphCanada.html
(Canadian Amphibian and Reptile Conservation Network)

Aquatic habitats
www.aquatic.uoguelph.ca/habitat.htm
(CyberNatural Software Group, University of Guelph)

Status of Endangered Wildlife in Canada (COSEWIC)
www.cosewic.gc.ca

Amphibian decline
http://www.carcnet.ca/english/amphibians/amphIssues.html
(Canadian Amphibian and Reptile Conservation Network)
www.frogweb.gov (Center for Biological Informatics, US Geological Survey)
www.open.ac.uk/daptf (Declining Amphibian Populations Task Force)

Status of Amphibian and Reptile Populations in Canada
http://www.eman-rese.ca/eman/reports/publications/2004/amph_rept_status/

Global Amphibian Assessment
http://www.globalamphibians.org/

NATURAL FACTORS

Chapter 3

ACTIVITY 1A: SCIENTIST FOR A SEASON

Overview

Students are introduced to a graphing tool used by scientists to detect events that impact frog and toad numbers in their natural habitat. Students, divided into small groups, graph population data and extrapolate the population trend. A representative from each group presents the group's findings to the class.

At the end of the activity, you reveal that each group had a subset of data from the same long-term population study. This demonstrates:

1) the use of short-term observations to determine the general health of a population can be misleading; and

2) long-term monitoring studies are essential for accurate measurement of influences—both natural and man made—on amphibian populations.

Target audience:
GRADES 7-12; small group graphing and extrapolation activity with brief class presentation

Materials list: data sets from TEACHER RESOURCE FOR ACTIVITY 1A; display blackboard or bulletin board and tape or tacks. Each group requires one copy of STUDENT WORKSHEET FOR ACTIVITY 1A, one ruler, one posterboard-sized paper and a marker.

Vocabulary: amphibian; anuran; biodiversity; chorusing or calling behaviour; extrapolate; habitat; herpetologist; indicator species; population; wetland

CURRICULUM MATCHES FOR ACTIVITY 1A

Below are general learning outcomes selected from the *Common Framework of Science Learning Outcomes: Pan-Canadian Protocol for Collaboration on School Curriculum.* For more information on specific learning outcomes, see APPENDIX A.

Grades 7-9

Science, technology, society and the environment (STSE)

109 Describe various processes used in science and technology that enable us to understand natural phenomena and develop technological solutions.

Skills

208 Ask questions about relationships between and among observable variables and plan investigations to address those questions; 208-5.

209 Conduct investigations into relationships between and among observations, and gather and record qualitative and quantitative data; 209-4, 5.

210 Analyze qualitative and quantitative data and develop and assess possible explanations; 210-2-6.

211 Work collaboratively on problems and use appropriate language and formats to communicate ideas, procedures and results; 211-2.

Knowledge: Earth and space science

311 Explain patterns of change and their effects on Earth; 311-8.

Grades 10-12

Skills

212 Ask questions about observed relationships and plan investigations of questions, ideas, problems and issues; 212-4, 8, 9.

213 Conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information; 213-1, 5-7.

214 Analyze data and apply mathematical and conceptual models to develop and assess possible explanations; 214-3-5, 10, 11, 18.

215 Work as a member of a team in addressing problems, and apply the skills and conventions of science in communicating information and ideas and in assessing results; 215-2, 3, 5.

Knowledge: Life science

316 Analyze the patterns and products of evolution; 316-3, 4.

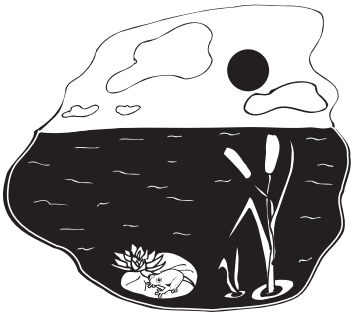
318 Evaluate relationships that affect the biodiversity and sustainability of life within the biosphere; 318-4, 5, 8-10.

Knowledge: Earth and space science

331 Describe and predict the nature and effects of changes to terrestrial systems; 331-6.

Introduction

Scientists can determine the health of an ecosystem, such as a local wetland, by studying its biodiversity. They may measure the number of species occurring there or look at the abundance of one or more indicator species found within it.



In population biology, the field of ecological research that studies populations, scientists often find that wild animals do not have a constant population size. Changes in population can be caused by natural factors or by human activity, such as the introduction of contaminants or non-native species (see page XX). Consequently, in field studies with amphibians, natural variation in population size, which can be caused by food shortage and predation for example, must be considered to determine if fluctuations are natural or evidence of an ecological problem resulting from human activity.

In ACTIVITIES 1A AND 1B, students will use graphs to discover natural variations in the abundance of a given frog or toad species.

Preliminary discussion

As a group brainstorm a list of examples to answer the following questions.

Discussion Q.1.
How can natural environmental factors increase or decrease anuran populations?
Students should consider this question from a seasonal perspective. Also remind them of an organism's basic needs for survival—food, water, shelter, and space. Make note of any examples that aren't "natural" factors, as these form the basis of Discussion Q.2.

Discussion Q.2.
What human factors impact frog and toad populations in the wild?
Frog and toad species are particularly sensitive to environmental stressors such as pollution, and are therefore, often considered an indicator species (see pg 56). Indicator species are generally chosen for study because they are abundant and easily detected. This allows scientists to establish a population baseline in a healthy environment. Any decrease in population can be an early warning of ecological change and may suggest ecosystem degradation.

Teacher instructions

i) Introduce students to the topic of "natural factors" using the INTRODUCTION and PRELIMINARY DISCUSSION above.

ii) Break the class into five groups and assign each group one of the DATA SETS from the table in TEACHER RESOURCE FOR ACTIVITY 1A. (Note: older grades can complete this activity individually.)

iii) Instruct each group to plot their data on the blank graph on STUDENT WORKSHEET FOR ACTIVITY 1A. After students have viewed the data and discussed it as a group, you may suggest they use bar graphs with the population size on the vertical Y axis, and month, which can be clustered by year, on the X axis. After receiving your approval, each group transfers their completed graph to the posterboard-sized paper for presentation to the class.

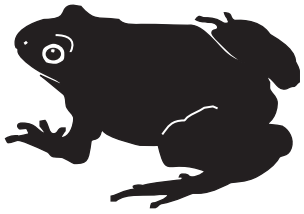
iv) Take up the answers to Q.1-3 as a class (see TEACHER DEBRIEF).

v) Instruct each group to share their answer to Q.4 in order from A to E. Ask each group to display their graph to the class, demonstrate the population trend, and predict what this means for the future of the population. Students can use a ruler and rotate it across the graph to simulate the line of best fit and extrapolate from the data. After each group completes their presentation, leave their graph posted at the front of the room. (Note: be sure to post all graphs in order, according to the year in which the data was collected.)

vi) Discuss the variety of student predictions for Q.4 (see TEACHER DEBRIEF). Now reveal that each data set was from the same population of anurans in the same area over several field seasons.

Teacher debrief

When responding to Q.1-3, students may identify a variety of problems with observing wild animals, including the inability to locate hidden animals and the misidentification of species. Other problems in population sampling data are spatial and seasonal bias.



Spatial bias can occur if some species spend little time on the shoreline where the herpetologist may have made most observations.

Seasonal bias may occur when using calls or chorusing to estimate population since major choruses occur during spring. It is problematic if the population is surveyed past this peak breeding season because not as many frogs are calling. Furthermore, in general, only the males are vocalizing. If scientists know the typical sex-ratio for that species, however, total population size can be calculated.

Since it's not possible to visually observe every individual in the field, seasonal bias can also occur because population surveys are nearly always an estimate of real population size, which varies depending on the season. For example, later summer surveys yield larger numbers compared to tallies of overwinter adults. Late summer numbers tend to be higher, reflecting tadpole transformation into froglets, however, after this initial population bloom, natural factors, such as predation, and human factors, such as road kill, reduce the population to a more typical size. Estimates from visual observations of population surveys can accurately indicate changes in population levels over time only if data is collected at the same time of year and in the same manner each time.

After discussing predictions for Q.4 you reveal that each data set was from the same population of anurans in the same area over several field seasons. Inaccurate predictions by students about the future of that species or population result because each group's data set represented only a short viewing period of the population. This demonstrates the importance of the "big picture" when determining the long-term stability of a population because of yearly fluctuations. Time permitting, lead the students through a follow-up class discussion based on the following prompt.

Discussion Q.3
To get a more accurate picture of changes in population size, which is better, long-term or short-term population data? Why?

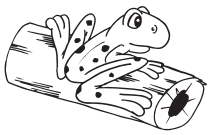
ACTIVITY 1A RESOURCES

Biodiversity
http://www.ec.gc.ca/default.asp?lang=En&n=CBCF3AB8-1 (Environment Canada)

Wetlands
http://www.hww.ca/hww2.asp?id=233 (Hinterlands Who's Who)
http://www.aquatic.uoguelph.ca (CyberNatural Software Group, University of Guelph)

Extension activity

Conduct a field trip to a local wetland or any natural area with a stable amphibian population. Show students how to use calling survey methodology, as described on the FrogWatch poster (available by making a request to info@naturecanada.ca) and ask them to estimate the population size of one or two species they detect. Encourage students to follow up and record this data on a weekly basis for the duration of the spring breeding season. As a class project, they can represent this in a graph or they can submit data to help scientists gather long-term population information. See the FrogWatch Web site or poster for details and tips on submitting observations.



EXTENSION ACTIVITY RESOURCES

FrogWatch Web site www.frogwatch.ca

Frog identification and vocalizations www.frogwatch.ca
(Click on your region of the map for a listing of frogs in your area.)

FrogWatching tips www.frogwatch.ca
(Includes best weather conditions for observing, and guidelines for not handling the animals.)

Distribute one data set per group of students.

GROUP A

DATE		POPULATION SIZE
JUNE	1992	32
AUGUST	1992	71
JUNE	1993	60
AUGUST	1993	28

GROUP B

DATE		POPULATION SIZE
JUNE	1994	11
AUGUST	1994	16
JUNE	1995	20
AUGUST	1995	49

GROUP C

DATE		POPULATION SIZE
JUNE	1996	88
AUGUST	1996	95
JUNE	1997	97
AUGUST	1997	109

GROUP D

DATE		POPULATION SIZE
JUNE	1998	92
AUGUST	1998	81
JUNE	1999	74
AUGUST	1999	69

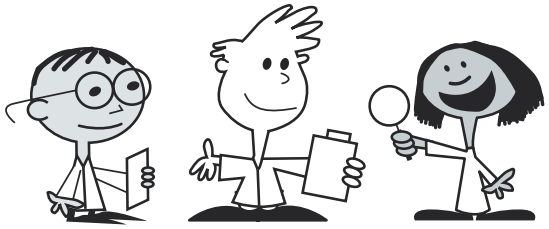
GROUP E

DATE		POPULATION SIZE
JUNE	2000	42
AUGUST	2000	33
JUNE	2001	25
AUGUST	2001	51

SCIENTIST FOR A SEASON

Background information

You are a scientist and have discovered a new population of anuran in a wetland near your school. Herpetologists are conducting research in the area and a wildlife technician has completed a visual survey of animals along the shoreline. As a scientist, you want to determine the long-term stability of this newly discovered population.



As a group, plot a graph from your assigned data set onto the blank graph below. After the teacher approves it, transfer the graph to the posterboard-sized paper.

POPULATION SIZE

DATE

Did you know?

Frogs are everywhere! They are found on every continent in the world except Antarctica.

SCIENTIST FOR A SEASON

Answer the questions below. Select a group spokesperson to present your group's findings to the class.

Q.1. You and your fellow scientists collected data using visual surveys of the animals. Will this tally accurately represent all individuals that exist in a wild population? Why or why not?

Q.2. How might this data be used as an estimate of actual population size? Compared to a visual survey, why is male chorusing or calling behaviour not an effective way to collect this annual set of data?

Q.3. Late summer populations of frogs and toads tend to be larger than spring populations. Hypothesize why.

Q.4. Overlay a line of best fit and have the line extend beyond the graph to extrapolate or predict the population trend that you observe from your data. Hypothesize about what might happen to this population in the next year. Will it increase, decrease or stay the same?

FROG FACT

Some frogs survive conditions well below freezing.

The wood frog makes its own antifreeze to stop its body from freezing completely. This allows it to survive even though its heart stops.

ACTIVITY 1B: POPULATION PARADE

Overview

Students use three frog and toad species profiles to answer questions, which can also be used to promote class discussion. Synthesis of the information enables students to relate the species studied to line graphs that depict three different cases of population change. In the process, students become familiar with population demographics and amphibian sensitivity to environmental factors.

Target audience:
GRADES 10-12; individual activity with graphed data, case studies, and question sheets.

Materials list: Each student will require one ruler and the four STUDENT WORKSHEETS FOR ACTIVITY 1B including species profiles for the spring peeper, northern cricket frog and Fowler's toad.

Vocabulary: carrying capacity; endangered; extinct; extirpated; threatened.

CURRICULUM MATCHES FOR ACTIVITY 1B

For general learning outcomes selected from the *Common Framework of Science Learning Outcomes: Pan-Canadian Protocol for Collaboration on School Curriculum*, see CURRICULUM MATCHES FOR ACTIVITY 1A on page XX. For more information on "specific" learning outcomes, see APPENDIX A.

Grades 7-9

Science, technology, society and the environment (STSE)

109 Describe various processes used in science and technology that enable us to understand natural phenomena and develop technological solutions.

Skills

208 Ask questions about relationships between and among observable variables and plan investigations to address those questions; 208-5.

209 Conduct investigations into relationships between and among observations, and gather and record qualitative and quantitative data; 209-4, 5.

210 Analyze qualitative and quantitative data and develop and assess possible explanations; 210-2-6.

211 Work collaboratively on problems and use appropriate language and formats to communicate ideas, procedures and results; 211-2.

Knowledge: Earth and space science

311 Explain patterns of change and their effects on Earth; 311-8.

Grades 10-12

Skills

212 Ask questions about observed relationships and plan investigations of questions, ideas, problems and issues; 212-4, 8, 9.

213 Conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information; 213-1, 5-7.

214 Analyze data and apply mathematical and conceptual models to develop and assess possible explanations; 214-3-5, 10, 11, 18.

215 Work as a member of a team in addressing problems, and apply the skills and conventions of science in communicating information and ideas and in assessing results; 215-2, 3, 5.

Knowledge: Life science

316 Analyze the patterns and products of evolution; 316-3, 4.

318 Evaluate relationships that affect the biodiversity and sustainability of life within the biosphere; 318-4, 5, 8-10.

Knowledge: Earth and space science

331 Describe and predict the nature and effects of changes to terrestrial systems; 331-6.

Introduction

Each frog and toad species has different life history traits, such as when and how often they breed, and maturation, survival and mortality rates. These traits determine each species' tolerance for various disturbances in their environment, whether caused by natural or human factors. This is turn affects population size.

Changes in population size can be visually represented as a species-specific line graph over time (see TEACHER RESOURCES FOR ACTIVITY 1B). Population biologists use this tool to identify the environmental event that may be causing the change in a species' abundance in a particular habitat.

Teacher instructions

i) Distribute copies of the four STUDENT WORKSHEETS FOR ACTIVITY 1B, including species profiles for the spring peeper, northern cricket frog and Fowler's toad, to each student. Once students have read the profiles, ask them to answer Q.1-5 on STUDENT WORKSHEET 1 FOR ACTIVITY 1B.

ii) If students previously completed ACTIVITY 1A, ask them to identify which of the three graphs on STUDENT WORKSHEET 1 FOR ACTIVITY 1B depicts the class data set used in ACTIVITY 1A, which shows severe, long-term population fluctuations.

iii) When students complete the worksheet, take it up as a class discussion (see TEACHER DEBRIEF).

Teacher debrief

It's important for students to recognize the value of long-term data collection because populations fluctuate annually. The natural variation in population size must be isolated from fluctuations due to human activities, which may be evidence of an ecological problem in the area.

These activities demonstrate how easily students can help scientists with this type of field research. (See EXTENSION ACTIVITY 2.)

ANSWERS TO THE STUDENT WORKSHEET:

Q1. The species' status and clues found in the profiles indicate the identity of each species. See graphs in TEACHER RESOURCES FOR ACTIVITY 1B.

Q2. Spring peeper—secure status. Northern cricket frog—at risk, endangered. Fowler's toad—at risk, threatened.

Q3. See graphs in TEACHER RESOURCES FOR ACTIVITY 1B.

Q4. Limited food, space and competition for mates are examples of factors that can limit population growth at carrying capacity.

Q5. Positive impact. The canal created new habitat for the frogs and allowed the population to grow and spread.

Indirect. The event altered frog habitat, not the frogs themselves. An example of a direct impact could be a harvest of frogs for bait or classroom dissection. This activity should demonstrate to students that even indirect human activities can impact frogs.

Extension activity

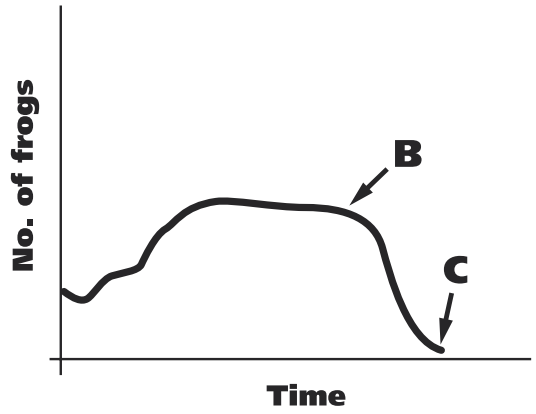
Ask students to research frogs and toads and learn how to identify the differences between the two. Students can present their findings in a list or use sketches. The FrogWatch poster can be used for assistance as well as the FrogWatch Web site. Use vocalizations, also available on the Web site, as an auditory quiz to help students learn different frog and toad calls.

EXTENSION ACTIVITY RESOURCES

FrogWatch Web site www.frogwatch.ca

Frog vocalizations www.frogwatch.ca

(Click on your region of the map for a listing of frogs in your area.)

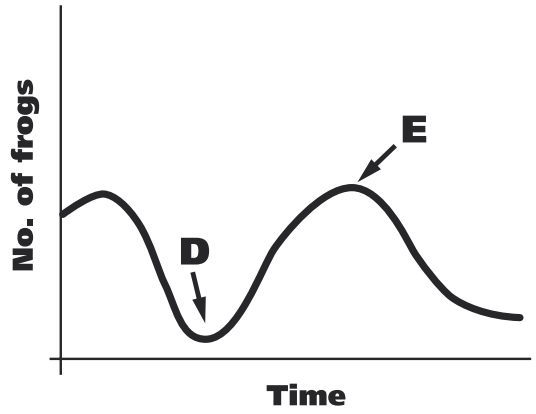


GRAPH A

CRICKET FROG (local extinction/extirpation)

B fluctuating water levels in the adjacent area greatly reduce habitat suitability

C population believed to be extinct in that area

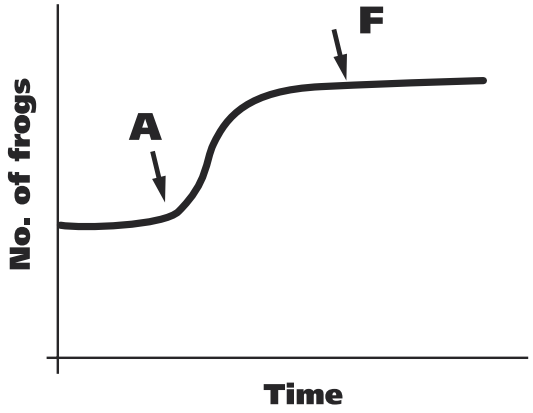


GRAPH B

FOWLER'S TOAD (fluctuating)

D new open water habitat provides ideal habitat for breeding in spring

E severe winter storm kills hibernating individuals



GRAPH C

SPRING PEEPER
(population growth and level at carrying capacity)

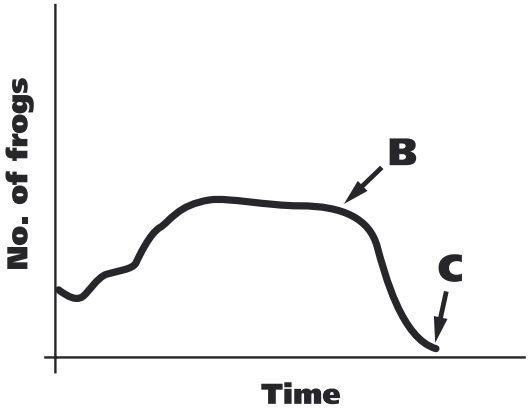
A new canal system changes population dispersal into a new habitat

F population at carrying capacity

POPULATION PARADE

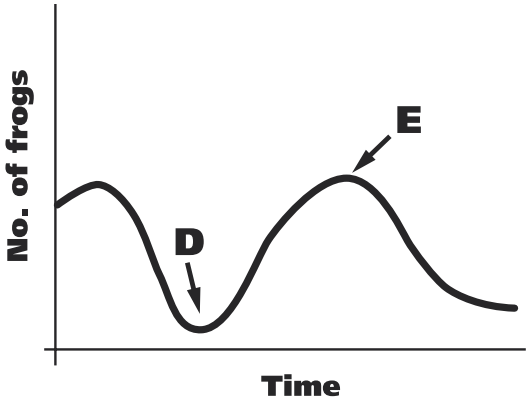
1. Read the species profiles for the spring peeper, northern cricket frog and Fowler's toad.

2. Match the species to the graphs using clues provided in the profiles.



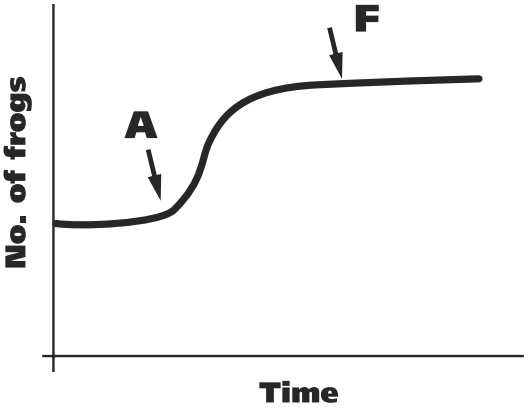
GRAPH A

SPECIES: _____



GRAPH B

SPECIES: _____



GRAPH C

SPECIES: _____

POPULATION PARADE

Q.1. Which species is being depicted by each graph? What clues did you use to determine this? Using a ruler, overlay a line of best fit and extend the line beyond the graph to extrapolate from the data. Predict what will happen to the population in the future.

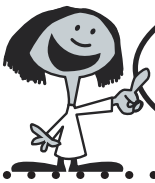
Q.2. Which graph depicts the most stable population? What is the current status of that species? What is the status of the other two species?

Q.3. Consider how the events listed below will impact a population (for example, will it cause a population increase or decrease?) then match the events with the arrows marked A to G on the three graphs. The first one has been completed as an example.

A new canal system allows population dispersal into a new habitat
____ severe winter storm kills hibernating individuals
____ population at carrying capacity
____ population believed to be extinct in that area
____ new open-water habitat provides ideal habitat for breeding in spring
____ fluctuating water levels in the adjacent lake greatly reduced habitat suitability

Q.4. What factors limit population growth at carrying capacity?

Q.5. The event indicated by arrow A coincides with a canal being built to connect waterways for shipping and crop irrigation. Some frog species can easily move into new environments as part of their early spring dispersal. Does the completion of the canal have a positive or negative consequence for the population depicted in this graph? Would this human activity be considered a direct or indirect factor causing population change?



Did you know?

A group of frogs is called an "army" and a group of toads is called a "knot."

NORTHERN CRICKET FROG

(Acris crepitans)
The subspecies found in Canada is Blanchard's cricket frog, *Acris crepitans blanchardi*

Approximately actual size

Appearance: A small frog with greenish-brown or reddish-brown warty skin, with brown or black blotches. The northern cricket frog has a dark triangular mark between its eyes and a pointed snout. It has a broad dark stripe on its long back legs and its back feet have webbed toes. This species is classified as a treefrog, however, its toe pads are small and it does not climb.

Body size: 1.6-3.8cm

Range/distribution: One of Canada's rarest frogs, this species is only found on Pelee Island, ON, where populations have been declining.

Call: Like the steady clicking of pebbles. Calling begins in early spring.

Status as per the Species at Risk Act: Endangered.

Biology: Northern cricket frogs breed in June and July. Females lay clusters of up to 400 eggs, which hatch in three to four days. Tadpoles metamorphose in five to 10 weeks.

Habitat: Cricket frogs are members of the treefrog family, but are mainly aquatic as adults. Northern cricket frogs live along the edges of lakes, ponds, rivers, streams, and sometimes, temporary ponds and rain pools. They are usually found on muddy shores or in aquatic vegetation in shallow waters.

Northern cricket frogs hibernate in leaf litter, under rocks or logs, or in holes and cracks in the shoreline. They are found only in Canada's most southern region because unlike other Canadian frogs they're not as tolerant of low temperatures.

Threats: Their island habitat is next to commercial vineyards. Loss of wetland habitat to development and habitat degradation due to runoff of pesticides and fertilizers are believed to be major causes of their decline and disappearance. Dykes from agricultural development have altered water levels in marsh habitat. Fluctuating water levels in Lake Erie may have flooded the shoreline wetlands where the frogs live and exposed them to predatory fish, reducing the population below an optimal size for survival.

Protection: The Northern Cricket Frog is protected under the federal Species at Risk Act (SARA). The Northern Cricket Frog is also protected by the *Ontario Endangered Species Act* and the *Fish and Wildlife Conservation Act.*

Information for this profile compiled from: Canadian Amphibian and Reptile Conservation Network Web site; Canadian Wildlife Service, Environment Canada Web site; Frogs *by David Badger;* The ROM Field Guide to Amphibians and Reptiles of Ontario *by Ross D. MacCulloch.*
Range map courtesy of the Canadian Wildlife Service, Environment Canada. Reproduced with permission of the Minister of Public Works and Government Services Canada, 2001. Illustration courtesy of the Toronto Zoo.

FROG FACT

Cricket frogs are known for their unique style of movement. They "skitter" across water, skipping or bouncing across the surface in quick jumps.

FOWLER'S TOAD

(*Bufo fowleri*)

Approximately 50% actual size

Appearance: Fowler's toads have grey- or brown-coloured skin with three or more "warts" on each of its numerous dark brown spots. It is slight and agile with a short, blunt snout. Males have a dark throat while the throat on females is white. Females are usually larger than males.

Body Size: 5.1-7.5cm

Range/distribution: Only found on the north shore of Lake Erie in Ontario at Rondeau, Long Point, and Point Abino. Historically, the toads were also found along western Lake Erie. Fowler's toads are very common in the eastern United States.

Call: A nasal "Waaah," like a baby crying. Calling begins in mid-spring.

Status as per the Species at Risk Act: Threatened

Biology: Fowler's toads are most active during the evening. They congregate in shallow areas of permanent water bodies to breed during May and June. Up to 8 000 eggs are laid in long strands. This species reaches sexual maturity in the second year, and lives for three to five years. Mortality is very high for tadpoles and young toads.

Fowler's toads rely on sand dune and lake shore habitats, which are continually created and destroyed by fluctuating lake levels and unpredictable floods and storms. As a result their populations vary substantially. Fowler's toads can rapidly re-populate a habitat because they are reproductively mature at an early age and produce large numbers of eggs.

Habitat: Breeds in open ponds along sandy shorelines. Outside the breeding season they are found in terrestrial areas such as meadows and woodlands and in sand dune and lakeshore habitats. Fowler's toads hibernate below the frost line in the sand, under debris and leaf litter. They are sometimes found hibernating in groups.

Threats: Populations of Fowler's toad are limited by natural environmental factors, such as floods, storms and the availability of habitat, as well as by the toad's natural population fluctuations. The toads are also sensitive to pesticides. Severe winter storms cause mortality among hibernating adults, but the storms also create ideal breeding sites.

At the western point of Long Point, the number of Fowler's toads has gone from dozens to hundreds of individuals and back between 1988 and 1997. A population viability analysis was carried out for the Fowler's toad using 13 years of data collected at Long Point. This type of analysis is typically done to estimate how viable a species is, or in other words, how likely it is to survive in a given area. Results indicate the species has approximately a 20 per cent chance of becoming extirpated (disappearing) from Canada in the next 100 years.

Protection: The Fowler's Toad is protected under the federal Species at Risk Act (SARA). The Fowler's Toad is protected by the *Ontario Fish and Wildlife Conservation Act.* Under this Act, it is prohibited to kill, harass, or capture this species.

Information for this profile compiled from: Canadian Amphibian and Reptile Conservation Network Web site; Canadian Wildlife Service, Environment Canada Web site. Range map courtesy of the Canadian Wildlife Service, Environment Canada. Reproduced with permission of the Minister of Public Works and Government Services Canada, 2001. Illustration courtesy of the Toronto Zoo.

FROG FACT

When this toad is handled it may roll over and play dead. It may even stop its breathing movements until the threat has passed.

SPRING PEEPER

(*Pseudacris crucifer)*

Approximately actual size

Appearance: A small, light brown or tan treefrog with enlarged toe pads. The spring peeper can be identified by the dark "X" on its back.

Size: 1.9-3.5cm

Range/distribution: Found in Canada from Manitoba eastward.

Call: A series of loud, sharp, high pitched "peeps," sometimes forming trills. The chorus of spring peepers resembles the jingle of sleigh bells when heard from a distance. The calls may be deafening up close and may be heard half a kilometre away. Calling begins very early in spring.

Status as per the Species at Risk Act: not at risk

Biology: This is one of the first frog species to chorus in the spring. Males may also call in the fall on rainy nights.

Females are larger than males and can lay up to a thousand eggs. Tadpoles hatch in one to three weeks and complete metamorphosis after two to three months. After the froglets hatch they may group together in search of new habitat and food.

Spring peepers are secretive. Many people hear the small frogs calling but few actually see them. They are well camouflaged and will stop calling when approached.

Peepers can jump remarkable lengths, reportedly seventeen times their own body length—the equivalent of a human jumping more than 30 metres!

Habitat: Spring peepers often breed in temporary woodland pools formed by rain and melting snow. This allows them to start breeding before the ice completely thaws on their breeding pond.

They hibernate under the soil or beneath logs, leaves, and bark, and move to woodland breeding ponds early in the spring. These frogs make glucose as natural antifreeze so their bodies can withstand temperatures below freezing.

Outside the breeding season, they forage in woodlands and in marshy areas bordering woodlands.

Threats: Development has reduced the range of this species. The spring peeper may still thrive where some urban development has taken place, as long as water tables are not lowered and woodland habitat with marshy borders is not disturbed.

Protection: No protection is necessary because this species is not designated at risk.

Information for this profile compiled from: Canadian Amphibian and Reptile Conservation Network Web site; Canadian Wildlife Service, Environment Canada Web site; Frogs *by David Badger; Guinness World Records Web site;* New Animal Discoveries *by Ronald Orenstein;* The ROM Field Guide to Amphibians and Reptiles of Ontario *by Ross D. MacCulloch. Range map courtesy of the Canadian Amphibian and Reptile Conservation Network. Illustration courtesy of the Toronto Zoo.*

FROG FACT

Canada's smallest frog is the spring peeper, but it's still much larger than the smallest frog in the world. The world's smallest frog, *Eleutherodactylus limbatus*, is found in Cuba. At only 8.4-12mm long when fully grown, it sits comfortably on a dime!

The smallest frog in North America is almost as small. The greenhouse frog, found in Florida, is 17-31mm in length. The baby froglets are so small they resemble tiny fleas!

HUMAN FACTORS

Chapter 4

ACTIVITY 2: BULLY FOR BULLFROGS

Overview

Students are assigned roles representing key players in the real-life issue of introduced bullfrogs in BC, which are disrupting native frog populations. Role-playing students present arguments and convey information to classmates in a classroom debate.

Their challenge is to deal with the invading species in a manner that best preserves native frog populations.

Target audience:
GRADES 7-12; class debate and role playing.

Materials list: role cards from TEACHER RESOURCES FOR ACTIVITY 2.
Each student will require the three STUDENT WORKSHEETS FOR ACTIVITY 2 including species profiles for the Oregon spotted frog and bullfrog.

Vocabulary: introduced species; invasive species; native species.

CURRICULUM MATCHES FOR ACTIVITY 2

Below are general learning outcomes selected from the *Common Framework of Science Learning Outcomes: Pan-Canadian Protocol for Collaboration on School Curriculum.* For more information on "specific" learning outcomes, see APPENDIX A.

Grades 7-9

Science, technology, society and the environment (STSE)

113 Analyze social issues related to the applications and limitations of science and technology, and explain decisions in terms of advantages and disadvantages for sustainability, considering a few perspectives.

Skills

208 Ask questions about relationships between and among observable variables and plan investigations to address those questions; 208-4.

209 Conduct investigations into relationships between and among observations, and gather and record qualitative and quantitative data; 209-5.

210 Analyze qualitative and quantitative data and develop and assess possible explanations; 210-8, 16.

211 Work collaboratively on problems and use appropriate language and formats to communicate ideas, procedures and results; 211-1-3, 5.

Grades 10-12

Skills

212 Ask questions about observed relationships and plan investigations of questions, ideas, problems and issues; 212-1.

213 Conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information; 213-6, 7.

214 Analyze data and apply mathematical and conceptual models to develop and assess possible explanations; 214-15.

215 Work as a member of a team in addressing problems, and apply the skills and conventions of science in communicating information and ideas and in assessing results; 215-1-6.

Knowledge: Life science

316 Analyze the patterns and products of evolution; 316-3.

318 Evaluate relationships that affect the biodiversity and sustainability of life within the biosphere; 318-8, 9.

Knowledge: Earth and space science

331 Describe and predict the nature and effects of changes to terrestrial systems; 331-6.

ACTIVITY 2: BULLY FOR BULLFROGS

Introduction

Humans can impact or threaten amphibians by introducing non-native species into their habitat. Plants and animals have historically been introduced or moved to new habitats with increased movement of people and freight between continents. This is sometimes deliberate and often by accident, such as European weedy plants brought in ships' ballast through the canal system into the Great Lakes. In most cases, these introduced species thrive in the new ecosystem because of the absence of predators, competition and other factors that would have evolved as natural factors controlling their population size in their homeland. These introduced species often become invasive species, which are a wildlife management problem because of the negative impact they have on native species.

Dealing with introduced species is somewhat controversial because of the difficulties with ecosystem-wide management strategies and the philosophical question of prioritizing the life of some organisms over others. Do we destroy a species because of its negative impact? As discussions around higher life forms continue, this is an increasingly difficult debate.

Teacher instructions

i) As a class, brainstorm the answers to Q.1-4 on STUDENT WORKSHEET 1 FOR ACTIVITY 2. Depending on your class' background, this could also be done as a small group activity. To answer Q.1, students can also discuss whether the species examples were introduced deliberately or by accident and they can identify how t he species were introduced into the new environment. Students may list global examples, such as toads in Australia. The second part of Q.1 attempts to generate discussion around Canadian examples.

ii) To prepare for the role-playing activity, ask students to read the BACKGROUND INFORMATION and the species profiles for the bullfrog and the Oregon spotted frog included with STUDENT WORKSHEETS FOR ACTIVITY 2.

ROLE-PLAYING ACTIVITY:

iii) Divide students into groups of three and assign each group one role card from TEACHER RESOURCES FOR ACTIVITY 2. Each group should discuss the role they have been given and consider the point of view of that role. Some roles will want to keep the bullfrogs in BC wetlands while others will want to remove them completely. See TEACHER DEBRIEF for examples.

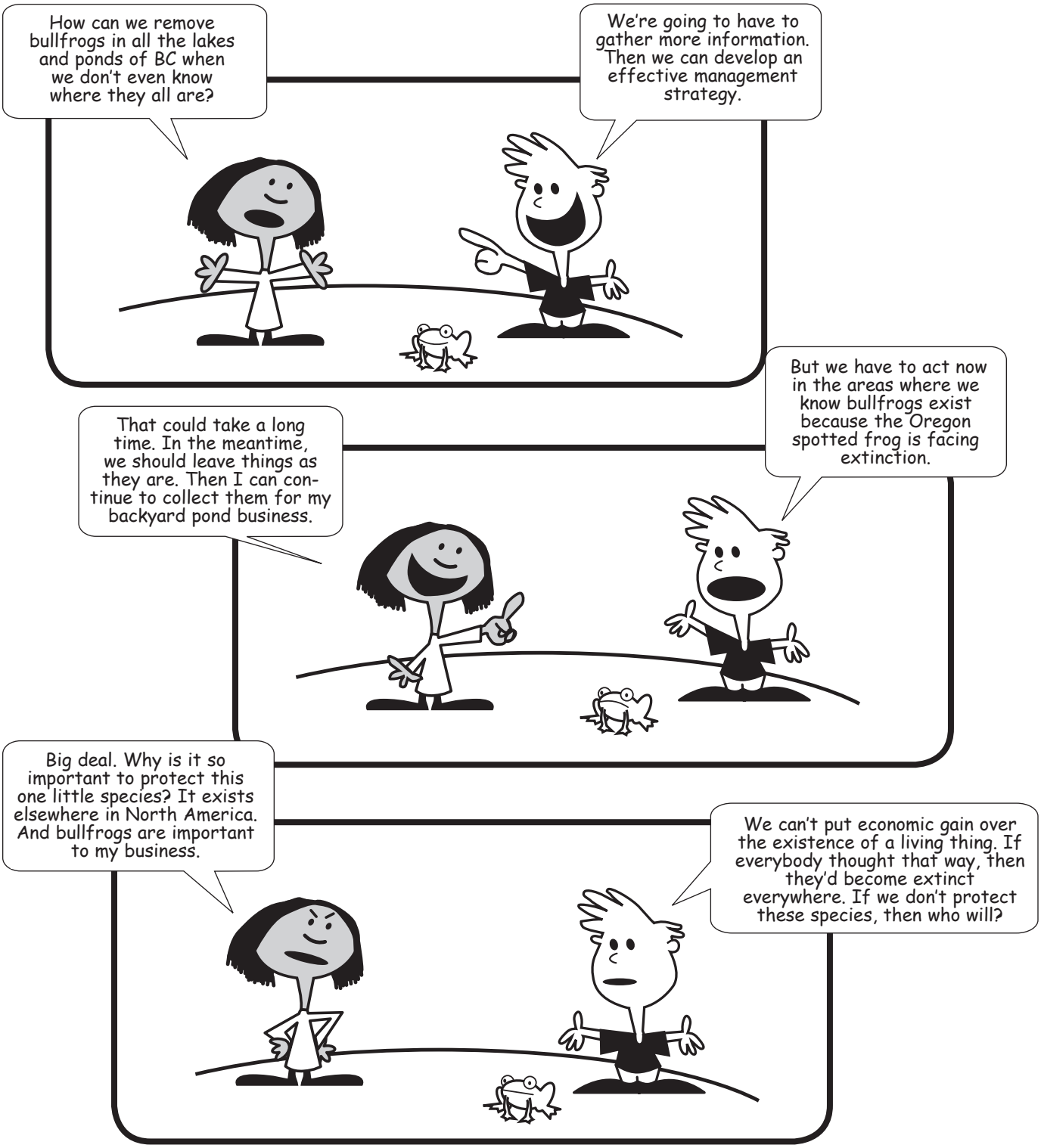
iv) Facilitate a debate between the groups, from the point of view of their respective roles, about the complete removal of bullfrogs from the wetlands of BC.

v) Help students brainstorm possible solutions to deal with the invasive bullfrogs and list the risks and benefits of removing them. The students' challenge is to deal with the invading species in a manner that best preserves native frog populations.

ACTIVITY 2: BULLY FOR BULLFROGS

Teacher debrief

There are no correct answers to removing bullfrogs completely from BC wetlands. The following cartoon strip illustrates some counter positions to this complex debate.



ACTIVITY 2: BULLY FOR BULLFROGS

PROS OF REMOVING THE BULLFROGS

- safe habitat regions will be restored for the critically endangered Oregon spotted frog
- the spread of the bullfrog invasion can be limited before they cause problems in even more areas
- the protection of endangered species, like the Oregon spotted frog, is more important than economic gain because extinction is forever
- professionals, not amateurs, will remove the bullfrogs thus ensuring habitat is not damaged and native species won't be mistakenly removed
- habitat won't be trampled and native frogs won't be misidentified and removed from the wild by amateurs looking for new sources of bullfrogs for commercial markets

CONS OF REMOVING THE BULLFROGS

- people may damage habitat even more by tramping through wetlands to remove the bullfrogs
- the wrong species may accidentally be removed, further damaging native populations
- the bullfrogs are generating money in local markets as a food delicacy or as pond pets

To learn more about their assigned roles, your students may want to research real-life examples around the management and/or removal of invasive species.

Extension activity

Instruct students to research examples of introduced species in Canada's history using print and on-line resources. A suggested list of aquatic species appears below.

purple loosestrife
red-eared sliders (turtles)
American mink
moose (Newfoundland population)
zebra mussels
ruffe (fish)
brown trout
carp
spiny water fleas
rusty crayfish
Eurasian water milfoil (plant)

Guide their research by asking them to answer STUDENT WORKSHEET Q.2-4 for their researched species. They should try to identify the country of origin for each of these non-native species and where the point of first introduction is thought to be. This often shows how the species arrived. Encourage students to determine whether any actions are being taken to control the impact of the species or minimize its presence. Where possible, students can research which introductions were accidental and which were intentional.

ACTIVITY 2 RESOURCES

Invasive bullfrogs http://web.uvic.ca/bullfrogs
(University of Victoria)

Invasive Alien Species in Canada
http://www.ec.gc.ca/eee-ias/Default.asp?lang=En
(Environment Canada)"

Introduced and invasive species lists http://invasivespecies.nbii.gov
(Center for Biological Informatics, US Geological Survey)

Global Invasive Species Database www.issg.org
(Invasive Species Specialist Group, World Conservation Union)

Invasive plants of Canada http://www.rbg.ca/cbcn/en/projects/invasives/invade1.html
(National Botanical Services)

List of common invasive or potentially invasive plants of Canada
www.eman-rese.ca/eman/ecotools/protocols/terrestrial (scroll down)
(Environment Canada's Ecological Monitoring and Assessment Network)

TEACHER RESOURCE

ACTIVITY 2

ROLES THAT MAY ADVOCATE KEEPING THE BULLFROG IN BC'S WETLANDS:

ROLES THAT MAY ADVOCATE REMOVING THE BULLFROG FROM BC'S WETLANDS COMPLETELY:

FISHERMAN

(USES FROGS AS LIVE BAIT AND MALE BULLFROGS ARE AN EASY CATCH)

FrogWatch

ENDANGERED SPECIES SCIENTIST

(WRITING LEGISLATION TO IMMEDIATELY PROTECT THE OREGON SPOTTED FROG)

FrogWatch

COLLEGE ANIMAL PHYSIOLOGY LAB INSTRUCTOR

(COLLECTS WILD BULLFROGS FOR CLASSROOM DISSECTIONS)

FrogWatch

HERPETOLOGIST

(WOULD LIKE MORE POPULATION SURVEYS OF ALL BC AMPHIBIAN SPECIES)

FrogWatch

EXOTIC CHEF

(COMMERCIALLY HARVESTS THE LARGEST MALE BULLFROGS FROM NATURAL AREAS FOR FROGS' LEGS DELICACY)

FrogWatch

NATURALIST

((OBSERVES BULLFROGS DISRUPTING ECO-SYSTEM BALANCES IN THE WILDS OF BC BY PREYING ON OTHER FROGS, INSECTS AND SMALL FISH)

FrogWatch

LANDSCAPER/AQUATIC NURSERY

(COLLECTS WILD BULLFROGS TO SELL TO ARTIFICIAL POND CUSTOMERS)

FrogWatch

BULLY FOR BULLFROGS

As a class, brainstorm the answers to the questions below.

Q.1. How many examples of introduced plant and animal species can you list? Which of these species have been introduced into Canada?

Q.2. How did each of these species arrive in their new ecosystem?

Q.3. What effects have these introduced species had on native species?

Q.4. What has been done to solve these problems? What could be done?

BULLY FOR BULLFROGS

Background information

The **bullfrog** is the largest frog species in North America. Bullfrogs spend most of their life in water. Their diet can include insects, mice, birds, and smaller frogs. They may cannibalize smaller bullfrogs. Bullfrogs occur naturally in most of Canada's eastern provinces. Since the Rocky Mountains provide a natural impassable barrier to the west, it is believed bullfrogs were deliberately introduced into BC by owners of aquatic plant nurseries for use in artificial backyard ponds, and for frog farms to produce frogs' legs for restaurants. Evidence also suggests educators introduced bullfrogs to BC so they could be raised for classroom dissections. The exact time of introduction is difficult to determine because the species was not monitored. Also, due to their slow rates of growth, development and maturation, the bullfrog invasion was gradual and may not have raised concern until the species was widespread. Unfortunately, bullfrogs prey upon native frog species. They have had a negative impact on most populations with which they share habitat where bullfrogs are not native.

The **Oregon spotted frog** is Canada's most endangered amphibian and was once thought to be extinct from our country. It was the first species to ever receive emergency listing by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) because of its imminent threat of extinction in Canada. This frog has a similar call and appearance to the Columbia spotted frog, which is found over much of BC, the Yukon, and western Alberta. Scientists conducted genetic analysis on these populations in 1997 to confirm the identity of these as a unique species. There are only three main sites in the Fraser River Lowlands where the Oregon spotted frog is known to exist. The loss and fragmentation of habitat through forestry practices are thought to be major contributors to the small and isolated nature of these remaining populations. These frogs are almost completely aquatic at all life stages and are therefore susceptible to bullfrog predation. This compounds their endangered species status. Scientists are studying Oregon spotted frogs to learn more about them and their interactions with other species in order to develop possible solutions to this problem.

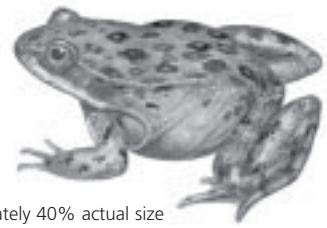
Read the species profiles for the bullfrog and Oregon spotted frog.

Did you know?

Scientists are tracking the Oregon spotted frog with radio transmitters. They want to learn more about these endangered creatures so they can develop effective recovery plans to support sustainable populations. In 2001, the total population of Oregon spotted frogs in Canada was estimated at only 300-350 individuals.

OREGON SPOTTED FROG

(*Rana pretiosa)*



Approximately 40% actual size

Appearance: The Oregon spotted frog has black spots with light centres on brown or reddish-brown skin. Its belly and upper thighs are marked with yellow, orange or red patches. The frog has a dark mask with a light coloured jaw stripe. Light brown or orange folds begin directly behind the eye and extend backwards over the tympanum (external eardrum) to the middle of the back. Its toes are webbed and its eyes are slightly upturned. Juveniles are olive green or light brown.

Size: 4.4-10cm

Range/distribution: The Oregon spotted frog has limited tolerance to cold and lives at the northern edge of its range in Canada where it is found in southwestern BC. This species was thought to be extinct from the wilds of British Columbia until three new populations were discovered in the Fraser River Lowlands where habitat is fragmented. As a result, the three populations appear to be isolated from one another. It is estimated the species has been lost from more than 90 per cent of its historic range in North America.

Call: A series of short, rapid clicks. Calling begins in early spring

Status as per the Species at Risk Act: Endangered

Biology: The Oregon spotted frog is aquatic and when frightened will swim to the bottom of the water body and remain still. It is unknown where they hibernate. The frogs become active in late winter or very early spring. Males move to breeding sites, gather very close to one another and call during both day and night. Female frogs lay a single annual egg mass per year. The females usually lay their eggs in large collective egg masses of 700-1 500 eggs on top of each other in tight groupings. Tadpoles emerge after 10 days to 3 weeks, depending on temperature and metamorphose after about four months. The tadpoles are vulnerable to freezing and desiccation (lack of moisture) and mortality rates can be high with all egg masses or tadpoles dying in an area in certain years. The frogs may take up to six years to reach maturity. Their lifespan is unknown.

Habitat: Oregon spotted frogs are found in large permanent water bodies such as lakes and marshes in mixed coniferous and subalpine areas. Shallow ephemeral, or temporary, pools connected with permanent water bodies also make important habitat.

Threats: The Oregon spotted frog occurs in extremely low population numbers in only a few small areas of Canada, making it very vulnerable. Populations are limited by the availability of suitable breeding habitat and by the isolation of the three existing populations so that exchange of individuals between populations is unlikely. This species is impacted by human activities such as habitat loss, fluctuating water levels in wetlands, and livestock management. The introduction of non-native species, such as predator bullfrogs and reed canarygrass, which chokes out its habitat, are also damaging.

Protection: The Oregon Spotted Frog is protected under the federal Species at Risk Act (SARA). The Oregon Spotted Frog is protected by the *British Columbia Wildlife Act.* Under this Act, it is prohibited to kill, collect, or hold captive any amphibian without a permit. The Act does not protect the species' habitat. One of the three sites where the frogs are found in Canada is land belonging to the federal Department of National Defence. This offers some protection to the frogs since access to the site is limited.

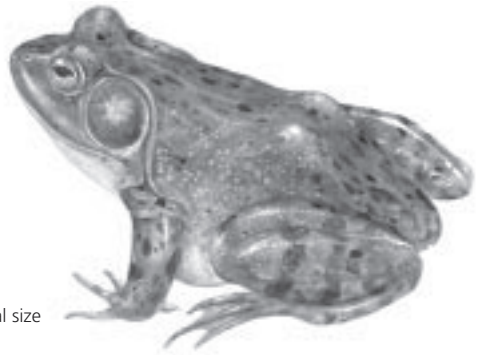
Information for this profile compiled from: Canadian Amphibian and Reptile Conservation Network Web site; Canadian Wildlife Service, Environment Canada Web site; Rory Tory Peterson Field Guides, Western Reptiles and Amphibians *by Robert C. Stebbins. Range map courtesy of the Canadian Wildlife Service, Environment Canada. Reproduced with permission of the Minister of Public Works and Government Services Canada, 2001. Illustration courtesy of the Toronto Zoo.*

FROG FACT

You can imitate the call of the Oregon spotted frog by rapidly clicking your tongue on the roof of your mouth.

BULLFROG

(*Rana catesbeiana*)



Approximately 30% actual size

Appearance: A large green or grayish-brown frog. The bullfrog has a prominent fold of skin from its eye and around the top of its eardrum. The male has a bright yellow throat and an eardrum twice the size of its eye (equal size in the female). The size of the eardrum is the easiest way to tell the difference between a male and a female.

Size: eastern 9-15.2cm; western 8.7-20cm

Range/distribution: Found in the eastern provinces except Prince Edward Island and Newfoundland and Labrador. Introduced to British Columbia.

Call: A deep and loud "jug-o-rum." Calling begins in early summer.

Status as per the Species at Risk Act: Secure

Habitat: Bullfrogs are found in large permanent water bodies. They prefer the shorelines of lakes, bays, large beaver ponds, and the mouths of slow-moving rivers. Bullfrogs overwinter in the mud at the bottom of lakes and ponds.

Biology: Bullfrogs are known for their appetites. They eat almost anything that is smaller than they are, including insects, birds, mice, snakes, fish, and turtles.

Male bullfrogs establish shoreline breeding territories and will defend their territory with a special encounter call. If this does not drive away an intruder, the male will jump at the invading male, push, lock arms, kick, and try to flip him over. These wrestling matches can often be observed during the spring mating season. It is only once territories are established that the loud "jug-o-rum" calls are given to attract females.

Bullfrogs breed in June or July, later than many other Canadian frog species. Large floating masses of about 8,000 eggs are laid. Larger females lay up to 20,000 eggs. The eggs hatch after a few days. Tadpoles do not metamorph until the following summer, thus deep, permanent water bodies are required for this extended life stage. Bullfrogs will sprout all four legs and begin moving out of the water before they start reabsorbing their tails. It has been estimated that some bullfrogs can live up to twenty-five to thirty years!

Threats: In the past, bullfrogs have been harvested for bait, classroom dissection, and for sale to restaurants for their legs and to backyard pond owners. The cause of their decline in some areas in not fully understood but is likely due to habitat degradation.

Protection: No protection is necessary because this species is not designated under the Species at Risk Act.

Information for this profile compiled from: Canadian Amphibian and Reptile Conservation Network Web site; Canadian Wildlife Service, Environment Canada Web site; Frogs *by David Badger; Guinness World Records Web site;* New Animal Discoveries *by Ronald Orenstein; "The Sound of Silence," by Stephen Leahy,* Nature Canada*; University of Victoria Web site. Range map courtesy of the Canadian Amphibian and Reptile Conservation Network. Illustration courtesy of the Toronto Zoo.*

FROG FACT

Canada's largest frog is the bullfrog. The world's largest frog is the goliath frog, *Conraua goliath*, from West Africa. This frog grows to 38cm long (longer than your ruler!) and weighs almost as much as a human baby—a whopping 3.1kg!

***The Guinness Book of Animal Facts and Feats* cites the largest bullfrog ever found. It was caught in Washington state in 1949 and weighed as much as a goliath frog at 3.25 kilograms.**

FOOD CHAINS & PYRAMIDS

Chapter 4

ACTIVITY 3A: TO BE PREY OR NOT TO BE PREY

(Based on an activity idea from Science Is, by Susan V. Bosak, 1991, Scholastic Canada Ltd.)

Overview

Students identify various species that exist in wetlands. Working in small groups they identify the feeding preferences of these organisms and order them into a simple food chain. Students then consider the consequences of removing one of the organism links from the food chain and relate this to real-life occurrences.

Target audience:
GRADES 7-9; small group activity and discussion.

Materials list: Each student will require STUDENT WORKSHEET FOR ACTIVITY 3A and a marker. Each group will require a half deck of cards and sticky notes for each card or blank index cards, and TEACHER RESOURCE SHEET FOR ACTIVITY 3A.

Vocabulary: carnivore; decomposer; food chain; food web; herbivore; insectivore; niche; omnivore; primary consumer; producer; secondary consumer; scavenger; tertiary consumer; trophic level.

CURRICULUM MATCHES FOR ACTIVITY 3A

Below are general learning outcomes selected from the *Common Framework of Science Learning Outcomes: Pan-Canadian Protocol for Collaboration on School Curriculum.* For more information on "specific" learning outcomes, see APPENDIX A.

Grades 7-9

Skills

210 Analyze qualitative and quantitative data and develop and assess possible explanations; 210-1, 2.

211 Work collaboratively on problems and use appropriate language and formats to communicate ideas, procedures and results; 211-2, 3.

Knowledge: Life science

304 Explain and compare processes that are responsible for the maintenance of an organism's life; 304-1, 2.

306 Describe interactions and explain dynamic equilibrium within ecological systems; 306-1, 2.

Knowledge: Earth and space science

311 Explain patterns of change and their effects on Earth; 311-8.

Grades 10-12

Skills

212 Ask questions about observed relationships and plan investigations of questions, ideas, problems and issues; 212-5.

214 Analyze data and apply mathematical and conceptual models to develop and assess possible explanations; 214-1-3, 17, 18.

215 Work as a member of a team in addressing problems, and apply the skills and conventions of science in communicating information and ideas and in assessing results; 215-1-4, 6.

Knowledge: Life science

316 Analyze the patterns and products of evolution; 316-1-5.

318 Evaluate relationships that affect the biodiversity and sustainability of life within the biosphere; 318-5, 6, 8-11.

Knowledge: Earth and space science

331 Describe and predict the nature and effects of changes to terrestrial systems; 331-6.

Introduction

This activity introduces students to wetland ecosystems by familiarizing them with the species that live there. It also demonstrates the great biodiversity found in wetlands and the interconnectedness of nature.

The previous activities introduced how scientists examine some threats to anurans. But a given population in a real ecosystem can be affected by other species and therefore, must be considered within the context of other organisms in that ecosystem.

One of the simplest relationships between species is that of predator and prey—the basis of a food chain. On a wider scope, we see that all organisms fulfill a role in their ecosystem—a functional niche—based on their trophic level. An ecologist interested in studying the health of a wetland by monitoring the presence of frog and toad species must look at the interconnectedness of their roles and relationships with other organisms that share the same habitat.

Teacher instructions

i) Introduce the topic using information and terminology from the INTRODUCTION above. Students should also read BACKGROUND INFORMATION on STUDENT WORKSHEET FOR ACTIVITY 3A.

ii) Brainstorm examples of species that play a role in wetland food chains.

iii) Examine the diversity of species brainstormed to see if students have given adequate representation to all trophic levels by comparing the students' list with the wetland species examples list below. (Also see TEACHER DEBRIEF.)

iv) Break students into groups of four. Give each group half a deck of playing cards with sticky notes covering the face or sufficient blank index cards, markers and a copy of the WETLAND SPECIES list in TEACHER RESOURCES FOR ACTIVITY 3A.

v) Students will transfer the names of the organisms provided in the WETLAND SPECIES list to the blank cards—one organism per card. Below is the same list sorted into trophic level for your reference.

WETLAND SPECIES BY TROPHIC LEVEL

PRODUCERS	PRIMARY CONSUMERS:	SECONDARY CONSUMERS:	TERTIARY CONSUMERS:	PRIMARY, SECONDARY AND TERTIARY CONSUMERS:	DECOMPOSERS AND SCAVENGERS
cattails	herbivores	insectivores	carnivores	omnivores	soil bacteria (decomposer)
waterlily	beaver	water strider	heron	raccoon	fungi (decomposer)
sedge (plant)	muskrat	diving beetle	merganser (waterfowl)	red fox	pond snail (scavenger)
bladderwort (plant)	moose	dragonfly	snapping turtle	painted turtle	crayfish (scavenger)
milfoil (plant)	Canada goose	red-winged blackbird	marsh hawk	skunk	
bulrush	tadpole	mallard duck	mink	mosquito	
duckweed	zooplankton	trout	garter snake	human	
reeds		tree frog			
phytoplankton (algae)					

vi) Instruct students to identify the feeding preferences of each organism and assemble the cards into realistic food chains. Bring up examples as a class or ask each group to bring their cards to the front of the class and describe their food chain in order of energy flow from the sun (see TEACHER DEBRIEF). Instruct the class to identify which organisms are the producers, herbivores, carnivores, and scavengers/decomposers.

vii) Ask students to follow all instructions and complete Q.1-4 outlined on STUDENT WORKSHEET FOR ACTIVITY 3A. To answer Q.3 and Q.4, students should consider a scenario where amphibians have been removed from the food chain, for example pesticide contamination, harvesting, or wetland drainage.

viii) Instruct the class to combine several food chains into a wetland ecosystem food web with realistic interrelationships between organisms, such as predators with alternative food sources and herbivores that graze on more than one plant species. Ensure students consider the ever-present role of decomposers.

ix) Ensure students keep their cards for use in Activity 3B.

Teacher debrief

There are no correct answers when examining the diversity of wetland species. However, students may have over-represented secondary consumers, in particular carnivores. One level often neglected is scavengers and decomposers, which are important in cycling energy found in dead animals and returning it to the food chain. If the number of producers is inadequate, remind students that in a real environment it is the overall abundance of these organisms that keeps an ecosystem balanced.

Organisms that use their energy directly from the sun are the basis of all food chains. Phytoplankton (algae) forms the basis of the aquatic food chain. Phytoplankton is grazed on by zooplankton (small aquatic invertebrates), insects, tadpoles and small fish. Amphibian eggs, tadpoles and small fish are eaten by larger fish, which are then eaten by birds, mammals and people.

In developing possible wetland food chains, students have an opportunity to be very creative. They should consider the dynamic role the size of an individual plays in food chains. For example, a small snake may be a food source for a large bullfrog, while a large snake would likely eat a small bullfrog. Students can also consider the role of eggs and larval stages of organisms. For example, turtle eggs are a favourite food source for raccoons and larval stages of aquatic insects are an important food source for frogs, fish, crayfish and other insects.

ACTIVITY 3 RESOURCES
Canada's Aquatic Environments: Aquatic animals and plants
www.aquatic.uoguelph.ca
(CyberNatural Software Group, University of Guelph)

WETLAND SPECIES LIST

- beaver
- cattails
- skunk
- tadpole
- fungi
- dragonfly
- water lily
- raccoon
- marsh hawk
- sedge (plant)
- soil bacteria
- muskrat
- bladderwort (plant)
- trout
- red fox
- zooplankton
- human
- water strider
- snapping turtle
- moose
- diving beetle
- treefrog
- mink
- bulrush
- pond snail
- duckweed
- merganser (waterfowl)
- red-winged blackbird
- painted turtle
- phytoplankton (algae)
- crayfish
- Canada goose
- reeds
- heron
- mallard duck
- garter snake
- mosquito
- milfoil (plant)

TO BE PREY OR NOT TO BE PREY

Background information

Predator-prey interactions are important to consider when scientists examine ecosystems, particularly those involving anurans because scientists consider frogs and toads as keystone species. Keystone species are those that have an important and/or unique role to play in an ecosystem. Their removal from the food chain is problematic because many other species depend on them in some way. Frogs and toads are important because they are voracious feeders and in turn, are a key food source for many predator species. Most adult anurans have a specialized diet of insects. When local insects start to hatch and fly in spring, this affects when frogs and toads are most active in a wetland and influences when their predators can use them as a food source.

Although adult frogs and toads are generally insectivores, a few of the larger species, such as the bullfrog and green frog, are carnivores and have been observed feeding on small fish, birds, mice and even small snakes. At the tadpole life stage frogs and toads are mainly herbivores, eating algae and other plant material, although they will sometimes scavenge things like dead tadpoles.

Since they live in both water and on land, frogs are also important in cycling nutrients between land and water. If they are not present to perform these roles other wetland species can be adversely impacted.

With your group, order your wetland species cards to depict a simple food chain showing the relationship between species. Try to use as many species as possible and make sure that one of the species is an amphibian.

Answer the following questions.

Q.1. What is the original source of energy in all food chains?

TO BE PREY OR NOT TO BE PREY

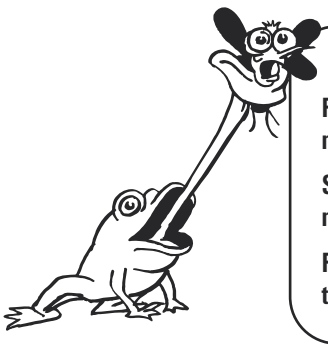
Q.2. How is energy returned back to the food chain from the top carnivore level?

Remove the amphibian species from the food chain. Propose a scenario where this could actually happen in the wild.

Q.3. What might happen to the organisms below the broken food chain link? Explain why.

Q.4. What might happen to those above the broken food chain link? Explain why.

Reassemble the species into as many realistic food chain combinations as you can. Remove links at different feeding levels and discuss the possible consequences for other species along the chain.



FROG FACT

Frogs and toads have remarkable tongues. Long and sticky, they can flip food into their mouths faster than the human eye can see.

Some frogs even use their eyes to help them feed. They lower their eyes into the roofs of their mouths to help push down and swallow large prey!

Frogs and toads also shed their skin like other amphibians. You won't find this skin though—they eat it!

ACTIVITY 3B: TROPHIC LEVEL TOWERS

(Based on an activity idea from *Science Is*, by Susan V. Bosak, 1991, Scholastic Canada Ltd.)

Overview

A wetland ecosystem example introduces students to the concepts of trophic levels and food pyramids. They learn about differences in biodiversity, abundance, and biomass of species at each level, and energy loss as it is transferred between trophic levels. Students extend their knowledge to understand how organisms can be sorted by the functions they fulfill in an ecosystem. In the EXTENSION ACTIVITY students learn how organisms are sorted by appearance, which is reflected in the structural classification system used in taxonomy.

Target audience:
GRADES 7-12; small group hands-on demonstration activity and discussion.

Materials list: Each group will require the wetland species cards from ACTIVITY 3A and six different coloured markers.

Vocabulary: autotroph; biomass; food pyramid; heterotroph; taxonomy

CURRICULUM MATCHES FOR ACTIVITY 3B

Below are general learning outcomes selected from the *Common Framework of Science Learning Outcomes: Pan-Canadian Protocol for Collaboration on School Curriculum.* For more information on "specific" learning outcomes, see APPENDIX A.

Grades 7-9

Skills

210 Analyze qualitative and quantitative data and develop and assess possible explanations; 210-1, 2.

211 Work collaboratively on problems and use appropriate language and formats to communicate ideas, procedures and results; 211-2, 3.

Knowledge: Life science

304 Explain and compare processes that are responsible for the maintenance of an organism's life; 304-1, 2.

306 Describe interactions and explain dynamic equilibrium within ecological systems; 306-1, 2.

Knowledge: Earth and space science

311 Explain patterns of change and their effects on Earth; 311-8.

Grades 10-12

Skills

212 Ask questions about observed relationships and plan investigations of questions, ideas, problems and issues; 212-5.

214 Analyze data and apply mathematical and conceptual models to develop and assess possible explanations; 214-1-3, 17, 18.

215 Work as a member of a team in addressing problems, and apply the skills and conventions of science in communicating information and ideas and in assessing results; 215-1-4, 6.

Knowledge: Life science

316 Analyze the patterns and products of evolution; 316-1-5.

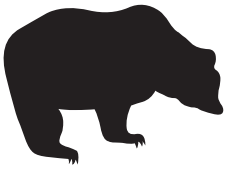
318 Evaluate relationships that affect the biodiversity and sustainability of life within the biosphere; 318-5, 6, 8-11.

Knowledge: Earth and space science

331 Describe and predict the nature and effects of changes to terrestrial systems; 331-6.

Introduction

Most real-life food chains have only four to six organism "links" in the chain. Leading theories suggest this is due to loss of sun-harnessed energy as it moves from plants to herbivores and again from herbivores to carnivores. After several of these energy loss steps, there is not enough energy left to support an additional carnivore level.



An animal usually gains only 10 per cent of the energy from the plant it eats because the rest is lost as heat or is never digested. Energy efficiency limits the overall biomass of top-level carnivores that an ecosystem can support. Only about one-thousandth of the energy fixed by green plants can flow all the way through a food web to a tertiary or quaternary consumer such as a hawk. Therefore, the energy at the top of a trophic pyramid is concentrated in a relatively small number of individuals.

Thus, the diagrammatic food pyramid is an important visual tool used by scientists to show the energy loss at successive levels, as well as the differences in the abundance and diversity of species from each trophic level.

Evidence suggests energy efficiency is not the only factor influencing the length of a food chain. Factors such as the complexity or size of an ecosystem may also play a role. For example, more complex ecosystems such as forests or coral reefs may have longer food chain lengths than more structurally simple ecosystems or smaller habitat patches such as a small pond or a grassland ecosystem.

Teacher instructions

i) Demonstrate a typical food pyramid shape (see TEACHER RESOURCES FOR ACTIVITY 3B) and ask students to identify and label the trophic levels as a class activity.

ii) Divide students into groups of four. Using the wetland species cards from ACTIVITY 3A, instruct them to sort the cards by trophic level and colour code the cards in each trophic level by placing a coloured dot or underlining the name on each card. Refer to the list of WETLAND SPECIES BY TROPHIC LEVEL in ACTIVITY 3A to assist students if necessary.

iii) Instruct students to physically build a card house or a tower to represent a real wetland food pyramid with at least three levels. Ask students the following questions in a discussion setting.

Discussion Q.1.
Are there enough plants at the base to support the food pyramid? Is this a realistic representation of a wetland ecosystem?

Students can reconstruct the card tower to reflect reality, perhaps adding the names of additional plant species

Discussion Q.2.
How would a reduction in biodiversity at any trophic level affect the structure and shape of a food pyramid?

ACTIVITY 3A: TROPHIC LEVEL TOWERS

PONDER THIS

You may have heard it's more environmentally friendly to "eat lower down on the food chain." This activity shows why.

A human obtains far more energy by eating grains or vegetables directly as a primary consumer, than by processing that same amount of grain through another trophic level and eating grain-fed beef. While it's important to eat a balanced diet, we could feed far more people in the world and use fewer resources if we all feed more efficiently by eating more grains and vegetables and less meat.

Teacher debrief

When illustrating the trophic level diagram to students it's important to note that in nature, organisms do not always fit neatly into trophic level categories. For example, scavengers and decomposers can be depicted in a side bar along the edge of the trophic level diagram since they feed on the remains of organisms at every trophic level.

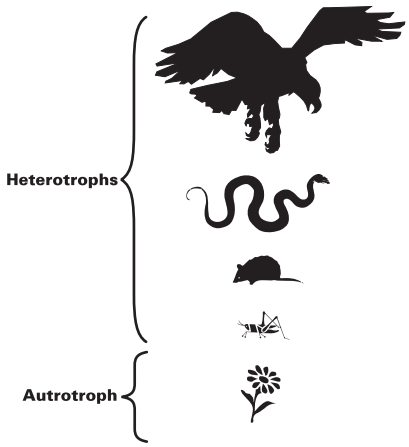
Similarly, omnivores do not fit neatly into one level. They are considered primary consumers when eating vegetable matter and secondary consumers when eating meat.

The top level of the trophic diagram is represented by tertiary consumers—carnivores who eat carnivores. Additional level quaternary consumers may also be found in nature, however, this level is typically small and is not often found in small wetland ecosystems. See the diagram below for examples of possible food chains labelled by trophic level.

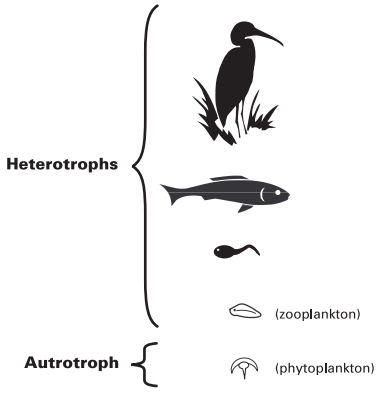
When constructing the trophic level towers ensure students adequately represent the number of producers. Remind them that in a real ecosystem it is the overall abundance of these organisms—the autotrophs—that keeps and ecosystem balanced. The physical structure of the card pyramid illustrates this balance. The broader the base, the higher the tower can be built.

FOOD CHAIN EXAMPLES

Terrestrial Food Chain



Wetland Food Chain



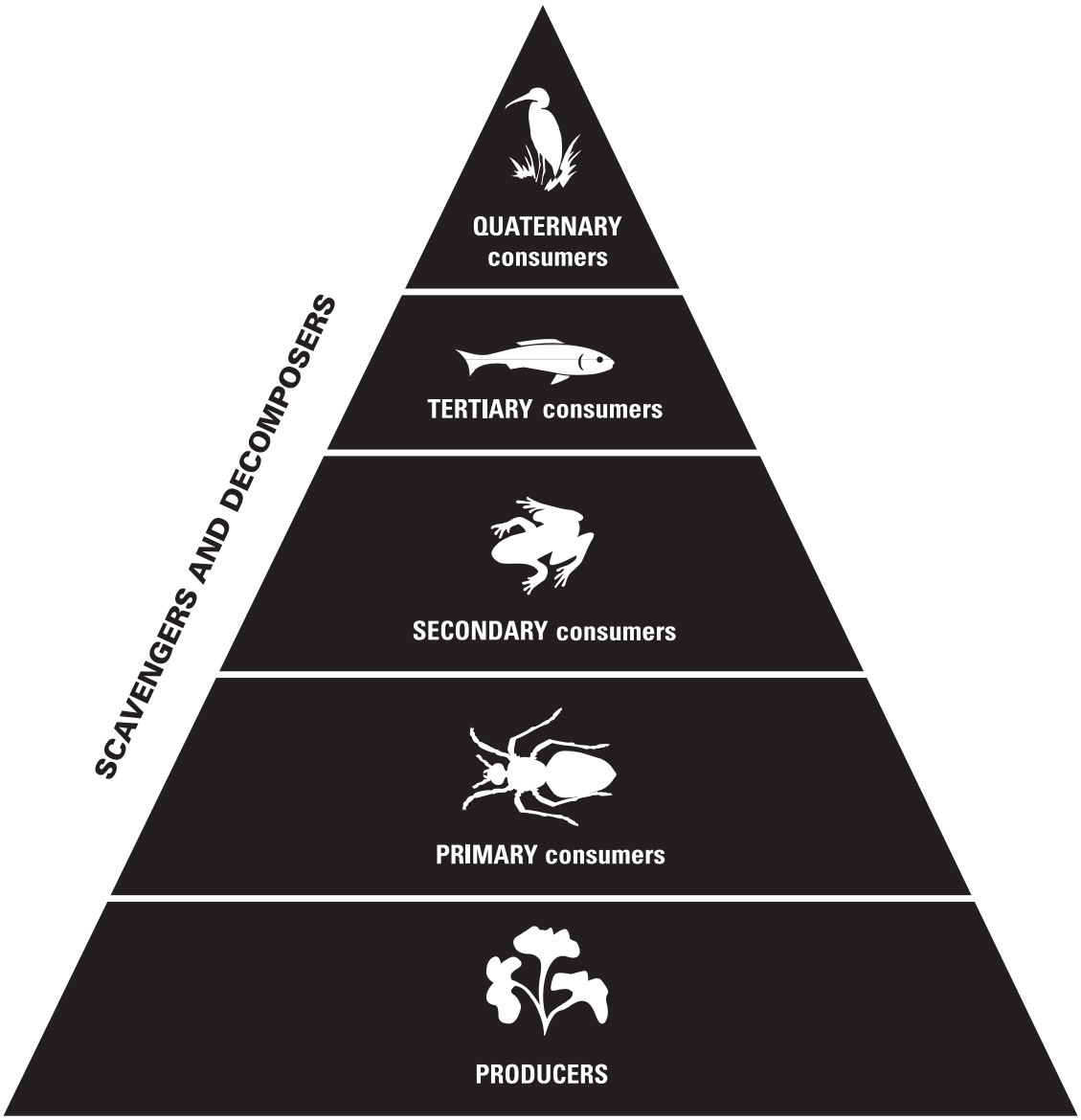
Extension activities

1. Ask students to consider the relationship between biodiversity and ecosystem stability using the example of a wetland ecosystem. From ACTIVITY 3A they may have begun to grasp how, in general, increased numbers of organisms performing a similar role increases the stability of an ecosystem. They may wish to develop a theory, and indicate if it would be testable, and how.

2. Using the wetland species cards from ACTIVITY 3A, ask students to list physical adaptations in wetland animals that help them survive. Students should consider how these animals travel and feed. For example, many ducks have webbed feet, waterproof feathers and wide beaks for straining bug food from the water surface; shorebirds like herons have long legs and pointed beaks for fishing; and beavers, muskrats and mink have webbed feet and waterproof fur.

3. As a class activity, ask students to categorize all the species cards to reflect a classification system based on structural features—appearance—of the organisms, which reflects modern day divisions in taxonomy, such as mammals, birds, reptiles etc. Point out that the food chain they completed in ACTIVITY 3A actually sorted the organisms based on the function they performed within that niche. Ask them to consider the pros and cons of each classification system and which system is more reliable. Depending on the age of your students you may want to introduce the value of biotechnology in determining evolutionary relatedness using genetic-based classification.

TROPHIC LEVEL TOWERS
FOOD PYRAMID



GLOSSARY

A

amphibian
A taxonomic class belonging to Subphylum Vertebrata. The word amphibian means "double-life." This refers to the typical aquatic larval and terrestrial adult life stages, which differentiates them from class Reptilia. Includes frogs, toads, salamanders and newts.

anuran
A taxonomic order belonging to the class Amphibia, which means "no tail." This more specific grouping includes all frog and toad species, but not salamanders and newts.

autotroph
An organism which obtains its energy directly from the sun. Examples include green plants and algae.

B

biodiversity
The variety of life on our planet, measurable as the variety within species (genetic diversity), the variety between species, and the variety of ecosystems.

biomass
The weight of living matter. Can include the weight of a group of organisms in an ecosystem, for example all of the frogs in a wetland or the mass of all the trees in the forest.

C

carnivore
An animal that eats other animals to survive.

carrying capacity
The number of individuals of a given species that can be supported by the resources in a given area.

chorusing or calling behaviour
The vocalizing of male anurans, designed to attract mates. Typically occurs during a discrete period in the spring.

D

decomposer
An organism that breaks down dead organic material or waste products into inorganic chemicals to be reused by plants. Examples include bacteria and fungi.

E

ecology
The study of the relationships between living things and their non-living environment.

ecosystem
All of the organisms living in a particular area and the physical environment and processes they rely on.

endangered
Species that are facing imminent extinction or extirpation.

extinct
Species that no longer exist anywhere on the planet.

extirpated
Species that no longer exist in the wild in Canada, but they occur elsewhere.

extrapolate
To estimate values lying outside the range of given data. For example, to extrapolate from a graph means to estimate points beyond those that are plotted.

F

food chain
A simple pathway that shows how nutrients cycle and energy flows between organisms in an ecosystem.

food pyramid
A quantitative representation of a food chain based on trophic level in which the producers form the base and the carnivores form the peak levels.

food web
The complex network of multiple food chains showing feeding relationships in an ecosystem.

H

habitat
The place where a plant, animal or microorganism lives.

herbivore
An animal that feeds exclusively on plant material.

herpetologist
A scientist who studies amphibians and reptiles. Includes areas of study such as ecology, physiology, behaviour, anatomy, paleontology and taxonomy of the animals in this grouping.

heterotroph
An organism that obtains its energy by consuming other organisms, for example herbivores and carnivores.

I

indicator species
Certain species of animals and plants whose presence or absence can be used by scientists to identify the state of health of an ecosystem.

insectivore
An organism that eats insects.

introduced species
Organisms that have been intentionally or accidentally introduced to a specific location outside their natural geographic range.

invasive species
Introduced species that experience extensive population growth in the absence of controlling factors from their native habitat. They can adversely impact native species by displacing or consuming them.

N

native species
Species that occur naturally in an area.

niche
The role or function of an organism in the environment including its activities and relationships in the community.

O

omnivore
An organism that feeds on both plant and animal material.

P

population
A group of organisms from the same species living in the same habitat.

primary consumer
An organism that feeds directly on green plants.

producer
An organism, such as a green plant, that transfers energy from the sun into food energy through photosynthesis.

Q

quaternary consumer
An organism that eats tertiary consumers.

S

scavenger
An organism that feeds on dead organic matter. Examples include crows which eat carrion, and pond snails which eat dead plant matter.

secondary consumer
An organism that feeds on herbivores.

special concern
A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.

T

taxonomy
The science of the classification of organisms. Organisms are grouped based on the extent that they resemble each other and are thought to share a common ancestry.

tertiary consumer
An organism that feeds on carnivores (secondary consumers).

threatened
Species likely to become endangered in Canada if limiting factors are not reversed.

trophic level
The division of species in an ecosystem based on their main nutritional source and feeding habits. The energy-producing plants of the first level are considered autotrophs, followed by several levels of heterotrophs. All of the organisms in a particular trophic level are the same number of food-chain steps away from the primary source of energy.

W

wetland
Lands covered with water, usually less than two metres deep. In Canada this includes ponds, marshes, swamps, bogs and fens.

APPENDIX A

Curriculum matches for Activities 1A and 1B

Specific learning outcomes from the *Common Framework of Science Learning Outcomes: Pan-Canadian Protocol for Collaboration on School Curriculum*

Grade 7-9

208-5 State a prediction and a hypothesis based on background information or an observed pattern of events.

209-4 Organize data using a format that is appropriate to the task or experiment.

209-5 Select and integrate information from various print and electronic sources or from several parts of the same source.

210-2 Compile and display data, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, bar graphs, line graphs, and scatter plots.

210-3 Identify strengths and weaknesses of different methods of collecting and displaying data.

210-4 Predict the value of a variable by interpolating or extrapolating from graphical data.

210-5 Identify the line of best fit on a scatter plot and interpolate or extrapolate based on the line of best fit.

210-6 Interpret patterns and trends in data, and infer and explain relationships among the variables.

211-2 Communicate questions, ideas, intentions, plans, and results, using lists, notes in point form, sentences, data tables, graphs, drawings, oral language, and other means.

311-8 Analyze factors that affect productivity and species distribution in marine and fresh water environments.

GRADE 10-12

212-4 State a prediction and a hypothesis based on available evidence and background information.

212-8 Evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making.

212-9 Develop appropriate sampling procedures.

213-1 Implement appropriate sampling procedures.

213-5 Compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data.

213-6 Use library and electronic research tools to collect information on a given topic.

213-7 Select and integrate information from various print and electronic sources or from several parts of the same source.

214-3 Compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots.

214-4 Identify a line of best fit on a scatter plot and interpolate or extrapolate based on the line of best fit.

214-5 Interpret patterns and trends in data, and infer or calculate linear and nonlinear relationships among variables.

214-10 Identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty.

214-11 Provide a statement that addresses the problem or answers the question investigated in light of the link between data and the conclusion.

214-18 Identify and evaluate potential applications of findings.

215-2 Select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results.

215-3 Synthesize information from multiples sources or from complex and lengthy tests and make inferences based on this information.

215-5 Develop, present, and defend a position or course of action, based on findings.

316-3 Analyze evolutionary mechanisms such as natural selection, genetic variation, genetic drift, artificial selection, and biotechnology, and their effects on biodiversity and extinction.

316-4 Outline evidence and arguments pertaining to the origin, development, and diversity of living organisms on Earth.

318-4 Explain why different ecosystems respond differently to short-term stresses and long-term changes.

318-5 Explain various ways in which natural populations are kept in equilibrium and relate this equilibrium to the resource limits of an ecosystem.

318-8 Describe population growth and explain factors that influence population growth.

318-9 Analyze interactions within and between populations.

318-10 Evaluate Earth's carrying capacity, considering human population growth and its demands on natural resources.

331-6 Analyze the impact of external factors on an ecosystem.

Curriculum matches for Activity 2

Specific learning outcomes from the *Common Framework of Science Learning Outcomes: Pan-Canadian Protocol for Collaboration on School Curriculum*

Grade 7-9

208-4 Propose alternative solutions to a given practical problem, select one, and develop a plan.

209-5 Select and integrate information from various print and electronic sources or from several parts of the same source.

210-8 Apply given criteria for evaluating evidence and sources of information.

210-16 Identify new questions and problems that arise from what was learned.

211-1 Receive, understand and act on the ideas of others.

211-2 Communicate questions, ideas, intentions, plans, and results, using lists, notes in point form, sentences, data tables, graphs, drawings, oral language, and other means.

211-3 Work co-operatively with team members to develop and carry out a plan, and troubleshoot problems.

211-5 Defend a given position on an issue or problem, based on their findings.

Grade 10-12

212-1 Identify questions to investigate that arise from practical problems and issues.

213-6 Use library and electronic research tools to collect information on a given topic.

213-7 Select and integrate information from various print and electronic sources or from several parts of the same source.

214-5 Propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each, and select one as the basis for a plan.

215-1 Communicate questions, ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others.

215-2 Select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results.

215-3 Synthesize information from multiple sources or from complex and lengthy tests and make inferences based on this information.

215-4 Identify multiple perspectives that influence a science-related decision or issue.

215-5 Develop, present, and defend a position or course of action, based on findings.

215-6 Work co-operatively with team members to develop and carry out a plan, and troubleshoot problems as they arise.

316-3 Analyze evolutionary mechanisms such as natural selection, genetic variation, genetic drift, artificial selection, and biotechnology, and their effects on biodiversity and extinction.

318-8 Describe population growth and explain factors that influence population growth.

331-6 Analyze the impact of external factors on an ecosystem.

Curriculum matches for Activities 3A and 3B

Specific learning outcomes from the *Common Framework of Science Learning Outcomes: Pan-Canadian Protocol for Collaboration on School Curriculum*

Grade 7-9

210-1 Use or construct a classification key.

210-2 Compile and display data, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, bar graphs, line graphs, and scatter plots.

211-2 Communicate questions, ideas, intentions, plans, and results, using lists, notes in point form, sentences, data tables, graphs, drawings, oral language, and other means.

304-1 Explain how biological classification takes into account the diversity of life on Earth.

304-2 Identify the roles of producers, consumers, and decomposers in a local ecosystem, and describe both their diversity and their interactions.

306-1 Describe how energy is supplied to, and how it flows through, a food web.

306-2 Describe how matter is recycled in an ecosystem through interactions among plants, animals, fungi, and micro-organisms.

311-8 Analyze factors that affect productivity and species distribution in marine and fresh water environments.

Grade 10-12

212-5 Identify the theoretical basis of an investigation and develop a prediction and a hypothesis that are consistent with the theoretical basis.

214-1 Describe and apply classification systems and nomenclatures used in the sciences.

214-2 Identify limitations of a given classification system and identify alternative ways of classifying to accommodate anomalies.

214-3 Compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatter plots.

214-17 Identify new questions or problems that arise from what was learned.

214-18 Identify and evaluate potential applications of findings.

215-1 Communicate questions, ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others.

215-4 Identify multiple perspectives that influence a science-related decision or issue.

316-1 Describe historical and cultural contexts that have changed evolutionary concepts.

316-2 Evaluate current evidence that supports the theory of evolution and that feeds the debate on gradualism and punctuated equilibrium.

316-3 Analyze evolutionary mechanisms such as natural selection, genetic variation, genetic drift, artificial selection, and biotechnology, and their effects on biodiversity and extinction.

316-4 Outline evidence and arguments pertaining to the origin, development, and diversity of living organisms on Earth.

316-5 Use organisms found in a local or regional ecosystem to demonstrate an understanding of fundamental principles of taxonomy.

318-5 Explain various ways in which natural populations are kept in equilibrium and relate this equilibrium to the resource limits of an ecosystem.

318-6 Explain how the biodiversity of an ecosystem contributes to its sustainability.

APPENDIX B
HOW YOU CAN HELP FROGS

At Home Action Opportunities

- Participate in the FrogWatch volunteer monitoring survey. Visit www.frogwatch.ca to learn more.
- Write a letter to your local politician and tell him/her you think wetlands are an important part of protecting wildlife in your area. Say why you think wetlands are important and how they should be protected.
- Join a junior naturalist club near you to find out more about nature in your area.
- Speak to your parents and neighbours about avoiding the use of pesticides and fertilizers. These chemicals can be very harmful to amphibians when they are washed into local water sources. Amphibians are natural bug controllers—a single toad might eat up to 1,500 earwigs in a summer!
- Create backyard habitat for amphibians. You can make a simple "toad abode" by placing a hole in the side of an upside down clay pot or by laying pieces of wood across small stones. This provides a cool, moist home for toads and in return they can eat insect pests in your garden.
- Create a backyard pond or make your pond friendlier to amphibians. Amphibians are attracted to ponds by the size of the reflective surface. In general, the larger the pond, the more attractive it is for amphibians. Landscape the pond using native plants that will provide shelter and hiding spaces for amphibians. The vegetation may also attract species such as birds and butterflies. Provide some areas of shallow water, and rocks rather than steep sided walls. Don't try to remove all of the algae in your pond—while "pea soup" water indicates an imbalance, some algae is good for your pond and is the main food source for tadpoles. To provide appropriate overwintering habitat for amphibians, dig your pond at least 1.5 meters deep and let some leaves and organic matter accumulate at the bottom.
- Do not try to introduce amphibians to your backyard. If the habitat is suitable, frogs will come. Although it often appears we can recreate wildlife habitat easily, there are many factors that we need to consider. If a frog is introduced to an unsuitable habitat it will not find adequate food or shelter and die in the strange new environment.

- Basement window wells are a death-trap for amphibians. Once they find themselves in these deep, steep-sided places, they cannot escape. You can help by planting around the edges or by placing branches or stones in the wells so amphibians can climb out.

- Provide habitat by leaving leaf piles or coarse woody debris, such as fallen tree trunks in your yard. The moist undersides of the trees and decaying leaf piles are perfect homes for salamanders. Leaf piles or compost heaps can serve as overwintering places for gray treefrogs, wood frogs, spring peepers and salamanders.

- Join a conservation group that is protecting wetlands. Help out with a stream or pond cleanup. If you know of a wetland area that needs a cleanup, organize a garbage pickup with your friends and family or school environmental club. Be sure to avoid trampling habitat and always keep safety in mind.

- Try to avoid handling frogs and toads. The chemicals found on your skin such as natural salts, sunscreen or bug repellent can be toxic to frogs since they can absorb these chemicals with the water and oxygen they absorb through their skin.

- Remember that frogs and toads are an important part of nature. Celebrate nature by enjoying their spring choruses!

Information for items 4-7 from The Urban Outback-Wetlands for Wildlife: A guide to Wetland Restoration and Frog-friendly Backyards, by Heather Gosselin and Bob Johnson.

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