A fun, informative, activity-filled teacher resource kit that introduces students to the concept of biodiversity and healthy habitats and our role in protecting them.

INCLUDES:

- Curriculum-linked integrated activities for teaching Grade 6 Science and Technology, Language, Social Studies, Health and Physical Education, and the Arts.
- Lessons and warm-up/wrap-up activities with extensions, suggestions for assessment and ideas to ensure inclusion.

Grade 6 Curriculum Kit

Invasive Species: A Biodiversity Challenge!

Invading Species Awareness Program
Ontario Federation of Anglers and Hunters
/Ontario Ministry of Natural Resources

4601 Guthrie Drive, P.O. Box 2800
Peterborough, ON K9J 8L5

www.invadingspecies.com • 1.800.563.7711

ONTARIO'S INVADING SPECIES AWARENESS PROGRAM

www.invadingspecies.com

Ontario

Canada

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INTRODUCTION

For millennia, humankind existed in balance, more or less, with the other parts of nature. But with growth in the world's population, the spread of industrialization, the sprawl of urban settlement and the intensive use of natural resources, the footprint that people have put on the Earth is now so large and so deep that we are overwhelming the capacity of our natural life support system to cope. (Ontario Biodiversity Strategy, 2005)

Biodiversity is the variety of life on Earth, from microbes to mammals: everything is interconnected. This diversity is essential for life as we know it, providing ecological, economic, social, cultural and intrinsic value. Rapid changes caused by human activity are threatening the resiliency of our natural ecosystems:

- reduced genetic variability within species, which can reduce the ability of organisms to survive environmental changes;
- decreased capacity of the environment to produce oxygen/ remove carbon dioxide from the air, store and recycle water, and regenerate the soil;
- reduced potential for medical and other discoveries in the natural world that would benefit humankind;
- decreased economic benefit from agriculture, fisheries, forestry, tourism and recreation; and
- reduced aesthetic value of our natural world.

Invading species are considered by many experts to be one of the greatest threats to Ontario's biodiversity. Originating from other regions of the world or outside of their present or historic range, these species have the potential to reproduce at a rapid rate and take over a habitat. Species can be introduced through natural pathways, such as wind, water currents or migration, and through human-assisted pathways, including ballast water, aquarium release, and improper cleaning of boats and equipment. Invading species alter biodiversity, for example through:

- the loss of native species as they are pushed out by invaders;
- deterioration and changes in habitat that, in turn, effect the survival of species;
- loss of genetic variation in species as invaders take over.

The changes to biodiversity that are caused by invading species further impact our economy, human communities and even human health. Every Ontarian has an important stewardship role to play to maintain the biodiversity of our province. This curriculum resource provides engaging warm up/wrap up activities and lesson plans that encourage students to explore concepts of biodiversity, and investigate the impact of invading species on biodiversity in an Ontario context. But, knowing is not enough: students need to be empowered to create change. Activities included in the resource have been designed to provide concrete opportunities for students to make a difference in their community.

To view the most current update on the status of Ontario's biodiversity visit the link below:

www.ontariobiodiversitycouncil.ca

Invasive Species: A Biodiversity Challenge! addresses the fundamental concepts of the revised (2007) Grade 6 *Ontario Science and Technology Curriculum - Life Systems* strand: systems and interactions, and sustainability and stewardship.

Integrated, interactive activities and lessons that are included in the resource cover overall and specific curriculum expectations and support the "big ideas":

1. *Biodiversity includes diversity of individuals, species, and ecosystems.*
2. *Classificiation of the components within a diverse system is a beginning point for understanding the relationships among the components.*
3. *Because all living things are connected, maintaining diversity is critical to the health of the planet.*
4. *Humans make choices that can have an impact on biodiversity.*

This teaching aid has been created for the **Invading Species Awareness Program –** a joint project of the *Ontario Federation of Anglers and Hunters* and the *Ontario Ministry of Natural Resources*.

Launched in 1992, the **Invading Species Awareness Program** is designed to address threats from exotic invading species. This initiative aims to:

- Raise public awareness of invasive species and encourage public participation in preventing their spread.
- Monitor and track the spread of invading species in Ontario through citizen reports to the Invading Species Hotline and the Invading Species Watch program.
- Conduct research on the impacts of invasive species and investigate methods of control.

The **Invading Species Awareness Program**'s ability to effectively track, monitor and control invading species relies directly on public awareness and action. Without the concern, dedication and voluntary participation from the public, this conservation program would not be the success that it is. ***Invasive Species: A Biodiversity Challenge!*** will help you understand the impacts of invasive species on habitats and ecosystems, and provide tools and strategies for you, your students and their families to help stop the spread of invasive species.

For more information:
visit www.invadingspecies.com,
email info@invadingspecies.com
or call 1-800-563-7711.

ONTARIO'S INVADING SPECIES AWARENESS PROGRAM

ONTARIO FEDERATION OF ANGLERS AND HUNTERS · Ontario · ONTARIO WILDLIFE FOUNDATION · Canada

OVERVIEW

Introduction to Invasive Species:

A Biodiversity Challenge!

All of the Earth's inhabitants, from mammals and plants to microbes and fungi, are interconnected and essential for human survival. However, these creatures are often threatened by human actions that threaten their survival. Pollution, overconsumption of resources, the spread of invasive species, climate change and habitat loss all threaten biodiversity.

Through *Invasive Species: A Biodiversity Challenge!*Grade 6 students develop their understanding of concepts related to biodiversity, and demonstrate how their personal choices and actions influence biodiversity in their world.

Invasive Species: A Biodiversity Challenge! Has been designed to meet the revised (2007) Ontario *Science and Technology Curriculum – Life Systems* strand expectations. Lessons are integrated and warm-up/wrap-up activities reach across many other subject areas. Subjects and strands included are:

Subject	Strand
Science and Technology	• *Life Systems*
Social Studies	• *Canada and World Connections*
Language	• *Reading / Oral Commuication* • *Media Literacy*
Health & Physical Education	• *Active Participation*
The Arts	• *Drama* • *Visual Arts*
Mathematics	• *Number Sense and Numeration*

TEACHING KIT OBJECTIVES

Invasive Species:

A Biodiversity Challenge!

will:

1. Meet curriculum expectations through lessons developed with constructivist and experiential teaching philosophies in mind – allowing students a deeper understanding of biodiversity and greater ownership over the knowledge they are gaining.

2. Teach science concepts through integrated activities, and differentiated instruction to accommodate varied learning styles and multiple intelligences.

3. Provide opportunities for integration among curricula by combining learning various subject areas within one lesson, giving students "real life" learning opportunities.

4. Enable students to understand new concepts by making connections to previous experience and to the world around them.

5. Provide teachers with easy-to-use lesson plans and activities that are flexible, and use readily available and inexpensive materials.

LEARNING GOALS

Through the lessons and activities in this kit, students will gain:

KNOWLEDGE BY…

- Exploring concepts of biodiversity, systems, interactions, sustainability and stewardship;
- Determining what an invasive species is and exploring the characteristics of various invading species;
- Exploring the classification of components of a system and understand the interrelationships within the system;
- Determining major threats to biodiversity, including the role of humans in introducing invasive species;
- Participating in environmental stewardship as it relates to invasive species; and
- Exploring ways to involve their community in invasive species stewardship behaviours.

ENDURING UNDERSTANDING BY…

- Investigating concepts related to **biodiversity**;
- Recognizing our role in maintaining healthy habitats and communities (**stewardship**); and
- Exploring tools for maintaining healthy habitats and communities, and protecting against the spread of invasive species (**action**).

Curriculum Expectations – Quick Reference

The following table provides "expectations at a glance" for the Ontario Grade 6 Science and Technology Curriculum. This will enable you to determine how *Invasive Species: A Biodiversity Challenge!* fits into your planning.

Subject Area/Strand							
WARM-UP/WRAP-UP ACTIVITIES							
Activity	**Enduring Understandings**	**Science**	**Math**	**Social Studies**	**Language**	**Physical Education**	**The Arts**
BioScape	Biodiversity Stewardship	✓			✓		✓
Invading Characters	Biodiversity	✓			✓		
Where Do You Stand?	Biodiversity Action	✓					
More Than A Million	Biodiversity	✓	✓				
Biodiveristy Name Game	Biodiversity	✓			✓	✓	
Invader Stretches	Biodiversity	✓				✓	
Tangled Web	Biodiversity Stewardship	✓					
A World of Products	Biodiversity	✓					
LESSONS							
Sea Lamprey Suck	Biodiversity	✓				✓	
Graffiti Gallery	Biodiversity Stewardship Action	✓			✓		✓
Invader Web Quest	Biodiversity Stewardship Action	✓		✓	✓		
Surprise Hitchhikers	Biodiversity Stewardship Action	✓					
Biodiversity Give and Take	Biodiversity Stewardship Action	✓					
Ballast Water Debate	Biodiversity Stewardship	✓		✓	✓		
Invader Takeover	Biodiversity	✓				✓	
Seeking Invaders	Biodiversity	✓					
Spread the Word, Not the Invaders	Biodiversity Stewardship Action	✓		✓	✓		✓
Diversity Jeopardy	Biodiversity	✓		✓	✓		

SCIENCE and TECHNOLOGY Curriculum Expectations (2007 Document)

Expectation		Warm Up/Lesson
OVERALL EXPECTATIONS:		
1.	Assess human impacts on biodiversity, and identify ways of preserving biodiversity.	W2, W7, W8, L4, L9
2.	Investigate the characteristics of living things, and classify diverse organisms according to specific characteristics.	W1, L8
3.	Demonstrate an understanding of biodiversity, its contributions to the stability of natural systems, and its benefits to humans.	W2, W7, W8, L2, L5
SPECIFIC EXPECTATIONS		
1.	**Relating Science and Technology to Society and the Environment**	
1.1	Analyse a local issue related to biodiversity, taking different points of view into consideration, propose action that can be taken to preserve biodiversity, and act on the proposal.	W3, L1, L3, L4, L6, L8, L9
1.2	Assess the benefits that human societies derive from biodiversity and the problems that occur when biodiversity is diminished.	W2, W7, W8, L3
2.	**Developing Investigation and Communication Skills**	
2.1	Follow established safety procedures for out-door activities and field work.	W1, L8
2.2	Investigate the organisms found in a specific habitat and classify them according to a classification system.	W1, L8
2.3	Use scientific inquiry/research skills (page 15) to compare the characteristics of organisms within the plant or animal kingdom.	L3

2.4	Use appropriate science and technology vocabulary, including classification, biodiversity, natural community, interrelationships, vertebrate, invertebrate, stability, characteristics, and organism, in oral and written communication.	ALL
2.5	Use a variety of forms (e.g., oral, written, graphic, multimedia) to communicate with different audiences and for a variety of purposes.	W1, W3, W7, L2, L3, L5, L6, L9
3.	**Understanding Basic Concepts**	
3.1	Identify and describe the distinguishing characteristics of different groups of plants and animals, and use these characteristics to further classify various kinds of plants and animals.	W1, L8
3.2	Demonstrate an understanding of biodiversity as the variety of life on earth, including variety within each species of plant and animal, among species of plants and animals in communities, and among communities and the physical landscapes that support them.	W2, W7, W8, L2, L5
3.3	Describe ways in which biodiversity within species is important for maintaining the resilience of those species.	W2
4.4	Describe ways in which biodiversity within and between communities is important for maintaining the resilience of these communities.	W2
3.5	Describe interrelationships within species, between species, and between species and their environment, and explain how these interrelationships sustain biodiversity.	W1, W2, W7, L7
3.6	Identify everyday products that come from a diversity of organisms.	W8
3.7	Explain how invasive species reduce biodiversity in local environments.	W2, W7, L3, L5, L7, L9

THE ARTS Curriculum Expectations (2009 document)

Expectation	Warm Up/Lesson
D 1.1 Create two-dimensional, three-dimensional, and multimedia art works that explore feelings, ideas, and issues from a variety of points of view	ALL
Note: Drama expectations may be met if the teacher chooses to extend W1 (*Bioscape*) to include a tableau strategy.	

HEALTH and PHYSICAL EDUCATION Curriculum Expectations (2010 document)

Expectation	Warm Up/Lesson
B 1.1 Perform smooth transfers of weight in relation to others and equipment in a variety if situations involving static and dynamic balance	W6
B1.2 Perform a wide variety of locomotor movements, in combination, at different speeds, in different directions, and using different pathways, while moving around others and/or equipment	W5, L1
B 2.3 Apply a variety of tactical solutions to increase their chances of success as they participate in physical activities	W5, W7

LANGUAGE ARTS Curriculum Expectations (2006 document)

Expectation	Warm Up/Lesson
ORAL COMMUNICATION	
1.2 Demonstrate an understanding of appropriate listening behaviour by adapting active listening strategies to suit a variety of situations, including work in groups.	ALL
1.6 Extend understanding of oral texts by connecting, comparing, and contrasting the ideas in them to their own knowledge, experience and insights; to other familiar texts, including print and visual texts; and to the world around them.	W3

2.3	Communicate orally in a clear, coherent manner, using appropriate organizing strategies and formats to link and sequence ideas and information.	W8, L3, L6
READING		
1.2	Identify a variety of purposes for reading and choose reading materials appropriate for those purposes.	W2, L3, L5, L6
1.3	Identify a variety of reading comprehension strategies and use them appropriately before, during and after reading to understand increasingly complex texts.	W2, L1, L3, L5
1.4	Demonstrate understanding of increasingly complex texts by summarizing and explaining important ideas and citing relevant supporting details.	W7, L1, L3, L4, L5, L6
1.8	Make judgments and draw conclusions about ideas in texts and cite stated or implied evidence from the text to support their views.	L3, L6
WRITING		
1.2	Generate ideas about a potential topic and identify those most appropriate for the purpose.	W7
1.3	Gather information to support ideas for writing, using a variety of strategies and a range of print and electronic resources.	L3
3.1	Spell familiar words correctly	W3, W7, L2, L3, L5, L6, L9, L10
3.2	Spell unfamiliar words using a variety of strategies that involve understanding sound-symbol relationships, word structures, word meanings, and generalizations about spelling.	W3, W7, L2, L3, L5, L6, L9, L10
3.3	Confirm spellings and word meanings or word choice using a variety of resources appropriate for the purpose.	W3, W7, L2, L3, L5, L6, L9, L10
3.4	Produce a variety of media texts for specific purposes and audiences, using appropriate forms, conventions and techniques.	L9

MATHEMATICS Curriculum Expectations (2005 document)

Expectation	Warm Up/Lesson
Number Sense and Numeration	
Represent, compare, and order whole numbers and decimal numbers from 0.001 to 1 000 000, using a variety of tools.	W4
Demonstrate an understanding of place value in whole numbers and decimal numbers from 0.001 to 1 000 000, using a variety of tools and strategies	W4

SOCIAL STUDIES Curriculum Expectations (2004 document)

Expectation	Warm Up/Lesson
Canada and World Connections: Canada's Links to the World	
Identify some countries with which Canada has links.	W8
Use a variety of primary and secondary sources to locate and process relevant information about Canada's links with the world	L3, L6
Describe some influence of other countries on contemporary Canadian society and the lifestyles of Canadians	L3, L6
Use base maps and a variety of information sources to sketch the relative position of places.	L3

Lesson Overview - Quick Reference
WARM-UP/WRAP-UP ACTIVITIES

Title	Description	Materials	Group Size
Bioscape	Through observation and a visual arts activity, students will have the opportunity to think about and recognize the diversity of life around them. An optional drama extension is included.	Paper/pencil, 11 x 17" paper	Individual/ Small group

Invading Characters	Students gain understanding of the concept of "invaders" through a language-based activity where letters in a paragraph are replaced by typographical characters.	**BLM 1, 2 & 3:** *Invading Characters Overheads*	Class/Pairs
Where Do You Stand?	Students respond to a statement about controlling invasive species, both at the beginning of the unit, and after exploring issues related to invasive species and biodiversity.	Masking tape, Permanent marker	Whole class
More Than A Million	There are between 1.5 million and 1.8 million identified species on Earth. This math activity will help students develop an understanding of "how much" those numbers really mean by giving them a chance to work with large values.	**BLM 4:** *More Than A Million Place Value Chart Overhead,* Unopened packages of photocopy paper, Pedometer	Pairs
Biodiversity Name Game	Students participate in a vigorous physical activity to collect "letters" for their team to spell the names of invading species, integrating science and language expectations.	Package of 1000 Popsicle Sticks, *Biodiversity Name Game Word List, Template for Lettering Popsicle Sticks,* Flip chart paper, Masking tape	Small group
Invader Stretches	Miming the characteristics of invading species helps students learn about their unique traits.	**BLM 7:** *Invader Stretches Call Out List*	Whole class
Tangled Web	Students work cooperatively to create a physical web that illustrates interactions within an ecosystem and the impact that invading species can have.	Flipchart paper/pen, Large ball of yarn, **BLM 8:** *Tangled Web Script* **BLM 9:** Tangled Web Role Cards	Whole class
A World of Products	If we continue to lose biodiversity, the wide range of products that we take for granted may not be available. Students record their use of everyday products that come from a diversity of organisms, to realize how dependent we are on biodiversity.	**BLM 10:** *A World of Products Recording Form,* Opaque bag (e.g. cloth gift bag), Variety of incidental items	Individual

LESSONS

Title	Description	Materials	Assessment Opportunities	Group Size
Sea Lamprey Suck!	Students learn about sea lamprey using kinesthetic learning strategies to complete an activity circuit.	**BLM 11:** *Background Information - Sea Lamprey,* **BLM 12:** *Sea Lamprey Suck! Activity Cards,* Gym equipment (specified on cards), Sea Lamprey Pamphlet from Resources Section, Sea Lamprey video clip from the videoSection	Observation Anecdotal Notes	Small groups
Graffiti Gallery	Working in small groups, students draw and briefly state their understanding and prior knowledge of key terms for the unit.	Flipchart paper, coloured markers, dictionary, masking tape, construction paper	Observation Anecdotal Notes Journal entry	Small groups
Invader Web Quest	Using a jigsaw strategy, students will follow an internet quest to research a given invading species.	Internet, **BLM 13:** Why Is Biodiversity So Important?, **BLM 14:** *Invasive Species Web Quest,* **BLM 15:** *Rap Sheets* for various invading species, **BLM 16:** *Master Copy* – Completed Rap Sheets for each invasive species studied	Observation Anecdotal Notes Rubric for newspaper article	Pairs

Surprise Hitchhikers	In this desktop simulation, students see first-hand how invading species are spread.	*Give One, Get One,* milk cartons, clear plastic cups, blue and red food colouring, water, DVD clip (Recreational Boating – 2 minutes), flip chart or overhead/pen, **BLM 18:** *How Do They Get Here? Invasive Species Pathways* * DVD clip can be found on the "Invaders in Our Waters" DVD	Observation Anecdotal Notes Peer Evaluation	Individual
Biodiversity Give and Take	Students gain and lose tokens as they explore factors that impact biodiversity.	Colour counters, Playing cards, **BLM 19:** *Threats to Biodiversity*, **BLM 20:** *Biodiversity Give and Take Game Sheet*, Sticky Notes	Journal Entry	Small groups
Ballast Water Debate	Ballast water is a major pathway for the introduction of invasive species into the Great Lakes, with subsequent impact on biodiversity in the Great Lakes as well as inland waterways. Students will consider the point of view of various stakeholders, and debate issues related to ballast water control.	**BLM 21:** *Background Information: Ballast Water*, **BLM 22:** *Stakeholder Position Cards*, DVD clip (Invaders In Our Waters – 7 minutes) * DVD clip can be found on the "Invaders in Our Waters" DVD	Observation Anecdotal Notes	Small groups, Whole class
Invader Takeover	In this tag game, students will see how an invasive species can take over native species through competition and predation.	**BLM 23:** *Invader Take Over,* DVD Clip (Round Goby), coloured clothespins * DVD clip can be found on the "Invaders in Our Waters" DVD	Observation Anecdotal Notes	Whole class

Seeking Invaders	Students complete a field study to look for native and non-native species, and participate in an invasive species watch program.	Internet, outdoor location, **BLM 24:** *Seeking Invaders Observation Form*	Observation Form Journal entry	Individual
Spread the Word, Not the Invaders	We all need to be stewards of Ontario's biodiversity. Students use arts and language-based strategies to promote stewardship within their school community.	Various art materials, **BLM 25:** *Peer Evaluation*	Rubric for Presentation/ Product Peer evaluation Portfolio	Small groups
Diversity Jeopardy	Using a trivia game format, students demonstrate their understanding of concepts related to biodiversity and invading species by creating trivia game questions (and answers!), and playing the game.	Internet, **BLM 26:** *Diversity Jeopardy Starter Deck Cards*, Index cards	Rubric for written work Observation Anecdotal Notes	Individual/ Whole class

WARM-UP / WRAP-UP ACTIVITIES

• ● Bioscape ● •

PURPOSE: *Through observation and a visual arts activity, students will identify and represent the diversity of life around them in the schoolyard. "Bioscape" provides a context for thinking about biodiversity, and is an introductory activity to the warm ups and lessons that follow. An optional drama extension is included.*

TIME:

15 minutes minimum

MATERIALS:

11" x 17" plain paper (one sheet for each student), Pencils

PROCEDURE:

1. Choose an outdoor location where students will have room to spread out.
2. Give each student a blank piece of 11" x 17" paper and pencil. Students mark an X in the middle of their paper to represent where they are sitting and sit quietly for 5-10 minutes drawing what they are able to see and hear, and where it is in relation to them. Encourage students to look closely, and to look big. Instruct students to use pictures and vivid words to record what they see and hear.
3. In small groups of four to six, ask students to share what they recorded on their paper. What is the same? What is different? Do people in your group feel differently about the same observations?
4. Conclude with a discussion about the diversity of life that students recorded during this observation exercise.
5. Add student drawings to their portfolio (See L1 – Graffiti Gallery).

EXTENSION:

1. Drama: Continuing in their small groups, students create a tableau to illustrate their findings to the class. What did they see? How did they feel?

   A tableau is a still image, a frozen moment or "a photograph". It is created by posing still bodies and communicates a living representation of an event, an idea or a feeling. To make it interesting, use shapes and expressions that are very dramatic, or bigger than life, exaggerated, and very dynamic (lots of energy). The expressive qualities you use are key to making a successful tableau. Everyone in the tableau has to be arranged so that the audience understands what the picture is about. A tableau should have shapes at different levels. It should have width and depth. The focus of participant's eyes or body helps to direct the audience to know where to look.

Suggested drama links:

http://kentaylor.co.uk/die/DramaUKFileArchive/home/sow_files/Intro_to_drama.doc

http://www.prel.org/eslstrategies/drama.html

2. Visual Arts: Students use their observation sheet to create a collage or origami sculpture to represent their observations. Encourage students to use found materials in nature or recycled materials to create their collage or sculpture.

Adapted with permission from Alberta-Pacific Forest Industries Inc. (AlPac):

http://www.alpac.ca/content/files/Open%20and%20Closers.pdf

• ● Invading Characters ● •

PURPOSE: *Students are challenged to read a paragraph about biodiversity with progressively more letters replaced with typographical characters in each version. The activity illustrates how an ecosystem (represented by the paragraph) can be disturbed by invaders (represented by characters), and introduces concepts of native species and biodiversity. Use this activity as a warm up for Lesson 1: Graffiti Gallery.*

TIME:

20 minutes

MATERIALS:

Flipchart/pen, Overhead projector, **BLM 1, 2 & 3:** Invading Characters #1, #2, #3 (copied on to overhead slides)

PROCEDURE:

1. Make a Biodiversity KWL chart. As a class fill in the K (prior knowledge) and W (want to know) columns. Post the chart for students to see as they complete the "*Invading Characters*" activity.
2. Ask for three volunteers who are comfortable reading aloud and ready for a challenge.
3. Put the first overhead slide up and explain that each letter in the paragraph represents a species in an ecosystem. Biodiversity is the variety of life on Earth; invading species threaten biodiversity by out-competing native species. Ask volunteer #1 to read the paragraph aloud, then have the whole class read it aloud.
4. With their elbow partner, have students use Think-Pair-Share to talk about what the paragraph means to them.

- What do we mean by "natural controls"? (e.g., climate)
- What could some of the devastating effects be?

5. Put up slide #2 and ask volunteer #2 to read it aloud, followed by the whole class reading aloud. Ask students:

- What is different about this slide?
- Who are the invaders?
  (It is the same paragraph with # added after every "a" and * added before every "d" throughout).

- How did the invaders affect your ability to read the paragraph?
  (Adding just two symbols (# and *) really changes the paragraph. Unfortunately, invading species don't just confuse an ecosystem by adding to it. They compete with other species for limited resources such as nutrients, space, sunlight, and clean water. Invading species often have no natural predators or controls so they are able to consume more resources and produce more offspring than native species. Before long, the native species disappear from the ecosystem.)

6. Put up slide #3 and ask volunteer #3 to read it aloud, followed by the whole class.

- Using Think-Pair-Share, ask students what is different about this slide? Try to find the pattern. What might be going on to allow this to happen?
  (The invading characters are doubled because the conditions are just right for them; the letters "c" and "e" are deleted throughout because the invaders have the same needs and have displaced them.)
- How do the changes represent what happens in nature?
  (Invaders can take over and push out native species. The paragraph illustrates how loss of diversity creates change (ie. the look of the paragraph is changed which makes it difficult to read).

7. Return to the KWL chart from step 1. As a class complete the "L" (learned) column and note any subsequent questions to be explored throughout the unit.

TRY THIS IDEA ...

Instead of using the overhead projector, print the paragraphs on large posters to use in a gallery walk around the classroom or use a smart board.

EXTENSION

Have students use the information they have on biodiversity up to this point to create their own paragraph; share student-written paragraphs in small groups or with the whole class.

Provide new text in an already invaded format, showing how difficult it is to put things right when the reader is unsure of the original text.

Adapted with permission from Hilltop Garden & Nature Centre:

http://www.indiana.edu/~tandlpub/story.php?story_id=39

Invading Characters
Overhead #1

Biodiversity is the variety of life on earth, from microbes to plants and animals. Invading species are one of the greatest threats to the biodiversity of Ontario's waters, wetlands, and woodlands. Coming from other regions of the world, and without their natural predators and controls, invading species affect biodiversity by taking over habitats and ecosystems, and reducing the numbers of native species.

Invading Characters
Overhead #2

Bio*diversity is the va#riety of life on ea#rth, from microbes to pla#nts an*d a#nima#ls. Inva#*ding species a#re one of the grea#test thre#ats to the bio*diversity of Onta#rio's wa#ters, wetla#n*ds, a#n*d woo*dla#n*ds. Coming from other regions of the worl*d, a#n*d without their na#tura#l pre*da#tors a#n*d controls, inva#*ding species a#ffect bio*diversity by ta#king over ha#bita#ts a#n*d ecosystems, a#n*d re*ducing the numbers of na#tive species.

Invading Characters
Overhead #3

Bio**divrsity is th va##rity of lif on a##rth, from mirobs to pla##nts an*d a##nima##ls. Inva##**ding spis a##r on of th gra##tst thr##ats to th bio**divrsity of Onta##rio's wa##trs, wtla##n**ds, a##n**d woo**dla##n**ds. Oming from othr rgions of th worl**d, a##n**d without thir na##tura##l pr**da##tors a##n**d ontrols, inva##**ding spis a##fft bio**divrsity by ta##king ovr ha##bita##ts a##n**d osystms, a##n**d r**duing th numbrs of na##tiv spis.

• ● Where Do You Stand? ● •

PURPOSE: *Students respond to a statement about controlling invasive species, both at the beginning of the unit, and after exploring issues related to invasive species and biodiversity.*

SUGGESTIONS:

This activity would be appropriate to do after students have developed a basic knowledge of biodiversity and invading species. Use *Where Do You Stand* as a warm up to Lesson 2: *Invader Web Quest*.

Repeat the activity at **end** of the unit to assess changes in student thinking.

TIME:

30 Minutes

MATERIALS:

"All About Biodiversity" (See page 111), Wide painter's tape or masking tape, Permanent marker

PROCEDURE:

1. Read "All About Biodiversity" aloud with students.
2. Clear a floor space and lay down a strip of tape that is at least twelve feet (3.7m) long. Use a marker and write "DO NOTHING" on one end of the tape, and "DESTROY INVADERS" at the other end.
3. As a whole class, work through the following scenario:

- Tell students that goldfish are an invading species. Sometimes aquarium fish, such as goldfish, grow too big and their owner can no longer keep them. The owner must decide what to do with the fish.
- Ask students to think about what the two extreme positions on the action line could be in this situation. (e.g., Kill the goldfish versus let it go in a body of water).
- What are considerations for each action? (e.g., Killing the fish takes care of the problem of the fish not fitting the aquarium but there is an ethical issue of taking the life of a living creature. Releasing the goldfish in a body of water also provides a solution to the problem, but can cause disruption to other fish species in the habitat, and may introduce diseases.)
- Brainstorm several median positions on the action line (e.g., Buy a bigger aquarium and move the fish; take the fish to a pet store and have them keep it; search for a new owner for the fish).

4. Explain that invading species, such as sea lamprey and purple loosestrife, are a difficult problem. Some people believe that we should leave them alone. Destroying invading species would take years and cost billions of dollars — money that could be spent on other important things.

   Another point of view is that invading species should be left alone because they add to biodiversity; for example, some people think of purple loosestrife as a beautiful and valued garden plant.

   Other people think that invading species should be destroyed because they change habitats and ecosystems. They can cause extinctions or declines of native species and impact fishery and recreation industries, agriculture and forestry, for example.

5. Give students one minute to think about what they know right now, and what they believe is important. At the end of one minute, ask them to move to stand on the tape line in the place that represents their thinking about invasive species. Students take a pen or pencil with them to write their name on the tape where they are standing.
6. Ask students in different positions on the line to briefly explain why they chose that location. (Students may choose median positions along the value line that represent options other than the two extremes. Median positions could include actions such as banning the sale of invasive species (e.g., fish and plants) and restricting the movement of invasive species.)
7. Lift the tape from the floor and anchor it in the classroom where it can be seen during the unit.

REPEAT THE ACTION LINE ACTIVITY AFTER ALL LESSONS HAVE BEEN COMPLETED:

8. At the end of the unit, lay down another piece of labeled tape on the floor. Repeat steps 4 to 6.
9. Ask students if their position on the action line changed compared to the previous action line activity at the start of this unit. Why or why not? Discuss as a class.
10. At the end of the activity, have students respond to prompts in their writing journal:
    - I learned that biodiversity is …
    - Invading species affect us because they …
    - One action that I will take to prevent the spread of invading species is …
11. Add the journal entry to the student portfolio (See L1 – Graffiti Gallery)

• ● More Than A Million ● •

PURPOSE: *More than 180 non-indigenous species have been identified in the Great Lakes basin area of Ontario. There are more than 1.5 million identified species on Earth. What do the numbers mean? In this math activity students will explore the large numbers relating to biodiversity and invading species.*

SUGGESTION:

Use *More Than A Million* as a warm up before using Lesson 7: *Seeking Invaders*.

TIME:

30 minutes

MATERIALS:

BLM 4: More Than A Million Place Value Chart, One package of unopened copy paper (500 sheets) for each group of 3-4 students, Pedometer

PROCEDURE:

1. Ask students to predict how many identified non-indigenous species there are in the Great Lakes. (Approximately 180). Ask students to predict how many identified species there are on Earth. (More than 1.5 million) What is another way of saying 1.5 million? (1 500 000).
2. Invite students to write the numbers 3 000 000 1 500 000 1 800 000 1 000 000 750 000 140 000 30 000 800 534 182 180 in a place value chart using **BLM 4:** More Than A Million.

   Point out to students that small numbers can have big impacts! The identified 180 non-indigenous species in Ontario may be a small number compared to the estimated 30 000 species in Ontario, but the impact of a small number of invasive species on our province's biodiversity is huge. Discuss other numbers in this lesson that may seem small but have big impacts.
3. Divide students into small groups.

4. Give each group a package of unopened copy paper (500 sheets per package). Ask students to solve the following problem:

   If they were to write the name of each of the 180 non-native species identified in Ontario on a separate piece of paper, approximately how high would the stack of paper be in centimeters? As a class, arrive at a consensus answer.

   Answer: Measure the height of 500 sheets of paper (unopened) in centimetres. Multiply the height of 500 sheets of paper by 180 and divide by 500.

   If they were to write the name of each of the known 30 000 species that are now in Ontario on a separate sheet of paper, how high would the stack be in kilometres?

   Answer: Multiply the height of 500 sheets of paper by 30 000 and divide by 500. Convert centimetres to kilometres.

5. Use a pedometer and take a class walk over the calculated distance in kilometres.

EXTENSION:

It is estimated that there may be up to 118 million species on Earth (including those not yet discovered). Calculate the height of a stack of paper if the name of each of the 118 million estimated species were written on a single sheet.

Adapted From: (Adapted from Illinois Biodiversity Basics)

References for Statistics Cited:

There are between1.5 and 1.8 million identified species on Earth.
An estimated 750 000 of the identified species on Earth are insects.
There are an estimated 140 000 species in Canada; only 70 000 have been identified.
http://canadianbiodiversity.mcgill.ca/english/species/index.htm

There are more than 30 000 known species in Ontario.
http://www.mnr.gov.on.ca/en/Newsroom/LatestNews/MNR_E004225.html

There are an estimated 800 exotic plant species in Canada.
http://canadianbiodiversity.mcgill.ca/english/species/index.htm

There are 534 species at risk in Canada; 182 of these are in Ontario.
http://www.on.ec.gc.ca/wildlife/factsheets/fs_sar_act-e.html

There are over 180 identified non-native species in the Great Lakes.
http://www.mnr.gov.on.ca/en/Newsroom/LatestNews/MNR_E004031.html

One zebra mussel can produce up to 1 000 000 eggs each year.
http://www.invadingspecies.com/Invaders.cfm?A=Page&PID=1

One purple loosestrife plant can produce up to 3 000 000 seeds per year.
http://www.purpleloosestrife.org/faq/index.html

There are a total of 448 Invasive plant species in Canada; 98% or 441 of those plant species can b found in Ontario alone!
Invasive Alien Plants in Canada – Summary Report Canadian Food Inspection Agency ©2008

More Than A Million Place Value Chart

- There are between 1 500 000 and 1 800 000 identified species on Earth.
- An estimated 750 000 of the identified species on Earth are insects.
- There are an estimated 140 000 species in Canada; only 70 000 have been identified.
- There are over 30 000 known species in Ontario.
- An estimated 800 plant species in Canada are exotic species.
- As of January 2007, there were 534 species at risk in Canada. Ontario is home to 182 of these species, the highest percentage of species at risk among the provinces.
- There are over 180 identified non-native species in the Great Lakes.
- One purple loosestrife plant can produce up to 3 000 000 seeds per year.
- One zebra mussel can produce up to 1 000 000 eggs each year.

Write these numbers in the place value chart:

3 000 000 1 500 000 1 800 000 1 000 000 750 000 140 000 70 000 30 000 800 534 273 182 180

Number	Millions			Thousands			Units		
	H	T	O	H	T	O	Hundreds	Tens	Ones

In your notebook, write each number in: standard form, expanded form and number word form.

• ● Biodiversity Name Game ● •

PURPOSE: *Students learn science vocabulary by racing to collect letter tiles to accurately spell a word list. The game can be played in the gym or on the schoolyard.*

TIME:

Minimum 15 minutes

MATERIALS:

Package of 1000 Popsicle Sticks, **BLM 6:** Template for Lettering Popsicle Sticks, **BLM 5:** Biodiversity Name Game Word List, Flip chart paper, Masking tape

PROCEDURE:

1. Use **BLM 6:** Template for Lettering Popsicle Sticks to write a single letter on each popsicle stick.
2. Divide students into teams of 4-5 members.
3. Post a sheet of flip chart paper with the Word List written on it; give each team a printed copy of **BLM 5:** BIODIVERSITY NAME GAME WORD LIST.
4. On a signal, students run laps of the gym or schoolyard, each collecting a popsicle stick from the teacher as every lap is completed (Popsicle sticks are distributed randomly).
5. At five minute intervals, the teacher signals a "team huddle" where students pool their popsicle sticks to make as many words on the word list as possible. Each group reports the words they are able to spell. On the flipchart Word List, the teacher gives one point for each word spelled. Bonus points are given if the team can give a correct definition for a word. Students continue running laps to collect more letters, to spell more words (Allow teams to trade extra letters after a few rounds).
6. The winner is the team with the most points at the end of the time allocated to play the game.

Adapted from:

Words in Motion, Hastings & Prince Edward Board of Education.

Biodiversity Name Game Word List

Each student collects a lettered popsicle stick for each lap completed. On a signal from the teacher, teams meet in a huddle to spell as many words as possible from the list below, using the lettered popsicle sticks collected. Check off each word completed and report to the teacher for points. Earn extra points by providing a definition for the word. The team with the most points at the end of the game is the winner!

Check (√)	**Word List**
	classification
	biodiversity
	natural
	community
	interrelationships
	vertebrate
	invertebrate
	stability
	characteristics
	organism

Template for Lettering Popsicle Sticks

Use a permanent marker to letter popsicle sticks using the following guide.

Letter	Number of Popsicle Sticks to Letter
a	90
b	40
c	50
d	20
e	100
f	10
g	10
h	20
i	110
j	10
k	10
l	40
m	20
n	40
o	50
p	10
q	5
r	80
s	60
t	110
u	20
v	20
w	10
x	10
y	20
z	5

(Leave the remaining sticks blank for "free" letters)

• ● Invader Stretches ● •

PURPOSE: *In this activity students will manipulate their body in space to mimic a named invasive species, helping them to remember characteristics and names.*

TIME:

Variable

MATERIALS:

BLM 7: Invader Stretches Call Out List

PROCEDURE:

1. In the gym or classroom, students try to mimic the creature as the teacher calls the name of different invading species out from a list. A list of suggested actions is included for teacher reference; for example, Zebra mussel – bend over and hold your ankles like a Zebra Mussel.

EXTENSION:

Use as a Physical Education warm-up while studying this unit or as a Daily Physical Activity.

Students can research additional invading species on the internet and add more invaders/actions to the call out list.

Once students are comfortable with the different stretches, divide the class into teams to compete in a relay. Have each team line up; assign each position in the line an invading species to mimic. Once the first person in the team has successfully mimed a zebra mussel, the second person mimes a rusty crayfish, and so on. The first team to finish, wins!

Invader Stretches Call Out List

Zebra mussel

bend over and hold your ankles, only slightly bending your knees to simulate the shape of a mussel shell

Rusty crayfish

lie on the floor, tummy-side down; push upper body off the floor with hands and "walk" using hands and dragging the rest of the body behind

Purple loosestrife

reach hands over head, clasp hands together, stretch as tall as possible to mimic a flower spike

Round Goby

cup hands beside ears to mimic gills, "swim" by darting around a small area

Eurasian Milfoil Weed

stretch arms overhead as high as possible, sway from side to side; shuffle walk closer, and closer together to simulate density of the plant growth

Sea Lamprey

place hands palms together and point arms in front of body; "swim" like a lamprey in the water while making sucking noises

Emerald Ash Borer

pivot on one foot to simulate how the insect bores into wood

Spiny Water Flea

balance on one foot with the other leg raised behind, arms in front moving up and down to "shred" prey

Asian Long Horned Beetle

hold arms above head with fingers extended to mimic antennae

• ● Tangled Web ● •

PURPOSE: *Students work cooperatively to create a physical web that illustrates interactions within an ecosystem and the impact that invading species can have.*

TIME:

20 minutes

LEARNING MATERIALS:

Flipchart paper/pen, Large ball of yarn, **BLM 8:** Tangled Web Script, **BLM 9:** Tangled Web Role Cards, adhesive name tags

PROCEDURE:

1. Make a T-chart on the board or flip chart. Write "Yes" on one side and "No" on the other side. Tell students that you are thinking of a word that is related to biodiversity ("web"). Their job is to figure out what the word is by asking yes or no questions. Record responses on the T-chart. Students use the information on the chart to guide their questioning and their thinking, to guess the mystery word.
2. Give examples of questions to start the activity; for example:

   Is it alive? No

   Is it something found in nature? Yes

   Does it swim? No

   Is it an animal? No

To provide an extra clue, have students unscramble the letters "bew" to spell the word. Talk about how the word "web" is connected to biodiversity.

(Answer: Systems are connected together in an intricate web made up of many diverse parts. Changes in one part may impact the rest of the web.)

3. In the following activity, students will construct a web and see the impact when invading species are introduced.

To play the Tangled Web game:

- Have students stand in a large circle.
- Each student selects a role card from the deck (some may have more than one).
- Give students one adhesive name tag for each role that they have. Ask students to write their role(s) onto their name tag and stick it on their person somewhere that it can easily be seen.
- Tell students that you are going to read a story about the impact of invading species on biodiversity; their job is to create a web, as you read, that shows the connections.
- Hand the ball of yarn to the first character in the story. As you read the **BLM 8:** TANGLED WEB SCRIPT, the first character tosses the ball of yarn to the next character mentioned, who tosses it to the second character and so. Remind students to hold the yarn firmly and taut, to make the web visible.
- As the invading species impacts start to unfold in the story, the affected characters drop their hold on the yarn and collapse the web.

4. At the end of the narrative, talk about the collapse of the yarn web and how this might apply in nature.
5. Have students write a response in their writing journal and add it to their portfolio for this unit (See L1 – Graffiti Gallery).

Tangled Web Script

Imagine that we are standing on the edge of a sparkling lake.

There are a variety of species of trees around the edge of the lake including maple and oak trees; their leaves are gently fluttering in the breeze (lake tosses the yarn ball to a tree; trees toss the ball from one to another).

There's a wetland at one end of the lake, with many cattails growing there. Look closely and you will see a muskrat enjoying a lunch of tasty cattails, and native crayfish in the shallows (tree tosses ball to wetland; wetland tosses to muskrat; muskrat tosses to cattails; cattails toss to native crayfish). There are bass in the lake, and lots of small minnows for the bass to feed on (crayfish tosses to bass; bass to minnows).

Just back from the lake shore there is a trail that weaves through the tall grass. Some people know that there is a big patch of delicious wild strawberries growing just off the trail. The birds and chipmunks love the strawberries too (minnows toss to tall grass; grass to strawberry)!

Here comes a boy, heading to the beach on the lake, carrying a … what is that he is carrying? An aquarium? Oh no, he's dumping gold fish from the aquarium into the lake! That is definitely not a good idea! The Gold fish will eat the plants in the lake, which takes away habitat for other fish. The Gold fish also will stir up sediments in the lake which changes the ecology of the lake. Find a new owner for unwanted aquarium fish or return them to the pet store (minnows drop the yarn).

The lake is a popular bass and walleye fishing spot. A boat is pulling into the boat launch after a long afternoon of fishing. Oh no! It looks like the fish were not biting today. One of the fisherman is emptying rusty crayfish from the bait bucket into the lake! Rusty crayfish push native crayfish to extinction where they are introduced because they out-compete natives for food and habitat, and by mating with native crayfish. Rusty crayfish also eat bass eggs and impact the bass population in the lake (bass drops the yarn). Leftover bait should be discarded on land (not in the water) or taken home and frozen or salted for later use (native crayfish drops the yarn).

The fishermen also did not realize that their boat was carrying zebra mussels from the first lake they fished in today. They have unknowingly invaded the lake with zebra mussels! The zebra mussels filter the water and make it too clear for walleye habitat (walleye drop the yarn).

A girl comes riding along the trail on her bike. She has muddy tires from the last trail she was on … and leaves behind clods of mud AND dog strangling vine seeds that are buried in the mud. It won't be long before the dog strangling vine takes over and there are no more strawberries (strawberry and grass drop the yarn; birds and chipmunk drop the yarn)!

The sun is starting to go down. A group of friends arrive at the beach for a campfire. One of them has brought firewood from home. What they don't know is that there are stowaway Asian Long Horned Beetles in the wood. The fire is lit … and the beetles scurry away looking for a new home. The trees along the lake shore will do just fine (the trees drop the yarn one by one)!

The wind picks up and blows across the water, and scatters purple loosestrife seeds from a flower garden into the wetland. The wetland is the perfect place for purple loosestrife to grow. Within a short period of time the cattails and water lilies will be gone. The muskrat will need to move to another area where there is food available (cattails, lilies and muskrat and wetland drop the yarn in sequence).

It did not take long for the unintentional actions of a few people to have a dramatic impact on the biodiversity of the lake environment.

Tangled Web Role Cards

Lake

Trees

as many as needed to give everyone a role
(maple, poplar, willow)

Wetland

Muskrat

Cattails

Water lily

Native crayfish

Tall grass

Strawberries

Birds

more than one, as needed
to include all students

Chipmunk

Bass

can be more than one fish
if have enough students

Minnows

can be more than one

Zebra Mussels

Walleye

• ● A World of Products ● •

PURPOSE: *Students will record their use of everyday products that come from a diversity of organisms. If we continue to lose biodiversity, the wide range of products that we take for granted may not be available.*

TIME:

30 minutes over two days

MATERIALS X 2:

BLM 10: A World of Products Recording Form, Opaque bag (e.g., cloth gift bag), Variety of incidental items that contain natural ingredients or materials (e.g., toothpaste, cereal bar, dental floss, Kleenex, face cloth, lip balm etc.)

PROCEDURE:

1. Place a variety of everyday products that contain natural ingredients or materials into an opaque bag (e.g., shampoo, toothpaste, cereal bar, dental floss, Kleenex, face cloth etc.).
2. Tell students that there are products in the bag that relate to biodiversity. Their job is to look for the relationship. As you walk around the classroom, invite students to take an item out of the bag and show it to the class. Have students stand together at the front of the class holding their item for all to see.
3. Once all items have been removed from the bag, ask students to explain how the products relate to biodiversity (they are all everyday products that we take for granted, but that come from a diversity of organisms. As we lose biodiversity, the range of products available may decrease).
4. Handout **BLM 10:** A WORLD OF PRODUCTS RECORDING FORM. Students are to record products that they use after school/in one evening and add to their portfolio (See L1 – Graffiti Gallery).

5. Use an Inside/Outside Circle strategy to share the information gathered by students when they completed their "A World of Products Recording Form." Ask the Inside students to describe the products used and the natural ingredients they contain, and describe their response to their research. Are they surprised by the number of products used? Are they surprised by the number of products that depend on a diversity of organisms? Students in the Outside Circle have a turn to report and respond. Shift positions in the circle (so that each student has a new partner). Inside Circle students share information shared by their last Outside Circle partner with their new partner and vice versa.
6. Ask for two or three students to share what their partner told them. Conclude by pointing out the variety of products that come from a diversity of organisms, and our dependence on them. We all have an important role to play to protect biodiversity.

Name: _____

A World of Products Recording Form

Record all of the products containing natural ingredients or materials that you use after school and in the evening (until you go to bed) for one day. Check labels or the Internet to find out what the product is made of and record the information on your sheet.

Product	Ingredients
e.g., Paper towel	Paper from trees

LESSON PLANS

• ● Sea Lamprey Suck! ● •

PURPOSE: *Sea lampreys are an invasive species that have impacted the Great Lakes since the early 1900s. Students will learn about characteristics of sea lampreys, and the interrelationships between this invader and other species, and the lake environment. Activities can be adapted for indoor or outdoor use.*

Duration: Minimum 45 minutes	**Assessment of student learning:** Observation	**Ensuring Inclusion:** Pairing Pictorial instructions for activities
Fit with Bloom's Taxonomy: Knowledge, Comprehension, Application, Evaluation **Fit with Multiple Intelligence:** Naturalistic, Visual/spatial, Interpersonal		
Learning Materials: • **BLM 11:** Background information: Sea Lamprey • **BLM 12:** Sea Lamprey Suck! Activity Cards (Equipment needs for each activity are specified on each card. Enlarge and copy the Activity Cards as posters.) • Smart Board OR Sea Lamprey: The Battle Continues brochure and the Sea Lamprey video clip from the Resources Section.		
Post-Lesson Teacher Reflections:		

LESSON SEQUENCE:

1. Using a smart board, click on: http://www.invadingspecies.com/invaders/fish/sea-lamprey/ for information and a video clip about sea lampreys (Alternatively, use the Sea Lamprey brochure included in the Brochures Section).

For use as a small group activity circuit:

2. Place Activity Card posters around the playing area, along with equipment listed on each card.
3. Divide students into small groups; assign each group a number from 1 to 5 to designate which station they are to start at.
4. On a signal from the teacher, students move to their first station. The teacher signals when it is time to move to the next station (approximately every 5 minutes).

The session is over when students have completed all of the stations.

CLOSURE/CHECK FOR UNDERSTANDING

6. Debrief as a whole class after completing the activity circuit.

Why are sea lampreys a problem (They kill fish and damage sport and commercial fishing

in the Great Lakes. There are few natural predators of sea lamprey to help keep their numbers under control)?

Control measures have been very effective in decreasing the number of sea lamprey in the Great Lakes; by up to 90%.

Ask students for their opinions about using the different control methods in rivers and streams to control sea lamprey populations? Are they a good idea? What are the concerns with each method, and how can they be addressed (e.g. Lampricides are a chemical which must be applied on a regular basis; are there concerns about its environmental effects versus the need to control lamprey populations for the recovery of lake trout populations, as well as recreation/tourism benefits.)

EXTENSION:

Students could investigate development of sea lamprey controls, such as sex pheromones. Visit the Great Lakes Fishery Commission's website at http://www.glfc.org/pubs_out/factsheets.php , for more information.

At the end of the unit, do the circuit again. Challenge students to design their own version of the activity, using information they have learned about invading species and biodiversity.

Background Information: Sea Lamprey (*Petromyzon marinus*)

Sea Lamprey are a primitive eel-like fish native to the Atlantic Ocean. They originally gained access to the Great Lakes via the Erie Canal, and were first observed in Lake Ontario in the 1830's. Although established in Lake Ontario, their spread to the remaining Great Lakes was restricted by Niagara Falls,which acted as a natural barrier. Unfortunately, with the creation of the Welland Canal, which bypassed Niagara Falls, Sea Lamprey were able to invade the rest of the Great Lakes. By 1938 Sea Lamprey could be found in all five of the Great Lakes.

Sea Lamprey migrate up spawning streams each spring to excavate a nest and deposit their eggs. Fertilized eggs hatch roughly two weeks later, and a wormlike larva (ammocoete) emerges and burrows into the bottom of the stream. Feeding on microscopic plant and animal material, lamprey larvae can spend anywhere from 3 to 6 years buried in the substrate before transforming into a parasitic adult. Adult lamprey will then migrate into the Great Lakes where they will spend 1 to 2 years feeding on fish, before returning upstream to spawn, dying shortly after.

Sea Lamprey are a highly specialized parasite, feeding on, and depleting populations of several species of Great Lakes fish, including: lake trout, salmon, rainbow trout (steelhead), whitefish, brown trout, burbot, yellow perch, walleye, catfish, and even sturgeon. When adult lamprey feed they attach to the host fish with their suction mouth, many sharp teeth, and rasping tongue to grind off the scales, skin, and flesh to feed on the fish's blood and bodily fluids. As far as physical characteristics and behaviour go, Sea Lamprey have remained relatively unchanged for the past 350-400 million years!

Sea Lamprey are extremely destructive invaders, a single adult Sea Lamprey will destroy up to 40 lbs (18 kgs) of fish during their adult lifetime (12-20 months), and only one in seven fish attacked by lamprey will survive. If the host fish survives the initial lamprey attack, the open wound left by the lamprey can leave the fish susceptible to infection.

The introduction of the sea lamprey has had an enormous impact on the Great Lakes fishery along with the Canadian and U.S. economies. For example a harvest of 7 million kgs of lake trout prior to the introduction of sea lamprey in the early 1900s was significantly reduced to 136 000kgs by the 1960s. Billions of dollars continue to be lost to the hungry mouths of sea lamprey.

Sea Lamprey populations exploded in the 1940's and 1950's, decimating a once vibrant commercial fishery. Because of the impacts associated with Sea Lamprey, an international agreement was signed between Canada and the United States to form the Great Lakes Fishery Commission in 1955 to study and control Sea Lamprey in the Great Lakes.

Biologists use several techniques to control sea lamprey populations in the Great Lakes. Several types of mechanical and electrical barriers have been built in key locations on streams and rivers leading into the Great Lakes. These barriers allow native fish to migrate upstream but prevent sea lamprey from reaching their spawning habitat. Sterilization programs for male sea lamprey have also reduced the sea lamprey population.

In the tributaries where larval sea lamprey are found, a lampricide is applied in an effort to reduce the number of lamprey before they transform into adults and have the chance to reproduce. TFM (3-trifluoromethyl-4-nitrophenol) is the lampricide currently used. Although it can be costly, this particular lampricide has the ability to kill the lamprey larvae within the stream with little to no impact on other fish or aquatic organisms within the stream. It is registered with

the U.S. Environmental Protection Agency and Health Canada and is not harmful to humans or other mammals at the concentrations it is applied. In areas where TFM has proven to be ineffective, the lampricide granular Bayluscide is used.

Sources:

www.glfc.org/sealamp

www.invadingspecies.com

ROM field guide to freshwater fishes of Ontario

Source: www.glfc.org/sealamp

Sea Lamprey Suck! Activity Cards

Sea Lamprey Suck! Activity 1 – Sea Lamprey Advantage

Note: Activity 1 can be adapted for whole class participation.

Sea Lamprey have few natural predators in the Great Lakes to keep their population in check. Therefore, the lamprey can feed on prey fish with little competition and can cause serious decline in fish populations.

Equipment: scooter boards, pinnies, 2 hockey nets, 1 soft ball
Requires one person to be a Referee

How to Play:

1. Divide into two teams, the Sea Lamprey and the Lake Trout; put on pinnies.
2. Each player gets a scooter board and lines up in front of their team net. The ball is placed on the floor in the centre of the play area.
3. On a signal, players try to score the ball in the other team's net. Lake Trout can use their feet only, no hands; Sea Lamprey can use feet and hands. This gives an advantage to the Sea Lamprey to simulate their advantage in a lake ecosystem.
4. The team with the most points at the end of the playing time is the more successful fish!

Sea Lamprey Suck! Activity 2 – Barrier Challenge

Scientists have come up with different ways to prevent Sea Lamprey from moving to rivers and streams, including setting up barriers like small dams which Sea Lamprey cannot swim over. In this activity, players try to go over a skipping rope that is held at different heights, simulating the challenge that barriers pose to the Sea Lamprey.

Equipment: skipping rope

How to Play:

1. Two players hold the skipping rope taut, starting at ankle height.
2. The remaining players number off into two groups, Sea Lamprey and Atlantic Salmon. Atlantic Salmon can jump; Sea Lamprey can not jump and must keep one hand or foot on the floor at all times.
3. Players must get over the rope any way they can without touching the rope. If they touch it, they must wait for the next round to try again.
4. The rope is held progressively higher for each round of the activity; players are challenged to find a safe way to get over the barrier without touching it (cartwheel, jump etc.).
5. The round is over when every player has touched the rope trying to cross.
6. Change players who are holding the rope and start over.

Sea Lamprey Suck! Activity 3 – Don't Get Trapped!

One way to control Sea Lamprey populations is to trap and remove them from waterways. In this game of dodge frisbee, "Sea Lamprey" try to dodge being "trapped".

Equipment: 10 or more Foam Frisbees

How to Play:

1. Divide into two teams, "Sea Lamprey" and "Managers"; the Sea Lamprey team forms a group in the middle of the play area and the Managers form a circle around them. (Use floor markings for circle if in a gymnasium).
2. On a signal, players try to "trap" players on the opposite team by hitting them below the waist with a frisbee. Players can not cross the circle during play. Once a player is hit, they are "trapped" and out of the game until the next round.
3. Play continues until one player is left.
4. Add more Frisbees to the play as players become familiar with the game.

Variation: If a player successfully makes a specified target (e.g., gets the Frisbee through a basketball hoop or hula hoop), all players who are trapped are freed and can return to the game.

Sea Lamprey Suck! Activity 4 – Vampire Tag

Sea Lamprey attach to various species of fish and suck the blood and fluids from them (like vampires!), killing the host fish after a period of time. The damage to commercial and sport fisheries in the Great Lakes is estimated at $4.5 billion per year.

Equipment: two colours of pinnies, stack of brightly coloured sticky notes

How to Play:

1. Divide into two teams, Sea Lamprey and Sport Fish; put on pinnies.
2. Each Sea Lamprey player gets 10 sticky notes.
3. On a signal, the Sea Lamprey tag as many Sport Fish (on the back or arms) as they can with their sticky notes.
4. Once all sticky notes have been used, players switch roles; reuse sticky notes and play again.
5. Challenge students to think of adaptations to the game: e.g., use a skipping rope to set up a barrier that sea lamprey cannot cross, declare Sport Fish dead when they have 4 sticky notes etc.

Sea Lamprey Suck! Activity 5 – Sea Lamprey Controls

Scientists use a variety of methods to control the spread of Sea Lamprey including constructing barriers, setting traps and using lampricide (a chemical called TFM that specifically kills Sea Lamprey larvae). Controls are expensive to maintain but have been very successful in preventing widespread movement of Sea Lamprey into Ontario rivers and lakes.

Equipment: small parachute
Requires one player to be the "Head Scientist" to read actions.

How to Play:

1. Divide into two groups: Scientists and Sea Lamprey.
2. Sea Lamprey and Scientists hold the edge of the parachute.
3. The Head Scientist (leader) reads out the actions for each Lamprey control:
   Lampricide – Sea Lamprey wriggle on their belly to the other side of the parachute
   Trap – Sea Lamprey crawl on hands and knees, under the parachute, to the other side
   Velocity Barrier – Sea Lamprey crawl backwards to the other side
   Adjustable Barrier – Sea Lamprey run underneath to the other side of the parachute
4. All players lift the parachute as high as they can; Sea Lamprey try to get to the other side using the called for action before the Scientists can bring down the parachute on them.
5. Sea Lamprey players who get "caught" become Scientists.
6. Switch roles and repeat.

• ● GRAFFITI GALLERY ● •

PURPOSE: *In small groups, students are invited to illustrate their ideas about four key concepts: ecosystems, biodiversity resiliency and invading species. Completed graffiti sheets are hung around the classroom and "toured" by all students. This activity allows the teacher to assess prior knowledge, address misinformation and set the stage for future lessons. "Graffiti Gallery" would be a logical follow up activity to the Invading Characters warm up.*

Duration:	**Assessment of student learning:**	**Ensuring Inclusion:**
60 minutes	Completed graffiti sheet Journal to assess communication Observation Anecdotal Notes	Strategic placement in groups Oral response instead of journal entry

Fit with Bloom's Taxonomy: Knowledge, Comprehension
Fit with Multiple Intelligence: Visual/spatial, Interpersonal

Learning Materials:

- Flip chart paper
- Coloured markers
- Masking tape
- Dictionary (one for each group)
- Construction paper

Post-Lesson Teacher Reflections:

LESSON SEQUENCE:

1. Make a T-chart on flipchart paper or an overhead; write "Same" on one side and "Different" on the other.
2. Ask students to raise their hand if they have a dog at home. Ask several students to describe their dog, noting similarities and differences (colour, size, temperament etc)

on the T-chart. After information is recorded on each side of the T-chart point out that the chart shows diversity: all the dogs belong to the same species, but there are many differences between individual dogs.

3. Ask students what they think "biodiversity" might mean?
   Answer: The diversity of all life on Earth, including humans.
4. Explain that students will be graffiti artists who will share their ideas about the meaning of four key concepts: ecosystems, biodiversity, resiliency and invading species (Concepts are explained at the end of this lesson). Students are to talk together in their group to decide how they will illustrate each concept. Completed sheets will be hung in the "art gallery" and toured by the class. Each group will need to assign a spokesperson to explain their graffiti sheet to the rest of the class during the gallery tour.

   At the end of the gallery tour, students will complete a journal entry about the graffiti activity.
5. Divide the class into groups of 4-5 students; for each group, turn desks together to form a hard surface large enough to accommodate a sheet of flipchart paper. Give each group one large piece of paper and set of markers. Divide the paper into four equal sections using a marker.
6. One at a time, write the four concepts on the blackboard or overhead. Students will write the concept in one square on their paper and then illustrate it. Allow 3-5 minutes of discussion for each concept. Students may use a dictionary as needed.
7. Hang the completed graffiti sheets in the classroom. As a class, tour the gallery of sheets and invite the spokesperson from each group to explain their work. Remind students how to be a good audience:
   - Listen
   - Ask relevant questions
   - Show appreciation for the work of others.

   Be sure to clarify any misinformation that is presented by students.
8. Ask students for their ideas about why these four concepts were chosen for this activity?
   Answer: Ecosystems are the interactions between plants, animals, microorganisms and their environment and how they work together; ecosystems need to stay in balance to survive. Resilience is the ability for parts of an ecosystem to adapt to survive change. Invading species are organisms (plant, animal etc.) that move to a new area where there are no natural controls so they can take over and out-compete native species; they change the ecosystem and native species may not be resilient enough to survive the change. Biodiversity refers to the diversity of all life on Earth. The health of our planet depends on each species serving its function.

CLOSURE/CHECK FOR UNDERSTANDING:

9. Following the gallery tour and discussion, students write in their journal to respond to the prompts:
   The information on the graffiti sheets made me think of …
   I was surprised to learn that …
   One thing I wonder about is …
10. Students will assemble a portfolio throughout the unit. Distribute construction paper for students to create a folder to keep pieces of their portfolio together as they work on each task. Students are to add the journal entry from (9) above to their portfolio.

TEACHER NOTE: DEFINITIONS

Ecosystems: Ecosystems are the interactions between plants, animals, microorganisms and their environment and how they work together; ecosystems need to stay in balance to survive.

Resiliency: The capacity to respond to or withstand change. The greater the genetic variability within a population, the greater the potential resiliency.

Invading Species: Invading species are organisms (plant, animal etc.) that move to a new area where there are no natural controls so they can take over and out-compete native species; they change the ecosystem and native species may not be resilient enough to survive the change.

Biodiversity: Biodiversity refers to the diversity of all life on Earth and the connections between all living things.

When an alien species enters an ecosystem, it can have an impact on the species that are present, on important habitats, or even on the ecosystem itself. Concern arises when an alien species changes the system for the worse, either by reducing or eliminating populations of native species, or by otherwise changing the way the ecosystem works.

These changes have made the invasion of alien species a major global problem. If organisms were not able to move beyond their normal ranges, each part of the world would have a unique array of plants, animals, and micro-organisms. But as species move from one area of the world to another, sometimes squeezing out the competition, different places in the world become more alike in their biology—a process called *biological homogenization*.

This process is undesirable because as it takes place, ecosystems often become less stable, and valuable biodiversity, or variety of life, is lost. This variety is essential to the health of our planet; each species performs a function that contributes to global well-being. The spread of invasive alien species is considered one of the major threats to biological diversity. Invasive alien species have obliterated about 110 vertebrate species around the world and have affected nearly every type of ecosystem. For example, in New Zealand, predatory European mammals such as rats, cats, and stoats have caused the extinction of nine native bird species, and they threaten many more. In Guam, the brown tree snake, an import that arrived hidden in ship cargo from New Guinea, has wiped out virtually all the island's native forest birds.

Invasive aliens pose a problem mainly in places with a warmer climate and a disturbed landscape. In Canada, these two factors come together in the south, where most of the human population lives. Urban and industrial development and activities such as forestry and agriculture disturb the landscape in ways that make it more vulnerable to alien invasions and endangerment of native species. In particular, southern British Columbia, Ontario, and Quebec are home to a large number of both invasive aliens and species at risk. Natural communities on islands are also particularly vulnerable to invaders. Their plants and animals have evolved in isolation from the mainland, and they do not have the adaptations needed to escape from or compete with outsiders. For example, almost half the mammal species found on the island of Newfoundland and on the Queen Charlotte Islands are invasive aliens.

Report sightings or obtain more information on invading species by calling the ***Invading Species Hotline at 1-800-563-7711*** *or visiting* ***www.invadingspecies.com***

• ● INVADER WEB QUEST ● •

PURPOSE: *This activity requires access to computers. Using a jigsaw strategy, students will follow an Internet quest to research a given invading species. Use "Where Do You Stand" as a warm up activity for this lesson.*

Duration:	**Assessment of student learning:**	**Ensuring Inclusion:**
3 x 30 minutes	Observation during individual and group work Anecdotal Notes Written work rubric (Invasive Species Rap Sheet, newspaper article)	Ability pairing Record research on tape

Fit with Bloom's Taxonomy: Knowledge, Comprehension, Application
Fit with Multiple Intelligence: Linguistic, Interpersonal, Naturalist

Learning Materials:

- **BLM 13:** Why Is Biodiversity So Important?
- **BLM 14:** Invading Species Web Quest
- **BLM 15:** Invading Species Rap Sheet
- **BLM 16:** Master Copy – Completed Rap Sheets for each invasive species studied

Post Lesson Teaching Reflections:

LESSON SEQUENCE:

1. Distribute BLM 13: WHY IS BIODIVERSITY SO IMPORTANT? As a class read the handout. Ask students to think of additional examples, as well as examples of resiliency (See All About Biodiversity for additional information).

2. Students will take part in a jigsaw activity to research an invasive species, and report back to their home group with their findings. Through reporting, students will build a portfolio of six invasive species impacting Ontario: purple loosestrife, Asian long-horned beetle, sea lamprey, round goby, rusty crayfish, and zebra mussels.

3. Divide students into home groups of 6 or more students.
4. Assign each home group member an invasive species to investigate. Distribute a copy of the respective BLM 15: Invading Species Rap Sheet to each student.

   "Invading species are a serious threat to biodiversity. Imagine that you are a newspaper reporter. Your Editor has just given you the opportunity of a lifetime to write a front page story about an exotic species invasion that is threatening your community. Where did it come from? What are the characteristics of this species? What impact is it having? What can be done about it?"
5. Students use the internet to follow their quest and complete the "Rap Sheet" for their invader, adding their completed Rap Sheet to their portfolio (See L1-Graffiti Gallery).
6. When all groups have completed their web quest, students return to their home group to report on their research.
7. Students in each home group are to complete a Rap Sheet for each invasive species reported on (using information shared from the in-group "expert") so that they have a full set of sheets completed.
8. Review Rap Sheet answers with the whole class to ensure that all students have a complete set.
9. Select students to use a length of yarn attached to two pins to show where their invasive species came from in relation to Ontario on a large world map, so that each species is represented.
10. Discuss the world map of invasion that students create from their research. How might Canada's relationship with other countries be affected by invading species issues?

CLOSURE/CHECK FOR UNDERSTANDING:

11. Students write a newspaper article about their invasive species using the information obtained from their Web Quest research and group discussion. Add the article to the student's portfolio.

EXTENSION:

Use the materials provided in this lesson to create a web based activity for students to complete. Use your classroom website to post the Web Quest, including the Introduction, Steps 1 to 3 (provide hot links to sites listed on the Web Links Sheet; see sample setup below) and the Conclusion.

Further exploration of social studies curriculum in relation to invading species.

Create a power point presentation on each invasive species using Internet research gathered.

Purple Loosestrife Web Quest			
Picture (hot link)	Characteristics (hot link)	Origin (hot link)	Pathway (hot link)
Arrival (hot link)	Distribution (hot link)	Impact (hot link)	Economic (hot link)
Prevention (hot link)			

Why is Biodiversity So Important?

Biodiversity is a source of strength in the ecosystem. A forest that contains many different types of trees will be stronger and more stable than a forest that has only one or two species. In a wheat field, there is only one species. If a disease attacks part of the wheat field, it can quickly spread to the whole crop.

Genetic diversity within species makes it easier for species to adapt to new or changed environments. By having a large gene pool, a species is more able to adapt. For example, the average moose in northern Canada is larger than those in southern Canada. This helps them to endure a longer, colder winter because larger bodies are easier to keep warm.

Do we need all species, or could we do without certain insects? Although another form of life may seem annoying to us, it is still very important. For example, bees and many other insects pollinate our orchard trees and crops as well as wild plants. Other insects, such as mosquitoes, are the main food for many species of songbirds and bats.

Different ecosystems, such as forests and wetlands for example, perform different functions. Each is important. If an exotic species thrives, a pre-existing animal or plant will dwindle in numbers and possibly lose its place in the ecosystem. Interrelationships among the remaining species will never be quite the same. The balance of nature will be upset, and the biodiversity that holds together the web of life will be weakened.

We have often seen examples of humans "fixing" ecosystems without knowing or understanding the function an ecosystem serves. Marshes (which filter the pollution out of water, provide habitat for many species and recharge groundwater) are drained or filled to make the land "better". Not really! And introducing non-native species into an environment can be damaging to native ecosystems. A good illustration of this kind of imbalance is the rusty crayfish, a heavily clawed, aggressive crustacean imported from the southeastern United States as fishing bait. This cantankerous crawdad displaces native crayfish, forcing them out of their habitats and leaving them vulnerable to predators. It also feeds greedily on native aquatic plants, reducing their abundance and diversity and depriving invertebrates and young fish of shelter. European frog-bit, purple loosestrife, red-eared sliders, and zebra mussels are a few more examples of invasive species that muscle out native species and throw ecosystems off balance.

Source: http://www.on.ec.gc.ca/community/classroom/c6-bio-e.html

Invading Species Web Quest

This Web Quest is designed to be completed by several groups of six students. The teacher should assign groups and roles before they begin the Web Quest. If you have less than six students in a group, students may need to become an expert on more than one invasive species.

Three activities are included in the task: completing a research form (BLM 15: Invasive Rap Sheet), preparing a brief presentation to group members and writing a newspaper article using information obtained through the Web Quest.

Introduction

Invading species are a serious threat to biodiversity. Imagine that you are a newspaper reporter. Your Editor has just given you the opportunity of a lifetime to write a front page story about an invasive species that is threatening your community. Where did it come from? What are the characteristics of this species? What impact is it having? What can be done about it?

The Task

After completing this Web Quest you will be an expert on your invasive species. At the end you will be able to teach your group members about your invasive species.

Your final product will include:

- A completed "Rap Sheet" about your invasive species.
- A brief presentation to your group members to explain your invasive species.
- A newspaper article about your invasive species.

The Process

You need to complete the following steps to fulfill your Web Quest:

Step 1

Your teacher will assign you to a group and determine each student's role in the group. Each member of your group will become an expert on a different invasive species (sea lamprey, zebra mussel, round goby, Asian long horned beetle, rusty crayfish, purple loosestrife).

Explore the web sites given to you by your teacher. Use the Rap Sheet for your invasive species and fill it in using information from your Internet search. Hand in your completed Rap Sheet. Add your final copy to your portfolio.

Step 2
Share your expertise with your group members. Use the information from your completed Rap Sheet to prepare a brief presentation about your invasive species to present to your group members.

Step 3
Use the information you collected on your web quest, and any questions and comments from your presentation to your group, to write a front page newspaper story about your invasive species. Hand in your completed story. Add your final copy to your portfolio.

Conclusion
You have learned about six invasive species that are threatening our biodiversity. As a class, use yarn and a large world map to illustrate where each invasive species studied in this lesson originated. What are some of the implications for Canada (e.g., Trade relations, economic impact, environmental impact etc.)?

Name: _____

Invading Species Rap Sheet

The Invading Species I will become an expert on is the… _____

☞ Using the Web Links page provided, answer each question below:

What are the characteristics of your invading species?

Where did your invading species come from?

How did it get to Ontario?

When did it arrive?

Where is it currently distributed?

What impact does it have on Ontario's biodiversity?

What impact does it have on Ontario's economy?

What efforts are in place to control your invading species?

What can be done to prevent the spread of your invading species?

WEB LINKS

The website links below will help you jump-start your research on invading species!

Purple Loosestrife	www.invadingspecies.com www.great-lakes.net www.lakeheadca.com www.purpleloosestrife.org
Rusty Crayfish	www.invadingspecies.com
Asian Long-horned Beetle	www.invadingspecies.com www.inspection.gc.ca
Round Goby	www.invadingspecies.com http://www.protectyourwaters.net/
Zebra Mussel	www.invadingspecies.com http://www.protectyourwaters.net/ http://www.great-lakes.net/ http://www.dfo-mpo.gc.ca
Sea Lamprey	www.invadingspecies.com http://www.protectyourwaters.net/ http://www.dfo-mpo.gc.ca

http://www.invadingspecies.com/invaders/plants-terrestrial/purple-loosestrife/
http://www.great-lakes.net/envt/flora-fauna/invasive/loosestf.html

MASTER COPY

Invading Species Rap Sheet: Purple Loosestrife

What are the characteristics of your invasive species?

Each flower spike is made up of many individual flowers. Individual flowers are small and have five or six pink-purple petals surrounding small, yellow centers. Purple loosestrife generally flowers from late June to early September and require pollination by insects or birds.

As flowers begin to drop off, capsules containing many tiny seeds appear in their place. Depending on where you live, plants may go to seed as early as late July.

Each mature plant can have more than thirty flowering stems which can produce up to 2.7 million seeds annually. As tiny as grains of sand, seeds are easily spread by water, wind, wildlife and humans. Germination can occur the following season and in many environmental conditions. Seeds are hardy and can lay dormant in the seed bank for several years before sprouting. Ornamental "seedless" cultivars have been shown to produce viable seeds when fertilized with pollen from naturalized populations.

Leaves are downy, with smooth edges. They are usually arranged opposite each other in pairs which alternate down the stalk at 90° angles, however, they may also appear in groups of three. Stalks are square, five or six-sided, woody, as tall as 2 m (6.5 ft) with several stalks on mature plants.

Where did your invasive species come from?

Purple Loosestrife *(Lythrum salicaria)* is a wetland plant from Europe and Asia. It was introduced into the east coast of North America in the 1800s.

How did it get to Ontario?

First spreading along roads, canals and drainage ditches, then later distributed as an ornamental, this exotic plant is in 40 states and all Canadian border provinces.

Plants were brought to North America by settlers for their flower gardens, and seeds were present in the ballast holds of European ships that used soil to weigh down the vessels for stability on the ocean.

When did it arrive?

The 1800's.

http://www.lakeheadca.com/lsstrife.htm
http://www.invadingspecies.com/invaders/plants-terrestrial/purple-loosestrife/

Where is it currently distributed?

Purple loosestrife is now found throughout most of North America with the exception of Mexico, Florida and northern Canada.

What impact does it have on Ontario's biodiversity?

Lythrum (Purple Loosestrife) is a very hardy perennial plant that can outgrow cattails, sedges, rushes and the other native aquatic plants on which wildlife depends. The roots of loosestrife form a dense mat that blocks other plants from growing up. Eventually, it chokes out the other vegetation and soon becomes the dominant species. In marshes where a loosestrife seed source is present, the plant can be expected to colonize exposed areas in high densities with great speed.

A change in the diversity and type of plant species threatens the hundreds of species of plants, birds, mammals, reptiles, insects, fish and amphibians that rely on healthy wetland habitat for their survival. For example, cattail stands are home to Muskrats and a variety of nesting birds, such as Marsh Wrens. Purple loosestrife does not provide the necessary shelter and food sources.

The dense loosestrife roots also clog water channels in the marsh. These are places where fish would come in to spawn, ducks would feed, nutrients would flow and insects could hide and feed along the edges.

What impact does it have on Ontario's economy?

Since purple loosestrife can invade drier sites, concern is increasing as the plant becomes more common on agricultural land, encroaching on farmers' crops and pasture land. The spread of purple loosestrife also has a direct economic impact when plants clog irrigation or drainage ditches on farmlands or cause degradation and loss of forage value of lowland pastures. An estimated 190,000 hectares of wetlands, marshes, pastures and riparian meadows are affected in North America each year, with an economic impact of millions of dollars.

What can be done to prevent the spread of your invasive species?

One of the simplest prevention measures one can take is to be sure that purple loosestrife (or one of the many "sterile" cultivars) is not growing in your garden and that you don't intentionally or unintentionally plant it (some wildflower seed mixes may contain purple loosestrife so be sure to read the label). The best time to control purple loosestrife is in June, July and early August when it is in flower and easy to recognize before it goes to seed. Hand-digging young plants can be done in an area with a small infestation. Cutting the flowers stalks before they go to seed also ensures that seeds will not produce future plants. Proper disposal of the plant to ensure

that seeds do not contaminate other areas is important. This can be done by putting plants in plastic bags that will remain intact at the landfill site. Plants can also be incinerated. Chemical control (herbicide) is another form of control but should only be used on individual plants, in dry, upland areas and on your own property.
For large infestations, the most effective method has been biological control through the release of insects that are the plant's natural enemy in its native habitat. Two beetle species: *Galerucella pusilla* and *Galerucella calmariensis* eat the leaves and new shoot growth which seriously affects growth and seed production of the plant. These beetles will not eradicate purple loosestrife, however, they will act to significantly reduce plant numbers and reduce seed production and therefore, the spread. The O.F.A.H. in partnership with Ontario Beetles and the Ministry of Natural Resources co-ordinated a beetle release program in Northern Ontario in 2003 and 80 releases in Eastern Ontario in 2004.

Many organizations throughout North America have taken action to control the spread of purple loosestrife. National wildlife services, state/provincial natural resource and environment agencies, universities, nursery trades associations, and conservation and community organizations have responded to the purple loosestrife invasion by raising awareness of the threat posed by this invasive plant, and how to prevent its spread. OFAH programs such as Project Purple and The Biological Control of Purple Loosestrife are examples of such actions that are being taken in Ontario and are available for the public and other conservation groups to get involved.

http://www.invadingspecies.com/invaders/invertebrates/rusty-crayfish/
http://www.invadingspecies.com/resources/distribution-maps/

MASTER COPY

Invading Species Rap Sheet: Rusty Crayfish

What are the characteristics of your invasive species?

Rusty crayfish have a brown body, and greenish-rusty coloured claws with dark black bands near the tip. The rusty crayfish has more robust claws and is larger than other native species of crayfish. There are prominent rusty patches on either side of the carapace (which may or may not always be present) as though you picked up the crayfish with rusty paint on your forefinger and thumb. It is on average 10 cm (3.9 inches) in length, not including the claws.

Rusty crayfish will inhabit lakes, rivers, ponds, and streams with adequate rock, log, and debris cover. They prefer bottoms of clay, silt and gravel, and are most active from spring to fall when temperatures are above 8° C. When the rusty crayfish reproduce, they can lay 50-575 eggs at one time.

Rusty crayfish are omnivores so they will eat anything but prefer high protein foods. They feed on aquatic plants, benthic invertebrates (which include aquatic worms, snails, leeches and aquatic insects), decaying plants and animals, fish eggs, and small fish. They have a more aggressive nature than the native species in areas they are introduced to.

Where did your invasive species come from?

Rusty crayfish are native to North America. They originate from streams in the Ohio, Kentucky, and Tennessee regions.

How did it get to Ontario?

It is likely that rusty crayfish were introduced as bait by non-resident fishermen.

When did it arrive?

The first findings in Ontario were as early as the 1960s.

Where is it currently distributed?

Primarily central and eastern Ontario, with some confirmation along the US border west of Lake Superior.

http://www.invadingspecies.com/invaders/invertebrates/rusty-crayfish/
http://www.invadingspecies.com/resources/distribution-maps/

What impact does it have on Ontario's biodiversity?

It is estimated that rusty crayfish can consume twice as much food as native species of the same size due to a higher metabolic rate (Jones & Momot, 1983). Rusty crayfish have a ravenous appetite for aquatic plants; they can degrade aquatic plant beds to the detriment of the aquatic invertebrates and juvenile fish that depend on these areas for habitat. It has been said that what the rusty crayfish does to aquatic plants is the equivalent of clear-cutting forests. Rusty crayfish, especially juveniles, also feed heavily on benthic invertebrates like mayflies, stoneflies, midges, and side-swimmers. By consuming large quantities of benthic invertebrates, fish eggs and young fish, these crayfish could also compete with juvenile game fish and forage fish species for food.

Not only does the rusty crayfish out-compete native crayfish species for food, they also chase them out of the best daytime hiding locations. This makes native populations vulnerable to being eaten by birds and fish. Many fish prefer native crayfish because they have a softer shell compared to the rusty crayfish and a decrease in their numbers could limit a food source for fish. The rusty crayfish is also more aggressive and under fish attack will not swim away like the native crayfish, but will hold its claws up in a defensive manner.

Native crayfish species have been displaced in the areas of the Kawartha Lakes region, northern Ontario and the northern Wisconsin lakes by the rusty crayfish (Gunderson, 1995). The rusty crayfish can mate with other species of native crayfish, such as which may hasten the local extinction of the native species.

What impact does it have on Ontario's economy? (Opportunity for critical thinking)

What can be done to prevent the spread of your invasive species?
Once introduced, rusty crayfish are difficult to control. Therefore, it is vital to prevent their spread to other waterbodies. Rusty crayfish could accidentally be transported in bait buckets. Always be careful to never take live bait from one waterbody and release it into another. Dump any unused, live crayfish bait in the trash.

Anglers – Recreational anglers who fish on lakes invaded by rusty crayfish are affected. The rusty crayfish out-competes native crayfish and fish species for food and living spaces. They also feed on the eggs and young of popular game fish.

- Once a rusty crayfish population becomes established in a lake it can effectively destroy any populations of native species. This in turn could affect the people who make a living by fishing these lakes, or who operate fishing resorts in these areas.

- Efforts going into researching, monitoring and attempting to control the rusty crayfish will require time and money. This will have an impact on both private and government organizations.

http://dnr.wi.gov/org/caer/ce/eek/critter/invert/lamprey.htm
http://www.protectyourwaters.net/hitchhikers/fish_sea_lamprey.php

MASTER COPY

Invading Species Rap Sheet: Sea Lamprey

What are the characteristics of your invasive species?

Sea lamprey are members of an ancient family of "jawless fishes" that were around before the time of the dinosaurs. They are 12-20 inches (30-50cm)long and eel-like. They have dark brown to black backs and light yellow to pale brown bellies. Look for a feathery fin from their midsection down and under the tail. Their mouth is circular with circular rows of teeth. They have large reddish eyes.

It is important to recognize the distinguishable features of Sea Lamprey because there are several native freshwater lamprey species found in the Great Lakes region. Some are parasites and some are not. These lamprey live in balance with their natural food chain and don't deplete fish populations

Where did your invasive species come from?

Sea lamprey are primitive fish native to the Atlantic Ocean.

How did it get to Ontario?

It is widely believed that they entered and spread throughout the Great Lakes via man-made shipping canals.

When did it arrive?

Reports of wounds on host species first appeared in L. Ontario around 1890

Sea lamprey were first observed in the Great Lakes in the 1830's.

Where is it currently distributed?

Sea Lamprey are found throughout the Great Lakes and clear, cold streams throughout the Great Lakes region. Construction and improvements on the Welland Canal (between Lake Ontario and Lake Erie) around 1921 allowed sea lamprey to get through the canal to the next lake. Here's a list of their arrival dates in each lake:

Lake Erie, 1921 • Lake Huron, 1932 • Lake Ontario, 1935 • Lake Michigan, 1936 • Lake Superior, 1938

What impact does it have on Ontario's biodiversity?

The introduction of exotic species is so detrimental to native species because exotics like the sea lamprey, have no natural predators or competitors in these new habitats. Native species often suffer because they have no prior experience with these exotics and in the presence of an abundance of food and favourable environment, exotic species rapidly increase and rarely are eliminated once established.

Sea lamprey are parasitic pests. They attach to fish with their suction cup mouth and teeth, and use their tongue to rasp through a fish's scales and skin so they can feed on its blood and body fluids. A single sea lamprey will destroy up to 18 kilograms of fish during its adult lifetime. Sea lamprey are so destructive that, under some conditions, only one out of every seven fish attacked will survive.

In the 1940's and 50's, sea lamprey populations exploded in the upper Great Lakes as there were no effective control methods. This contributed significantly to the collapse of valuable fish populations, such as lake trout and whitefish, which were the economic mainstay of a vibrant Great Lakes fishery.

Sea lamprey will lay over 100,000 eggs when spawning, much more than the native lamprey species.

What impact does it have on Ontario's economy?
OPPORTUNITY FOR CRITICAL THINKING

Anglers – Recreational anglers who fish for lake trout, salmon, rainbow trout (steelhead), brown trout, whitefish, yellow perch, burbot, walleye, and catfish are affected by sea lamprey. This parasitic fish attach themselves to popular gamefish and effectively destroy them.

When they first arrived on the Great Lakes scene, sea lamprey killed large numbers of predatory sport fish. People began to notice the lack of large fish and the scars on others. Lamprey preyed on whitefish, lake trout and chub populations in lakes Superior and Michigan. The lamprey invasion made it hard on the people who fished the Great Lakes to make a living.

What can be done to prevent the spread of your invasive species?

Through intensive control programs, lamprey populations have been reduced by almost 90% of their peak numbers in the early 1960s. This has allowed the Great Lakes fishery to slowly rebound. The control program is administered by the Great Lakes Fishery Commission in cooperation with the Department of

Fisheries and Oceans Canada, and the U.S. Fish and Wildlife Service. Initiatives include:

1. the application of lampricide to selectively kill lamprey larvae in streams where the adults spawn (of the 5,747 stream and tributaries of the Great Lakes, 433 are known to produce sea lamprey and about 250 are treated on a regular cycle);
2. construction of barriers that allow fish to travel upstream, but prevent the migration of spawning lamprey upstream;
3. releasing sterilized male sea lamprey into streams to compete with spawning males and reduce the reproductive success of females.

Scientists have recently isolated a sex pheromone released by male sea lamprey that attract the females for spawning purposes. It may hold great promise as many scientists are concerned about the long term affects of chemical applications of T.F.M. and if lamprey will eventually become resistant to it.

http://www.seagrant.umn.edu/ais/roundgoby
http://www.invadingspecies.com/invaders/fish/round-goby/
http://www.invadingspecies.com/invaders/fish/tubenose-goby/
http://www.glsc.usgs.gov/main.php?content=research_invasive_goby&title=Invasive%20Fish0&menu=research_invasive_fish

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Invading Species Rap Sheet: Round Goby

What are the characteristics of your invasive species?

Gobies are relatively small fish that dwell near the bottom of the water column. The round goby can reach lengths of 10 inches (25 cm) and live for up to five years. Gobies are usually mottled brown in colour, and bear a resemblance to our native sculpins. Unlike the sculpin, gobies have unique pelvic (bottom) fins that are joined underneath the body to form a suctorial disc. This disc makes them identifiable from other fish species, and enables them to stay on the bottom in fast currents. The round goby also has a prominent black spot on its first dorsal fin.

Round gobies prefer rocky and sandy bottoms. They occupy a broad range of depths but are most abundant near shore. Tubenose gobies prefer shallow areas with aquatic vegetation. Where the round goby has been introduced, their populations become very abundant due to its aggressive nature and its ability to spawn several times each season. Both species of gobies feed largely on insects and other small organisms found on the bottom. As round gobies grow larger, they feed heavily on zebra mussels and occasionally on small fish and fish eggs. Unfortunately, it is unlikely that gobies will be successful in controlling zebra mussel numbers.

Round gobies can reach up to 10 inches in length as adults, but usually they are less than 7 inches long in the Great Lakes. Females and immature male round gobies are a mottled gray and brown color. Spawning males turn almost solid black. Round gobies have a soft body and a large, rounded head with eyes that protrude near the top. Round gobies look similar to our native sculpins, but the two species can be easily separated by the fused pelvic fins on the underside of round gobies. Sculpins have two distinct pelvic fins, not one large fin. This fin can be used by gobies as a suction cup to anchor to rocks and other hard substrates during times of high water flow.

Where did your invasive species come from?

Eastern Europe

How did it get to Ontario?

Ballast water

When did it arrive?

Late 1980s in the St. Clair River

Where is it currently distributed?

After being discovered in the St. Clair River in 1990, both goby species have been found in Lake St. Clair, the Detroit River, and Western Lake Erie. Round gobies have also been found throughout much of Lake Erie, Lake Huron, Lake Ontario, southern Lake Michigan, and western Lake Superior. It has been found in Michigan's inland waters and recently in inland Ontario, at Trent Severn Waterway (between village of Hastings and Healey Falls), Rice Lake, the Pefferlaw River and Lake Simcoe at the mouth of the Pefferlaw River. The round goby has completed their dispersal throughout the five Great Lakes in less than a decade, a dispersal almost as fast as the zebra mussel. It is believed that the isolated Great Lakes populations on Lake Superior were transported by intra-lake ship ballast water transfers from the St. Clair River area.

Distribution map available.

What impact does it have on Ontario's biodiversity?
The round goby is an aggressive fish that can spawn several times each season. These characteristics, combined with its abundance and relatively large size, mean that the round goby will probably have an impact on native fish species. As round gobies have flourished in the St. Clair River, the abundance of the small, native, bottom-dwelling fish such as mottled sculpin and native logperch (a small relative of the yellow perch) has declined dramatically in the river. Similar changes are expected to occur where the round goby becomes abundant elsewhere. It is not clear what this will mean for larger fish species, but it could affect their feeding habits. Round gobies have also been observed feeding on the eggs and fry of sport fish and may impact on these populations. Although walleye and other predators are feeding on gobies, their populations have continued to expand despite this predation. Because adult round gobies feed predominantly on zebra mussels, which often have high contaminant levels in their tissues, concerns have been expressed that fish predators may be exposed to higher levels of contaminants by feeding on round gobies. Out-breaks of botulism Type-E (*Clostridium botulinum*) have been observed to impact round gobies eating infected zebra mussels resulting in die-offs. The out-breaks can go further up the food chain, however, when ducks and/or other fish eat the infected gobies. All of the above impacts are still being researched and studied by several agencies in the Great Lakes region.

The round goby can displace native fish, eat their eggs and young, take over optimal habitat, spawn multiple times a season, and survive in poor quality water — giving them a competitive advantage.

What impact does it have on Ontario's economy?
OPPORTUNITY FOR CRITICAL THINKING

- In some areas round gobies have become an annoyance to anglers due to their habit of stealing bait. The round goby is an aggressive fish that can spawn several times each season. These characteristics, combined with its abundance and relatively large size, mean that the round goby will probably have an impact on native fish species. This in turn means that recreational anglers as well as people who rely on the native fish species to make a living will likely be affected.

- Efforts going into researching, monitoring and attempting to control the round goby will require time and money. This will have an impact on both private and government organizations.

What can be done to prevent the spread of your invasive species?

Although anglers and boaters can help to prevent the spread of gobies to inland waterways, there are no known ways of eliminating gobies from a large open system such as the Great Lakes. Gobies, like many other exotic species are here to stay. Although some predators are feeding on gobies, it is unlikely that they will significantly reduce goby numbers. The proliferation of zebra mussels and quagga mussels in the Great Lakes provides an ample food supply for the round goby, and they will continue to expand their range in the Great Lakes. Early detection of isolated populations may help slow or restrict the spread of round gobies. You can do the following to prevent the spread:

- Learn to identify round gobies and if caught, kill them. Do not throw them back alive
- Do not use round gobies as baitfish
- Dispose of bait properly: Do not release bait into the water
- Always drain water from your boat, livewell, and bilge before leaving any water access
- Never dip your bait bucket into a lake or river if it contains water from another water source
- Never dump live fish from one body of water into another body of water

Gobies and many other exotic species have been introduced to the Great Lakes through the ballast water of ships. The zebra mussel, spiny water flea, and ruffe were all transported from Europe in this manner. All ships are now required to exchange their ballast water at sea before entering the Great Lakes. Research is also being conducted to find effective ways of treating ballast water to prevent the introduction of harmful exotic species and their movement by ships within the Great Lakes.

http://www.inspection.gc.ca/plants/plant-protection/insects/asian-long-horned-beetle/faq/eng/1337876837572/1337877395314

MASTER COPY

Invading Species Rap Sheet: Asian Long-Horned Beetle

What are the characteristics of your invasive species?

Asian long-horned beetles (ALHB) can range between 2.5 to 4 cm long. They are black and shiny with white spots they have blueish while legs and long banded (black & white) antenaae that can reach a length of up to 10 cm. They are sometimes confused with the Pine sawyer beetle (*Rosalla funebris*) in Ontario. The ALHB does have wings and can fly but for only short distances because of it's size and weight.

ALHB attache a large variety of both healthy and weakened deciduous trees with maples, poplar and willow being among its favourites. They also attack elm, ash, birch, horse chestnut and boxwood. Female ALHB will chew through the bark of a tree down to the cambial layer leaving a round hole approximately 1 cm across. Teh female will then back out of the hole, turn around and deposit an egg. Females can lay up to 32 eggs and will lay them anywhere on the trunk and larger branches of a tree. The larvae burrow further in the tree to feed on the phloem and xylem layers. They over-winter either in the larvae or pupal stages and emerge as adults anywhere from May to October with July being the peak period for emergence.

Where did your invasive species come from?

Asia

How did it get to Ontario?

Global trade is responsible for bringing the Asian long-horned beetle to North America. For decades, the beetle has attacked poplar and willows growing in plantations and forests in China. Infested wood from these plantations was turned into crates, pallets, spools and dunnage - cheap packing material for cargo carried by ships to overseas markets. Thus, infested cargo is the pathway by which this beetle came to North America.

When did it arrive?

Early 1990s

http://www.inspection.gc.ca/plants/plant-protection/insects/asian-long-horned-beetle/faq/eng/1337876837572/1337877395314

The first report of this beetle being established outside of its native range was from the cities of Brooklyn and Amityville, New York in 1996.

In September of 2003 the ALB was detected for the first time in Canada, in the Woodbridge area of southern Ontario.

Where is it currently distributed?

The Asian long-horned beetle was first detected in the U.S. and Canada at ports and inland warehouses in the early 1990s. To date, at least 15 U.S. states and two Canadian provinces (British Columbia and Ontario) have reported interceptions at these locations.

The CFIA confirmed the introduction of ALHB in a concentrated area of an urban industrial park located in Woodbridge and Toronto, Ontario in September 2003. The beetle has subsequently been found in the area of Toronto – Vaughan. All infested trees have been removed, along with all susceptible trees in a 400-metre radius. The area is now regulated to prevent the spread of the pest.

Infestations have been found in Austria and the United States including New York (1996), Illinois (1998) and New Jersey (2002 & 2004) and have resulted in the removal and destruction of over 5000 trees. Millions of dollars have been spent on the required surveys and control programs.

What impact does it have on Ontario's biodiversity?

ALHB larvae feed within the trunk and limbs of trees and eventually riddle the trees with holes, causing them to die. In some situations, mature trees may be killed in one or two growing seasons.

The adult beetles can also feed on leaves, bark and shoots, causing considerable damage to the tree.

Tree species that were found to be attacked by the ALHB in the Woodbridge area include: all species of maple, elm, poplars, oaks, horse chestnut, birch, willow, Sycamore, mountain ash, hackberry, and mimosa (silktree).

The ALHB is extremely destructive. The damage is caused by beetle larvae, which burrow deep within a tree to feed on its food and water conducting vessels. Continued feeding causes structural defects and eventually kills the life-sustaining cambial layer by girdling. Mature beetles then burrow out of the tree leaving holes the diameter of ball-point pens. Heavy ALHB infestations can kill otherwise healthy adult trees.

http://www.inspection.gc.ca/plants/plant-protection/insects/asian-long-horned-beetle/faq/eng/1337876837572/1337877395314

What impact does it have on Ontario's economy?
OPPORTUNITY FOR CRITICAL THINKING

The decline or elimination of hardwoods from the North American landscape will have both economic and aesthetic impacts. Many hardwoods are found in urban and rural landscapes and mature trees that are lost in these settings will be difficult to replace and often have to be replaced with less desirable, ALHB resistant specimens. The impacts in the forest product industry could be devastating for furniture, building product, and recreational product manufacturers since ALHB turn lumber that is high-grade into low-grade material generally used only for packing. The nursery trade could also feel an impact by limiting the number of tree species it can sell if ALHB can be transported on nursery stock.

What can be done to prevent the spread of your invasive species?

The ALHB is one of many insect pests capable of surviving transport in wood and wood packaging materials. On arrival, pests contained within the wood may emerge and move to local host trees to feed and complete their life cycles.

The CFIA has implemented strict import policies to regulate wood packaging and wood products. The CFIA also supports the adoption of a international standard created by the International Plant Protection Convention (IPPC) to reduce the plant health risks associated with wood packaging used in trade.

Since the initial find in September 2003, the CFIA has been conducting visual surveys to determine the extent of the introduction and damage. Where infested material is found, it will be destroyed to eliminate the risk of ALHB spreading to uninfested trees.

The ALHB has no natural controls in North America. The only way to stop the beetle's spread is to remove all susceptible trees within 400 metres of an infested tree.

The CFIA maintains and enforces restrictive measures for the movement of potentially infested wood items from areas where the beetle was found. A regulated area has been established in parts of Toronto and Vaughan in order to prevent the spread of the ALHB.

There are prohibitions or restrictions of movement on **nursery stock, trees, leaves, logs, lumber, wood, wood chips and bark chips from certain deciduous trees identified as hosts of the** ALHB **and firewood of all species**. Unless authorized by the CFIA, their movement out of or through the regulated area is prohibited. This is necessary to prevent the spread of the ALHB throughout Toronto and the rest of Ontario and Canada.

The CFIA is also asking for the public's help in spotting the beetle and reporting it to their local CFIA office. To control the spread of the ALHB, all plant material must be destroyed by chipping. CFIA inspectors investigate all links to the infested trees, conducting intensive surveys in surrounding areas and determining movement of any infested tree material.

http://www.invadingspecies.com/invaders/invertebrates/zebra-and-quagga-mussels/
http://lakehuron.ca/index.php?page=zebra-mussels

MASTER COPY

Invading Species Rap Sheet: Zebra Mussel

What are the characteristics of your invasive species?

Zebra mussels filter plankton from the surrounding water at a rate of up to one litre per day. The mussels are relatively small (3 cm in length) and live approximately 2-3 years. Their shell is brown, cream and yellow striped and triangular in shape with one edge flattened. Small threads called byssal threads attach the mussel to hard surfaces.

Where did your invasive species come from?

These mollusks are native to the Black and Caspian Sea region of Asia.

How did it get to Ontario?

It is believed that the mussel was introduced to the Great Lakes via ballast water dumping from foreign ships.

When did it arrive?

It is believed that zebra mussels entered the Great Lakes in the early to mid 1980s. They were first discovered in North America in 1988. The first account of an established population came from Canadian waters of Lake St. Clair, a small water body connecting Lake Huron and Lake Erie. By 1990, zebra mussels had been found in all the Great Lakes.

Where is it currently distributed?

Zebra mussels have spread throughout all of the Great Lakes passively carried by water currents or intra-lake ship ballast discharge. Zebra mussels have been spread unintentionally by people into waterways such as the Trent-Severn and Rideau Canal and some inland lakes in southern and central Ontario.

What impact does it have on Ontario's biodiversity?

Zebra mussels are notorious for their ability to reproduce. In one location researchers noted that in one square metre, Zebra Mussel populations jumped from 1000 to 700 000 in six months.

Zebra mussels filter out large amounts of phytoplankton, and compete with many species of zooplankton which are an important food source for young fish. Species such as whitefish and

other prey fish including alewife, bloater, smelt and sculpin directly depend on *zooplankton* as a food source. The decline in *zooplankton* may be linked to declines in numbers and the condition of species such as whitefish, sculpin, smelt and young lake trout from various Great Lakes. This may further have an impact on sport fish such as adult salmon, trout and walleye which feed on prey fish.

The feeding activity of zebra mussels results in changes in the normal energy cycle within a water column. Each mussel can filter about one litre of lake water per day, however, not all of what they consume is digested. What they don't eat is combined with mucus as "pseudofeces" and is discharged onto the lake bottom where it accumulates. Organisms that benefit most from these changes are those that live on the lake bottom such as invertebrates (which include aquatic insects, worms, snails, etc.) and aquatic plants. This filtering causes the water to become clearer allowing more sunlight to penetrate the water column. Changes in weed growth patterns occur and forces some fish, such as walleye that are light sensitive, to find new habitat.

When zebra mussels filter the water, they also remove contaminants which become concentrated in their tissues. Although this may sound like a positive thing, organisms that feed on zebra mussels may accumulate these contaminants in their own tissues. An example are some duck species such as Lesser and Greater Scaup, which now feed on zebra mussels, have elevated levels of contaminants in their tissues which may influence their survival and/or reproduction success. Another invader, the round goby, which predominantly feeds on zebra mussels, may accumulate contaminants in their tissues and may pass those contaminants on to sport fish species which are now consuming the round goby.

Scientists are also finding a link with zebra mussels and the occurrence of toxic blue-green algal blooms or microcystis. Zebra mussels will spit out microcystis into the water and at the same time eat other algae that may be competitors with or help control microcystis. The mussels also produce nutrients that further fertilize microcystis.

Botulism Type-E (*Clostridium botulinum*) has also been found in the tissue of zebra mussels when out-breaks occur. Species that feed on zebra mussels such as round gobies, freshwater drum and ducks such as scaup may be impacted by eating infected zebra mussels which could result in die-offs. The out-breaks may go further up the food chain still when ducks, loons, grebes, gulls and/or other fish eat the infected species and other animals such as raccoons scavenge the contaminated victims.

http://www.invadingspecies.com/invaders/invertebrates/zebra-and-quagga-mussels/

Zebra mussels will cover any hard surfaces including: rock, metal, rubber, wood, boat hulls, native aquatic animals such as clams and crayfish and even aquatic plants. Some fish prefer rock, and boulder substrates to spawn, and can be deterred from spawning in the areas that are covered in zebra mussel colonies. In some areas, populations of native clams have significantly decreased or completely disappeared as a result of infestation. Zebra mussels will colonize on top of native clams preventing them from opening and closing and also exposing them to predators, parasites, disease, and noxious water quality. Respiration and feeding for native clams is difficult as a result of zebra mussel colonization on their shells.

What impact does it have on Ontario's economy?

Navigational markers and fishing buoys used for directing boat traffic can accumulate large numbers of zebra mussels, causing them to sink. Commercial fishing gear such as trap nets and gill nets can also collect enough zebra mussels to render the equipment useless and difficult to retrieve. The hulls of boats and ships can become so infested that sailing efficiency can be impaired. Zebra mussels colonize industrial, boat and domestic water intake pipes, reducing flow rates, and even preventing water flow. It is estimated that facilities on the Great lakes spend millions of dollars each year to combat zebra mussels.

Industries that use river water for cooling and other processes spend millions of dollars per year to remove the encrusted mussels clogging intake or outflow pipes and structures. The sharp shells can also be a danger to swimmers. Decay odour along beaches and historical sites like shipwrecks encrusted with mussels are having a negative impact on tourism in many areas around the Great Lakes.

What can be done to prevent the spread of your invasive species?

There are no known methods for eliminating Zebra Mussels from an area once they have become established. Public assistance in preventing the spread of this highly invasive species and reporting new infestations is essential to help reduce their negative impacts on the local environment and economy.

Presently, the best defence we have against the spread of zebra mussels is to restrict its movement between waterbodies. Once they become established in a lake, there is no known way to eradicate them. Please take the following precautions to help prevent the spread of zebra mussels and other exotic species:

http://www.invadingspecies.com/invaders/invertebrates/zebra-and-quagga-mussels/

Inspect your boat, trailer, boating equipment, fishing tackle and nets and remove any visible plants or animals before leaving any waterbody.

Drain water from motor, live well, bilge and transom wells while on land before leaving the waterbody.

Empty your bait bucket on land before leaving the waterbody. Never release live bait into a waterbody, or release animals from one waterbody into another.

Wash/Dry your fishing tackle, nets, boat and equipment to kill harmful species that were not seen at the boat launch. Some species can survive for several days out of water, so it is important to:

- rinse your boat and equipment with hot tap water (> 40° C); or
- spray your boat and equipment with high pressure water (250 psi); or
- dry your boat and equipment for at least five days, before transporting to another waterbody.

Call the **Invading Species Hotline at 1-800-563-7711** if you find zebra mussels in an area not shown on the distribution map.

• ● SURPRISE HITCHHIKERS ● •

PURPOSE: *In this simulation activity, students are introduced to the concept of invasive species, and learn how invasive species spread and become established in a new area. Students will also identify strategies to limit the spread of aquatic invasive species.*

Duration:	**Assessment of student learning:**	**Ensuring Inclusion:**
45 minutes	Observation Anecdotal Notes Give One/Get One completion	Ability pairing

Fit with Bloom's Taxonomy: Knowledge, Comprehension, Application
Fit with Multiple Intelligence: Naturalistic, Lingustic, Visual/spatial, Interpersonal

Learning Materials:

- **BLM 18:** Give One, Get One
- 5 empty 250 mL milk cartons (rinsed)
- Clear plastic cups (one for each student minus five "boats")
- 1 vial each of blue and red food colouring drops
- Water
- OFAH Invading Species DVD clip (Invaders in Our Waters) * DVD clip can be found on the "Invaders in Our Waters" DVD
- OFAH Invading Species DVD clip (Recreational Boating – 2 minutes) * DVD clip can be found on the "Invaders in Our Waters" DVD
- Flip chart or overhead and pen
- **BLM 17:** How Do They Get Here? Invasive Species Pathways
- Prior to class, partially fill three milk cartons with water and add enough blue food colouring to strongly colour the water. Partially fill the remaining two cartons with clear water. These are the "boats".

Post-Lesson Teacher Reflection:

LESSON SEQUENCE:

1. Show OFAH DVD clip on boating and spread of invasive species: Recreational Boating (2 minutes). Emphasize that invading species can quickly, easily and unknowingly be spread from lake to lake through boat traffic.
2. Complete the simulation activity:
   - Explain that students will either be "lakes" or "boats" in this activity.
   - Select five students to be boats and give them prepared milk cartons.
   - Give each remaining student a clear plastic cup with a small amount of clear water in it and ask them to place it on the front of their desk; students with clear cups then hide their eyes.
   - The boats visit different lakes; three of them will be coloured to represent carrying a tiny invader (such as zebra mussels, fanwort, or spiny water flea); the other two are clean.
   - The lakes that change colour after a boat has visited have been invaded!
   - Once all milk cartons are empty, students can open their eyes and look for a water colour change in their cup.
   - Students set their plastic cups in a row at the front of the classroom where they can be seen by everyone.
3. As a class, tally results on the board/ flipchart:
   - number of cups that changed colour (ie. were invaded), and
   - number of cups that are still clear.

Are there some cups that are a more intense colour than others?

Why might that happen?

Answer: "Visited" by more than one infected boat.

What would happen to the biodiversity of the lake?

Answer: Reduced native species

4. Rinse out the cups and cartons. Repeat the activity but this time put a few drops of red dye in five plastic cups to represent healthy recreational and commercial fisheries. Have boats visit plastic cups as outlined above.
5. Line the clear plastic cups up and tally results:
   - number of cups with clear water (healthy environment)
   - number of cups with red water (healthy fishery)
   - number of cups with blue water (invader present)
   - number of cups with purple water (fishery damaged by invader)
6. What can boaters and fishermen do to avoid spreading aquatic invasive species? Use BLM 18: GIVE ONE, GET ONE. In the top two boxes, students write their ideas about how to stop the spread of aquatic invasive species. On a signal from the teacher, students travel around the room to fill in the remaining two boxes with strategies shared by classmates. Add completed sheets to student portfolios. Ask for responses from several students as a check on learning.

Possible answers:

- Thoroughly wash their boat/trailer and gear with hot water or high pressure water before traveling to another lake;
- Let boat/trailer sit in the sun for a minimum of five days before moving to another lake;
- When leaving a lake, check the boat/ motor/trailer and gear for any clinging mud, bits of plant material etc.;

- Freeze or salt bait to use later instead of dumping in the lake; dump unwanted bait in the garbage or on dry land, never in the lake.

CLOSURE/CHECK FOR UNDERSTANDING:

7. As a class, brainstorm a list of other ways that invading species can spread. Ask how many people have an aquarium at home? Sometimes aquarium fish grow too big, or people get tired of them and they let them go in a lake or river. Is this a good idea? Why or why not?

Answer: No, it is not a good idea. Released fish may compete with native species for food and habitat, and may eat eggs and fry of native fish. Fish that do not belong in the lake ecosystem upset the balance and may out-compete native species. Always take unwanted aquarium fish to a reputable pet store.

8. Distribute BLM 17: HOW DO THEY GET HERE? INVASIVE SPECIES PATHWAYS for students to read and include in their portfolio.

EXTENSION:

After the first round of boat "visits", designate an additional five students to become boats and continue visiting lakes. The coloured water will become more widely distributed, illustrating how invasive species travel from one affected location to another.

Make a mathematics connection! Graph the data generated, or calculate the probability of a lake becoming invaded.

Discuss the current status of Asian Carp in the Great Lakes water basin.
Visit: www.glfc.org/fishmgmt/carp.php

TEACHER NOTE:

A native species is an animal or plant species that originates from the same area that it is found. They have adapted over many thousands of years to specific conditions, developing and maintaining a healthy balance with the other animals and plants that share the habitat (community).

Non-native species are those that did not originate in the habitat it has been introduced to. These species have been brought to their new habitat mainly through human-related activity. Non-native species that have very robust adaptations, that is, adaptations that give them a survival advantage over native species, do harm to native species and their ecosystems, and have an economical impact are considered invasive species. These species are often able to live in many types of habitats; their adaptations ensure their survival and growth rates are generally greater than those of other species. Their exceptional survival rate often causes a negative change to the entire habitat.

* It is important to note, that not all non-native species become invasive.

How Do They Get Here? Invasive Species Pathways

Global trade, travel and tourism have resulted in intentional and unintentional introductions of invasive species that are severe and irreversible. The methods of introduction are called pathways and can include the goods themselves (such as direct trade in invasive species); and species that 'hitch-hike' on goods and packaging materials, as well as the ships, planes, trains, and vehicles that transport people and goods.

Invasive species can spread readily… and we're the one's who often inadvertently help them! Below are the main ways these wily critters make their way into Ontario habitats:

1. AQUARIUMS AND WATER GARDENS

We love the tranquil beauty of our aquariums and water gardens. Unfortunately, many of the aquatic plants and animals that are promoted and for sale in many pet stores, garden centres and nurseries are not native to our area and some have the potential to become seriously invasive aquatic weeds, invertebrates and fish. Aquarium owners may feel they are doing the right thing for their pets by releasing them back to nature and water gardeners may not realize that their contained gardens are not so contained. If invasive species get into the wild, they can do severe damage to habitats, our economy and maybe even our health.

2. GONE FISHING

Fishing is a popular pastime that allows many kids and families to enjoy Ontario's sparkling lakes and rivers. It is common for anglers to use *live bait* like minnows and crayfish when they are fishing. Unfortunately, many people don't realize that releasing this bait into the water after fishing is illegal and can introduce new and potentially harmful species to those habitats. Invasive species in the bait bucket can wreak havoc on our lakes and rivers. These new species may: compete with native species for food and space; feed on the eggs and young of native fish; and, occasionally, carry and spread disease. Not only does this affect habitats but it can also harm local livelihoods and recreation. Examples of invasive species that have been spread in this way are: Rusty Crayfish, Rudd and Round Goby. Invertebrate species such as zebra mussels, and the spiny and fishhook water flea or their eggs may be in bait bucket water and could also be spread to new lakes.

3. STOCKING A LAKE OR A GREAT ESCAPE

Some species that are native to Ontario but not native to a particular area can have the potential to become invasive and alter ecosystem functions. This often happens when people want to improve a fishery by releasing species that they like to fish such as rock bass, black crappie or even pike. Escapes can also happen from aquaculture facilities with the potential for introducing potentially harmful species to new habitats.

4. BOATING FOR FUN

Invasive species are cunning hitchhikers, finding their way into Ontario waters by clinging to commercial and recreational boats or by hiding out in the water contained in watercraft. Boaters must be very wary, cleaning and inspecting their boats before moving them from water body to water body. Boats have been a major mode of transportation for: zebra mussels, the spiny and fishhook water flea, and plants such as European frog bit and Eurasian water milfoil. As well as boats, invasive species can attach themselves to propellers, trailers and other boating gear and equipment.

5. THE MARKETPLACE

We love our food and as a result, there is a growing culinary interest in buying live fish from the market. This is great but we need to exercise caution! Some exotic food species are aggressively invasive and if released into Ontario's aquatic habitats, they can take over food and space from other species and generally have few natural enemies. Asian carp are examples of fish that once were sold in Ontario fish markets, but now are prohibited to be sold live.

6. ROAD TRIP

Invasive insects, such as the Asian Long-horned Beetle and the Emerald Ash Borer, can travel on infested packing crate material and firewood. The growth of global trade has greatly increased the potential for inadvertent transport of invasive species around the world.

7. BY FOLLOWING NATURAL WATER ROUTES (Migration)

Invasive species have been know to follow waterways. If the new territory they venture into can support their basic needs, the invasive could potentially become established.

Everyone can help keep our habitats healthy!

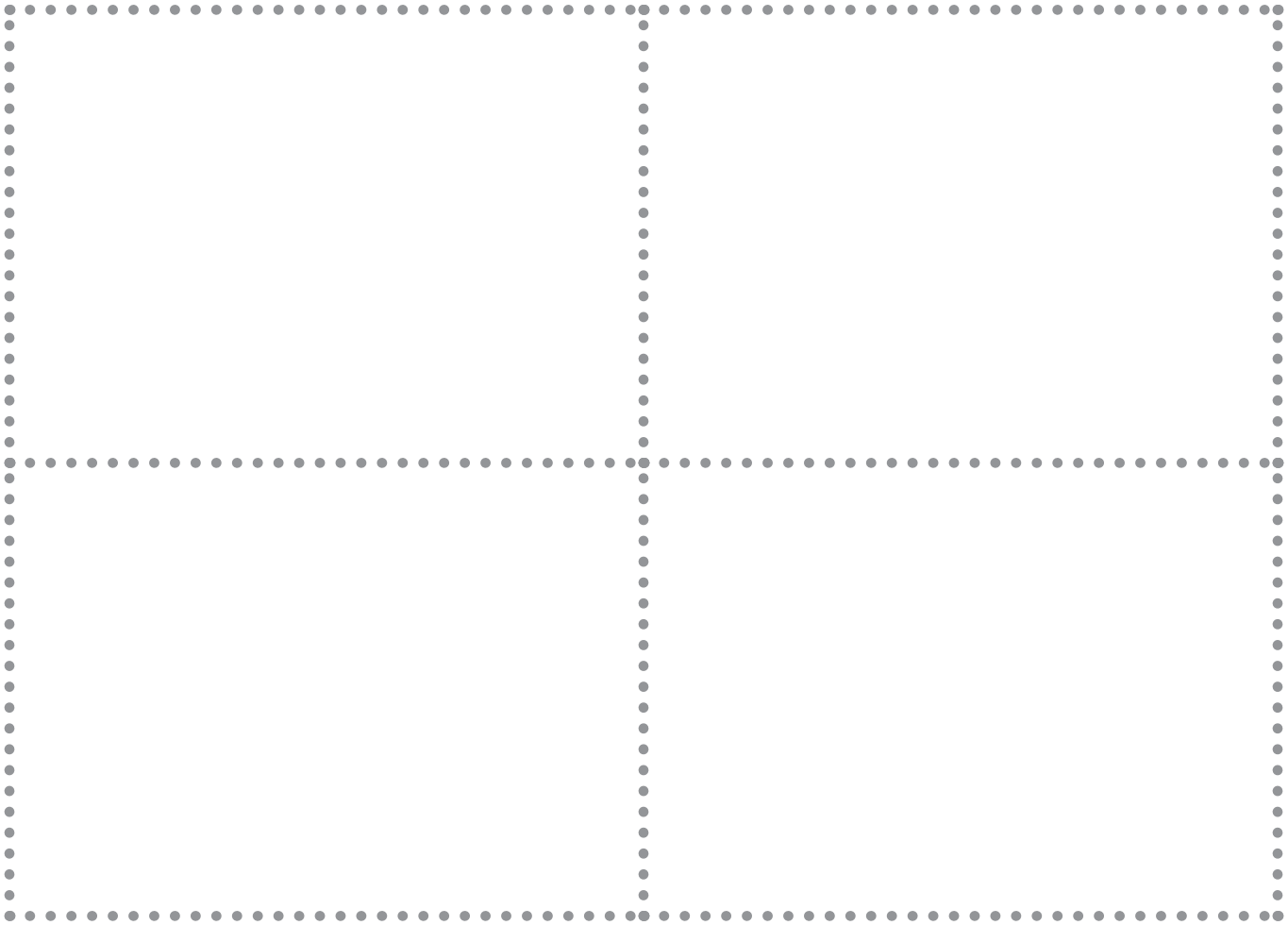
Many invasive species were brought to Ontario through human activity. We now need human activity to help solve this harmful problem. It's a big task that requires us all to pitch in!

Name: _____

Give One/Get One
Surprise Hitchhikers

In the top two boxes, write down two things people can do to prevent the spread of invading species in lakes.

When your teacher gives you a signal, share ideas from your first two boxes with classmates, and get ideas from them to fill in your sheet … GIVE AND GET!



• ● BIODIVERSITY GIVE AND TAKE ● •

PURPOSE: *In this game, students learn about threats to biodiversity and actions that help to sustain biodiversity. Players gain and lose chips according to cards that are drawn during the game. The player with the most chips at the end of the game is the most successful organism. Instructions are included for a physically active version of the game.*

Duration: 45 minutes	**Assessment of student learning:** Journal response	**Ensuring Inclusion:** Ability grouping; Verbal response to prompt
Fit with Bloom's Taxonomy: Knowledge, Comprehension, Application **Fit with Multiple Intelligence:** Naturalistic, Lingustic, Visual/spatial		
Learning Materials: • Set of counters (or chips) for each group of students • Deck of playing cards for each group of students (remove face cards and Jokers from decks) • **BLM 19:** Threats to Biodiversity • **BLM 20:** Biodiversity Give and Take Game Sheet • Sticky notes		
Post-Lesson Teacher Reflection:		

LESSON SEQUENCE:

1. Review the definition of biodiversity with students. Ask students to work with their elbow partner to brainstorm a list of current threats to biodiversity; students write each threat on a sticky note.
2. Write the four threats to biodiversity on the Smart/black board as headings: habitat loss, climate change, invasive species and pollution. Have students group their sticky notes under the appropriate heading. Hand out BLM 19: THREATS TO BIODIVERSITY for students to put in their portfolio.
3. Divide students into groups of 3-5 players. Give each group a deck of playing cards, a set of chips/markers and a copy of BLM 20: BIODIVERSITY GIVE AND TAKE GAME SHEET.

Explain how to play the game:

- Each player gets 10 chips to start with; the rest of the chips are left in the middle of the table. Place the deck of playing cards facedown on the table.
- The first player draws the top card from the deck of cards, shows the card and looks up the card on the game sheet (BLM 20: BIODIVERSITY GIVE AND TAKE GAME SHEET) and reads the instruction aloud. For example, if the five of diamonds was drawn, the student would read "A Rusty Crayfish invaded a Walleye nest and ate all of the fish eggs. Lose two chips." The player would then put two of their chips back into the centre pile.
- The second player draws the next card from the deck; for example, the two of spades. The player reads the instruction from the game sheet and follows the instruction.
- The game continues for a set period of time (determined by the teacher). The player with the most chips at the end of the game is declared to be the most successful organism.

CLOSURE/CHECK FOR UNDERSTANDING:

4. After playing the game, have students respond to the following prompt in their writing journal and add it to their portfolio:

One fact I learned by playing Biodiversity Give and Take is …

One action I will take to help maintain biodiversity is …

EXTENSION:

Make Biodiversity Give and Take an active game. Rather than using counters or chips, have students take steps forward or backward. In this version, divide students into groups of 6-8 and assign one person to be the Game Master. Students stand in a straight line on a field or gym marking. The Game Master draws a card from the deck of playing cards, looks up the corresponding line on the game sheet, and reads the instruction inserting "steps" for "counters". The first player carries out the instruction (e.g., takes two giant steps forward). The player who advances forward the furthest by the end of the game is the most successful organism.

Threats to Biodiversity

Threats to biodiversity include habitat loss, climate change, invasive species and pollution.

Threats to Biodiversity: In part because the value of biodiversity and the resulting ecosystem services are poorly understood by a lot of people, nature's "cogs and wheels" are going missing at an alarming rate — on the order of 100 to 1000 times the background rate, estimated from fossil records to be from one to ten species/year (Pimm, et al., 1995 and others). Some estimates of current rates are much higher. There have been five mass extinctions in the past 500 million years, the most recent about 65 million years ago (Raup and Sepkoski, 1982). We appear to be in the sixth, with the major difference being that for this one, the cause appears to be not a major physical catastrophe such as severe volcanism or a meteor strike, but a single species: us.

Threats to biodiversity include habitat loss, climate change, invasive species and pollution.

Habitat loss and degradation is the leading cause for biodiversity loss. Habitat destruction is widespread in many parts of southern Canada where most Canadians live. Natural habitats that are necessary for species to flourish are converted to roads, building sites, and for industrial or agricultural use. In less populated areas, resource extraction for mining, energy, or forestry may leave poorly functioning ecosystems. In these cases, habitats may be fragmented, which leaves wildlife open to predators and unable to reach feeding and breeding sites. This fragmentation makes it difficult for species to adapt and survive.

Climate change affects every Canadian ecozone, but rising temperatures are causing particularly visible damage to arctic environments. When permafrost melts, the ground loses its supporting network of ice crystals. This can destabilize the land and make animal habitat and human infrastructure vulnerable. The warming conditions in the Arctic may force various arctic species to migrate further north in order to survive. They may have to do this at a quicker rate than they are able. It is estimated that species will have to move about one kilometer each year to survive. However, plants such as lichen, an important food source for caribou, are limited in their ability to spread. The inability of plants to adjust quickly could have detrimental effects on animals that rely on them as a food source. The loss of arctic species may be as high as 20 percent. With this potential reduction of species, many benefits of biodiversity are threatened.

Invasive Species are organisms that are not indigenous to regions, but have been transported there by human activity or natural occurrences. They are able to thrive in these new areas because they have no natural predators or diseases. Non-native species can damage native environments by altering habitat, competing for resources, causing disease, or by hybridization (interbreeding and altering the gene pool). All these elements throw the ecosystem out of balance and reduce the environment's ability to cope with change.

Dumping products like paint, detergents, and oil down the drain **pollutes** waters and can kill fish, amphibians, and aquatic plants. Proper removal of toxic liquid and other materials like batteries, computers, medications, and electronics should be done with care. Most muncipalities provide special depots for these materials to be disposed of safely.

Sources:

http://www.eman-rese.ca/eman/reports/publications/rt_biostrat/cbs4.htm
http://www.mnr.gov.on.ca/en/Business/Biodiversity/2ColumnSubPage/STEL02_166814.html

Biodiversity Give and Take Game Sheet

CARD	ACTION
Ace of clubs	Global warming leads to lower water levels in the Great Lakes which decreases spawning grounds for fish and breeding grounds for birds. Lose two chips.
Ace of spades	You rode your bicycle to school, saving gas and helping to preserve biodiversity. Way to go! Take two chips.
Ace of diamonds	You used a power washer to rinse your Dad's boat after the fishing trip. Great work! Take two chips.
Ace of hearts	After fishing, you took the leftover bait home to freeze it, rather than dumping it in the lake. Good move! Take two chips.
Two of clubs	You slept in, and missed the school bus. Your Mom had to drive you to school. That burns extra gas and adds to climate change. Lose two chips.
Two of spades	You gave up a Saturday to volunteer with a "Project Purple" crew to control purple loosestrife. Take three chips.
Two of diamonds	You planted a native tree to celebrate your Mom's birthday. Take three chips.
Two of hearts	You checked to make sure that no invasive plants were going to be planted in the school garden. Way to go! Take three chips.
Three of clubs	Plants provide food and some common medicines. Losing biodiversity may mean losing future sources of medicine and food. Lose two chips.
Three of spades	Species and ecosystems evolved over thousands and million of years, much of it before humans arrived. The impact of human choices has increased the rate of change dramatically. Lose five chips.
Three of diamonds	You help your dad change the oil on the car and instead of dumping it down the sewer drain, you take it your local Household Hazardous Waste Depot. Take 3 chips.
Three of hearts	You decide to plant the native Blue Vervain in your garden instead of transplanting Purple Loosestrife. Take 2 chips.
Four of clubs	You and your family built a wood duck nesting box and mounted it on a tree near a pond down the road. Take 3 chips.
Four of spades	After painting your bedroom, you dumped the rest of the paint down the drain, which will eventually make its way into nearby lakes and rivers. Lose 3 chips.
Four of diamonds	Instead of turning on the air conditioner, you decided to draw the curtains to keep the warm sun out. Take 2 chips.
Four of hearts	Your family only uses paper plates and plastic cutlery for dinnertime meals. Fewer dishes, but more waste. Lose 1 chip.

Five of clubs	After you discovered Zebra Mussels in the lake at your cottage, you call the Invading Species Hotline @ 1-800-563-7711. Take 1 chip.
Five of spades	You bring your own wood camping this summer and discover that it's infested with Emerald Ash Borers. Lose 2 chips.
Five of diamonds	A Rusty Crayfish invaded a Walleye nest and ate all of the fish eggs. Lose two chips.
Five of hearts	After reading information on invasive species that your teacher gave to you, you pass it on to your uncle Joe. Take 1 chip.

Six of clubs	Instead of using toxic chemicals to clean the bathroom, you use baking soda and vinegar instead. Take 2 chips.
Six of spades	A sea lamprey attacks a Lake Trout. Although the initial bite doesn't kill the fish, it dies three days later from an infection in the lamprey wound. Lose 3 chips.
Six of diamonds	You and your big fuzzy dog run through a patch of Garlic Mustard and brush the seeds off in your backyard before going inside. Lose 2 chips.
Six of hearts	After a long day of fishing you are too tired to deal with the bait and dump it in the lake when your dad isn't looking. Lose 2 chips.

Seven of clubs	Your family is moving to another province and you can no longer keep your goldfish aquarium. You dump the entire contents of the tank into the pond down the road. Lose 1 chip.
Seven of spades	Your family purchases organic vegetables from your local farmer's market. Take 2 chips.
Seven of diamonds	Your family has a yard sale. Someone else's junk is another person's treasure. Take 1 chip.
Seven of hearts	A new subdivision has just gone up down the street and the land has been completely cleared. Lose 3 chips.

Eight of clubs	Your class participates in a city-wide litter clean up project. Take 2 chips.
Eight of spades	You and your classmates do a research project on the biodiversity of the forest behind the school. The more you know, the more you can help. Take 2 chips.
Eight of diamonds	You watch as a friend picks every last native Trout Lily in the forest, leaving none behind to spread their seeds, and you don't say a word. Lose 2 chips.
Eight of hearts	Even though you know that Round Goby is an Invasive Species, they seem to catch the biggest fish and you continue to use them as bait. Lose 1 chip.

Nine of clubs	You decide to cut the length of your shower time in half, saving water and energy. Take 1 chip.
Nine of spades	You convince your mom to wash your clothes in cold water, which uses less energy. Take 2 chips.
Nine of diamonds	Instead of cranking up the heat in the winter, you decide to put an extra sweater on to stay warm. Take 1 chip.
Nine of hearts	You convince your parents to bring their own cloth bags to the grocery store. Take 1 chip.

Ten of clubs	Giant Hogweed has spread into the south end of your city, competing for sun with native plants around it. The Giant Hogweed wins. Lose 2 chips.
Ten of spades	Although Dog Strangling Vine hasn't strangled any dogs, it has strangled out the native plants around it. Lose 3 chips.
Ten of diamonds	Your boat motor gets clogged with a giant mass of the invasive Eurasian Watermilfoil. Lose 2 chips.
Ten of hearts	You enjoy being outdoors and convince three other friends to become a part of your community's outdoors club. Take 2 chips.

• ● BALLAST WATER DEBATE ● •

PURPOSE: *Ballast water is a major pathway for the introduction of invasive species into the Great Lakes, with subsequent impact on biodiversity in the Great Lakes as well as inland waterways. Students will consider the point of view of various stakeholders, and debate issues related to ballast water control.*

Duration: 60 minutes	**Assessment of student learning:** Observation, Anecdotal Notes	**Ensuring Inclusion:** Flexible grouping
Fit with Bloom's Taxonomy: Knowledge, Comprehension, Application, Analysis, Evaluation **Fit with Multiple Intelligence:** Naturalistic, Lingustic, Interpersonal		
Learning Materials: • **BLM 21:** Ballast Water Background Information • **BLM 22:** Stakeholder Position Cards • OFAH Invading Species DVD clip (Invaders in Our Waters – 7 minutes) * DVD clip can be found on the "Invaders in Our Waters" DVD		
Post-Lesson Teacher Reflections:		

LESSON SEQUENCE:

1. Show the DVD segment on ballast water. Briefly discuss the segment to clarify any questions that students may have.
2. Ask students to share their ideas about how ballast water is relevant in your community.

Answer: Any community that is adjacent to the Great Lakes, or connected to the Great Lakes through waterways, is vulnerable to the invasive species pathway provided by ballast water. This is another example of the interconnections that exist when thinking about biodiversity.

3. Divide the class into four groups, and assign each group a role as environmental groups, local government, commercial fishermen or shipping industry. Give each group the Position Statement card for their role.
4. In their small groups, students are to read their position statement and talk about what they think it means. The teacher circulates to clarify and guide discussion as needed.
5. Each group selects a spokesperson to present their stakeholder position to the rest of the class.

CLOSURE/CHECK FOR UNDERSTANDING:

6. Once all four positions have been put forward, hold a class discussion to come to consensus to answer the question: Should ocean-going vessels be allowed to use the Great Lakes to ship goods?

EXTENSION:

Allow students time to research the position of their stakeholder group using the Internet, and personal interviews.

Ballast Water Background Information

Ship ballast refers to any solid or liquid that is brought on board a ship to help stabilize the vessel during transit. In the past ships used solid ballast consisting of sand, rocks, and soil that were hauled on board and stored in cargo holds. The loading and unloading of solid ballast was a labour intensive practice, and would not be practical today. Technology has advanced to the point where water can easily be pumped in and out of holding tanks making water the ballast of choice today. Ballast water is necessary to increase the ships stability during travel in rough ocean waters in the absence of cargo. When water is being drawn into ballast water tanks, small organisms and sediment can often be drawn in as well. Some organisms can survive the entire journey across the ocean, spending days or weeks living inside ballast tanks. Upon the ships arrival to the Great Lakes, ballast water is exchanged for cargo and the water is released (…along with the organisms!). If the conditions are right and the new aquatic environment is similar to the organism's original environment, they can survive and spread, potentially impacting the Great Lakes ecosystem. These foreign organisms can be spread within the Great Lakes as ships, known as 'lakers', fill and empty ballast tanks when they move from port to port. A laker is a ship designed to only carry freight within the Great Lakes. This freight is usually passed on from boats known as 'salties' who bring cargo in from ocean ports.

An increase in global trade has resulted in an increase in non-native "hitch-hikers" within the Great Lakes basin. In 2005, strict regulations were put into place to prevent further introduction of non- native species via ballast water exchange. Because ships are travelling from country to country these regulations are developed in accordance with the U.S. Coast Guard requirements and the International Maritime Organization and enforced by Transport Canada.

Regulations state that ships must exchange or flush the contents of their ballast tanks in water at least 2,000 metres deep and at a distance of 200 nautical miles from shore before entering waters under Canadian jurisdiction. Alternative exchange zones also exist within the Canadian jurisdiction as a place where ships may exchange their ballast water. These alternate zones have been approved by Transport Canada based on scientific research provided by the Department of Fisheries and Oceans. Current regulations also outline that it is up to the operator of a ship to develop a ballast water management plan to ensure that the water is managed safely and successfully.

QUICK FACTS:

- Ballast water capacity of ships coming to the Great Lakes ranges from 1,000-20,000 cubic metres (one Olympic size swimming pool holds 2500 cubic metres!)
- Even if all ballast water tanks are empty, having as little as 1 or 2 cm water depth left in tanks, there may be 20-30 cubic metres of unpumpable residual ballast water present across the whole bottom of the ship (that's about 10-15 bathtubs full of water).
- Residual ballast water may contain up to 5000 invertebrate animals in one cubic metre of water.
- Flushing tanks with saltwater typically reduces the number of invertebrate animals to less than 500 per cubic metre - and most of these will be oceanic animals that will not be able to live in the freshwater Great Lakes.

Sources:

www.tc.gc.ca www.great-lakes.net www.dfo-mpo.gc.ca

Ballast Water Debate Stakeholder Position Cards

Environmental Groups

Invasive species are a serious threat to our natural environment. Many invasive species have entered the Great Lakes through ships dumping their ballast water.

Treating ballast water may not be enough to kill off all potential invasive species that have been picked up in the water. Some may escape treatment, or be immune to it.

Current regulations that require ballast water to be treated are insufficient to prevent the spread of invasive species, and are not enforced adequately.

Commercial Fishermen

Invasive species are a serious threat to our natural environment. Invasive species can have a devastating economic impact on commercial fisheries (for example, sea lampreys).

Many invasive species have entered the Great Lakes through ships dumping their ballast water.

Treating ballast water may not be enough to kill off all potential invasive species that have been picked up in the water. Some may escape treatment, or be immune to it.

Current regulations that require ballast water to be treated are insufficient to prevent the spread of invasive species, and are not enforced adequately.

Shipping Industry

We agree that invasive species are a serious problem.

If we cannot send ships into the Great Lakes, we will be forced to used land routes to transport goods from coastal ports to inland cities. This will increase the cost to consumers, and increase use of fuels that contribute to global warming and climate change.

Local Government

Invasive species are a serious problem. Ballast water dumping from ocean-going vessels is a key pathway for invasive species to arrive in our community.

The money we make by charging shipping companies to use our local port is used to pay for other services in the community. Without that revenue, we will either need to cut services or increase other costs paid by our residents.

Tourism and the commercial fishery are very important industries in our community, providing many jobs for our residents. Invasive species can seriously damage these industries, leaving people out of work and possibly moving away from our community.

• ● INVADER TAKE OVER ● •

PURPOSE: Invader Take Over illustrates concept of species loss and competitive advantage. Students are either Round Goby, adult Bass or Bass eggs as indicated by the colour clothespin they wear. In the game, the Round Goby eliminate the adult Bass (by taking their clothespin) in order to get to the Bass eggs. By the end of the game, the Bass are eliminated and only Round Goby remain.

Duration:	**Assessment of student learning:**	**Ensuring Inclusion:**
30 minutes	Observation Anecdotal Notes	Assign partners to assist students with special needs

Fit with Bloom's Taxonomy: Knowledge, Comprehension, Application, Analysis, Evaluation
Fit with Multiple Intelligence: Naturalistic, Lingustic, Visual/Spatial, Interpersonal

Learning Materials:

- Coloured clothespins (3 different colours)
- (Pylons and several skipping ropes if playing field is not marked)
- DVD clip Live Bait (2 minutes)

Post-Lesson Teacher Reflections:

LESSON SEQUENCE:

1. Have students close their eyes and visualize sitting on the shore of a lake, fishing on a hot summer day. The fish haven't been biting very well and it's time to go home. You know that if you take your bait fish home they will likely die in the bucket by tomorrow, and your Mom will not be impressed with dead fish in the bait bucket. You decide it would be better to give them the chance to live by dumping them into the lake.
2. What happens to the fish you dump in the lake? What happens to the lake? Ask students to make predictions.
3. Play the DVD clip "Live Bait" (2 minutes).
4. Introduce Invader Take Over by reading the game instructions (BLM 23: INVADER TAKE OVER) aloud. Explain that Invader Take Over is a tag game that shows how invading species, however well intentioned their introduction may be, can have serious consequences for biodiversity.
5. Play Invader Take Over.

CLOSURE/CHECK FOR UNDERSTANDING:

6. Briefly review the game.

What happened as the adult Bass changed into Round Gobies?

Answer: The population of Round Gobies rapidly increased, making it more difficult for remaining adult Bass to survive.

What happened to the Bass eggs?

Answer: They disappeared because there were no adult Bass left to protect them.

What happened to the Bass population?

Answer: There were no more Bass because the gobies out-competed them.

What advantage do Round Gobies have that allow them to take over?

Answer: Round Gobies can spawn seven times a year, but native fish only spawn once. Native fish are soon seriously outnumbered, and lose their food supply and habitat!

What might happen to a community that depended on fisherman coming to fish for Bass, if Round Gobies ended up in the lake?

Answer: Businesses that provide goods and services to fisherman would lose business and the whole community would be negatively impacted.

Extension:

Have students research the economic impact of invading species on commercial and sport fishing in Ontario.

Invader Take Over

Students learn of the damaging impact that release of invading species can have on the ecology of a lake by playing a variation of clothespin tag. Round Goby try to take clothespegs from the adult Bass, who then become more Round Gobies. Bass eggs are safe in centre field until there are no more adult Bass to protect them, and they are targeted by the Round Goby. The game illustrates concepts of species loss and competitive advantage.

Invader Take Over can be played indoors or outdoors. A field/gym that is marked with a circle in the centre of the playing area and boundaries on four sides is ideal. Alternatively, use skipping ropes to mark a centre circle, and pylons to identify the four corners.

Equipment

Clothespins in three bright colours (one colour for Round Goby, one colour for adult Bass and one colour for Bass eggs. You will need enough of the Round Goby colour for each student to get one, and fewer of the other two colours of clothespins)
(Pylon and skipping ropes to mark the play area if needed)

How To Play The Game

1. Divide students into three groups:
    - Round Goby – 4 students
    - Bass eggs - 25% of students in the class
    - Adult Bass – remaining students in the class

2. Distribute one clothespin to each student, corresponding to the colour for their group. Students clip their clothespin on the bottom edge of their shirt in the back so that it is visible.

3. Position players on the field:
    - Bass eggs stay together in the centre circle.
    - Round Goby are on the outside of the field, just beyond the sideline (one on each of four sides).
    - Adult Bass can take a position anywhere inside the sideline but outside the centre circle.

4. Introduce the Game:
   In this game each of you will play the role of either a Round Goby, an adult Bass or a Bass egg. We will imagine that the playing field is lake, and that the sidelines are the shore of the lake. An angler dumps her leftover bait bucket into the lake at the end of a fishing trip which happened to contain a few Round Goby. Let's see what happens to the Bass in the lake when the Round Goby come in.

5. On a signal from the teacher, the Round Goby cross the sidelines onto the playing field and try to capture the adult bass clothespin.

When an adult Bass loses their clothespin, they must leave the playing field, get a Round Goby colour clothespin (from the teacher or a container), and come back over the sideline as a Round Goby, trying to capture the adult Bass clothespin from another player.

The Bass eggs are safe in the centre circle until all of the adult Bass have been eliminated. Once there are no adult Bass left, the game shifts to the centre circle, as the Round Goby try to capture the Bass eggs' clothespins (all players must stay within the centre circle). When a Bass egg loses their clothespin, they go and get a Round Goby pin outside the sideline and return to the game to try and capture a Bass egg clothespin.

The game is over when there are no adult Bass, and no Bass eggs left. The Round Goby have eliminated the Bass population in the lake.

Teacher Note:

- Choose energetic "Round Goby" players who will enthusiastically chase adult Bass to get the game started.
- Move pylons inward to decrease the playing area if the game is moving too slowly.

• ● SEEKING INVADERS ● •

PURPOSE: Issues relating to invading species and biodiversity come alive for students as they look for, and document, invasive species in their own community. The task is authenticated when students are given the tools to report their findings to Ontario's *Invading Species Hotline*.

Duration:	**Assessment of student learning:**	**Ensuring Inclusion:**
15 minutes X 2	Observation Form Journal entrys	Ability pairing Use of camera to record data

Fit with Bloom's Taxonomy: Knowledge, Comprehension, Application, Evaluation
Fit with Multiple Intelligence: Naturalistic, Lingustic, Visual/Spatial, Interpersonal

Learning Materials:

- **BLM 24:** Seeking Invaders Observation Form
- Flipchart paper/pen
- Outdoor space

Post-Lesson Teacher Reflection:

LESSON SEQUENCE:

1. Before starting the lesson, select an area for students to search for evidence of invading species; school yard/boundary, park, trail, natural area etc. Consider pairing students to make their observations.
2. Tell students that they will have the opportunity to help protect biodiversity in Ontario by doing field work in their own community to look for and report invading species. Explain that data gathered by the class will be sent to Ontario's Invading Species Hotline, to help track the spread of invasive species across the Province.
3. Ask students why invasive plant species are a threat to biodiversity in Ontario?

   Answer: They can out-compete native species and seriously reduce the number and type of plants, which can impact the availability of habitat for other species.
4. Review the data recording form (BLM 24: SEEKING INVADERS OBSERVATION FORM) with students before heading outdoors, telling students that you will be collecting their sheets to generate a report to the Invading Species Hotline.
5. Review expectations and guidelines for working outside the classroom.

6. Take students outdoors to complete their field observations. If resources permit, disposable cameras to visually record observations would be a great help!

7. At the end of the session, collect student data forms. Add to student portfolios.

CLOSURE/CHECK FOR UNDERSTANDING:

8. As a class, chart students' observations. Introduce students to a simple classification system (See Teacher Note on Classification Systems). Refer to the student observations that are listed on the chart to compare characteristics of plants and animals, and classify observed organisms.

9. Through discussion, generate a list of observed invasive species to report to the Invading Species Hotline.

10. Submit invasive species information online http://www.invadingspecies.com/report/ or by calling 1-800-563-7711.

EXTENSION:

Have students look for invasive species around their home and add their observations to the class data.

Report sightings or obtain more information on invading species by calling the
Invading Species Hotline at 1-800-563-7711
or visiting ***www.invadingspecies.com***

TEACHER NOTE:
Classification Systems

"Classification" refers to the arrangement of objects, ideas, or information into groups, making things easy to find, identify, talk about, and study. Given that there are millions of species on Earth, scientists have developed classification systems to be able to accurately communicate information about them.

The classification system we often use today was developed by the Swedish naturalist Carolus Linnaeus (1707-1778), who separated animals and plants according to certain physical similarities and gave identifying names to each species.

Organisms can be divided into five kingdoms: Monera, Protista, Fungi, Plantae and Animalia. Within each kingdom there are groups of increasing specificity, each one containing fewer species of increasingly close evolutionary relationship to each other. These groups are phylum, class, order, family, genus and species. This hierarchy enables scientists to group organisms based on their characteristics and evolutionary relationships. Species in any given order are more closely related to each other than to species in any other order; species in any given family are more closely related to each other than to species in any other family and so on.

Monera (Bacteria)

The Monerans are the earth's bacteria. They are single celled organisms that are organized into two divisions: those that obtain energy by making their own food (autotrophs) and those that eat other organisms to obtain food (heterotrophs). Unlike the cells of other organisms, a moneran's cell has no nucleus, which is the control center in the cells of other organisms. Monerans are one of the oldest life forms on earth and do not have many of the structures found in the cells of other living things. Scientists estimate that the earth is about 4 billion years old and that the monerans have been around for 3.5 billion years. Plum Pox is an example of an invasive species of bacteria, affecting stone fruit crops in Ontario's Niagara Region.

Protists

The kingdom Protista consists of single-celled organisms. Protists have a nucleus as well as other cell structures that perform specific jobs. Protists include certain types of algae, slime molds, amoebas and diatoms.

Fungi

Most fungi are made of many cells. Mushrooms, molds, yeasts and mildews are examples of fungi. Until recently, fungi were classified as plants. Scientists now place fungi in their own kingdom because, unlike plants, they are not able to make their own food from sunlight, carbon dioxide and water. Instead, they get their food energy by digesting the organisms on which they grow (usually plants). Downy Mildew is an example of an invasive fungi that affects cucumber, squash, melon and pumpkin agricultural crops in Ontario. Spores blew north from the southern USA in summer 2006. Farmers were unprepared for the invader fungi, and consequently lost crops which affected consumer supply and prices.

Plants (Plantae)

As you might guess, this is the kingdom of plants. Most plants produce their own food energy through photosynthesis — a chemical reaction involving sunlight, carbon dioxide and water in the presence of chlorophyll. Flowering plants, mosses, ferns and certain types of algae are members of this kingdom. Purple Loosestrife is an invading species from this kingdom.

Animals (Animalia)

Most animals are multicellular organisms that have specialized tissues, organs and organ systems. Unlike plants, animals cannot make their own food, and their cells don't have cell walls. Animals can be divided into vertebrates (e.g., mammals, birds, amphibians, reptiles and fish) that have a backbone and invertebrates (e.g., insects, spiders, scorpions, worms, crustaceans and jellyfish) that do not. Vertebrates generally have a larger and more complex body structure than invertebrates. Invertebrates far outnumber vertebrates on our planet.

(source: http://www.fieldmuseum.org/biodiversity/illinois_basics/Activity1-2.pdf
http://www.seedquest.com/News/releases/2007/july/19940.htm)

Name: _____

Seeking Invaders Observation Form

Complete the form for each observed organism that is listed below.

NON-NATIVE SPECIES	Student Observations (location, characteristics, significant features)	Classification
Dog Strangling Vine		
Oxeye Daisy		
Chickory		
Canada Thistle		
Garlic Mustard		
English Sparrow		
Pigeon		
Starling		
Lady Bug		
Dandelion		

NATIVE SPECIES	Observation (location, characteristics, significant features)	Classification
Sugar Maple	Can you tell the difference between a Sugar Maple and a Norway Maple?	
White Oak		
Gull		
Blue Jay		
Crow		
Mallard Duck		
Grasshopper		
Other Observations:		

• ● SPREAD THE WORD, NOT THE INVADERS ● •

PURPOSE: Students take an active role in promoting environmental stewardship by applying their understanding to create a presentation for their school community (students, teachers, parents) about the importance of preserving biodiversity and preventing the spread of invasive species.

Duration:	**Assessment of student learning:**	**Ensuring Inclusion:**
30 minutes X 3 (plus performance)	Rubric for Presentation or Product Peer evaluation Unit Portfolio	Ability pairing

Fit with Bloom's Taxonomy: Knowledge, Comprehension, Application, Analysis, Synthesis, Evaluation

Fit with Multiple Intelligence: Lingustic, Interpersonal, Visual/Spatial, Musical, Naturalistic

Learning Materials:

- Varied. Teachers will need to select the range of projects and materials that they will make available to students.

Post-Lesson Teacher Reflection:

LESSON SEQUENCE:

1. Throughout the unit, students will have gathered resources and information to create a presentation for their school community (students, teachers, parents) about the importance of preserving biodiversity and preventing the spread of invasive species. Students will select a presentation topic drawing on their learning during the unit; for example, profile a specific invasive species, highlight threats to biodiversity or illustrate stewardship actions that others can take.
2. Students will choose the format of their presentation. Presentations may include PSA radio ad, video, poster, puppet play, or power point, for example. Students may work individually or in pairs.

3. Provide class time for students to expand their research (if needed) and prepare presentations. Build in adequate time for students to practice their delivery. Have students present their work in-class to (a) practice their presentation and (b) provide an opportunity for peer evaluation of projects. BLM 25: PEER EVALUATION provides a peer assessment tool using a "Three Stars And A Wish" strategy.
4. Add final student's final products and peer evaluation forms to their portfolio.

CLOSURE/CHECK FOR UNDERSTANDING:

5. Provide an opportunity for student work to be presented to an audience:
    - Radio PSA scripts and power point presentations can be presented during a school assembly.
    - Puppet plays can be presented to other classes/divisions within the school.
    - Songs/jingles to be performed and/or taped for use during morning announcements.
    - Hang posters in a prominent location in the school for all to see.

Extension:

Arts and Media Literacy curriculum expectations may be met depending on how the teacher chooses to define the task parameters.

Peer Evaluation: Spread the Word, Not the Invaders

Three Stars and A Wish

Your Name: _____ Presenter Name: _____

Give three "stars" about the presentation (e.g., What did you enjoy? What useful information did you learn? What was done well? What did you find interesting?)

star _____

star _____

star _____

Give one "wish" about the presentation to help make it better (e.g., What could be added? What would you like to know more about?)

Wish _____

Peer Evaluation: Spread the Word, Not the Invaders

Three Stars and A Wish

Your Name: _____ Presenter Name: _____

Give three "stars" about the presentation (e.g., What did you enjoy? What useful information did you learn? What was done well? What did you find interesting?)

star _____

star _____

star _____

Give one "wish" about the presentation to help make it better (e.g., What could be added? What would you like to know more about?)

Wish _____

• ● DIVERSITY JEOPARDY ● •

PURPOSE: In this simplified version of Jeopardy, students create game questions using information learned during the preceding lessons and activities, and test their knowledge by playing a game of "Diversity Jeopardy".

Duration:	**Assessment of student learning:**	**Ensuring Inclusion:**
30 minutes X 4	Rubric for student written questions/ answers Observed participation in the game Anecdotal Notes	Additional wait time to answer questions Scribing

Fit with Bloom's Taxonomy: Knowledge, Comprehension, Application, Analysis,
Fit with Multiple Intelligence: Lingustic, Interpersonal, Naturalistic

Learning Materials:

- **BLM 26**: Diversity Jeopardy Starter Questions
- Index Cards

Post-Lesson Teacher Reflections:

LESSON SEQUENCE:

1. Tell students that they will play a game called Diversity Jeopardy, loosely based on the television show. "Contestants" take turns answering questions, ranging from easy to challenging, to accumulate points. Questions are selected at random from a game deck. The team with the most points at the end of the game, wins.
2. Students are responsible for writing questions for the game. Each student will use the information gained from studying biodiversity and invading species to write five questions and answers. Easy questions carry a value of 10points, up to 50points for challenging questions.

3. With the whole class, model writing questions of varying degrees of difficulty. Use Bloom's taxonomy as the basis for modelling various types of questions. If students only submit "knowledge" level questions, they may be giving easy questions to the opposing team (players do not get to choose which questions they will answer).
4. Provide time for students to research their questions. Questions and answers prepared by students will be handed in for marking. The teacher can also add questions to the game deck (See sample questions).
5. Once questions and answers have been submitted, marked and corrected, students will write a good copy of each of their five question/answer sets on index cards. All index cards are collected to form the game deck. Students should include a copy of their work in their portfolio.

CLOSURE/CHECK FOR UNDERSTANDING:

6. To play the game:
   - Divide the class into two teams. Each student will take a turn as the "contestant". Flip a coin to determine which team will go first.
   - One player from each team steps forward for the round.
   - The teacher draws the top card from the game deck and reads it aloud for the student to answer.
   - If the student gives the correct answer, they score one point and the play passes to the opposing team.
   - If the student does not know the answer, or gives an incorrect answer, the turn goes to the opposing player. If they give a correct answer, they score one point for the question and their turn continues with another card drawn. If they do not know the answer, or give an incorrect answer, the card is returned to the deck to be played later.
7. The game is over when all questions have been answered (or allotted time is up).
8. Tally game score.

Diversity Jeopardy Starter Questions

Amazing Aquatic Invaders	Totally Terrestrial Invaders	Biodiversity Blues	How Can I Help?
Since its discovery in the St. Clair River in 1990, this bottom-dwelling invasive fish has spread rapidly to lakes and rivers in the Great Lakes Region (Answer: What is the Round Goby)	This invasive plant has small purple flowers and has spread through much of Canada and the United States (Answer: What is purple loosestrife)	Many experts consider this to be one of the greatest threats to biodiversity (Answer: What are invasive species)	If you go camping, you can help stop the spread of invasive species by not transporting this item (Answer: What is firewood)
Lampricide is one method used to control this invader (Answer: What is the Sea Lamprey)	This metallic green insect attacks all species of ash trees in North America (Answer: What is the Emerald Ash Borer)	This word means "the variety of life on earth" (Answer: What is biodiversity)	Doing this to your boat before venturing onto another lake will help stop the spread of invasive species (Answer: What is washing your boat)
This invader has the ability to attach itself to nearly any firm surface using their small thread-like features called byssal threads (Answer: What is the zebra mussel)	This invasive woodland plant can produce thousands of seeds each year; the seeds can germinate up to five years after they are produced (Answer: What is garlic mustard)	This provincial plant is threatened by the invasive plant garlic mustard (Answer: What is the trillium)	By not dumping your aquarium, you are helping to keep this member of the carp family out of waterways (Answer: What is a goldfish)

All About Biodiversity

Ecosystems, composed of a great variety of animals, plants and other organisms performing specialized roles, provide ecological services such as the conversion of energy from the sun into carbohydrates and protein, oxygen production, water purification and climate moderation. They produce the soil that supports crop production and they remove greenhouse gases from the air. Human health depends on these ecological services yet these services have not been fully valued by society. For example, when we go to the pharmacy to have a prescription filled, few of us think about the connection between our medicine and biodiversity. Yet many of today's medicines have been developed from plants found around the world. For instance, the active ingredient in aspirin was first discovered in the white willow.

The diversity of the Earth's lifeforms provides us with a wide array of options for satisfying our current and future needs and desires. The long-term security of many jobs depends upon the conservation of biodiversity. Agriculture, fishing and forestry, which together employ millions of people, all rely upon biological resources. Eco-tourism and outdoor recreation activities are an increasingly important part of our economy and generate many jobs across the country. Pharmaceutical and biotechnological research and development are becoming more important to our economy. Many indigenous communities, particularly in the north, depend on the sustainable harvesting of biological resources to provide a large portion of their food and income.

Maintaining the Earth's biodiversity and using biological resources sustainably means maintaining future options for responding to unforeseen and changing environmental conditions. It will also maintain our potential as a country to be creative, productive and competitive and will provide opportunities for discovering and developing new foods, drugs and industrial products. For example, many of our native plant species must endure both cold winters and hot summers. These plants may possess genetic material that supports the development of agricultural crops that can withstand greater temperature ranges. Failing to conserve biodiversity puts future options, flexibility and economic opportunities at risk and passes enormous costs onto future generations. Conserving biodiversity is an investment in the future and makes good business sense.

Despite the importance of biodiversity to humanity, we are currently witnessing a global biodiversity crisis. Ecosystem, species and genetic diversity are being reduced, largely by human activity, at a rate that far exceeds what is natural. It has been estimated that the current rate of global species extinction is 1,000 - 10,000 times greater than the natural rate. Scientists estimate that upwards of 25 percent of the total number of species on Earth could vanish by the first decades of the next century. Forests, wetlands, lakes, coastlines and other natural areas are also being altered by human activities while genetic variation within species, including domesticated crops and animals, is decreasing. These changes threaten our ecosystems and the ecological services that make life possible on the planet.

The reduction of biodiversity in Canada has been due primarily to human activities associated with industrial development. The cumulative impacts of farming, forestry, commercial fishing, expanding urban areas, development of transportation corridors, industrial activities and our high per capita consumption of resources have led to the degradation of ecosystems and habitats, and the reduction of species and genetic diversity. Habitats have also been degraded by pollution, introduction of alien species, and fragmentation resulting from many aspects of human activity. Moreover, as human activity has spread across the landscape, the true value of biodiversity has not been fully recognized.

Threats to Biodiversity: In part because the value of biodiversity and the resulting ecosystem services are poorly understood by a lot of people, nature's "cogs and wheels" are going missing at an alarming rate — on the order of 100 to 1000 times the background rate, estimated from fossil records to be from one to ten species/year (Pimm, et al., 1995 and others). Some estimates of current rates are much higher. There have been five mass extinctions in the past 500 million years, the most recent about 65 million years ago (Raup and Sepkoski, 1982). We appear to be in the sixth, with the major difference being that for this one, the cause appears to be not a major physical catastrophe such as severe volcanism or a meteor strike, but a single species: us.

Threats to biodiversity include habitat loss, climate change, invasive species and pollution.

Habitat loss and degradation is the leading cause for biodiversity loss. Habitat destruction is widespread in many parts of southern Canada where most Canadians live. Natural habitats that are necessary for species to flourish are converted to roads, building sites, and for industrial or agricultural use. In less populated areas, resource extraction for mining, energy, or forestry may leave poorly functioning ecosystems. In these cases, habitats may be fragmented, which leaves wildlife open to predators and unable to reach feeding and breeding sites. This fragmentation makes it difficult for species to adapt and survive.

Climate change affects every Canadian ecozone, but rising temperatures are causing particularly visible damage to arctic environments. When permafrost melts, the ground loses its supporting network of ice crystals. This can destabilize the land and make animal habitat and human infrastructure vulnerable. The warming conditions in the Arctic may force various arctic species to migrate further north in order to survive. They may have to do this at a quicker rate than they are able. It is estimated that species will have to move about one kilometer each year to survive. However, plants such as lichen, an important food source for caribou, are limited in their ability to spread. The inability of plants to adjust quickly could have detrimental effects on animals that rely on them as a food source. The loss of arctic species may be as high as 20 percent. With this potential reduction of species, many benefits of biodiversity are threatened.

Invasive Species are organisms that are not indigenous to regions, but have been transported there by human activity or natural occurrences. They are able to thrive in these new areas because they have no natural predators or diseases. Non-native species can damage native environments by altering habitat, competing for resources, causing disease, or by hybridization (interbreeding and altering the gene pool.) All these elements throw the ecosystem out of balance and reduce the environment's ability to cope with change.

Dumping products like paint, detergents, and oil down the drain **pollutes** waters and can kill fish, amphibians, and aquatic plants. Proper removal of toxic liquid and other materials like batteries, computers, medications, and electronics should be done with care. Most muncipalities provide special depots for these materials to be disposed of safely.

Sources:

http://www.eman-rese.ca/eman/reports/publications/rt_biostrat/cbs4.htm
http://www.mnr.gov.on.ca/en/Business/Biodiversity/2ColumnSubPage/STEL02_166814.html

All About Invasive Species

There are many non-native species living in the habitats around us. Evolving in a foreign environment, non-native species have adaptations suited to meet the resources of a community and habitat different from the one in which they are introduced. These species become *invasive* when they take away habitat and food from native species to an extent where they do harm to the environment and economy. The adaptations of invasive species are particularly competitive as they may:

- Have few natural predators, disease or parasites to keep their numbers in balance,
- Reproduce quickly and often,
- Adapt to many conditions,
- Be able to migrate (and therefore spread) easily,
- Be *generalists*; they can eat a variety of foods and live in a variety of habitats; and
- Often defend themselves well or are particularly aggressive predators.

Alien species are found nearly everywhere in Canada. They can belong to any of the categories of organisms in the world, including plants, mammals, birds, reptiles, amphibians, invertebrates, and micro-organisms. They include species native to one part of Canada that move to another region of the country, as well as those that come from outside the country. These aliens are any species that has spread beyond its natural range into new locations as a result of human activity.

Many of Canada's alien species are beneficial, but a great number are not. Sometimes the conditions are right for alien species to become *invasive*—they move into new habitats and take over, their populations sometimes expanding beyond control. The harm they cause to the environment, the economy, or human health can be costly and sometimes irreversible.

Seafaring European explorers and settlers were the first to introduce new species to Canada. They brought cattle, goats, and other domestic animals, along with familiar crops like wheat, when they came by ship to explore and settle the New World. Without meaning to, they also introduced unwanted organisms—pests, like the Norway rat, and viruses, like deadly influenza and smallpox.

Today, alien species are still being imported intentionally into Canada from around the world for use in many areas, from agriculture and horticulture to the pet trade to medical and scientific research. A variety of legislation regulates the importation of alien species into Canada and their movement once they are in the country. Unfortunately, even when programs are in place to monitor and contain imported species, the effects the species can have on the environment if they accidentally escape from their intended habitat is not always considered.

Accidental arrivals are rarely discovered until they have become invasive and spread some distance from their point of entry. For example, many unwanted aliens arrive in ballast water, the seawater or freshwater used to stabilize large ships during travel; aquatic species are taken up along with ballast water at one port and released at the destination port. About half of the alien shellfish species in Canada, including the highly invasive zebra mussel, probably arrived in North America in this way. Shipping-crate wood and packing materials may also contain unwanted species, such as insects. As well, unwanted aliens may travel with intentionally imported ones. For example, plants, seeds, and bulbs that are imported for use in landscaping may harbour foreign insects and fungi or may be contaminated with the seeds of other plants. Domestic animals and aquaculture species may carry foreign diseases or parasites.

Alien introductions into Canada are becoming more frequent and difficult to track as global trade and travel expand. In recent years, more species have been arriving from Asia, some with telltale names like the Asian long-horned beetle, Japanese bamboo, and Eurasian water milfoil. More frequent travel between regions within Canada is also speeding up the spread of alien species to remote areas, isolated water bodies, and islands.

What's the Concern?

When an alien species enters an ecosystem, it can have an impact on the species that are present, on important habitats, or even on the ecosystem itself. Concern arises when an alien species changes the system for the worse, either by reducing or eliminating populations of native species, or by otherwise changing the way the ecosystem works

These changes have made the invasion of alien species a major global problem. If organisms were not able to move beyond their normal ranges, each part of the world would have a unique array of plants, animals, and micro-organisms. But as species move from one area of the world to another, sometimes squeezing out the competition, different places in the world become more alike in their biology—a process called *biological homogenization*.

This process is undesirable because as it takes place, ecosystems often become less stable, and valuable biodiversity, or variety of life, is lost. This variety is essential to the health of our planet; each species performs a function that contributes to global well-being. The spread of invasive alien species, like habitat loss, is considered one of the major threats to biological diversity. Invasive alien species have obliterated about 110 vertebrate species around the world and have affected nearly every type of ecosystem. For example, in New Zealand, predatory European mammals such as rats, cats, and stoats have caused the extinction of nine native bird species, and they threaten many more. In Guam, the brown tree snake, an import that arrived hidden in ship cargo from New Guinea, has wiped out virtually all the island's native forest birds.

Invasive aliens pose a problem mainly in places with a warmer climate and a disturbed landscape. In Canada, these two factors come together in the south, where most of the human population lives. Urban and industrial development and activities such as forestry and agriculture disturb the landscape in ways that make it more vulnerable to alien invasions and endangerment of native species. In particular, southern British Columbia, Ontario, and Quebec are home to a large number of both invasive aliens and species at risk. Natural communities on islands are also particularly vulnerable to invaders. Their plants and animals have evolved in isolation from the mainland, and they do not have the adaptations needed to escape from or compete with outsiders. Almost half the mammal species found on the island of Newfoundland and on the Queen Charlotte Islands are invasive aliens.

The Cost of Invasion

The damage cost caused by invasive alien species in Canada and the cost of controlling these species is not precisely known. But these costs are considerable and will continue to grow. Forestry companies and farmers lose millions of dollars in products each year because of alien pests and disease, and they spend millions more on pesticides, fungicides, and herbicides to control the invaders. Tens of millions of dollars have already been spent repairing the damage caused by the zebra mussel to industrial intake and output pipes and to locks and other waterway structures in the Great Lakes system. Unless checked, further damage by this invasive mollusc over the next 10 years is expected to cost Canada and the United States another $5 billion. Invasive aliens also take a toll on health. The West Nile virus, for example, a disease transmitted by infected mosquitoes, has caused numerous deaths in humans and wildlife in Canada and the United States since it was first detected in North America in 1999.

How Invasive Species Thrive

Successful invaders are species that have some advantage over native species. These advantages are often enhanced when aliens move into ecological niches and thrive because, outside their natural environments, they are not held back by natural predators, parasites, disease, or competition in the way that native species are. Here are some Canadian examples of how alien species affect the species around them:

Competition: In many cases, invasive species out-compete native species for space, water, food, and other essential resources. For example, non-native starlings eliminate native Canadian birds like bluebirds, Red-headed Woodpeckers, and Tree Swallows by taking over their nesting sites. In addition, often invasive species reproduce more successfully than indigenous species, quickly outnumbering the natives.

Many threatened and endangered species are placed at grave risk by invasive species. An

estimated 16 percent of endangered plants in Canada are negatively affected by competition with invasive plant species. For example, endangered native white wood aster, ginseng, and wood poppy are all threatened by the invasion of non-native garlic mustard.

Predation: Some invasive species cause native populations to decline by being aggressive herbivores or predators – defoliating or overgrazing native plants or preying on native animals. Introduced rats and raccoons eat the eggs and nestlings of Ancient Murrelets and other seabirds living on the coast of the Queen Charlotte Islands. By depleting this population, the invasives may also be affecting the vulnerable Peale's Peregrine Falcon, for which Ancient Murrelets are a food source. Another invasive, the gypsy moth, defoliates (eats the leaves of) many tree species. This causes widespread damage to Canadian forests and huge losses to the forest industry.

Disease: Sometimes, invasive species are diseases. Chestnut blight, a fungal disease that came to North America on nursery stock from Asia around 1900, has devastated the population of chestnut trees in eastern Canada and the United States.

Parasitism: At times, invasive species feed on, or parasitize, native species, severely weakening them but not necessarily killing them. The sea lamprey, which parasitizes other fish, was introduced into the upper Great Lakes in the 1800s and early 1900s. Along with other factors, it was responsible for severely reducing the native population of lake trout, the system's top natural predator.

Hybridization: Sometimes invasive species weaken the gene pool of native species by interbreeding with them, a process called *hybridization*. In southwestern Ontario, native red mulberry is imperilled by hybridization with the alien white mulberry, brought to Canada from China in an attempt to start a silk industry here. With continued hybridization, the gene stock of the red mulberry is becoming diluted. There are now as many stands of hybrid mulberry as red mulberry.

Habitat alteration: When they change the structure or composition of a habitat, invasive species make it unsuitable for other species. This process is called *habitat alteration*. Careful management of the introduced moose is required to prevent overgrazing of forests and wetlands on the island of Newfoundland. Foresters in areas that are overpopulated by moose find that the animals' grazing harms the regrowth of forest trees. This may seriously reduce future timber crops as well as the breeding habitat of songbirds that nest in deciduous shrubs. Overgrazing can also expose low-nesting birds and leave them vulnerable to predation. Invasive species can also seriously affect the environmental processes that all species, including humans, depend on. For example, the alien aquatic plant Eurasian water milfoil forms dense mats along shorelines and in slow-moving rivers. These mats sometimes interfere with the local nutrient cycle. When they die and decay, large amounts of phosphorus are added to the water, making it too rich in nutrients.

Human Activities and Invading Species

Human activities have a great impact on the spread of invasive species around the world. (Remember that there are invasive species in all kingdoms, not just plants and animals. Bacteria, protists and fungi can also be invasive.) The global transport of people and goods is unprecedented, and can set up conditions that are ideal for the spread of invasive species, either intentionally or unintentionally, through:

- tourism and other travel. An estimated 650 million people cross international borders as tourists every year. The opportunities for them to transport invasive species with them, as unwitting "hitchhikers" or intentionally is profound and increasing;
- agricultural trade including trade of agricultural products, and international food aid distribution programs that move food products around the world;
- escapes from horticulture, game, fur and fish farming, fish stocking, research and zoos can also spread of invasive species;
- species introduced to an area for hunting;
- movement of species to new locations through internet and mail order; and
- transport of products such as seed and wood products, solid wood packing materials and dunnage. For example, the brown spruce longhorn beetle (*Tetropium fuscum*) arrived in Nova Scotia from Europe in packing wood and became established on spruce trees in Halifax's Point Pleasant Park. While the beetle in its European natural habitat feeds primarily on dead wood, it infested healthy trees in the park, and it posed a serious threat to North American forests. The government of Nova Scotia was so concerned about the threat to its US$1.5 billion per year softwood industry that it cut down and burned 10,000 affected trees, in hopes of eradicating the beetle.

The Relationship Between Climate Change and Invasive Species

Many biological impacts of climate change can be expected, including:

- Change in the distributions of species, and changes in species abundance within existing distributions;
- More favourable conditions for the establishment and spread of invasive species, as well as change the suitability of local climates for native species and the nature of interactions among native communities;

- Change in the patterns of production and trade in agricultural commodities, with crops adapted to tropical conditions being grown more competitively in higher latitudes and altitudes. The opportunities for tropical invasive species to contaminate such crops in new ranges will also increase.

- Reduced ability to resist invaders (for example, insects and diseases) among plants that are stressed due to climate change.

- Changes in the frequency and intensity of extreme climatic events that disturb ecosystems, making them vulnerable to invasions and providing exceptional opportunities for dispersal and growth of invasive species. For example, a drought that kills native plants can leave gaps in vegetation that may be quickly occupied by invasive species. For another example, Downy Mildew is an invasive fungi that affects cucumber, squash, melon and pumpkin agricultural crops. In summer 2006, downy mildew spores blew north from the southern USA. Ontario farmers were unprepared for the invasive fungi and consequently lost crops which, in turn, affected consumer supply and price.

- By altering the frequency, intensity and duration of flooding, climate change may enable aggressive species to escape from local, constrained areas. For example, the "sensitive plant" (*Mimosa pigra*), a woody legume, escaped from the Darwin Botanical Gardens during a major flood that took seeds into the Adelaide river in Australia. *Sensitive plant* has now become a significant problem in the region and in other areas of the world.

Sources

http://www.hww.ca/hww2.asp?id=220
http://www.gisp.org/publications/brochures/globalstrategy.pdf

A Sampling of Invasive Species

EURASIAN RUFFE *(Gymnocephalus cernuus)*
Eurasian ruffe (rhymes with "tough") are small fish, native to Europe. They were first brought to the Great Lakes in the ballast water of ships, and have been further spread by anglers who have used them as bait, releasing the live fish into ruffe-free waters accidentally. Ruffe eat a variety of foods, including fish eggs. Their small size, hard spikes and the fact they spend their nights in shallow water feeding, and their days swimming safely in deep water, ensures that they can avoid predation better than native fish. This allows them to reproduce more frequently and to extend their habitat range. Ruffe have no value to commercial and recreational fisheries.

EUROPEAN FROG-BIT *(Hydrocharis morsus-ranae)*
European frog-bit looks like a miniature water lily with a small white flower. It is originally from Europe and Asia. This plant lives in calm waters. Frog-bit reproduces both sexually and asexually at rates faster than native species and grows quickly. It floats on the water's surface, blocking sunlight and creating poor conditions for native plants growing beneath it.

EMERALD ASH BORER *(Agrilus planipennis Fairmaire)*
The emerald ash borer is an invasive insect which attacks all species of ash trees in North America. Emerald ash borer adults are metallic green, 8.5 to 13.5 mm long, and slender. The head is flattened, with black compound eyes that cover most of the side of the head. Arriving through improperly treated wooden packaging material from Asia, the beetle is now found throughout much of Essex County and part of Chatham-Kent in Ontario, and has continued to spread to new areas. Some of this spread has been natural dispersal, but long distance spread has been helped by people, especially through the movement of nursery stock or infested firewood from infested areas. Emerald ash borer is very difficult to detect early. When infested trees are found, it's often 1 year or more after the attack occurred. In addition, there are several other factors affecting ash health in Ontario which may disguise its presence. Estimates show the emerald ash borer has killed several hundred thousand ash trees in Essex County , Ontario. If not effectively controlled, the emerald ash borer is expected to spread across the entire range of ash, causing widespread tree mortality.

FANWORT *(Cabomba caroliniana)*
Fanwort is a subtropical, submersed South American plant commonly sold for use in aquariums. Released into the wild, fanwort can establish itself in slow flowing water. It spreads when its broken stem fragments continue to grow, becoming a new plant. Fanwort can form dense mats, crowding out native plants, clogging drainage canals and areas where there is still water. It can make swimming and boating difficult and may impact fisheries.

GOLDFISH, KOI AND CARP SPECIES *(Carassius spp., Cyprinus spp.)*
Goldfish and koi are popular and beautiful aquarium fish. These and other carp species used in aquaculture have the potential to become quite destructive to Ontario's lakes and rivers. This is due to the fact that they can grow and reproduce quickly and in the process consume large quantities of aquatic vegetation that native species may depend on for food, shelter, laying eggs and protecting their young.

PURPLE LOOSTRIFE *(Lythrum salicaria)*
Purple loosestrife is a plant with a bright purple flower spike that contains many small purple flowers. It can grow to be over 1 m tall. Purple loosestrife reproduces aggressively. Its flowers produce millions of seeds each year that are blown in the wind and carried on water to new locations. The plant can also reproduce when its roots are split apart. Loosestrife takes over wetland habitats limiting biodiversity and sources of food and habitat for native species. This is a huge problem, as wetlands are the most biologically diverse productive components of our ecosystem.

ROUND GOBY *(Neogobius melanostomus)*
Originally from Europe, Round Gobies were brought to Ontario in the ballast water of ships. They can reach up to 25 cm in length and are grey/brown in colour. Round Gobies have a bottom fin shaped like a suction cup - this allows them to sit on the bottom of streams and rivers. Round Gobies are able to reproduce up to six times each year. Rapid reproduction, aggressive competition for food resources, along with preference for widely available zebra mussels that no other fish eat, gives the Round Goby an advantage over native species. Sport fish that eat Round Gobies, including smallmouth bass and walleye, may accumulate contaminants that are present in the zebra mussels that gobies eat, a process called biomagnification. Mussels can also pass on type E botulism to gobies, which then kill sturgeon, loons, walleye and gulls. There are also unanticipated benefits of the Round Goby. The Lake Erie water snake was near extinction before the Round Goby came on the scene. The snakes have discovered that the male gobies will not leave nests while eggs are being hatched and attack for an easy meal. Not only is this beneficial in reviving the Lake Erie water snake, it also helps limit Round Goby populations since it drastically impedes reproduction.

RUSTY CRAYFISH *(Orconectes rusticus)*
Rusty crayfish are native to the Ohio River in the United States. These crayfish have larger, stronger claws and are more aggressive than other crayfish. This aggressive behaviour forces native crayfish from their hiding places thus making them more vulnerable to predation. The rusty crayfish also eats 2-3 times as much as our native crayfish. By consuming large amounts of benthic organisms, and fish eggs and fry, they compete directly with young fish. They also eat aquatic plants in significant quantities, limiting nursery habitat and shelter for young and small fish. The main way rusty crayfish have spread is by accidental release into the wild - from anglers' bait buckets and hobbyists' aquariums.

SEA LAMPREY *(Petromyzon marinus)*
The sea lamprey is a long, boneless (it has cartilage), fish without scales that resembles an eel. They have horn-shaped teeth set in a disk-shaped mouth which they use to attach themselves to the sides of fish. They then eat away the fishes' skin and scales to feed on its blood and body fluids. This either kills the fish or leaves them with serious wounds that are susceptible to parasites and disease. Originating in the Atlantic Ocean, sea lamprey were prevented from migrating to most inland Ontario waterways by physical barriers such as waterfalls. Shipping canals built at the turn of the century allowed sea lamprey to expand their range into all of the Great Lakes.

SPINY WATER FLEA *(Bythotrephes longimanus)*
Spiny water fleas are tiny crustaceans (the size of your baby fingernail) with a large black eye. They feed on other crustaceans, often eating two to three times more food than native crustaceans. By eating this much, they limit food for native zooplankton and fish. The spiny water flea, as its name suggests, has a long tail spine with barbs on it. The barbs make it difficult for young fish and fry to swallow—they literally cough them up -further limiting feeding opportunities for local species. The spiny water flea can hitchhike to other waters on boats, boat trailers and other equipment such as fishing gear and snorkeling/scuba gear. They were originally brought to the Great Lakes in the ballast water of foreign ships. The FISHHOOK WATER FLEA *(Cercopagis pengoi),* is similar to the spiny water flea but is smaller with a loop or hook at the end of its tail. Their impact is similar.

ZEBRA MUSSEL *(Dreissena polymorpha)*
Zebra mussels are small crustaceans with a yellow, brown and cream-striped shell, introduced to the Great Lakes by foreign ships dumping their ballast water. Zebra mussels have all the adaptations needed to make it a highly successful invasive species. As well as producing a great many offspring, zebra mussels require very little space to grow, are able to survive in a wide range of environmental conditions and have few predators. Female zebra mussels produce over one million eggs each season which spread throughout water systems by floating on currents and being inadvertently transferred by people and their boats. Zebra mussels prefer warmer, shallower waters while the related quagga mussels live in colder, deeper waters, therefore, when both inhabit a waterbody, they can be found in all areas. Zebra mussels eat by filtering phytoplankton (tiny plants) out of the water. Zooplankton (the primary food of young fish) also eat these plants. This competition with zebra mussels for food can have impacts throughout the food chain. Zebra mussels attach themselves to hard surfaces such as clam shells, crayfish, boat hulls, docks, buoys, etc. and can clog water pipes. They can also hurt swimmers' feet and they can infect predators such as the few duck and fish species that consume them with bacteria and contaminants. (This infection can subsequently make its way up the food chain if these species are consumed by a higher predator.). Often fish cannot spawn in areas covered with zebra mussels. Once zebra mussels are in a lake, there is no way to control or eradicate them so preventing their introduction is critical.

BLOODY RED SHRIMP (*Hemimysis anomala)*
The Bloody red shrimp is a new invader in the Great Lakes, arriving from the Black Sea and Caspian Sea in ballast tanks. Bloody red shrimp can reach one centimeter in length and prefer rocky bottoms near shore and shaded areas around docks, boats and piers. They can be difficult to see, but are highly visible when swarming in shaded areas. It is too early to fully understand the impacts that the Bloody red shrimp will have on the Great Lakes ecosystem. There are concerns that they will compete with young fish and predatory zooplankton species for food. Bloody red shrimp feed rapidly, and because of this they produce high quantities of fecal pellets. The high deposition rate of fecal matter means that these shrimp have the potential to alter the environment. Another area of potential concern is the biomagnification of contaminants through the food chain. To date, Bloody red shrimp have not been found in inland lakes, but could be inadvertently spread through water in bait buckets and live wells.

ASIAN LONG HORNED BEETLE *(Anoplophora glabripennis)*
The Asian long-horned beetle is a forest pest that attacks and kills a wide range of hardwood trees, including maple. A native of China, it was likely introduced into North America by way of wooden pallets, crates, or packaging materials used in shipping. Canada 's temperate climate is well suited for the establishment of the insect as the larva spends winters deep within the wood protected from harsh winter conditions. The beetle has no known natural enemies within Canada's forests. Insecticides do not protect infested trees and only kill some beetles when applied to uninfested trees before attack. The only way to combat the beetle is to identify, cut down, and burn or chip the infested tree. Infested trees are also prone to secondary attack from other insects and diseases. Once established, the beetle is extremely difficult to eliminate.

GARLIC MUSTARD *(Alliaria petiolata*)
Garlic mustard likely arrived in North America with pioneer settlers, who brought it with them as a source of food. The plant starts out as a low group of bright green leaves in the first year. It stays green all year-round and produces a tall stalk in the second year with a cluster of small white flowers at the top in May-June. Long slender seed pods form in early June and dry out over the summer. Each plant can produce up to 1000 seeds, and seeds can lie dormant for up to five years. As seeds germinate in subsequent years, Garlic Mustard forms a dense mat on the forest floor that can out-compete native spring plants. Garlic Mustard stays green and photosynthesizes all winter (look for it's bright green leaves as the snow is melting!), which gives it a competitive advantage over other plants in the spring. Garlic Mustard can be found throughout Southern and Central Ontario.
Garlic Mustard produces a substance that is toxic to fungi that are beneficial to the root system of hard wood trees, such as sugar maples. The fungus penetrates and extends the root system of the tree, helping to nourish it. Garlic Mustard kills the fungus, resulting in less nourishment for the tree and slowed/stunted tree growth.

PHRAGMITES *(Phragmites communis)*
Phragmites are tall reeds that look like ornamental grasses seen in gardens, and produce a large "plume" at the top of the grass. A mature plant can reach a height of 4 meters! Phragmites secrete a toxic acid from their root system that disintegrates the structural protein in roots of neighbouring plant, eliminating competition. Phragmites are spread by rhizomes and form a dense mat that effectively prevents other plants from growing. This invasive plant can take over wetlands decreasing biodiversity, reducing the food and habitat available to wildlife, and altering wetland hydrology. (http://www.sciencedaily.com/releases/2007/10/071012084128.htm)

Actions to Stop Species Invasion!

Invasive species pose enormous threats to our aquatic ecosystems. Fortunately, the actions we can take to prevent these invaders are simple:

AQUARIUM CARE-IUM

Responsible aquarium owners and habitat stewards will:

- *Never release or flush aquatic plants or fish into a lake, river, pond, stream, drainage ditch or sewer. It is illegal!*
- *Return or donate unwanted aquarium animals and plants to local pet stores, school groups, or community centres.*
- *Find out about the Fish Rescue Programs that can help you find a home for your unwanted pet by contacting the Invading Species Hotline toll-free at 1-800-563-7711 or visit www.invadingspecies.com*

Aquarium owner's motto: **Aquarium in! Nothing out!**

GARDENERS

Responsible owners of water gardens and habitat stewards will:

- *Dispose of unwanted and invasive plants by drying them completely and discarding them in household garbage. Don't compost them because some seeds can withstand drying and freezing.*
- Learn which plant species are invasive, and remove them from your garden.
- *Consider using native plants and animals found at your local nursery. Ask to be sure that their native range includes your region. Never collect native plants from the wild.*
- *Select a site for your water garden as far away as possible from natural waterways and any areas subject to flooding.*
- *Remove potential "hitchhikers" from your purchases by rinsing in a light coloured bucket until free of soil.*

Gardener's motto: **Grow Native! Not Invasive!**

FISHING CREDO

Responsible anglers and habitat stewards will:

- *Never release live bait or live baitfish, or empty the contents of a bait bucket into any waterbody within 30 m of any waterbody.*
- *Only use crayfish as bait in the waterbody where they were caught, and never transport them over land.*
- *Save unused baitfish for future use by freezing, salting, or giving to a friend.*
- *Never use Round Goby as bait! It's illegal!*

Angler's motto: **Here native fishy, fishy, fishy!**

AHOY THERE, BOATER!

Responsible boaters and habitat stewards will:

- *Inspect their boats, trailer and equipment before leaving any body of water, removing any plants, mud and animals that they see.*
- *Drain water from their boat including the live well, bilge, and motor while still at the lake or river they have just enjoyed.*
- *Wash their boat and gear with hot water or high-pressure water (like a garden hose spray) or dry it out in the sun for at least 5 days before moving it to another body of water.*

Boating enthusiasts motto: **A loved boat is a scrubbed boat.**

AT THE MARKET

Responsible chefs and habitat stewards will:

- *Refuse to buy or sell specific species of live carp (grass, big head, silver or black) or snakeheads (a vicious type of fish!) since this is illegal!*

Food lover's motto: **Just say no to live carp and snakeheads!**

OUT IN THE WOODS

Responsible campers and cottagers will:

- *Not transport firewood or other wood with bark attached over long distances. Invasive species such as the Emerald Ash Borer and Asian Long-horned Beetle may be stowed-away and unknowingly transported to a new area in the wood load.*

Camper's Motto: **Leave the firewood at home!**

WORDS OF WISDOM

- *Keep natural habitats on your property healthy.*
- *Volunteer with local environmental organizations that work to maintain healthy ecosystems or restore degraded ecosystems.*
- *Know where consumer products come from (especially food, pets, and biological pest-control products). Buy from local sources where possible, and be particularly cautious about purchasing from Internet-based companies.*

(source: http://www.hww.ca/hww2.asp?id=220)

1. **<u>Learn</u> how to stop invasive species and help habitats stay healthy!**
2. **Help out more by <u>teaching</u> others!**
3. **Enjoy and <u>protect</u> our beautiful Ontario!**

INVASIVE SPECIES TEACHING RESOURCES

CURRICULA

Community Stewardship Projects on Exotic Aquatic Species
Booklet of activities and community stewardship projects developed by students as part of Sea Grant's "Exotic Aquatics on the Move" education project. To download the booklet, please visit… **www.seagrant.umn.edu/publications/X78**
Produced by the Illinois-Indiana Sea Grant Program. 2001.
Contact: Valerie Eichman, IL-IN Sea Grant [eichman@uiuc.edu] [217/333-8055] or Doug Jensen, MN Sea Grant [djensen1@d.umn.edu] [218/726-8712]
Cost: Single hard copies available free of charge

EATM: Exotic Aquatics on the Move
CD: "Building a Web of Awareness for Geography Educators and Students." Twenty-seven lessons on aquatic invasive species available as printable PDF files and in alignment with the National Geography Education Standards. Visit… **http://www.iisgcp.org/EXOTICSP/**.
Produced by six Sea Grant Programs (IL-IN, LA, MN, NY, OH, and WA) and six Geographic Education Alliances (IL, IN, LA, MI, NY, and WA). 2001.
Contact: Robin Goettel, IL-IN Sea Grant [goettel@uiuc.edu] [217/333-4780] or Doug Jensen, MN Sea Grant [djensen1@d.umn.edu] [218/726-8712]
Cost: $2.50

ESCAPE Compendium and Board Games Package
Two laminated color board games and the ESCAPE compendium for use in educating K-12 students about exotic aquatics including zebra mussels, purple loosestrife, sea lamprey, round gobies, rusty crayfish, and many more found in the Great Lakes and other freshwater ecosystems.
Contact: http://www.seagrant.umn.edu/publications/X79pkg
Cost: $70

Hands On Nature
Take a glimpse into the Royal Ontario Museum's life sciences collections while learning about the importance of biodiversity, both close to home and around the world. This school case, with everything from skulls to spiders, introduces the topics of biodiversity, classification, adaptation and species at risk. Active learning though observations and experimentation stimulates the student to become more aware of their natural surroundings. Contents: 5 activity centres, 25 specimens, 80 colour photo cards, and teacher's notes.
Contact: http://www.rom.on.ca/schools/edukits-casesC.php email: schoolc@rom.on.ca
Cost: Rental fee.

Native Species, Nature's Choice
A 24-page curriculum unit informs young Canadians about the nature of invasive species, how they are introduced and spread, their impacts on native species and spaces, and how to protect our natural riches in the face of this threat. This unit uses inquiry-based lesson plans focusing on alien species for Grades 4-12 available in both French and English. To download this free unit, please visit… **www.wildeducation.org/programs/nww2003/nww2003booklet_e.pdf.** Also available is **Battle with the Alien Space Invaders,** an on-line game that can introduces the threats of invasive species and how to solve the problem through the restoration cycle. Please visit… **www.wildeducation.org/maze_invasives/battle_mazec.htm**
Produced by the Canadian Wildlife Federation (CWF)
Contact: Canadian Wildlife Federation [info@cwf-fcf.org]
Cost: Free

SEE CELLA CHOW! A Purple Loosestrife Biological Control Manual for Teachers
Fifteen activities focus on wetland ecology and invasive species. Lessons emphasize biocontrol efforts, including the development, rearing, and release of beetles to combat purple loosestrife. The activity set provides teachers with background information, links to state standards, and activity instructions. To download, please visit…
http://www.dnr.state.wi.us/org/es/science/publications/ss981_2003.htm#document
Produced by the Wisconsin Department of Natural Resources, the Wisconsin Wetland Association and Wisconsin Teachers. 2003.
Contact: Derek Strohl, WI Wetland Assoc. [derek@wiscwetlands.org] [608/250-9771] or Brock Woods, WI DNR [Brock.Woods@dnr.state.wi.us] [608/221-6349]
Cost: Determined at publication time

POSTERS and PRINT MATERIALS

A Sampling of Invasive Species
The Invading Species Awareness Program, a partnership program between the Ontario Federation of Anglers and Hunters and the Ontario Ministry of Natural Resources provides free outreach materials that include posters, stickers, magnets, watch cards, factsheets and brochures explaining the aquatic invasive species of concern in Ontario and the Great Lakes, pathways of introduction and impacts. Please visit… **http://www.invadingspecies.com/resources/** to view and order on-line.
Produced by the Invading Species Awareness Program, a partnership of the Ontario Federation of Anglers and Hunters and the Ontario Ministry of Natural Resources.
Contact: The Invading Species Hotline [1-800-563-7711] [info@invadingspecies.com]
Cost: Free

Aliens Among Us
Ohio Department of Natural Resource's colorful poster visually explores aquatic and wetland invasive plants and animals. Graphics include fish, mollusks, and plants, as well as ways to prevent their spread.
Produced by Ohio DNR's Division of Wildlife in collaboration with the Division of Natural Areas & Preserves and the U.S. Fish & Wildlife Service. 2002.
Contact: Jennifer Windus, ODNR [Jennifer.Windus@dnr.state.oh.us] [614/265-6468]
Cost: Single copies available free of charge

Photo-Mural: Invasive Non-Native Plants
Large, laminated photo-mural of 37 invasive non-native plants found in the U.S. Plants are depicted in attractive color photographs. To view, visit… **http://aquat1.ifas.ufl.edu/**.
Produced by the Center for Aquatic and Invasive Plants, University of Florida, Bureau of Invasive Plant Management, the Florida Department of Environmental Protection, Sea Grant, and Cerexagri. 2001.
Contact: APIRS Photo-Mural, Center for Aquatic and Invasive Plants, 7922 NW 71 St, Gainesville, FL 32653
Cost: Free (requests in writing – limited copies available)

Stop Aquatic Hitchhikers!
Sticker lists four easy steps boaters and anglers can take before and after using their watercraft. To view, visit… **http://www.protectyourwaters.net**.
Produced by the ANS Task Forces' Communication, Outreach and Prevention Committee's National ANS Outreach Campaign. 2002.
Contact: MN Sea Grant [218/726-6191]
Cost: Single copies available free of charge

Wild Cards
Wisconsin Department of Natural Resources has developed a series of identification cards for a variety of native and non-native plants and animals found in Wisconsin, including nine aquatic invaders. Designed for children, the cards include photos and descriptions, as well as how invaders pose problems and why native species are beneficial.
Produced by the Wisconsin Department of Natural Resources. 2002.
Contact: Ron Martin, WI DNR [martir@dnr.state.wi.us] [608/266-9270]
Cost: Single cards available free of charge

VIDEOS and DVDs

Invaders in Our Waters
A comprehensive DVD package that includes: a 7 minutes overview of the impacts of aquatic invasive species with a focus on the pathways of how they can be introduced; six-two minute and four-30 second PSA messages focusing on each pathway of concern; and a list of resource materials available free from the Invading Species Awareness Program.
Produced by the Invading Species Awareness Program, a joint partnership of the Ontario Federation of Anglers and Hunters and the Ontario Ministry of Natural Resources in conjunction with the Ontario Ministry of Agriculture, Food and Rural Affairs.
Contact: Invading Species Hotline [1-800-563-7711] [info@invadingspecies.com]
Cost: Free

Alien Ocean
Zebra mussels from the Black Sea. Green crabs from the Baltic Sea. How did they get here and what impacts do they have on our waters? Alien Ocean tells the dramatic story of scallop fishermen, cargo ship captains, pilots and the scientists who are pioneering a new field called "invasion ecology."
Produced by the Maryland Sea Grant Program. 1998.
Contact: MD Sea Grant [mdsg@mdsg.umd.edu] [301/403-4220]
Cost: $24.95

Aquatic Invaders
"Cutting Edge Technology Report" shares the threats and challenges aquatic invaders have on our nation's ecosystems. Provides an overview of the problem, including highlighted segments on Chinese mitten crabs, European green crabs, zebra mussels, and sea lampreys.
Produced by the Information Television Network. 2000.
Contact: Doug Jensen, MN Sea Grant [djensen1@d.umn.edu] [218/726-8712]
Cost: $5

STOP EXOTICS: Clean Your Boat
Eleven-minute video featuring John Ratzenberger ("Cliff" from TV show, Cheers). The video explores steps boaters, sailors and personal watercraft users can take in order to prevent the spread of exotic plants and animals. For more information, please visit… **http://www.seagrant.umn.edu/publications/x97.**
Produced by the Minnesota Sea Grant Program. 2000.
Contact: Doug Jensen, MN Sea Grant [djensen1@d.umn.edu] [218/726-8712]
Cost: $10

You Ought To Tell Somebody! Dealing with Aquatic Invasive Species
Twenty-three minute video provides an overview on aquatic invasive species, as well as the identification and natural history behind one significant new threat, the Chinese mitten crab. Visit… **http://seagrant.oregonstate.edu/sgpubs/you-ought-to-tell-somebody-video**.
Produced by the Oregon Sea Grant Program. 2001.
Contact: Paul Heimowitz, OR Sea Grant [paul.heimowitz@orst.edu] [503/722-6718]
Cost: $18.95 + 3.95 (postage)

BOOKS and CDs

Exotics To Go! Presentations and Publications to Prevent the Spread of Aquatic Invasive Species
Compact disc includes seven "conveniently wrapped" PowerPoint presentations on aquatic invasive species, loaded with images of problem species, fact sheets, brochures, and pamphlets. Presentations and documents designed to give general audience a greater understanding of the impacts of AIS. To order, visit… **http://www.seagrant.umn.edu/exotics/exoticstogo.html**.
Produced by the Minnesota and Illinois-Indiana Sea Grant Programs. 2001.
Contact: MN Sea Grant [218/726-6191]
Cost: $2.50

SGNIS (Sea Grant Nonindigenous Species)
Compact disc contains a collection of educational materials and peer-reviewed research publications produced by the National Sea Grant College Programs. To view contents, visit SGNIS's homepage at… **http://www.iisgcp.org/exoticsp/sgnis_cd.htm**.
Produced by Minnesota Sea Grant on behalf of the Great Lakes Sea Grant Network. 2001.
Contact: MN Sea Grant [218/726-6191]
Cost: $8

Think About the Planet
A musical CD by *Remy Rodden* that includes a song about invasive species titled "The Invadin' Alien Blues". Please visit… **www.thinkabout.ca/**
Produced by Think About…Productions
Contact: Remy Rodden [1-867-668-7953] or Canadian Wildlife Federation [1-800-563-9453]
Cost: $20 CD and $17 cassette, S&H and taxes included

Visualizing the Great Lakes
Compact disc contains 500 high-quality images gathered from 30 Great Lakes' agencies. A great tool to assist in the development of publications and PowerPoint presentations. Visit… **http://www.seagrant.umn.edu/**.
Produced by the Minnesota Sea Grant Program and the U.S. Environmental Protection Agency's Great Lakes National Program Office. 1998.
Contact: MN Sea Grant [218/726-6191]
Cost: $12

WEB SITES

The following web sites provide general information on biodiversity and invading species.

http://www.ontariobiodiversitycouncil.ca
Ontario Biodiversity Council link to the state of Ontario's Biodiversity Reports.

https://www.k12.gov.sk.ca/curr_inst/iru/bibs/update06/science69.html
Biodiversity Perspectives publications to download. Documents include global, national, regional, and provincial perspectives (Saskatchewan, Alberta and Manitoba).

http://www.cwf-fcf.org/
Canadian Wildlife Federation: A bilingual site that includes a section on invasive species and houses "The Invasive Species in Canada database" which describes the species that are considered invasive in Canada, where they're from, where they're found, how they're introduced and their ecological impacts. Includes several educational programs and resources for educators and students.

http://www.gisp.org/publications/brochures/globalstrategy.pdf
Global Invading Species Programme: This site provides an international perspective on invading species, patterns of invasion and their economic impact. Great background information for Grade 6 social studies integration re: Canada and the World strand.

http://www.hww.ca/en/issues-and-topics/invasive-alien-species-in.html
Canadian Wildlife Service/Canadian Wildlife Federation: This site provides Canadian perspective on biodiversity and invasive species, how they spread and thrive, and control measures. Also includes links to other online resources.

http://archive.fieldmuseum.org/biodiversity/investigate_basics.html
The Field Museum (Illinois): This site includes an easy-to-read primer on biodiversity, factors that are diminishing biodiversity and the impact of losses.

http://www.mbgnet.net/
Biomes of the world, freshwater ecosystems and marine ecosystems are just a click away on these webpages from the Missouri Botanical Gardens.

http://www.habitattitude.net/faqs/
Habitattitude is a partnership between government and trade organizations to address aquatic invasive species issues. Some content is specific to the United States, but the website includes action ideas, resources and background information that is useful.

www.invadingspecies.com
Invading Species Awareness Program: This site, representing a partnership program of the *Ontario Federation of Anglers and Hunters* and the *Ontario Ministry of Natural Resources*, has detailed information of aquatic invasive species found in Ontario. In addition, it provides many activities that enable citizens to participate in the prevention of invasive species spread and to assist in control efforts.

http://www.protectyourwaters.net
Protect Your Waters is designed for anyone who enjoys spending time on the water. The Web site, based on a national media campaign, includes procedures and tips for boaters and personal watercraft users to assist in preventing the spread of aquatic exotic species. The frequently updated site includes ways to "Become Informed and Take Action."

http://nas.er.usgs.gov
US Geological Survey: Nonindigenous aquatic species. Information resource pages include updated distribution maps identifying locations and spread of aquatic invasive species by region, as well as species' facts, images, biology and updated status reports.

http://www.seagrant.umn.edu
University of Minnesota Sea Grant College Program. Invasive species pages include updated information on zebra mussels, round goby, ruffe and other aquatic invasive species affecting the Great Lakes region. Contains links to many prominent AIS Web sites.

http://www.greatlakesseagrant.org/
Great Lakes Sea Grant Network. A network of Sea Grant programs working in partnership with government and private sectors. Site includes general information on aquatic invasive species, as well as links to additional, helpful sites.

http://www.glifwc.org/invasives/index.html
Great Lakes Indian Fish and Wildlife Commission. Emphasis on invasive plants and ecological impacts on the Great Lakes… interactive maps, slide library, educational materials and more.

http://nature.org/initiatives/invasivespecies/
The Nature Conservancy identifies invasive species as one of the most critical conservation issues today. Web site includes photos, graphs, and downloadable documents relating to invasive species, ecosystems, and habitat loss.

http://canadaforests.nrcan.gc.ca/article/biodiversity
Natural Resources Canada: Canadian perspective on biodiversity and conservation in Canada's forests.

http://www.toronto.ca/trees/pdfs/Fact_3_Controlling_Invasive_Plants.pdf
Toronto Urban Forestry Fact Sheet on controlling invasive species.

The following Web sites offer in-depth, detailed information on invasive species. Sites include technical reports, newspaper and journal articles, and access to photo, video, and slide libraries.

http://www.anstaskforce.gov/
Aquatic Nuisance Species Task Force. An intergovernmental organization dedicated to the prevention and control of AIS, established through U.S. Congress's Nonindigenous Aquatic Nuisance Control and Prevention Act of 1990.

http://www.great-lakes.net
Great Lakes Information Network (GLIN). Current information from newspaper and journal articles, scientific papers, conferences, press releases and education curricula. Includes an education and curriculum page for students and teachers.

www.agf.gov.bc.ca/cropprot/alhb.htm
Government of British Columbia: Information about the Asian Long Horned Beetle.

The following Web sites include lessons and games on invasive species and biodiversity. Sites may prove useful for educators integrating invasive species education into broader curricular units.

http://www.wildeducation.org
Fishways / Project Wild / Focus on Forests / Below Zero: Interactive games, activities and lesson plans educating children on the importance of healthy habitats and ecosystems from the Canadian Wildlife Federation. *Fishways* contains lesson plans that teach about fish and Ontario's aquatic habitats. This website also provides access to the curricular programs Project Wild, Focus on Forests and Below Zero.

http://www.nps.gov/learn
The National Park Service. A compilation of games and activities set up to assist educators teaching about plant and wildlife management. Includes "The Deadly Plant Invaders Game" –an active lesson engaging students in learning about the effects of invasive species.

http://www.vims.edu/bridge/
The Bridge: Ocean sciences education teacher resource site. Includes links to interactive activities for all ages as well as updated information on water studies. A unique clearinghouse to some of the best K-12 science education sites available online.

http://www.iisgcp.org/EXOTICSP/index.html
Exotic Aquatics on the Move: developed by National Sea Grant and Geographic Education Alliance. Site offers general invasive species information, as well as case studies on a wide array of species. Also features links and access to instructional materials.

http://www.campsite24.ca
Ontario Parks—Campsite 24.This website is for both students and teachers, and brings Ontario's parks and protected areas to your home, classroom or library. Download curriculum-linked resources for grades 2-6

GLOSSARY

Adaptations	The traits and characteristics that help plant and animal species live in a particular habitat and community.
Ballast Water	Water that is taken on by ships to stabilize it in the water. Organisms can be inadvertently transported when ballast water that is taken on in one location is discharged in a different location.
Biodiversity	The variability among living organisms from all sources including terrestrial, marine and other aquatic ecosysytems and the ecological complexes of which they are a part. Diversity within species and diversity between species.
Biotic Elements	The living parts of an environment.
Characteristics	A feature or attribute that distinguishes something.
Community	A group of plants and animals living and interacting together in a habitat.
Competition	The interaction between species that occurs when they require the same, limited resource (ex. light energy, food energy, living space, etc.)
Ecosystem	The community of living things and non-living things around it (air, water, soil and rock, for example) and the interactions between them.
Environment	The physical, chemical and biotic factors that act on an organism or ecological community.
Habitat	A place that is home to a plant, animal or community of plants and animals.
Inter - relationships	The connection between organisms or systems.
Invasive Species	Harmful non-native species whose introduction or spread threatens the environment, the economy or society, including human health. Invasive species can originate from other countries, neighbouring countries or from other ecosysytems.
Invertebrate	An animal without a backbone. Invertebrates include insects, arachnids (e.g., spiders and ticks), gastropods (e.g., snails and slugs), crustaceans (e.g., crayfish and isopods), centipedes, and worms.
Native Species	An animal or plant species that originates from the same area that it is found.

Natural Community	A distinct assemblage of "living things" naturally associated with each other and their physical environment.
Non-Native Species	Species introduced by human action outside their natural past or present distribution. They are also known as Exotic,foreign or alien.
Organism	A form of life composed of mutually interdependent parts that maintain various vital processes (e.g., an animal, a plant, a fungus).
Pathways	The ways in which invasive species are introduced or spread. Introductions can be intentional or accidental.
Resiliency	The capacity to respond to or withstand change. The greater the genetic variability within a population, the greater the potential resiliency.
Species	All living organisms.
Stewardship (environment)	Taking care of our habitats; making responsible choices and taking action to ensure they remain healthy for the species that live within them.
Vertebrate	An animal with a backbone and a brain enclosed in a skull.