PULLING FOR BIODIVERSITY

MANAGING INVASIVE SPECIES IN ONTARIO

AN EDUCATION PROGRAM DEVELOPED FOR

INTERNATIONAL BIODIVERSITY DAY, 2009

BEAN

Biodiversity Education and Awareness Network

UNIT INTRODUCTION

What is biodiversity? Simply put, biodiversity is life in all its variety: over 14 million species found from mountain top to deep-sea vent. But it is much more. Those species connect, and interact. Those interactions create communities and systems, and those systems provide goods and services such as oxygen production, pollination, water filtration and storage, pest control, food production, carbon storage and erosion control. Again, simply put, biodiversity anchors *nature's life support system.*

Why is there a concern? The world is losing biodiversity at an alarming rate. And the causes of this loss, the threats to biodiversity, can all be traced back to us. Each one of us. We need to connect with biodiversity, understand it, and identify what we can do to slow and even reverse its loss.

What is the role of invasive species? According to the United Nations Convention on Biological Diversity, invasive species form the second most dangerous threat to biodiversity, trailing only habitat destruction in a list that includes pollution, over-consumption, climate change and human population increase.

Invasives are alien species whose introduction or spread threatens the environment, the economy, and/or society, including human health. They tend to be highly aggressive and competitive, and lacking in natural enemies, often eliminating or replacing native species within an ecosystem, reducing biodiversity and, often, system stability.

Invasive species are the theme for International Biodiversity Day, May 22, 2009.

The Asian Long-horned beetle, for example, pictured here on the International Logo, is a threat to hardwood trees in Ontario, and one of the causes of the ban on moving firewood from one part of the province to another. In North America, it threatens 71 billion trees valued at US $2 trillion.

This unit has been developed for International Biodiversity Day, 2009, by the Biodiversity Education and Awareness Network.

What this unit does. This unit is designed to introduce the concept of invasive species, and explain in an interactive and engaging manner why they are so destructive to native biodiversity, ecosystems and our economy, and what resource managers and ordinary citizens can do about them. The focus is on Rusty Crayfish and Garlic Mustard, the two species targeted for action in Ontario on or near to the IBD. Activity thumbnails:

<u>Activity 1. What Are Invasive Species?</u> Through a matching exercise, students evaluate species' similarities and differences, categorizing species as either native, introduced/non-invasive, and invasive.

<u>Activity 2. Musical Mussels</u> Students role-play lake animals in a version of musical chairs to discover how and why invasive species spread so easily.

<u>Activity 3. Crayfish Conundrum</u> Through an active simulation game, students experience the dynamics of invasive introductions and population fluctuations within a simple aquatic system, focusing on Rusty Crayfish.

<u>Activity 4. Garlic Mustard Invasion</u> Students become plants and compete for resources with this specific forest invader, and discover why it is so successful.

<u>Activity 5. Managing Invasive Species</u> Students will learn about either Garlic Mustard or Rusty Crayfish, and then come up with ways to remove them or limit their spread. If students will be engaged in IBD activities, a connection will be made to the actions that they will undertake in the field.

ACTIVITY 1 What Are Invasive Species?

Purpose*: To differentiate among native, introduced/non-invasive, and invasive species.*

Outcomes*: Students will be able to distinguish among native, introduced and invasive species by location of origin and behaviour*

Subject: *Science, Biology (Ecology)*

Group size*: Class; groups of 3*

Site*: Classroom or outside*

Time*: 15 minutes*

Supplies*: Teacher Resource Sheets 1-3, copied onto three different colours of paper by category: native, introduced/non-invasive, and invasive.*

Leader prep: *Cut out individual species cards, and mix randomly into sets of 3, one of each colour. Species can be repeated to make up enough card sets.*

A QUICK LOOK:

Through a matching exercise, students evaluate species' similarities and differences, categorizing species as either native, introduced/non-invasive, and invasive.

BACKGROUND:

It is important that students and others understand the differences among native, introduced/non-invasive, and invasive species, particularly so that all introduced species are not tarred with the *invasive* brush, and scarce resources for removal efforts are focused on species that matter.

Native species are those that evolved within the ecosystems where they are found. They are generally in balance with their neighbours and there are natural controls, often predators or parasites, in place to limit population growth. There are many examples of native Ontario species, but they will vary by geographic location.

Introduced species are those that are brought into an area, either on purpose or accidentally, by people. They can come from another continent[1], or another part of the same continent. They can even come from the next watershed, if they have never

[1] Introduced species from far away are often termed *exotic.*

historically been found in the watershed in question. Introduced species can be either non-invasive, or invasive.

Non-invasive species are introduced species that either do not appear at all in native ecosystems (e.g. tulips, or ornamental roses), or if they do, they fit fairly well into the natural system without major disturbance to native species, and may even contribute to ecological functions. For example both Rainbow Trout and Pink Salmon, west coast natives, have fit into stream-spawning, lakeshore habitats in Ontario. Species of this type are often labeled as *naturalized.* There is, however, some risk here. Some species may appear to be fitting in, but may have subtle ecological impacts that we are not aware of. Other species, like Dog Strangling Vine, may have low, localized poplulations for years before exploding and doing significant harm. Since there are always limited resources to deal with invasives, managers must take a cost/benefit approach to risk management.

Invasive species, on the other hand, definitely do *not* fit. They disturb or degrade ecological functions, displace native species, and often their population explodes because there are few to no biological controls in place, and native species are not adapted to compete effectively with them. Plant or animal, they could be termed aggressive, *weedy* species. Ontario examples include: Common Buckthorn, Japanese Knotweed, Purple Loosestrife, Starlings, Zebra Mussels and Common Carp.

Note: Nature is rarely clear-cut. Some species expand their range with no help from people, and some of those may appear as invasive, e.g. Common Cormorants. Others appear to be moving north due to global warming, and the question becomes, should we facilitate this type of range movement, in order to keep continential species diversity as high as possible? See also non-invasive discussion above.

READY, SET, GO!

1. Divide class into groups of 3, and give one card set to teach group. Have each student in each group take a card and read it.

2. Once each student understands their plant or animal, have them explain who they are, and where they come from, to the others in their group.

3. Ask each group to subdivide into two, based on the characteristics of their species, i.e. into a single and a pair (possible combinations: plants vs. animals; aquatic vs. terrestrial; type of plant or animal; native or non-native). Have them divide several times, based on different characteristics.

4. In a loose circle of group clusters, popcorn and list some of the categories that were used to divide the groups. Pick out and emphasize native and non-native. Ensure that everyone understands the difference.

5. Now ask the groups to divide the non-native pair using a characteristic related to being non-native. They should quickly arrive at non-invasive and invasive. Have them come up with an initial list of characteristics for invasive species.

TRANSITION:

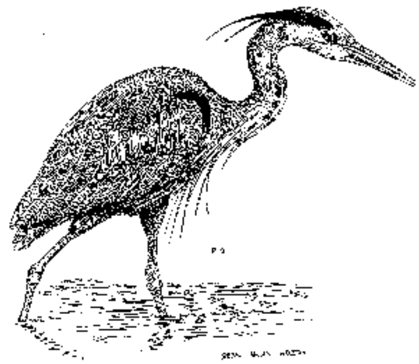
Indicate that they will explore those invasive characteristics further in the next activity by examining the success of a common aquatic invader to Ontario: Zebra Mussels.

RESOURCE SHEET 1 Native Species

SNAPPING TURTLE

I am a reptile, and native to slow moving and shallow waters, like lakes and wet-lands, in Ontario. I “snap” at my prey, which include: fish, crayfish, frogs, tadpoles and aquatic plants. Birds, raccoons, skunks and foxes prey upon my eggs and babies – but enough will survive to replace me. My greatest predators are humans who eat me or hit me accidentally with their cars. I am shy and very sensitive to habitat destruction.

GREAT BLUE HERON



I am a great blue heron and native to Ontario, but I fly south in winter. I live along the wooded shorelines of lakes, rivers and wetlands. I feed on fish and frogs in shallow water. I have few predators as an adult bird but raccoons and some other birds will eat my eggs and babies.

NORTHERN RIVER OTTER

I am a mammal, and native to the wooded shorelines of lakes, rivers, ponds and wetlands in Ontario. I eat fish, frogs, and crustaceans like crayfish. My natural predators include the wolf and I am used by humans who trap me for my fur. I am harmed by water pollution and habitat destruction.

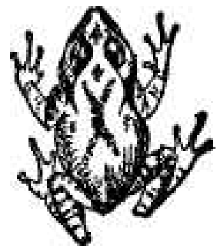
MONARCH BUTTERFLY

I am native to Ontario, but only spend part of the year here, going on a great migration to the highlands of Mexico during the winter. As a caterpillar, I eat only milkweed plants, and a chemical from the milkweed makes me bad-tasting to birds. I may lay eggs on closely-related plants, like Dog Strang-ling Vine, but my caterpillars won’t develop there.

WHITE TRILLIUM

I am a native, white spring wildflower that grows underneath moist, broad-leaved forests in southern and central Ontario. My seeds are spread by mice and ants, who eat the fleshy part and leave the seed behind. It takes me a long time to produce my single flower (up to 5 years!), so please don't pick me. I'm also the provincial flower of Ontario.

SPRING PEEPER

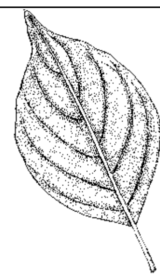


I'm a small (3 cm) tree frog with a big voice, and I'm native to Ontario. I'm hard to spot and can change colour, but have a big "X" on my back. I also have adhesive toe pads that let me climb vegetation. My "peep!" is one of the first signs of spring, once I wake up from my winter hibernation under logs or bark – come listen for me along the edges of wetlands or temporary woodland ponds, but I can no longer be found in the Toronto area.

SUGAR MAPLE

I'm a hardwood tree native to Ontario – so native that my leaf is on the Canadian flag, and the penny. I'm used to make furniture, baseball bats and, of course, maple syrup. I can be found over much of southern and central Ontario. I am sensitive to pollution, particularly acid rain and salt. A small plant called Garlic Mustard is beginning to invade my understory. A lot of it can keep my seeds and saplings from growing.

ALTERNATE LEAFED DOGWOOD



I'm a large, native shrub that lives within, or on the edges of, woodlands. My dark purple berries are eaten by many animals, including ruffed grouse and chipmunks. I am also a good landscape plant, and can either be grown from seed or purchased from a native plant nursery. I can be crowded out of wood margins by Common Buckthorn, an introduced shrub.

RESOURCE SHEET 2 Introduced Species

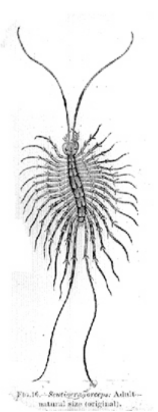
COLTS FOOT

I'm a small, early-blooming plant native to Europe and Asia. In flower and in seed, I look a bit like a dandelion, but my leaves are way different! I'm found mostly in old fields and road edges, where few native plants grow. Sometimes I grow along natural stream banks alongside natives. Slince I bloom so early, I have become an important local food source for some of the early spring insects. People make cough syrup from my leaves. I might be consdered a "weed" by some farmers.

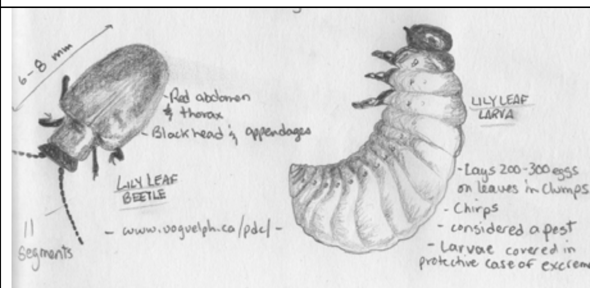
WHITE CLOVER

I'm a small plant in the bean family that comes from Europe, Africa and Asia. I'm used in in lawns, pastures and for erosion control. I rarely grow outside of cultivated or highly disturbed areas. I can take nitrogen out of the air and make it into soil fertilizer, and native bees and butterflies love my nectar. Some native butterfly larva eat and grow on me.

HOUSE CENTIPEDE



I'm a 25 – 50 mm long inver-tebrate. While my name means "hundred legs" I only have about 30. And they're fast! I'm from the Medi-terranian area originally, but am now found across North America. However, like some of you couch potatoes *wish*, I never leave the house! I'm a predator, and eat bedbugs, ants, termites and cockroaches, so I'm doing you a favour. I do have a venemous bite, but only if you bug me. It's like a mild bee sting. I have no impact on native species or communities.



LILLY LEAF BEETLE

I'm a shiny, red beetle with a black head. I'm originally from Europe and North Africa, and have only been in Ontario since the mid-1940's. As my name implies, I eat only lily leaves. I'm never found far from cultivated lilies, and seem to have no taste for native lily species. So I'm only a problem in your garden, at least for now.

GINKGO TREE

Dinosaurs once rub-bed up against me and my close relatives, but now I'm the only one left. Originally from Asia, I resist insects and air pol-lution, and so am often planted in cities. I am also used in traditional medicine. While I can live for 4000 years, I am not very aggressive, and do not invade natural areas near where I am found. I can be male or female, but more male trees are planted because my fleshy seeds smell bad. And if you handle those seeds, you may get a rash.

EUROPEAN HARE

I am native to Europe, but now I also live in southern Ontario. I like open meadows and fields, and can be found mostly near farmlands and the edges of towns. Farmers don't like me, but I don't really compete much with native hares and rabbits. I like to eat grasses and herbs during the summer and twigs, bark, and buds in winter.

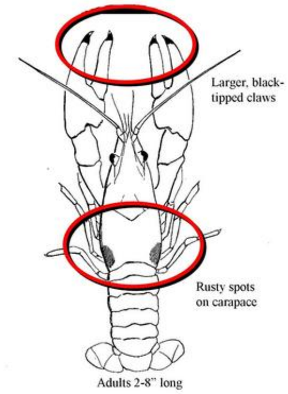
HELLEBORE

I'm a small, broad-leafed evergreen garden plant originally from southern Europe. My rose-like flowers bloom early in the spring, and poisons in my sap make me pest-resistant. Like many garden flowers, I don't escape into natural woods or meadows.

FOX SQUIRREL

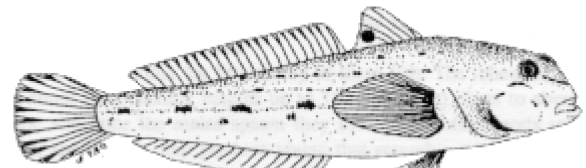
I'm the largest tree squirrel in North America, but not native to Ontario. I'm usually found farther south in hardwood forests and agricultural areas. People tried to introduce me to Ontario, but most of these introductions failed. Right now, I'm only found on Pelee Island in Lake Erie, but I might move north if global warming allows more of the trees I like to grow in southern Ontario. Right now I don't compete much with native squirrels.

RESOURCE SHEET 3 Invasive Species



RUSTY CRAYFISH

I am originally from the south/ central United States. I now live in some Ontario lakes, ponds and streams, probably brought here in bait buckets. I am an aggressive omnivore that needs to eat a lot. I eat a wide variety of aquatic plants and animals. I have fewer predators than native crayfish, in part because I get so big. I crowd out native crayfish, and can destroy native plants that I clip and eat.


Drawing by Donna Francis

ROUND GOBY

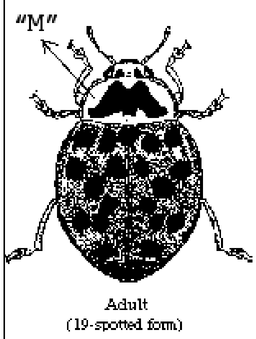
I am an aggressive, bottom-living fish originally from Europe, probably brought here in the ballast water of large ships. I now live in some Ontario rivers and lakes. I eat many types of small aquatic species, including the eggs of my fellow fish and can survive in many types of waters. I can spawn (reproduce) up to six times in one season—this is a lot for a fish! My numbers are currently expanding, and I am replacing native fish in some areas.

GARLIC MUSTARD

I am a small plant from Europe, originally brought here by settlers as a cooking herb. My roots produce a poison that kills off native plants, and even deer don't like to eat me. I'm now the only thing you can find growing under some southern Ontario forests, and I am slowly spreading, carried as tiny seeds by animals and people.

DOG STRANGLING VINE

I am an aggressive vine from eastern Europe. I grow well in shade, partial shade, full sun and all soil conditions. I spread rapidly, overtop and choke out almost all native vegetation and reduce wildlife, including Monarch Butterflies. Other than cows and sheep, nothing seems to want to eat me.

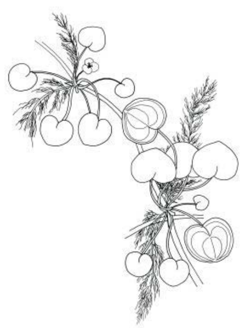


MULTI-COLOURED ASIAN LADY BEETLE

I am a 'ladybug' native to Asia, and origninally brought to the United States to contol insect pests in trees like the pecan. My spots vary from many to few to none on a yellow to red background, and I have a musty smell. My populations began to explode in the mid-90's, moving far beyond fruit and nut trees. I'm now the most abundant ladybug by far in Ontario, and I've helped eliminate two common native ladybugs from the province, and reduced populations of others, reducing native biodiversity. In winter, you may find me in your house.

COMMON BUCKTHORN

I am a shrub or small tree, originally from Europe, with wicked thorns on my branches. I can form dense thickets, aggressively crowding out native plants and reducing biodiversity in southern Ontario. I produce lots of fruit, which which either fall and sprout, or are eaten by birds and deer. They then spread my seeds in their poop, which allows me to spring up in new areas. I like light shade and will readily invade open woods.



EUROPEAN FROG-BIT

I'm a free-floating aquatic plant that's native to Europe, but now found in southern Ontario. I look like a small water lily, and live in marshes and quiet lake and river edges. I can form dense mats of many plants. I out-compete other floating plants, and prevent sunlight from reaching plants growing from the bottom. I can grow from pieces of myself, and can travel from one place to another attached to boats and propellers.

SPINY WATER FLEA

I'm a crustacean like lobster or shrimp, but I'm only about a centimeter long. Originally from Europe, I can now be found in many Ontario lakes – you might have seen me stuck to your fishing line. I eat three times as much as similar native water fleas, and compete for their food. While native fish eat me, my tail spine gets caught in the throat of small ones, and they cough me out again! How much damage I might cause is uncertain at this point.

Resource Sheet illustration credits:

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ACTIVITY 2 Musical Mussels

Purpose: *To have students experience, through action, the invasive potential of zebra mussels.*

Outcomes: *Students will be able to:*
1. *explain why animal populations cannot increase indefinitely;*
2. *list three reasons why zebra mussels have an advantage over native lake animals; and*
3. *state two things they or their families can do to limit the spread of zebra mussels.*

***Subject*:** *Science, Biology (Ecology)*

Group size: *Class; minimum 10-12*

Site: *Classroom or outside*

Time: *30 to 45 minutes*

Supplies: *10 chairs or large paper plates if playing outside; Teacher Resource Sheets 1 and 2; sheet(s) of mailing labels; 2 predator labels*

Leader prep:
1. *Copy, cut and laminate ten mussel cards from Teacher Resource Sheet 1, or redraw onto card stock. Two will have to be repeated.*
2. *Copy Teacher Resource Sheet 2 (the sheet of Zebra Mussels) onto a sheet of mailing labels.*
3. *Print a large "P" on two clean labels (for predators).*
4. *Assemble the chairs or paper plates in two rows, back to back.*

References: *http://www.invadingspecies.com/Invaders.cfm?A=Page&PID=1; adapted, with permission, from Fish Ways Primary/Junior Manual, Queen's Printer for Ontario, 1991.*

A QUICK LOOK:

Students will role-play lake animals in a version of musical chairs to discover how and why zebra mussels are spreading through the Great Lakes.

BACKGROUND:

Introduced species, plants and animals that do not belong in a certain natural system are a common phenomenon. As humans began to move around the world, many other things moved with them, either accidentally or on purpose. In the past, little consideration was given to the general or long-term effects of these introductions, and some were even encouraged. For example, there was once a society dedicated to introducing to North America all plants and animals mentioned in the works of William Shakespeare.

Aquatic introductions to Ontario waters can be divided into a number of categories:

Animals introduced on purpose that have been "successful". Success here means that the animal has fit fairly well into the natural system without major disturbance to native species. The best example is the rainbow trout, a West Coast native that has fit into a stream-spawning, lakeshore habitat not presently populated by any native fishes, and has provided a healthy sport fishery.

Animals introduced on purpose that have caused disturbance. One hundred years ago, carp were considered the "fish of the future", and were brought over from Europe. Tough and adaptable, carp soon spread from inland lakes and ponds to the Great Lakes. They tore up large areas of aquatic plants, displaced bass and ducks and generally made a nuisance of themselves. Animals introduced by accident that have been "successful". In 1957, pink salmon from the West Coast were being raised in Thunder Bay for introduction into James Bay; 21,000 excess fingerlings were flushed into the Current River where, as salt-water fish, they were expected to become seagull food. Instead, the salmon survived and reproduced. By 1975, they occurred in almost all rivers flowing into Lake Superior and supported another flourishing sport fishery.

Animals introduced by accident that have caused disturbance. "Disastrous" is a better term for the sea lamprey, which entered the upper Great Lakes through the Welland Canal soon after 1900. A blood-sucking parasite, they caused lake trout populations to plummet and affected many other fishes before being brought under control in the late 1950s.

Our most recent invader, zebra mussels, may fit right in with the sea lamprey as a disastrous accidental introduction. Thought to have been brought over from Europe in 1986 in a freighter's ballast water, the small (1 to 5 cm) mussel was introduced to the Great Lakes when that ballast was pumped out into Lake St. Clair. By June of 1990, they had spread throughout Lake St. Clair, Lake Erie and the western end of Lake Ontario. All of the Great Lakes have now reported at least scattered concentrations of zebra mussels, usually in port areas. Mussels can live on any hard surface, and by the end of 1989, had colonized practically every surface of that type in Lake Erie. They will live on other clams (smothering them), other zebra mussels (not smothering themselves) and even crayfish. By growing on themselves, they can even extend out over soft, muddy bottoms up to a metre from the nearest hard surface.

There are several reasons for the success of zebra mussels:

1. The plankton-rich, lower Great Lakes are perfect habitat.

2. There are no native competitors for the firm surfaces required by the mussels.

3. Reproductive potential is enormous. Mussels have been found in densities of 30 to 100 000 per square metre, and each can produce a between 40,000 and a million eggs over the course of a summer. Even though only a fraction find good habitat after floating for 8 to 12 days as free-swimming larva, populations will continue to grow.

4. Few natural predators seem to be interested in the mussels. Freshwater drum (sheepshead) and diving ducks will eat them, but neither exist, or are likely to exist, in the numbers necessary to control the mussels.

The effects of the mussels are already significant. They are clogging the water intake pipes of thermal power and municipal treatment plants, and even power boat intakes, and it is already costing millions to clean or treat the pipes. The shells are sharp, and can cut swimmers or those walking the beaches.

Effects on the natural system of the Great Lakes is harder to predict. Mussels colonize the spawning beds of fishes such as walleye, smallmouth bass and white bass. The effects on these fishes are not known at this time. Each adult mussel can filter about one litre of water a day. Although they eat mostly algae, nearly all particulate matter, including plankton of all sizes, is removed from the water, bound into a pellet, and dropped outside the shell. Plankton - tiny, drifting plants and animals - forms the food base for a lake's sport and commercial fisheries. Again, the long-term effects of this competition is unknown. Mussels can also carry parasites that can then be passed on to certain fishes and birds. The following comments relate specifically to the statements on the zebra mussel cards used in this activity.

"You're meeting your needs!" Drum, or sheepshead, actually eat mussels, so they may benefit from their presence.

"Zebra mussels are taking your food. You can't stay." Emerald shiners eat the same type of food that mussels either eat, or filter out of the water. The extent of direct effects on small plankton eaters like the emerald shiner are unknown at this time.

"Zebra mussels are crowding you out." Local freshwater clams provide another hard surface for mussels to live on. They will clog the intake siphons of the clams, suffocating and starving them.

"The zebra mussels on your back make it hard to move and find food." Crayfish provide another hard surface, and the weight of the mussels may make it harder to find food and avoid predation.

"Zebra mussels are making the water too clear, and the light hurts your eyes. Go deeper!" Mussels filter and deposit large quantities of particulate matter from the water, in some cases increasing water clarity and light penetration by up to 80%. This may drive light-sensitive fishes like the walleye away from traditional, shallow water feeding areas.

"Your eggs won't hatch among zebra mussels. Lay them somewhere else!" Fishes such as rock bass, walleye and lake trout spawn over rocky shoals that are rapidly being colonized by zebra mussels. The build-up of mussels and their wastes reduce water circulation and foul the habitat, using up oxygen and making it acidic. These conditions may affect the hatching success of these species.

"Because the mussels eat so much, there are fewer small fish and animals to eat. Go away!" Although adult whitefish do not compete directly for food with the mussels, many of the animals that whitefish eat do. If the populations of these prey species decrease as a result, the populations of larger predators like the lake whitefish may be affected.

"Zebra mussels are clogging pipes. You can't get enough water!" Mussels directly affect people as well, and have significantly reduced volumes entering some water treatment plants along the Lake Erie shore. Cleaning or replacing pipes is becoming a significant expense.

Elimination of zebra mussels, once they are established, is not possible at this time, and they are probably here to stay. There is no known chemical that will kill only mussels. Chemicals such as chlorine can be used in intake pipes, but the compounds formed may affect other animals as well. Control efforts are centred on limiting the spread of the mussels to inland lakes away from the Great Lakes system. People can assist in this effort by:

1. not moving any water from one lake to another via bait buckets, live wells, etc.;

2. not using live bait from the Great Lakes in other lakes; and

3. cleaning any boat before moving it from an infested lake to any other lake. Boats can be scraped, steam cleaned, cleaned with high pressure water (250 psi), cleaned with a bleach solution or left out of water for two or three days under hot, dry conditions. Do not clean your boat near water. Carefully clean drain holes, brackets, intake ports, etc. Rinse live wells with bleach solution (1 tbsp/gallon).

In this activity, students should grasp the competition for resources caused by introduced species, particularly the zebra mussel, and begin to understand some of the reasons introduced species can spread so extensively. They will experience firsthand the advantages and disadvantages of such a competition.

READY, SET, GO!

1. Introduce or review the concept of basic needs: food, water, shelter/space, and others of their kind. Indicate that all animals must meet these needs.

2. Ask students to remember a time when they went to get or buy something special, and it wasn't there. Or, when they went or wanted to do something, and there weren't any places left. Accept all answers and probe feelings. Ask students to imagine what it would be like to not be able to "get" or meet a basic need. Might this might happen in nature, and how? Indicate that they will see how in a different kind of musical chairs.

3. Play the game.
   a) Start with two rows of five chairs, back to back. The chairs represent food, water and shelter/space. Choose five students to be animals in a lake, and play the game normally, having them walk around until the music (something "fishy" or at least nautical would be appropriate) stops. The students will easily find seats.
   b) Indicate that, since they were so successful in meeting their needs, they were able to reproduce. Add five more students and play again. The seats will now be full.
   c) Add five more students (due to reproduction) and play again, observing the competition for needs when the music stops. Those not finding seats/needs must return to their desks. Indicate that this often happens in nature. A few "too many" creatures are produced, and those not able to find food or other needs must leave to find them somewhere else, or die.
   d) Play other rounds with 15 students, choosing new students to replace those who can't meet their needs.
   e) After several rounds, put zebra mussel cards face down on three of the seats. Play the round, and ask those landing on mussel cards to read or interpret them. Indicate that the mussels are a new kind of animal that humans have accidentally let loose in the area,

and they are competing for the same needs as the local student-animals. If students have a "no" symbol (a circle with a diagonal line) on their card, they must return to their desks along with those who couldn't find a seat.

f) Pick up the mussel cards, shuffle them and put six down. Play the round with ten students (less food, water and shelter means reproduction is down). Again, those with "no" symbols must sit down.
g) Pick up, shuffle and put down nine cards. Play the round with six students.
h) Cover all ten chairs with cards (shuffling in between rounds) and play with surviving students until no one is left.

4. Ask students how they feel about the zebra mussels taking over "their" lake. Ask if they know of other plants or animals that try to come in where they don't belong. Dandelions or other lawn and garden weeds are a good example. Indicate that these "misplaced" plants and animals, often brought far from their normal homes, are called "introduced species", and can present real problems for the native plants and animals.

5. Ask why zebra mussels took over in the chair game (they took over the basic needs). Why might they take over in nature? Accept and list all answers. Indicate that you'll play another game to show why the mussels are so successful.

6. Play the game again, with the following modifications.
   a) Start with the same setup as before. Have ten native animals and one zebra mussel (identified by an adhesive mussels label). Add two predators (identified by a "P" label). Predators must walk around trying to tag the native animals only. They don't like zebra mussels. If they touch an animal, that animal must sit down. So native animals must avoid predators and try for a seat when the music stops. They are "safe" if they reach a seat. Play the first round.
   b) Add two zebra mussels for every successful mussel. If the first mussel somehow doesn't find a seat, get a new mussel and try again. Add half the number of successful native animals (four if eight found seats). Play again, and indicate that two mussels can share a seat if all the others are taken.
   c) Keep playing until the mussels have taken over most or all of the seats.

7. Again, ask why the mussels were so successful (the predators didn't eat them, they could crowd together and they produced more babies than the native animals did). Indicate that these reasons are all true for the mussels in real life, and that they are gradually expanding their homes in the Great Lakes.

8. Indicate some of the other problems mussels cause/ and the things that they and their families can do to help prevent the spread of mussels to inland lakes.

EXTENSIONS:

1. Ask the students what they might do to control zebra mussels. Change the game to reflect their controls, and see if they work.

2. Contact your MNR office to find out if any mussel infestations exist in your area, and whether or not they could be safely seen by your class.

3. Have students find out about other introduced pests such as purple loosestrife (plant), sea lamprey, termites or earwigs.

TRANSITION:

At this point, the program moves from a general introduction to invasives and their characteristics to two specific species: Garlic Mustard and Rusty Crayfish. These are the focus species for International Biodiversity Day 2009 actions in Ontario. If your group will be involved with one of the two species, then focus on that species. If you are using these activities as a general unit on invasives, then use either Activity 3 or 4, or both.

Indicate that while Zebra Mussels have a fairly high profile in Ontario, many more invasive species are a concern. Some, such as Purple Loosestrife, are fairly well known, while others, such as fishhook Water Flea, may be less recognizable to most people. In the next activity, we will be looking at one of those species.

<u>If you are using Activity 3 (Rusty Crayfish)</u>: Ask, “Who has ever caught crayfish in a stream or pond?” Note that crayfish are found all over Ontario, which has 7 native species and 3 introduced ones. Point out that one of those introduced species in particular is creating problems, and that they will see why in the next activity.

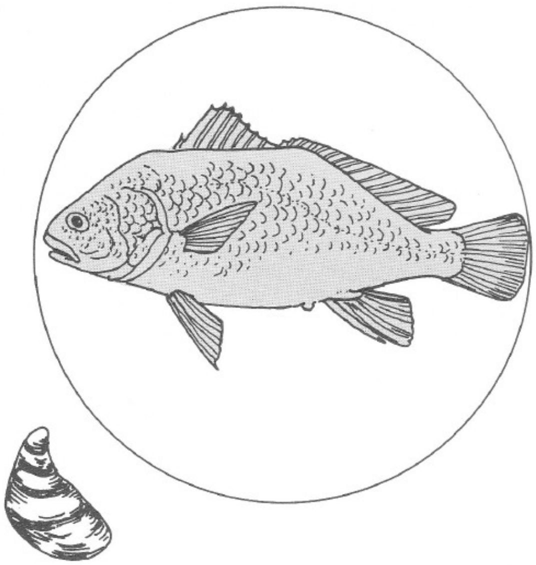
<u>If you are using Activity 4 (Garlic Mustard)</u>: Note that we’ve just seen that animals compete for habitat, and ask if they think that plants compete for habitat compontents in the same or similar ways. See if they can come up with any examples, e.g. trees growing up and shading out understory plants. Indicate that they are now going to look at plant competition, and how a specific invader has competitive advantages.

Resource Sheet

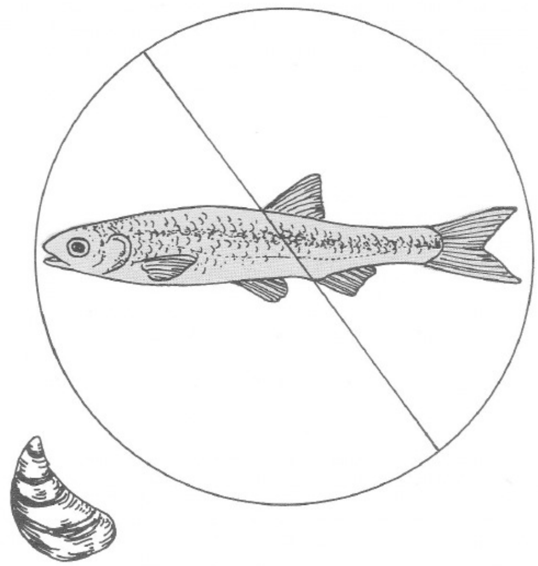
Musical Mussels

ZEBRA MUSSEL CARDS

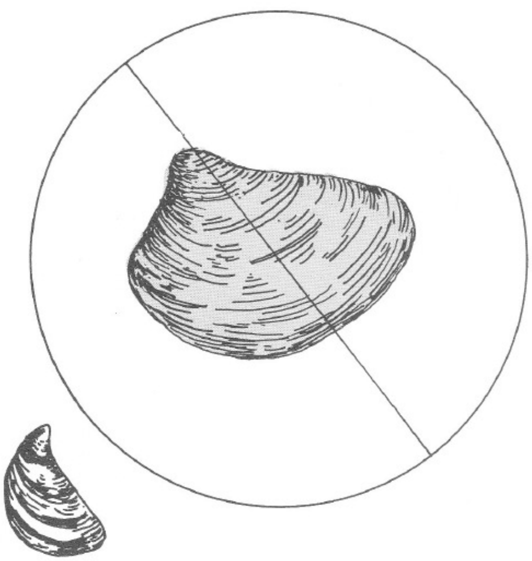
You're meeting your needs!



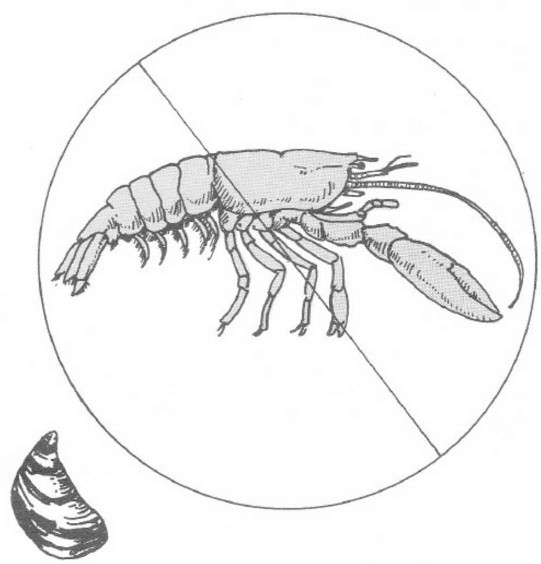
Zebra mussels are taking your food. You can't stay.



Zebra mussels are crowding you out.

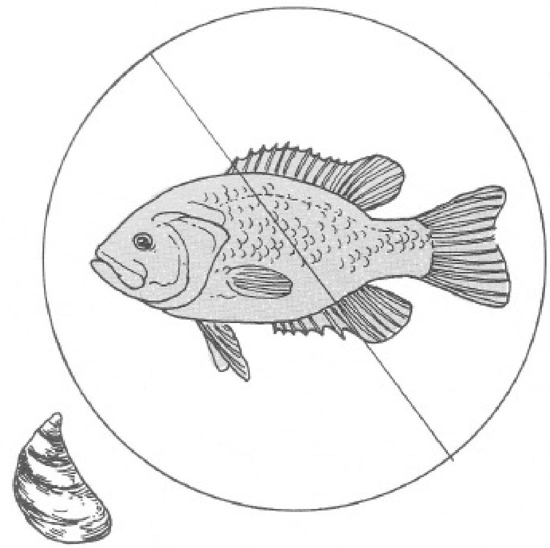


The zebra mussels on your back make it hard to move and find food.



Zebra mussels are making the water too clear, and the light hurts your eyes. Go deeper!

Your eggs won't hatch among zebra mussels. Lay them somewhere else!



Because the mussels eat so much, there are fewer small fishes and animals to eat. Go away!

Zebra mussels are clogging pipes. You can't get enough water!

ACTIVITY 3 Crayfish Conundrum

Purpose: *To allow students to experience, in an active way, the invasion of a local water body by Rusty Crayfish.*

Outcomes: *Students will be able to:*
1. *explain why Rusty Crayfish have a competitive advantage in Ontario*
2. *identify the causes of population changes in simple systems; and*
3. *predict any additional changes to those systems.*

Subject**:** *Science, Biology (Ecology)*

Group size: *Class; minimum 10-12*

Site: *Classroom or outside*

Time: *30 to 45 minutes*

Supplies: *An area either indoors or outdoors with enough space for the students to form a large open circle; armbands, coloured elastics for wrists or coloured vests; clipboard and marker; index cards marked with a 'B'. Teacher Resource Sheet (Summary Chart).*

Leader prep: *Collect all required materials.*

References: *Adapted, with permission, from Fish Ways Primary/Junior Manual, Queen's Printer for Ontario, 1991; based on "Foxes and Rabbits" in Acclimatizing by Steve Van Matre. The Institute for Earth Education, Box28B, Warrenville IL 60555, 1974. Used by permission.*

A QUICK LOOK:

Through an active simulation game, students will experience the dynamics of invasive introductions and population fluctuations within a simple aquatic system.

BACKGROUND:

Rusty Crayfish is a crustacean, like shrimp, crab or lobster. It is one of about 350 crayfish species found in North America. Rusty crayfish is native to the Ohio River system in the States, but has been introduced to many northern lakes and streams. Rusty crayfish may have been introduced through bait bucket dumping or released from an aquarium. Fertilized eggs and newly hatched young are carried on the underside of a female's abdomen for protection, so it is possible for a single crayfish to start a new population if moved to a new water body. The species prefers rock, log and debris cover, as well as bottoms of clay, silt and gravel.

The species is omnivorous, eating aquatic plants, benthic invertebrates (e.g. worms, snails, leeches, and aquatic insects found at the bottom of a water body), decaying plants and animals, fish eggs, and small fish. Young crayfish especially feed heavily on benthic invertebrates like mayflies, stoneflies, midges, and sideswimmers.

Rusty Crayfish can eat twice as much as native crayfish. By consuming larger quantities of benthic invertebrates, Rusty Crayfish competes with young game fish and forage fish for food. This could impact the recreational and commercial fishery. Also, Rusty Crayfish consumption of vegetation reduces the abundance and diversity of aquatic plants. Many invertebrates and fish rely on these plants for habitat. Fish populations might be further impacted by Rusty Crayfish feeding on the eggs and young of native fish.

Any habitat must provide for the basic needs that must be met if a species is to survive and reproduce. Any habitat will be able to meet the needs of only so many individuals. This *carrying capacity* is not stable, but will fluctuate based on changes in environmental conditions, the actions and reactions of other organisms, and the actions and reactions of the species itself. Taken together, these changes lead to fluctuations in the populations of all living things in the habitat. These fluctuations are termed population dynamics.

In this activity, a simplified, three-way interaction introduces the concept of population dynamics in an active, involving way. Since the students simulate this interaction in a way that cannot be predicted in advance, many outcomes are possible, and the simulation game can be run many times with different results. Some of the more common results: An overabundance of predators will depress the prey population, and lead to eventual starvation and drastic declines (in this simple system) in the predator population. Note: if you run out of prey, be sure to run one more round (with no prey to catch) to drive home the point.

Few or no predators will inflate the prey population, with a resultant decrease in food for the prey. A drastic decline in prey may result. A relatively balanced system may be maintained for a remarkably long time, with minor fluctuations in all three populations. Small responses to population shifts can be pointed out.

The interaction used in the simulation is a real one. In recent years, the rusty crayfish has moved into a number of Ontario lakes from the United States. While smallmouth bass usually eat crayfish, this new species grows very quickly, and soon becomes too large for most smallmouth bass to eat. The crayfish compete with young smallmouth bass for the aquatic insects that live among the plants, cropping the vegetation off at the base to feed more readily on both the plants and the insects. In a short period of time, the rusty crayfish may destroy the aquatic vegetation that provides shelter for the fish (symbolized in the simulation by making any bass that cannot find a plant start farther back), and cause a decline in the bass population.

READY, SET, GO!

1. Explain to students that they are about to become part of a smallmouth bass food chain and that they will have to get everything they need to survive from a lake. Review the basic elements fishes need in their habitat: water, food, shelter and space within a suitable distance.

2. Divide the class into three groups and hand out identifiers (armbands, vests, etc.) to the crayfish and bass. Plants can simply stand still with one hand in the air. From a class of 30, one group of 13 becomes aquatic plants and forms a large circle. The circle, which is the shallow water at the perimeter of the lake, should have a diameter of at least 10 m.

3. Choose seven students to become smallmouth bass and tell them to seek shelter or hide behind the aquatic plant of their choice. Have the remaining ten or so students go in the middle of the circle of aquatic plants to become crayfish, a favourite food of smallmouth bass. The crayfish should be instructed to sit on the ground in the middle of the "lake", Point out to students that the area inside the aquatic plants where the smallmouth bass are taking shelter represents the space in which the smallmouth bass will later hunt for crayfish. Record the number of each group on the summary chart.

4. Round one in the simulation takes three to four minutes. To begin, explain that when you call "splash", the crayfish stand and try to reach and touch an aquatic plant to find shelter before being tagged ("eaten") by a smallmouth bass (only one crayfish per plant). Each smallmouth bass tries to eat a crayfish by coming out from behind its aquatic plant and tagging a crayfish that has not reached a plant. Remind students that they are responsible for the safety of other students; neither grabbing nor tackling is allowed. Give the splash signal to begin.

5. At the end of the round, explain that smallmouth bass that captured a crayfish remain smallmouth bass and crayfish that were eaten become smallmouth bass. Smallmouth bass that were not able to capture a crayfish "die" and now become aquatic plants in the outside circle. Crayfish that were not eaten and that safely reached an aquatic plant remain crayfish, and the plant they reached also becomes a crayfish. Have students take their new positions and record the new populations on the summary chart. If there are more bass than plants, make the "extra" bass start 5 paces back from the original circle, a handicap symbolizing lack of shelter.

6. Have students continue the activity for eight to ten rounds, lasting three to four minutes each. If a student remains a plant for two rounds, have them switch with a bass or crayfish.

7. Partway through, give cards marked with a ‘B’ to any crayfish that survives one round. Briefly describe Rusty Crayfish, and indicate that these crayfish are now too big to eat. Those crayfish cannot be caught by the bass in subsequent rounds.

Continue play, and note how the dynamic changes. You should end up eventually with nothing but rustys, or wildly fluctuating dynamic of rustys and plants.

8. In a group discussion, ask students to summarize some of the things that they have learned from this activity, such as what fishes need to survive, what happens to the number of smallmouth bass when there are a large number of crayfish, and what happens when Rusty Crayfish move into an area.

OTHER IDEAS:

1. Have students write a letter, from a fish's point of view, to cottagers who want to remove all aquatic plants from their shoreline.

2. Have the class investigate the food and shelter requirements of another species of fish such as rainbow trout. Have students think of ways of changing the simulation game to reflect another fish's needs. Try the simulation again using the suggestions.

3. Give students several different combinations of smallmouth bass, crayfish and plants, and have them predict the result of one or two rounds of play. Have them defend their predictions and then test the results by playing those rounds.

TRANSITION:

Well, Rusty Crayfish have arrived, now what do you do? The last activity looks at characteristics of the crayfish in more detail, and *you* get to decide what to do about them!

Resource Sheet

Crayfish Conundrum

ORG'S / ROUNDS	BASS	CRAYFISH	PLANTS
START			

ACTIVITY 4 GARLIC MUSTARD INVASION:

A Simulation of an Invasive Species in Forest Ecosystems

***Purpose**: To have students experience, through action, the invasive potential of Garlic Mustard.*

***Outcomes**: Following participation in this simulation, students will;*
1. *Understand the basic need of plants.*
2. *Understand the adaptive advantages that allow species to become invasive.*
3. *Understand the consequences of introducing an invasive species into an ecosystem.*

***Subject**: Science, Biology (Ecology)*

***Group size**: Class (25-30 students)*

***Site**: Gymnasium or outside*

***Time**: 30-45 minutes*

***Supplies**: 4 pylons to mark boundries; 4 sets of pinnies or other means to identify players; Sun, Water, and Nutrient cards (15 of each)*

***Leader prep:** Copy and cut out cards*

***References:** http://www.invadingspecies.com/Invaders.cfm?A=Page&PID=38*

A QUICK LOOK:

Students become plants and compete for resources with this specific forest invader, and discover why it is so successful.

BACKGROUND:

All plants need sun, water, nutrients and space and avoid being eaten to survive and reproduce. Any plant that can do any of these things better than the other plants around it has a huge advantage and may come to dominate the landscape. This game simulates the introduction of one non-native invasive species, garlic mustard, into the landscape and the resulting changes in the plant community. Note that some key content is scattered through the activity steps below.

READY, SET, GO!

Note: This game is played in several rounds. Each round will simulate different conditions in the forest ecosystem.

1. Have students list plants that they might see or expect to find in a forest community. Introduce the idea that some plants are native to an area and others are introduced. Generate a list of native and non-native plants. Discuss what might happen to plants who come to live in a new environment.

2. Play Round 1 – The Undisturbed Forest
   a) Distribute Sun, Water and Nutrient cards at one end of the playing area.
   b) Five students will start as native plants at the other end of the play area.
   c) One student will be an herbivore in the middle.
   d) Remaining students start on the sidelines but will be brought into the game quickly.
   e) In order to survive the first round, plants must collect one each of the Sun, Water and Nutrient cards. They may only pick up one card each trip down the field. They must avoid being eaten by the herbivore.
   f) The herbivore may tag the plants when they are between the pylons. They must escort tagged plants to the sidelines before they may tag another plant.
   g) The round ends in three minutes or when all the plants have been caught or collected three cards, whichever comes first.
   h) Surviving plants reproduce. For each plant that survives, one student from the sidelines will join the game as a native plant.

3. Play Rounds 2 & 3 – The Invader Arrives
   a) Redistribute the cards to one end of the field and the surviving and new plants at the other.
   b) Add one student as a garlic mustard plant, newly arrived in the area.
   c) One student will be an herbivore in the middle.
   d) In order to survive the first round, plants must collect one each of the Sun, Water and Nutrient cards. They may only pick up one card each trip down the field. They must avoid being eaten by the herbivore.
   e) The herbivore may only tag the native plants when they are between the pylons. They must escort tagged plants to the sidelines before they may tag another plant. The herbivore does not recognize garlic mustard as food or does not like its taste and therefore leaves it alone
   f) The round ends in three minutes or when all the plants have been caught or collected three cards, which ever comes first.
   g) Surviving plants reproduce. For each native plant that survives, one student from the sidelines will join the game as a native plant. Garlic mustard produces large numbers of seeds so two students from the sidelines will become garlic mustard plants in the next round for each garlic mustard that survives.
   h) Redistribute the cards and repeat the round.
   i) At the end of this round some plants may not survive because there is not enough sunlight, water or nutrients to go around. Any plant not getting one of each card does not survive and moves to the sidelines.

4. Play Round 4 – The Competition
   a) Redistribute the cards in the playing area.
   b) Garlic mustard is a biennial which means that its life cycle takes two years to complete. It overwinters as a rosette of leaves under the snow. This gives it a head start in spring - most native woodland species are either annuals, starting from seed each year, or perennials that start from roots or bulbs underground. It grows quickly and spreads rapidly, crowding out native species. To simulate this, in this round, the surviving garlic mustard plants get a 15-second head start on the native plants.

   c) If there are any native species left at the end of the round, go on to play round five. Other wise skip to the Discussion 1.

5. Play Round 5 – The Domination
   a) Redistribute the cards.
   b) Garlic mustard plants release a chemical into the soil that kills soil fungi. This inhibits the formation of connections between the roots of native plants and fungi in the soil that help them absorb water and nutrients. This gives garlic mustard a huge advantage. To simulate this, the garlic mustard players may pick up both Water and Nutrient cards on the same trip.

6. Discuss what happened during the game:
   a) What advantages does garlic mustard have over native species?
   b) What would happen to the herbivores after all the native species are gone?
   c) What can be done to control garlic mustard?

EXTENSIONS:

Note: The extensions deal with garlic mustard control. Since this is the topic of Activity 5, you might want to postpone these activity modifications until after that activity. Consider adding to the controls below to reflect any additional ideas proposed by the students.

1. In additional rounds add in one or more of the following possible controls;
   a) Human cutting. Add one or more people to the middle to tag the garlic mustard players. This represents people manually cutting the plants before they flower to prevent them from reproducing. Eventually the seed supply will be exhausted and garlic mustard will be controlled, but this takes several years.
   b) Bio-Control. Add one or more people to the middle to tag the garlic mustard. This represents the possible outcome of research that is currently underway to find something that will eat garlic mustard but not everything else.
   c) Fire. Add many people to the middle during the first 15 seconds of the round. They may tag garlic mustard, even out of bounds. This represents the use of controlled burn fires in the early spring when garlic mustard has begun to grow, but native plants are still dormant.

   Discuss:
   a) Do the controls work?
   b) What are the limits/risks of the controls?
   c) Is it easier to prevent the introduction of an invasive species or to try to control it after it has escaped?

Note: This activity was developed for BEAN by the Royal Botanical Gardens.

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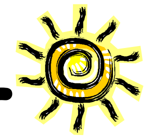
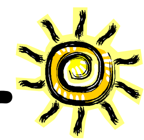
Water 

Sunlight 

Water 

Sunlight 

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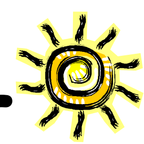
Sunlight 

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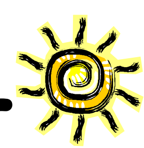
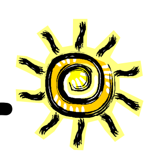
Sunlight 

Water 

Sunlight 

Nutrients

Nutrients

Nutrients

Nutrients

Nutrients

ACTIVITY 5 Managing Invasive Species

***Purpose**: To introduce students to methods for managing invasive species, in particular Garlic Mustard or Rusty Crayfish.*

***Outcomes**: Students will be able to describe the best methods for removing, or limiting the spread of, Garlic Mustard or Rust Crayfish.*

***Subject**: Science, Biology (Ecology)*

***Group size**: Class; groups of 3*

***Site**: Classroom or outside (Garlic Mustard site optional)*

***Time**: 30 minutes*

***Supplies**: Garlic Mustard and/or Rusty Crayfish Fact Sheets; paper and pens; flip chart and markers*

***Leader prep:** Copy one Fact Sheet per triad (one-sided)*

***References:** http://www.invadingspecies.com/Invaders.cfm?A=Page&PID=4 http://www.invadingspecies.com/Invaders.cfm?A=Page&PID=38*

A QUICK LOOK:

Students will learn about either Garlic Mustard or Rusty Crayfish, and then come up with ways to remove them or limit their spread.

BACKGROUND:

While both Garlic Mustard and Rusty Crayfish are now established in southern Ontario, resource managers are still trying to limit their spread, and where possible in the case of Garlic Mustard, to remove the plant and rehabilitate the forest understory. Once Rusty Crayfish gain a foothold, however, it is very difficult to remove them from a watershed, or limit their spread within that watershed. Additional information can be found in the Fact Sheets.

READY, SET, GO!

1. Divide the class into groups of three, and give each group page 1 of the appropriate Fact Sheet, a sheet of paper and a pen. Indicate that they are going to use what they have learned in the previous activities, and the information contained in the sheet, to come up with ways to reduce the impact of either Garlic Mustard or Rusty Crayfish.

2. Have each group study the information, and brainstorm: 1) possible ways to eliminate the species from an area, and 2) possible ways to limit their spread into new areas. Remember, more is better!

3. In a loose circle of group clusters, have each group list one new method of elimination each until all methods are out and recorded on the flip chart. Then do the same with ways to limit the spread. Rank what they think are the best methods in each case.

4. Give each group page 2 of the Fact Sheet, and compare methods. Did they come up with the same ones? Any new ones? Are their "best" ones reflected on the sheet? How might they move forward with their top ideas?

OTHER IDEAS:

Find a nearby location with Garlic Mustard, and design and carry out a local public information campaign about the plant and how people can limit its spread.

If Rusty Crayfish are in your area, design and carry out a local public information campaign focused on bait bucket introductions and how to eliminate them.

CONCLUSION TO THE PROGRAM:

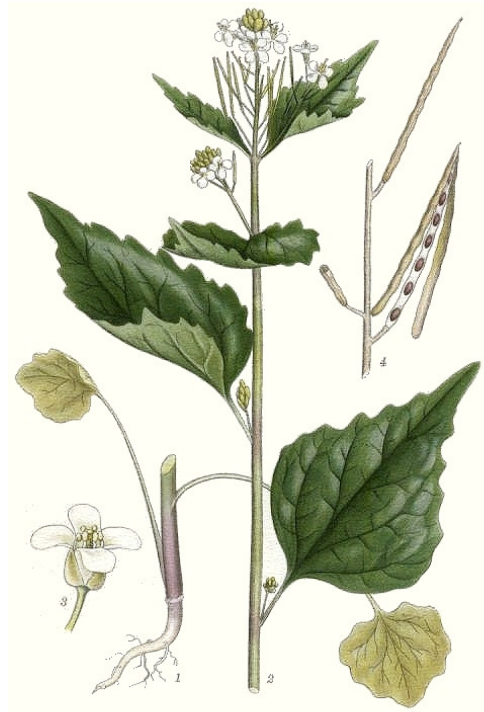
Note: If the group is going to be working with either Garlic Mustard or Rusty Crayfish, the protocol for that species can be introduced at that time, and the key points reviewed.

If you're wrapping up the program, get the students to summarize the key points about invasives and biodiversity:

- Invasive species are non-native species, but not all non-native species are invasive.
- Invasive species disrupt natural systems and can reduce native biodiversity.
- Invasive species are successful because they are aggressive competitors, but generally also because they have left their diseases, parasites and predators behind.
- Invasive species can have both biological and economic impacts.
- Rusty Crayfish and Garlic Mustard are invasive species with specific impacts.
- Efforts are being made to manage these and other invasive species.
- Each of us can do things to reduce the spread of these and other invasive species. Reinforce this point in your final statement.

Garlic Mustard Fact Sheet

The Plant: Garlic Mustard is a cool-season, biennial (i.e. two-year growth cycle) herb with stalked, triangular to heart-shaped, coarsely toothed leaves that give off an odor of garlic when crushed (particularly new leaves). First-year plants appear only as a cluster of green leaves close to the ground. Clusters remain green through the winter and develop into flowering plants the following spring. Flowering plants of Garlic Mustard reach from 0.6 to 1 m in height and produce button like clusters of small white flowers, each with four petals in the shape of a cross. Flowers are either self-pollinated, or pollinated by insects.



C.A.M. Lindman

Garlic Mustard, showing first and second year leaves, flowers, seedpod, seeds and root.

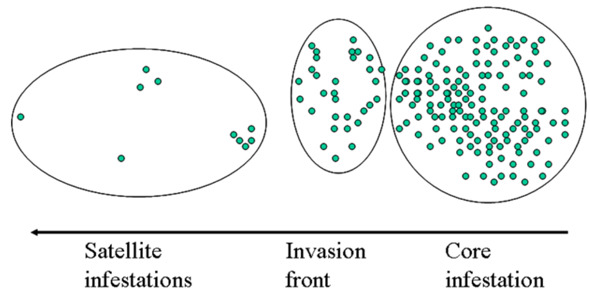
Beginning in May, tiny seeds are produced in erect, slender pods, and become shiny black when mature. Seedpods may hold fertile seed through the summer. In dense woodland stands, seed production can range from 9,500 to over 100,000 seeds per square metre per year.

When mature, the capsules burst open and can throw seeds several metres. Further distribution is mostly by humans and other animals accidentally carrying seeds, or mud containing seeds. Seeds aren't easily blown around, and do not float well. Populations spread an average of 5.4 m/year, which may not sound like a lot until you add it up: 6,400 km^2/year in North America! Because it's primarily carried by humans and animals, natural or human-made roads and trails become prime corridors for invasion. Seeds quickly sprout in disturbed soil, and disturbing soil with seeds in it will cause more seeds to sprout. Seeds can remain alive in the soil for five years or more.

The Threat: Garlic Mustard is one of the few non-native herbs able to invade and dominate both disturbed and undisturbed forest understory communities. Its ability to grow in low light, high seed production, and relatively rapid spread make Garlic Mustard a strong competitor, dominating forest groundcover within 5-7 years of introduction. It takes resources away from native spring woodland plants such as Spring Beauty, White Trillium, Trout Lily, Sweet Cicely and many others. Because it begins growing very early in the spring, Garlic Mustard has a head start on other flowering plants and tree seedlings.

It also changes the soil, impacts natural associations between plants and fungi by destroying the fungi, and changes the forest ecosystem. Several chemicals produced by Garlic Mustard reduce the growth of grasses, herbs and tree seedlings, including Sugar Maples. Researchers in Ohio removed Garlic Mustard from a forest understory and found that the richness and abundance of annuals and woody perennials, including tree seedlings, increased.

Garlic Mustard appears to reduce habitat quality for several species of salamanders and molluscs through changes in forest litter layer depth and composition. Insect communities are also impacted by the presence of Garlic Mustard. The impacts of Garlic Mustard on vertebrates are largely unknown. Deer do not eat it, but encourage its spread by grazing on native competitors, disturbing the soil, and carrying seed from one location to another.



Doug Landis Michigan State University

Management Efforts: Garlic Mustard spreads from established (core) infestations along an invasion front. Satellite infestations occur when seeds are transported to new areas. This often occurs along trails, roads or forest edges. Priority should be given to annual removal of all satellite infestations to prevent further spread.

In addition, satellite areas and invasion fronts nearest to or within prime native habitat should have top priority. After these areas are treated, begin working back through the invasion front.

Monitoring should focus on areas where Garlic Mustard seeds are likely to be dispersed and find disturbed areas suitable for germination. Trails, parking areas, transportation corridors and recreation sites in suitable habitats are known sites of early infestation.

There are a number of approaches to removal:

1. Cutting flowering plants near ground level by hand will kill a high percentage of Garlic Mustard plants. The lower the cut, the more effectively the plant will be killed. Because cutting does not remove the root crown, it may be necessary to cut multiple times in a season to prevent seeds from developing on secondary stems. If cut precisely after flowering and before seed maturation (when the stem becomes tough and fibrous), resprouting is less likely. Even though cutting does not disturb the soil, it may still be necessary to cut for at least five consecutive years or until the seed bank is exhausted, but less regrowth might be expected than with pulling.

2. Pulling individual Garlic Mustard plants by hand is a simple and effective approach to managing small or isolated infestations. However, Garlic Mustard prefers and can rapidly spread in disturbed areas. Because pulling disturbs the soil, seeds remain alive in the soil for **at least five years**, and root fragments may regenerate plants, it is important to pull **all** Garlic Mustard plants in an area every year until the seed bank is exhausted and seedlings no longer appear. This may require multiple efforts each year as rosettes can continue to grow and produce flowers over an extended period (April-June).

3. Pulling, treating and transplanting. If you combine pulling with soil treatment, for example the use of clean mulch, and the transplanting of native species back into the area, you may be able to reduce the number of years it takes to exhaust the seed bank and re-establish native species.

4. Other methods. In limited, very controlled situations, fire or herbicides may be used by experts in the use of these methods.

Of course, the best approach would be to limit the spread of Garlic Mustard in the first place. People should be told about the plant and how it's spread, asked to restrain dogs in invaded areas, and encouraged to brush off any bits of mud or vegetation from clothing, boots or paws before leaving the area.

Rusty Crayfish Fact Sheet

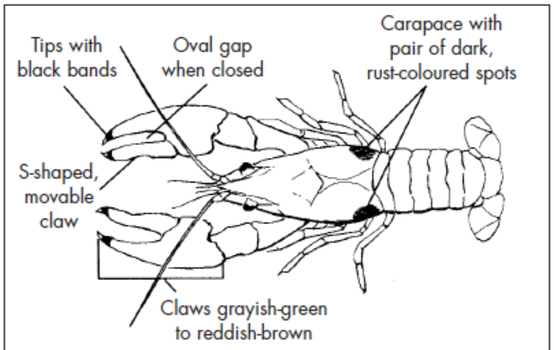


Illustration: Great Lakes Sea Grant Network and U.S. Fish and Wildlife Service

What is Rusty Crayfish? Rusty Crayfish is a crustacean, like shrimp, crabs or lobsters. It is one of about 350 crayfish species found in North America. Rusty crayfish is native to the Ohio River system in the States, but has been introduced to many northern lakes and streams. Rusty crayfish may have been introduced through bait bucket dumping or released from an aquarium.

This species has a brown body and claws with dark black bands near the tips (see diagram). There are prominent rusty patches (which may not always be present) on either side of the carapace as though it was picked up by a person with rusty paint on their forefinger and thumb. Rusty Crayfish grows to an average length of 10 cm, not including the claws. Its claws are more robust and larger than native Ontario species.

Rusty Crayfish can live three to four years. A female lays from 50 to 575 eggs, which hatch in three to six weeks depending on water temperature. Fertilized eggs and newly hatched young are carried on the underside of a female's abdomen for protection, so it is possible for a single crayfish to start a new population if moved to a new water body.

Where is it found? Rusty Crayfish inhabits lakes, rivers, ponds, and streams which have water in them year-round. The species prefers rock, log and debris cover, as well as bottoms of clay, silt and gravel. It is most active from spring to fall at temperatures above 8°C.

The first Ontario reports of this species were from the Kawartha Lakes in the early 1960s. Rusty Crayfish has since become established in several areas of southern and northwestern Ontario.

What does it eat? The species is omnivorous, eating aquatic plants, benthic invertebrates (e.g. worms, snails, leeches, and aquatic insects found at the bottom of a water body), decaying plants and animals, fish eggs, and small fish. Young crayfish especially feed heavily on benthic invertebrates like mayflies, stoneflies, midges, and sideswimmers.

What are the impacts? Rusty Crayfish can eat twice as much as native crayfish. By consuming larger quantities of benthic invertebrates, Rusty Crayfish competes with young game fish and forage fish for food. This could impact the recreational and commercial fishery. Also, Rusty Crayfish consumption of vegetation reduces the abundance and diversity of aquatic plants. Many invertebrates and fish rely on these plants for habitat. Fish populations might be further impacted by Rusty Crayfish feeding on the eggs and young of native fish.

Rusty Crayfish can displace native crayfish and contribute to their local extinction. The native species are forced by Rusty Crayfish out of their daytime hiding sites, so they are more vulnerable to predation by birds and fish.

Management efforts: There is no practical means of controlling the Rusty Crayfish population once introduced to a lake or stream, so the best method to limit them is to prevent or slow their spread into new waters. There are no chemical or other means that selectively kill only Rusty Crayfish, and selective harvest will only remove large adults

You can help!

The Ontario Federation of Anglers and Hunters (O.F.A.H.) and the Ontario Ministry of Natural Resources (OMNR) have set up a toll-free Invading Species Hotline 1-800-563-7711 and website www.invadingspecies.com for you to obtain information on and report sightings of rusty crayfish and other invading species.

- Report sightings. If you find Rusty Crayfish in a new area, freeze it or preserve it in rubbing alcohol, then call the Invading Species Hotline or contact your local OMNR Office to report your finding and confirm your specimen as Rusty Crayfish.
- Get involved. Participate in one of our many community based monitoring programs to detect and prevent the spread of invading species.
- Find out more. Contact the Invading Species Hotline 1-800-563-7711 or visit www.invadingspecies.com

Boaters and Anglers – You can help!

It is extremely important to prevent the further spread of rusty crayfish. To protect your lake and prevent the spread of rusty crayfish and other invading species, please take the following precautions before leaving a water body and entering another:

- Never use rusty crayfish as bait!
- Do not release live bait! Empty your bait bucket on dry land, or freeze or salt the bait for later use. It is illegal to release or transfer live fish or crayfish from one water body into another.
- Inspect your boat, trailer and equipment – remove all plants, animals and mud, and dispose of them on dry land or in the garbage.
- Drain water from motor, live well, bilge and transom wells while on land.
- Remove organisms you can't see on your boat, trailer and equipment by:
    - Rinsing them with hot water (>40℃), or
    - Spraying with high pressure water (250 p.s.i.), or
    - Drying them in the sun for at least 5 days.

Adapted from *RUSTY CRAYFISH Invades Ontario Waters*, by Ontario's Invading Species Awareness Program.

Keep All Our Lakes Great!™

You can stop invading species

www.invadingspecies.com