Invasive Crayfish Collaborative
Great Lakes

Lesson 4

Native + Invasive Crayfish

Subjects Science, Math, Language Arts

Grade Levels Ideal for grades 6–12, adaptable for 3–5

Time 50 minutes or more

A native white river crayfish *Photo: Chris Lukhaup*

Lesson Overview

In this lesson, students explore native and invasive crayfish species of the Great Lakes and their roles in freshwater ecosystems. Activity options include having students brainstorm what they already know about native and invasive crayfish, matching cards of crayfish ecosystem roles and photos with their descriptions, and writing creatively about what they have learned. See the "Enrich/Extend" section near the end of the lesson with more ways to engage all learners.

Goals

- Increase students' understanding of native and invasive crayfish and their roles in freshwater ecosystems
- Get students to think critically about how invasive crayfish can be a threat to different native species and biodiversity
- Increase students' understanding of how certain species can have negative impacts on ecosystems
- Increase students' understanding of the various ways that invasive crayfish can be introduced to new waterbodies

Objectives

- Students will learn about species from the Great Lakes region to determine their roles in freshwater ecosystems.
- Students will demonstrate understanding of native and invasive crayfish species, including ways to identify them and their impacts on freshwater ecosystems.
- Students will express orally and/or in writing what they have learned about native and invasive crayfish and their impacts on freshwater ecosystems.

Next Generation Science Standards

Performance Expectations

Building Toward

- MS-LS1-4: Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.
- MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
- MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
- MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- HS-LS2-2: Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.
- HS-LS2-6: Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

Crosscutting Concepts

- Structure and Function
- Cause and Effect: Mechanism and Explanation
- Stability and Change

Science & Engineering Practices

- Asking Questions and Defining Problems
- Obtaining, Evaluating, and Communicating Information
- Constructing Explanations and Designing Solutions

Core and Component Ideas in the Life Sciences

LS1.A: Structure and Function

LS1.B: Growth and Development of Organisms

LS2: Ecosystems: Interactions, Energy, and Dynamics

- LS2.A: Interdependent Relationships in Ecosystems
- LS2.C: Ecosystem Dynamics, Functioning, and Resilience

Common Core State Standards

Speaking and Listening Standards for Grade 6

(similar standards for grades 4–5; 7–12)

Standard 1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly.

Standard 4. Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes; use appropriate eye contact, adequate volume, and clear pronunciation.

Standard 6. Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate.

College and Career Readiness Anchor Standards for Writing

Standard 6. Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

Standard 7. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

Center for Great Lakes Literacy Principles

Principle 5. The Great Lakes support a broad diversity of life and ecosystems.

Principle 6. The Great Lakes and humans in their watersheds are inextricably interconnected.

Teacher Background

Crayfish Diversity

The eastern United States is home to more than 60% of the world's known crayfish species, making it a global hotspot for crayfish biodiversity (Richman et al., 2015). The American states and Canadian provinces surrounding the Great Lakes are home to approximately 40 crayfish species (Taylor et al., 2015), and a number of these species are rare or have narrow natural ranges (Page, 1985; Taylor et al., 2015; Richman et al., 2015). Some states in the southernmost areas of the Great Lakes region such as Illinois, Indiana, and Ohio have numerous crayfish species with narrowly endemic ranges, including the sinkhole crayfish *(Faxonius theaphionensis)* in central Indiana and the depression crayfish *(Cambarus rusticiformis)* in southern Illinois.

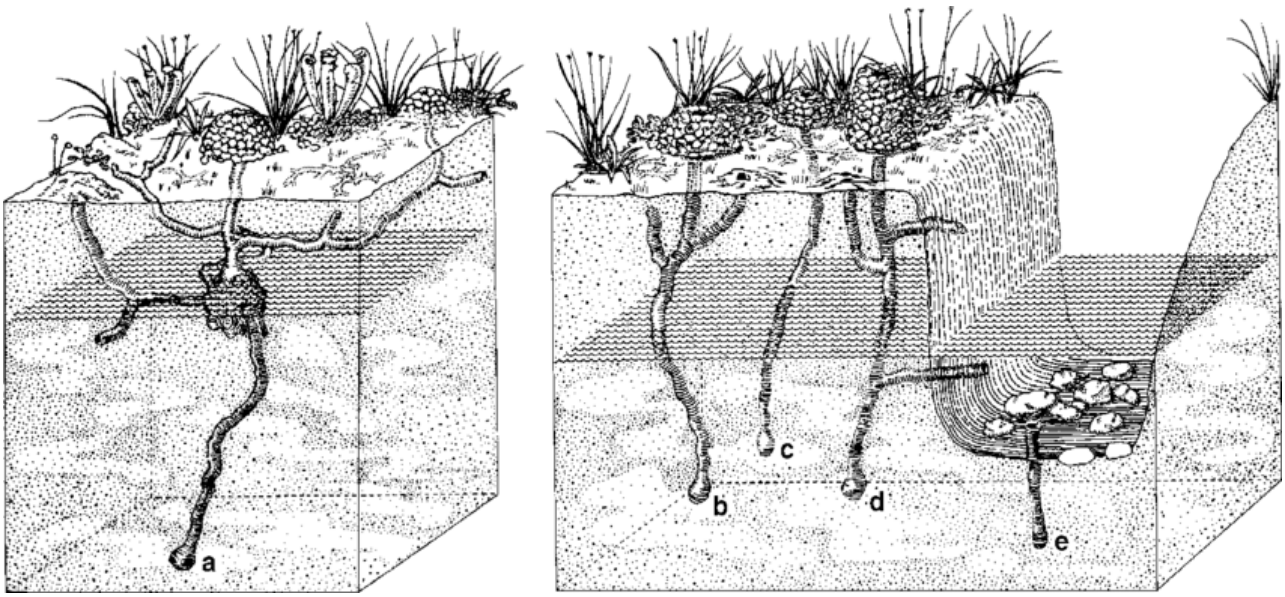
A terrestrial crayfish burrow *Photo: C.A. Taylor*

Many crayfish species in the Great Lakes region are known to occur only in streams and rivers (i.e., "lotic" ecosystems with actively moving water), but some species can persist or even thrive in "lentic" habitats (still waters) such as ponds, lakes, or reservoirs. An even smaller number of these crayfishes are almost completely terrestrial and spend most of their lives in underground chambers removed from direct contact with permanent water bodies.

The Great Lakes region includes a number of native species that are important to freshwater ecosystems. Many are described in the species guide at the end of the lesson. Important roles they serve include:

- **As food:** Over 200 animal species, including mammals, birds, reptiles, amphibians, fishes, and insects eat crayfish (DiStefano, 2005). Fish, such as bass, are especially prominent crayfish predators (Probst et al., 1984; Rabeni, 1992). A wide variety of other fish species, from brook trout to creek chubs, also consume crayfish (Gowing & Momot, 1979; Newsome & Gee, 1978). Crayfish are a vital food source for other important animals in freshwater ecosystems, such as the hellbender, an endangered salamander (Wiggs, 1976). Crayfish are also consumed by many terrestrial animals including minks, raccoons, and wading birds (Baker et al., 1945; Martin & Hamilton, 1985; Toweill, 1974).
- **As consumers:** Crayfish are opportunistic omnivores. They eat a wide variety of food items from phytoplankton to fish.
    - **Detritus**: Crayfish can consume large amounts of detritus, primarily in the form of leaf litter and other decaying plant material (Huryn & Wallace, 1987; Schofield et al., 2001). The processing of large amounts detritus by crayfish, such as dead animals and plant matter, can help keep freshwater ecosystems clean and healthy. It can also strongly alter the abundances of insect larvae, such as heptageniid mayflies (Creed & Reed, 2004), which can be an important food source for fishes and other aquatic vertebrates (Hoopes, 1960).
    - Crayfish also eat primary producers such as algae (Goldman, 1973) and aquatic plants (Creed, 1994). Some crayfish can consume so much algal and plant material that they strongly influence the population densities of these organisms (Goldman, 1973). Crayfish also feed on many different types of invertebrate prey, including snails (Kreps et al., 2012), insects and their larvae (Parkyn et al., 2001), and even other crayfish (Nakata & Goshima, 2006). Crayfish also eat vertebrates such as fish (Rahel & Stein, 1988) and amphibians, particularly their eggs or larvae (Axelsson et al., 1997).
- **As ecosystem engineers:** Crayfish live in a variety of aquatic and terrestrial (land-based) habitats. They can impact habitat quality and available resources for other organisms (Reynolds et al., 2013).
    - **Burrowing** is a fascinating crayfish behavior. The ability to dig burrows and other underground chambers is an important behavioral adaptation of many species of crayfish that helps them survive in multiple ways:
        - **Protection from predators**: Burrowing provides protection from the many animals that eat crayfish. It offers them a secure hideaway from fish, birds, insects such as dragonfly larvae, and even other crayfish.
        - **Shelter**: Burrows provide shelter against harsh weather conditions, such as drought and heat.
        - **Temperature and moisture regulation**: Burrows allow crayfish to regulate their body temperature and stay hydrated. Crayfish that spend most of their life in burrows will usually dig vertically to reach the water table, which allows their gills to remain moist and allows them to survive times of drought. In areas where water levels fluctuate, such as ponds or creeks that may dry up occasionally, crayfish burrow into the moist soil to avoid dehydration.

- Crayfish burrows also create spaces that can be used by other organisms (Creed & Reed, 2004).
- Burrowing can also increase erosion rates (Statzner et al., 2000; 2003). In terrestrial habitats, primary burrowing crayfish (species that spend most– or all–of their adult lives underground in fields, ditches, prairies, and wet meadows) construct complex networks of tunnels and chambers deep into the soil. These often-expansive subterranean networks can serve as critical conduits for water or gas exchange, thus oxygenating and draining otherwise poor soils (Richardson, 1983; 2007).
- **Types of Crayfish Burrowers** (as shown with letters a–e in the image below):
  - **Primary Burrower (a)**: Primary burrowing crayfish spend most of their lives in burrows they dig in the ground. These burrows can be very deep, sometimes as deep as three meters (about 10 feet). Inside, the burrows have many openings, tunnels, and chambers where the crayfish can move around and live.
  - **Secondary Burrower (b, c, d)**: Secondary burrowers also spend a lot of time in burrows, but their burrows are usually not as deep or complicated as those of primary burrowers. They often dig their burrows near creeks or ponds. These burrows are simpler but still provide a safe home for the crayfish.
  - **Tertiary Burrower (e)**: Tertiary burrowers are sometimes called non-burrowers and only occasionally retreat into simple and shallow burrows when they need to, like during a drought or when water levels are low. Most of the time, they stay out in open water.



Different types of crayfish burrows, ranging from primary (a), secondary (b, c, d) and tertiary (e)
Illustration from Hobbs (1981)

Impacts of Invasive Species

Unfortunately, non-native crayfish species introduced through human activities present a significant threat to many of the native crayfish species in the Great Lakes and surrounding areas. In some cases, these non-native crayfish can be considered invasive (i.e., cause ecological and economic harm), given their abilities to rapidly colonize new habitats and displace native species. Invasive crayfish have already displaced native

crayfish from considerable portions of their ranges and have dramatically altered ecosystem structure in some places (Wilson et al., 2004). Invasive crayfish are therefore a formidable threat to both crayfish biodiversity and freshwater ecosystems in the Great Lakes and worldwide (Lodge et al., 2000a).

Invasive crayfish in the Great Lakes region are described in the guide at the end of the lesson. They negatively impact countless species, including many native crayfish species, which have become one of the most threatened groups of organisms in the world. In fact, an estimated "48 percent of North American crayfish species are at risk of extinction" (Larson & Olden 2010: jstor.org/stable/40864210). Invasive crayfish are believed to be the leading cause of this decline, and humans have played a significant role in the spread of crayfish, through release of classroom science organisms, live fishing bait, pets, etc.

An **invasive species** is defined as any non-native organism that causes harm to the environment, economy, or human health ("Invasive Species in the Great Lakes," EPA). It can take over the habitat of native species, forcing the native species to decline in population or to disappear from their natural environment. Invasive species tend to be highly competitive, highly adaptive, and successful at reproducing (Washington Invasive Species Council).

Introduction pathways of invasive species are presented with visuals as cards at the end of this lesson. Additional information about native and invasive crayfish is found in the "Common Native and Invasive Crayfishes of the Great Lakes Region" guide and the "Expand Knowledge + Skills" section at the end of the lesson.

Materials

- Copies of the following for each student or group of 3–4 students (found after lesson):
  - "Common Native and Invasive Crayfish of the Great Lakes Region"
  - Sets of crayfish roles and introduction pathways cards
- Copies of the "Communicating about Crayfish + Their Impacts" handout for each student
- *Optional:* Colored pencils, markers, and/or crayons for students to share
- *Optional:* Posterboard

Preparation

1. Ensure all materials above are ready for student use. Cut up cards and separate them into two groups:
   - Crayfish roles, and impacts of invasive crayfish
   - Introduction pathways
2. *Optional:* Learn more about topics addressed in the lesson with the sources listed in the More Resources/References section at end of the lesson to prepare to answer student questions.
3. *Optional:* Arrange for a guest speaker with expertise on freshwater habitat restoration projects to visit your class. Contact us for possible recommendations: invasivecrayfish.org/contact-us.

Teaching Suggestions in the 5E Model

Engage

1. Engage students by showing them live crayfish (if available) or preserved crayfish. Pass out the "Common Native and Invasive Crayfishes of the Great Lakes Region" guides and ask them to work in small groups of 3–4 students to identify the species, using the guides, prior knowledge, and/or additional research.

Explore

2. After a few minutes, discuss student ideas and how they were able to identify the species.
3. Ask students to take out their science notebooks or blank paper. Invite them to draw a vertical line down a blank page to create two columns of about the same width. Ask them to label the first column "Crayfish Roles" and the second column "Impacts of Invasive Crayfish." Invite them to brainstorm ways native crayfish can benefit their ecosystems and record those ideas in the first column. Negative impacts of invasive crayfish can also be brainstormed in their groups; students can record their ideas in the second column.
4. Circulate through the groups, answering (and asking) questions to help them get started (if necessary). After a few minutes, tell students they will have one more minute to brainstorm and to be prepared to share their best ideas with the class.
5. Allow groups to share their ideas and then pass out the sets of cards that describe crayfish roles and impacts from the end of the lesson. Ask them to work with their groups to try to match the photo cards with the correct descriptions, as well as organize them into groups for the positive roles of natives and negative impacts of invasive crayfish.

Explain

6. Pass out the "Communicating about Crayfish + Their Impacts" handout, one for each student. Ask them to read through the questions together and discuss their ideas. Then invite them to write creatively to complete the activity. Circulate through the room to support students, or you might consider taking them outside to work.
7. After about 15 minutes, tell them they can take a break in two minutes to share one of their creative responses if they would like to do so.
8. After a couple of minutes, invite students to share one of their responses with the class and discuss it.
9. Give students most of the remainder of the class to complete their responses. Tell them that they can also continue writing outside of class time, if desired. Five minutes before the end of class, ask more students to share their responses with the class. Discuss the issues they raise in their funny stories, etc.
10. Close with a discussion of different ways invasive species can be introduced to ecosystems and ways that students can help prevent the problem. You might also ask students to discuss ways they might help to reduce problems of invasive crayfish after they have already been introduced.

Enrich/Extend

- Invite students to choose a native or invasive species from the guide to create posters about them.
    - Pass out posterboard (if available) or students could use backs of used sheets or posters to create colorful, labeled scientific illustrations of the species. Students can annotate the illustrations with descriptions and how they impact their ecosystems.
    - Invite students to conduct additional research, as necessary. They may use the Internet and other available reference sources; they should cite the sources they use for additional information.
- Students can observe live or preserved crayfish and/or their body parts under magnification with a microscope, hand lens, and/or macro lens. You can also use a microscope or macro lens connected to an electronic device and/or data projector to show them to the whole class.
- Invite students to create public service announcement videos about ways to help keep invasive crayfish out of our ecosystems.
- Ask students to use the "Native & Invasive Crayfish of the Great Lakes Region" guide to help them compare a native crayfish species found in your area with an invasive crayfish species that is causing problems in your area. This can be done using a graphic organizer such as a Venn diagram and/or a written analysis.
- Have students read cartoons about invasive crayfish and/or create their own cartoons. Excellent examples and ideas are listed in the "Stone Soup: Invasive Species and Cartooning" lesson plan found on the Take AIM website: takeaim.org/wp-content/uploads/2016/11/StoneSoupTeachersLP.pdf

Evaluate

- Review student projects and answers to the handout questions.
- Use student participation in class discussion and activities to help determine student understanding.
- Record levels of oral participation and student understanding of native and invasive crayfish and their impacts on freshwater ecosystems, etc.
- Ask students to reflect on the lesson in writing and/or orally, including about what they learned and what you, as the teacher, might do to improve the lesson next time.

Expand Knowledge + Skills

Science/References

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- "Crayfish: Identify Aquatic Invasive Species." canr.msu.edu/invasive_species/uploads/files/DFW04_Brochure-Crayfish_FINAL-DIGITAL.pdf
- "Crayfish of Michigan." Poster from Michigan Dept. of Natural Resources: michigan.gov/dnr/-/media/Project/Websites/dnr/Documents/Education/Misc/Crayfish-of-Michigan-Poster-72024.pdf
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Videos

- "The Threat of Invasive Species–Jennifer Klos." TED-Ed: ed.ted.com/lessons/the-threat-of-invasive-species-jennifer-klos
- "What Are Invasive Species?" Explore Nature/National Park Service via YouTube: youtube.com/watch?v=_ZzPM7Dw9Gg

Lessons/Activities

- "Bugs Don't Bug Me" and many more aquatic macroinvertebrate lessons, in the "Stream Side Science" program from Utah State Univ. Extension Service: extension.usu.edu/waterquality/educator-resources/lessonplans
- IDAH$_2$O water education resources, including curriculum and videos, Univ. of Idaho Ext.: uidaho.edu/extension/idah2o/resources
- Washington Invasive Species Council curriculum: invasivespecies.wa.gov/educational-materials/teacher-curriculum
- "Watershed Detectives" lesson from Utah State University Ext.: extension.usu.edu/waterquality/files/watershed-detectives.pdf

Name(s): _____ Period: ____ Date: _____

Communicating about Crayfish + Their Impacts

Explore the crayfish guide and cards with a small group. Then work individually to . . .

1. **Imagine a new student joins your class on a day you are sampling for crayfish.** How would you explain to them how to identify different native and invasive crayfish species? Include specific characteristics for at least 4 species you might find and differences and similarities between them. You can use sentences and/or labeled illustrations. Feel free to use separate paper or notebooks.

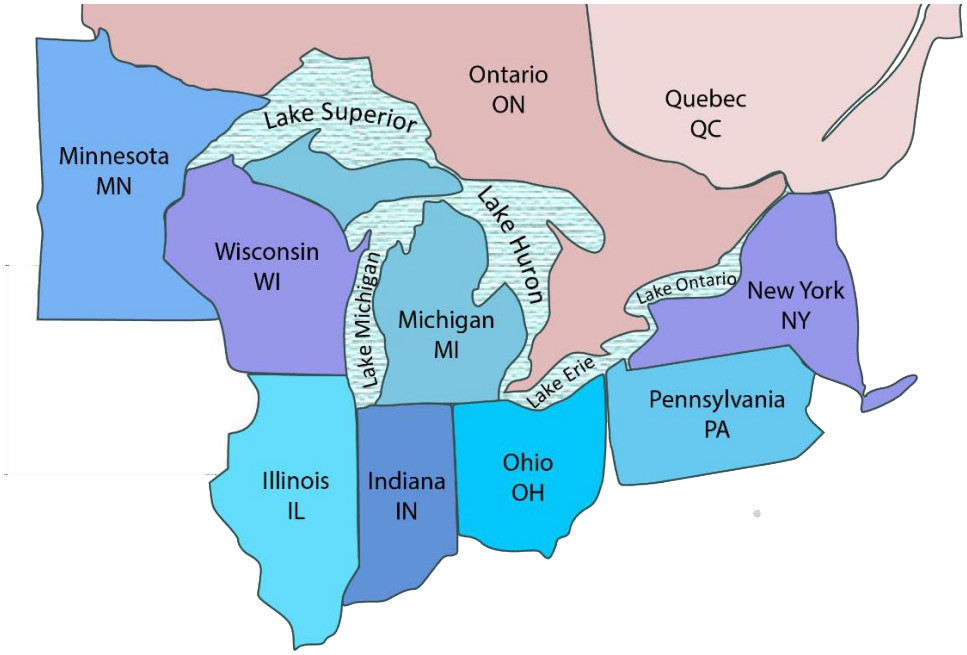
2. **Imagine you are a crayfish species known to be invasive in the Great Lakes region.** Make up a short funny story about how you and your fellow invaders were able to spread into the area using one of the most common dispersal methods.

3. **Imagine you are a native crayfish.** Brag to the other aquatic animals about all the positive roles that you and other native crayfish play in aquatic ecosystems.

4. **Imagine you are a native fish or amphibian.** Write about invasive crayfish and all the trouble they are causing you and other native species. What would you recommend scientists and wildlife managers do to solve the problem?

Learn more:
"Invasive Crayfish 101." Invasive Crayfish Collaborative: invasivecrayfish.org/invasive-crayfish-101

Common Native and Invasive Crayfishes in the Great Lakes Region



The Great Lakes region includes the eight U.S. states and two Canadian provinces shown above.
Graphic: Rick Reynolds, adapted from map of North America by El bart089 CC-BY-SA 3.0

Native Crayfish Species	Invasive Crayfish Species	Other High-Risk Species
Big water crayfish *Cambarus robustus*	**Obscure/Allegheny crayfish** *Faxonius obscurus*  *Photo: Smithsonian Environmental Research Center CC BY 2.0*	**Common yabby** *Cherax destructor*  *Photo: Daiju Azuma CC BY-SA 2.5*
Digger crayfish *Creaserinus fodiens*  *Photo: Don Henise CC BY 2.0*		
Calico crayfish *Faxonius immunis*	**Rusty crayfish** *Faxonius rusticus*  *Photo: Wisconsin Dept. of Natural Resources*	**Australian redclaw** *Cherax quadricarinatus*
Northern clearwater crayfish *Faxonius propinquus*		**Signal crayfish** *Pacifastacus leniusculus*
Virile crayfish *Faxonius virilis*		
Devil crayfish *Lacunicambarus diogenes*	**Red swamp crayfish** *Procambarus clarkii*  *Photo: Luc Hoogenstein CC BY-SA 4.0*	**Florida/electric blue crayfish** *Procambarus alleni*
Paintedhand mudbug *Lacunicambarus polychromatus*		
White River crayfish *Procambarus acutus*		**Marbled crayfish** *Procambarus virginalis*

NATIVE CRAYFISH SPECIES

Big Water Crayfish (*Cambarus robustus*)

A big water crayfish in its rocky habitat. *Photo: Zack Graham*

Description: Big water crayfish are a large species. Carapace lengths can be more than 5 cm long. The overall body color is greenish-brown. They have:

- Large, strong chelae with two rows of tubercules (bumps).
- A long, narrow rostrum with rounded corners.
- An areola that is open and somewhat wide.

Habitat: Big water crayfish are commonly found under large, flat rocks. They do not usually burrow, except to survive freezing temperatures or prevent drying out when it is hot. They can live in a wide range of water temperatures and pH levels. They can move short distances over dry land.

Distribution:

- Native to the Great Lakes and Ohio River watersheds
- Found from central Michigan to northern Indiana and northern and eastern Ohio
- They are also found throughout southern and central Ontario, as well as throughout Quebec.

Source: "Cambarus robustus." USGS: nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=207

Digger Crayfish (*Creaserinus fodiens*, formerly *Cambarus/Fallicambarus fodiens*)

Like most crayfish, digger crayfish can survive out of the water for short periods. *Photo: Zack Graham*

Description:

- Heavy-bodied, olive-brown or reddish-tan colored
- A pale, iridescent stripe along the midline of the abdomen
- Dark brown blotches cover the body
- Broad chelae with wide, flattened fingers
- Deep groove at base of moveable finger
- Broad rostrum with a trough-like depression
- No areola

Habitats:

- Seasonal wetlands, wooded floodplains, and low-lying fields
- Often lives in burrows up to 3 feet deep

Distribution:

- Digger crayfish live in the Mississippi, Ohio River and Great Lakes watersheds.
- Found from southeastern Wisconsin and central Illinois to eastern Ohio and southern Michigan
- They also live throughout southern Ontario.

Sources:

- "Digger Crayfish." Missouri Dept. of Conservation: mdc.mo.gov/discover-nature/field-guide/digger-crayfish
- "Digger Crayfish." Illinois Dept. of Natural Resources: dnr.illinois.gov/education/wildaboutpages/wildaboutinvertebrates/wildaboutcrayfish/wacfdiggercrayfish.html

Calico Crayfish (*Faxonius immunis*)

Calico crayfish are also called papershell crayfish. They have thin shells.
Photo: Chris Lukhaup

Description:

- Calico crayfish have a range of color patterns, from black and brown to mottled green, gray, and brown.
- They sometimes have blue, green, or purple chelae.
- Chelae are large with fairly long fingers. Chelae have large tubercules.
- They have an hourglass pattern on their carapace and tail segments.

Habitats:

- Calico crayfish live in many habitats. These include small gravel-bottom streams and slow-flowing creeks, lakes, and ponds with muddy bottoms.
- They can build simple burrows to prevent getting dried out.

Distribution:

- Calico crayfish live in clean rivers across the Midwest. They are also found in southern Ontario and throughout Quebec.
- They do not live in northwestern Minnesota, central and northern Wisconsin, and southern and eastern Ohio.

Sources:

- "Faxonius immunis." USGS: nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=210
- "Common Crayfishes of the Chicago Region." Field Museum: fieldguides.fieldmuseum.org/sites/default/files/rapid-color-guides-pdfs/981_usa_common_crayfishes_of_the_chicago_region.pdf

Northern Clearwater Crayfish *(Faxonius propinquus)*

Photo: Chris Lukhaup

Description:

- A relatively small crayfish with a carapace length of 25–35 mm
- Usually brownish-green with a dark saddle spanning the top (dorsal side) of its abdomen
- Large chelae; the tips are orange or red with black rings
- Areola is open and wide

Habitats:

- Found in rivers, swiftly flowing streams, and lakes
- Prefer rocky areas; will seek shelter in shallow crevices

Distribution:

- They are found in the Mississippi River and Great Lakes. They are abundant across the upper Midwest east of the Mississippi River.
- They live in eastern Minnesota and Iowa to northern Ohio, in the Wabash River watershed of Illinois and Indiana, and throughout Ontario and Quebec.

Sources:

- "Faxonius propinquus." USGS: nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=2249
- "Northern clearwater crayfish." Illinois Dept. of Natural Resources: dnr.illinois.gov/education/wildaboutpages/wildaboutinvertebrates/wildaboutcrayfish/wacfnorthernclearwatercrayfish.html

Virile (Northern) Crayfish *(Faxonius virilis)*

Photo: Alan Schmierer CC0

Description:

- Varies in color, from light brown to olive-brown
- Body has dark brown markings on each segment of abdomen
- Long, sharp tubercles along the middle margin of the chelae
- Tips of chelae are orange
- Upper walking legs and chelae can be bluish in color
- Areola is narrowly open

Habitat:

- They live in small streams, large rivers, and inland lakes.
- Prefer hard, rocky surfaces but can use areas with plants
- Can live in small burrows in muddy river bottoms.

Distribution:

- Native to the Great Lakes, Missouri River, upper Mississippi River, and lower Ohio River
- They are also found in Missouri, Arkansas, Oklahoma, Texas, and New York.
- They occur throughout Ontario, as far north as the James Bay watershed, and in Quebec.
- Non-native introductions have been made in parts of Ohio, Pennsylvania, and New York.

Sources:

- "Faxonius virilis." USGS: nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=215
- "Virile crayfish." NatureServe: explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.112669/Faxonius_virilis
- "Faxonius virilis." Smithsonian Environmental Research Center: invasions.si.edu/nemesis/species_summary/97425

Devil Crayfish (*Lacunicambarus diogenes*, formerly *Cambarus diogenes*)

Photo: Chris Lukhaup

Description:

- Usually olive or tan in color, without obvious blotches or spots
- Chelae have large knobs and tubercules, as well as long bright red/orange highlights on tips.
- Rostrum is deeply grooved and deep red in color.
- Areola is closed.

Habitat:

- Found near streams, ponds, lakes, and ditches
- They burrow and spend most of their time underground. They pile balls of mud at the top of their burrows. They often reveal their presence by these "mud chimneys."

Distribution:

- Occur across much of the eastern United States
- They are in every state east of the Rocky Mountains except the New England states.

Sources:

- "Devil crayfish." Missouri Dept. of Conservation: mdc.mo.gov/discover-nature/field-guide/devil-crayfish
- "Devil crayfish." Illinois Dept. of Natural Resources: dnr.illinois.gov/education/wildaboutpages/wildaboutinvertebrates/wildaboutcrayfish/wacfdevilcrayfish.html
- "Lacunicambarus diogenes." Georgia Dept. of Natural Resources: georgiabiodiversity.org/portal/profile?es_id=405722&group=crayfish

Paintedhand Mudbug (*Lacunicambarus polychromatus*)

Paintedhand mudbug with a tan/olive green coloration. *Photo: Zack Graham*

Description:

- Broad body and reddish-tan to olive green in color
- Segments of the abdomen and tail fan have red edges.
- Chelae are large, often with green, blue, and olive tones. They have red tips.
- Chelae are covered with many small tubercules.
- The rostrum is deeply grooved and highlighted in deep red.
- Areola is closed.

Habitat:

- They are widespread and common in wetlands, wet meadows, stream banks, and ditches.
- They spend most of their life in deep, complex burrows.

Distribution:

- Occur in the lower Mississippi and Ohio River watersheds
- They are in southern Illinois and northeast through southern Michigan and western Ohio.
- They are also found in southwestern Ontario, in the Detroit River basin in Windsor.

Source:

- "Paintedhand mudbug." Missouri Dept. of Conservation: mdc.mo.gov/discover-nature/field-guide/paintedhand-mudbug

White River Crayfish (*Procambarus acutus*)

Photo: Chris Lukhaup

Description:

- Large-bodied and usually brick red or tan. They have a black wedge on the top (dorsal surface) of the abdomen.
- They have very long and narrow chelae. Their chelae and body are covered with small (usually black and white) tubercles.
- Rostrum is flat. Areola is open.
- Don't mistake them for invasive red swamp crayfish! Red swamp crayfish have red tubercles on their chelae instead of black.

Habitat:

- They live in wetlands, ditches, creeks, and lakes.

Distribution:

- White river crayfish are found in the southern Great Lakes watersheds to the Gulf of Mexico.
- They also live in the Atlantic Slope (from Maine to Georgia).
- They are an invasive species in Ontario. They are non-native in southeastern Wisconsin and western New York.

Sources:

- "Procambarus acutus." USGS: nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=216

INVASIVE CRAYFISH SPECIES

Obscure/Allegheny Crayfish *(Faxonius obscurus)*

Photo: Smithsonian Environmental Research Center (CC BY 2.0)

Description:

- Small-bodied (4–8 cm) with light brown to olive-green coloration.
- Has a dark brown wedge on the abdomen (tail).
- Large chelae with two rows of rounded tubercles along the middle margin. The tips of its fingers are orange with black bands.
- Rostrum curves inward. Areola is open.

Habitat:

- They are found in small to medium-sized creeks with rocks, gravel, or sand.

Distribution:

- Native range includes the Ohio River watershed in extreme eastern Ohio. Also found in parts of Quebec.
- They are invasive throughout southern and central Ontario.
- Non-native in Lake Huron and Lake Ontario
- Likely introduced to new areas through bait bucket releases. They are a known threat to native crayfish due to competition.

Sources:

- "Allegheny crayfish." NatureServe: explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.112938/Faxonius_obscurus
- "Faxonius obscurus." USGS: nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=2243

Rusty Crayfish (*Faxonius rusticus*)

Photo: Lake County AIS CC0

Description:

- Olive-green to gray in body color
- Rusty-colored spot on each side of the carapace
- They have black rings around the tips of orange fingers.
- Larger individuals sometimes have chelae with light blue or violet colors.
- Areola is open.

Habitat:

- Rusty crayfish can live in many habitat types. These include lakes, ponds, streams, and rivers.

Distribution:

- Rusty crayfish are native to the Ohio River basin. This includes parts of Kentucky, Ohio, Indiana, and northern Tennessee.
- Rusty crayfish are one of the most widespread invasive crayfish in the U.S. Non-native populations are in the Great Lakes region, including parts of Canada.
- They have also spread as far west as Oregon and as far east as Maine.
- They have moved into new areas partly due to canals connecting waterways in the upper Midwest and Great Lakes regions.
- Bait bucket releases may have increased their spread.

Sources:

- "Rusty crayfish." USFWS: fws.gov/sites/default/files/documents/Ecological-Risk-Screening-Summary-Rusty-Crayfish.pdf
- "Rusty crayfish." USDA: invasivespeciesinfo.gov/aquatic/invertebrates/rusty-crayfish

Red Swamp Crayfish (*Procambarus clarkii*)

Photo: Luc Hoogenstein CC BY-SA 4.0

Description:

- Adults are easily identified by their brick red body.
- They differ from most other crayfish species found in the Great Lakes by having chelae that are long and slender.
- Red tubercles on the chelae often extend onto the body.
- Juvenile red swamp crayfish are difficult to identify. They are a variety of tan or brown shades.

Habitat:

- They are found in rivers, lakes, ponds, streams, and canals and live in seasonally flooded swamps and marshes and ditches with mud or sand bottoms.
- Can live in a range of temperature, pH, oxygen, and pollution levels

Distribution:

- Native to the south central U.S. along the Gulf Coast and along the Mississippi River basin.
- Non-native populations live as far north as southern Illinois and in several other Great Lakes, and mid-Atlantic states.
- They have spread to Idaho, Utah, Arizona, South Dakota, Nebraska, and Georgia.
- They are among the most popular and frequently raised crayfish species in the world. They are found in the bait, aquaculture, and pet trade industries.

Sources:

- "Red swamp crayfish." USFWS: fws.gov/sites/default/files/documents/Ecological-Risk-Screening-Summary-Red-Swamp-Crayfish.pdf
- "Procambarus clarkii." USGS: nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=217

OTHER HIGH-RISK AND PROHIBITED CRAYFISH SPECIES

The following species have not yet been established in the Great Lakes region. However, they are high risk or prohibited based on risk assessments and Great Lakes region crayfish regulations.

Common Yabby (*Cherax destructor*)

Photo: Daiju Azuma CC 2.5

Description:

- A very large and aggressive crayfish. They can grow up to 30 cm.
- They have a smooth body and short, stout pincers.
- Their rostrum is short, broad, and triangular.
- Their color ranges from green-beige to almost black. Captive animals are usually blue-grey.

Habitat:

- They can live in many environments and habitats. These include springs, lakes, alpine streams, subtropical creeks, swamps, dams, and canals.
- In Australia, they burrow extensively. Burrows can destabilize shorelines.

Distribution:

- They are native to Australia.
- They have been transported globally for aquaculture, food markets, and aquariums.
- They are not yet found in the U.S. or in any waters connecting to the Great Lakes. If introduced into the Great Lakes, they may change aquatic food webs. They would compete with native crayfish and could spread diseases, such as crayfish plague.

Sources:

- "Yabby (Cherax desctructor)" USFWS: fws.gov/sites/default/files/documents/Ecological-Risk-Screening-Summary-Yabby_0.pdf
- "Cherax destructor." NOAA: nas.er.usgs.gov/queries/greatlakes/FactSheet.aspx?Species_ID=3648&Potential=Y&Type=2

Australian Redclaw (*Cherax quadricarinatus*)

Photo: 5snake5 CC BY-SA 4.0

Description:

- This is a large-bodied and aggressive crayfish. They can grow up to 25 cm.
- Blue-green to green coloration and red/maroon highlights
- Adult males have a bright red patch on the outer margins of their chelae.
- Four long, distinct ridges on the head

Habitat:

- Found in freshwater creeks and water bodies in tropical regions of Australia
- Can live in habitats with a wide range of temperatures and dissolved oxygen levels

Distribution:

- Native to Australia
- Introduced in parts of California, Nevada, and Texas
- They may impact native species through competition, predation, or habitat changes. They carry diseases that could spread to native crayfishes and shrimps.
- They are a popular aquarium animal because they are colorful and hardy. Aquarium dumps are a possible means of introduction.

Sources:

- "Cherax quadricarinatus." USGS: nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=220
- "Redclaw (Cherax quadricarinatus)." USFWS: fws.gov/sites/default/files/documents/Ecological-Risk-Screening-Summary-Redclaw.pdf

Signal Crayfish (*Pacifistacus leniusculus*)

Signal crayfish female with eggs on the lower abdomen.
Photo: Alaska Region USFWS CC0

Description:

- They are usually bluish-brown to reddish-brown in color on their dorsal side. Average carapace length is 50-70mm.
- The undersides of their claws are bright red. The base of each claw joint has a white or turquoise colored patch.
- The surfaces of the claws and carapace are smooth. They lack the tubercles that are typical of other non-native crayfish.
- Areola is open.

Habitat:

- They have moved into many types of habitats. These range from warm coastal waterways to sub-alpine waters.

Distribution:

- They are native to the northwestern U.S. They live in the Columbia River Basin and areas of Washinton, Oregon, Idaho, and British Columbia.
- They are now found in the midwestern region of the U.S. Scientists confirmed sightings in Lake Winona, Minnesota in October 2023.
- May spread to new areas due to live bait release, stocking for harvest, or stocking for fish food.

Sources:

- "Pacifastacus leniusculus." USGS: nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=200
- "Signal crayfish (Pacifastacus leniusculus)." Minnesota Dept. of Natural Resources: dnr.state.mn.us/invasives/aquaticanimals/signal-crayfish.html

Florida/Electric Blue Crayfish *(Procambarus alleni)*

Photo: Chris Lukhaup

Description:

- Wild Florida crayfish can be blue, brown, or red in color. Captive crayfish have been bred to have a brilliant blue color.
- They have dark, circular areas called “headlights” at the base of both antennal glands.
- They have a narrowly open areola.

Habitat:

- They tolerate a wide range of habitats. These include seasonal and permanent wetlands, ditches, and small streams.

Distribution:

- Native range includes most of central and southern Florida.
- They are not established in the Great Lakes yet.
- There is a high risk of introduction. They are popular in the aquarium trade due to their color. Future introductions may occur through aquarium releases.

Sources:

- “Florida Crayfish (Procambarus alleni).” USFWS: fws.gov/sites/default/files/documents/Ecological-Risk-Screening-Summary-Florida-Crayfish.pdf
- “Procambarus alleni.” USGS: nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=2812

Marbled Crayfish (*Procambarus virginalis*)

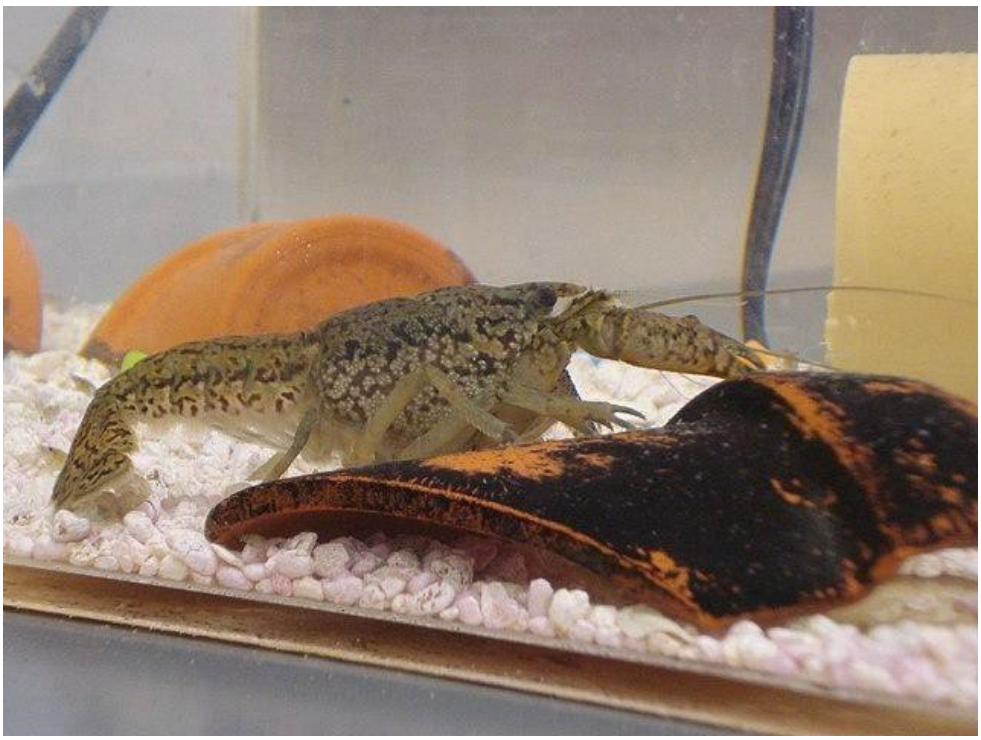


Photo: Zfaulkes CC0

Description:

- Are usually olive to brown in color when found in the wild
- Have a marbled pattern that covers their entire back and claws
- A dark stripe runs down each side of their carapace and abdomen.
- Male marbled crayfish do not exist. All individuals are female and reproduce by parthenogenesis.

Habitat:

- This species does not occur naturally in the wild. They are descended from the slough crayfish, found in the southeastern U.S.
- Their environmental impacts are unknown.

Distribution:

- The marbled crayfish is a common species in the pet trade.
- Multiple individuals have been found in the Lake Ontario watershed near Toronto.
- Only one individual is needed to establish a population. Thus, it the potential to be highly invasive.
- Not yet found in the U.S. as of this writing.

Sources:

- "Marbled Crayfish (Procambarus virginalis)." USFWS: fws.gov/sites/default/files/documents/Ecological-Risk-Screening-Summary-Marbled-Crayfish.pdf
- "Procambarus virginalis." USGS: nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=3656

Crayfish Role: **Prey**

Photo: Brocken Inaglory CC BY-SA 3.0

- Over 200 animal species eat crayfish, including mammals, birds, reptiles, amphibians, fishes, and insects, like dragonfly larvae (DiStefano, 2005).
- Fish, such as bass, are especially prominent crayfish predators (Probst et al., 1984; Rabeni, 1992).
- A wide variety of other fish species, from brook trout to creek chubs, also consume crayfish (Newsome & Gee, 1978; Gowing & Momot, 1979).
- Crayfish are a vital food source for other important animals in freshwater ecosystems, such as the hellbender, an endangered salamander (Wiggs, 1976).

Photo: Brian Gratwicke CC BY-SA 2.0

- Crayfish are also consumed by many land-based animals including minks, raccoons, and wading birds (Baker et al., 1945; Toweill, 1974; Martin & Hamilton, 1985).

Crayfish Role: **Consumers**

Crayfish compete with other invertebrates, such as snails, for food. Crayfish also eat them!
Photo: Mlogic CC BY-SA 3.0

- Crayfish are **omnivores**: They eat a wide variety of food items, from tiny phytoplankton to fish.
- Crayfish are also important **scavengers** of dead animals and dead plant matter, such as leaves.
- Crayfish eat producers such as algae (Goldman, 1973) and aquatic plants (Creed, 1994). Crayfish can eat so much algae and plant material that they strongly impact the densities of these organisms (Goldman, 1973).
- Crayfish also feed on many different types of invertebrate prey, including snails (Kreps et al., 2012), insects and their larvae (Parkyn et al., 2001), and even other crayfish (Nakata & Goshima, 2006).
- Crayfish also eat vertebrates such as fish (Rahel & Stein, 1988) and amphibians, especially their eggs and larvae (Axelsson et al., 1997).

Crayfish Role: **Ecosystem Engineers**

A burrowing crayfish peeks out of its burrow.
Photo: Mlogic CC BY-SA 3.0

Crayfish can impact habitat quality for other organisms (Reynolds et al., 2013). This can happen through:

- **Burrowing**: Many species of crayfish build burrows. These create spaces that can be used by other organisms (Creed & Reed, 2004). Burrowing can also increase erosion rates (Statzner et al., 2000; 2003). Burrowing crayfish species can construct complex networks of tunnels and chambers deep into the soil. These can help water and gases to move, adding oxygen and draining soils (Richardson, 1983; 2007).
- **Consuming detritus**: Crayfish can also eat large amounts of leaf litter and other dead plant and animal matter (Huryn & Wallace, 1987; Schofield et al., 2001). The processing of detritus by crayfish can change the number of insect larvae, which can be an important food source for fishes and other aquatic vertebrates (Creed & Reed, 2004; Hoopes, 1960). Removing detritus can also help keep water clean.

Impact of Invasive Crayfish: **Displacement + Loss of Biodiversity**

An invasive red swamp crayfish
Photo: National Park Service CC 0

Invasive crayfish are aggressive and fast-growing. This threatens native crayfish biodiversity. In fact, the introduction of nonnative crayfish may be the single greatest threat to global crayfish biodiversity (Lodge et al., 2000a).

In the Great Lakes region, invasive crayfish such as the rusty crayfish (*Faxonius rusticus*), have displaced native species from large portions of their natural ranges (Momot, 1996; Taylor & Redmer, 1996; Olden et al., 2006).

Impact of Invasive Crayfish: **Effect on Other Aquatic Invertebrates**

A mayfly nymph: important food for fish
Photo: National Park Service CC 0

- Invasive crayfish can cause populations of other aquatic macroinvertebrates (like insect larvae) to decline (Charlebois & Lamberti, 1996).
- Invasive crayfish have also been shown to reduce macroinvertebrate biodiversity in stream ecosystems (Stenroth & Nyström, 2003).
- A long-term study in Wisconsin showed a dramatic decline in snail densities after rusty crayfish were introduced (Wilson et al., 2004). The same study also reported big declines in insect species such as dragonflies and caddisflies.

Impact of Invasive Crayfish: **Declines in Native Fish Populations**

Humans and wildlife depend on native fish, like this walleye, for food. *Photo: Pverdonk CC BY-NC 2.0*

Invasive crayfish can reduce native fish populations by:

- Competing with native fishes for similar prey species.
- Reducing the density of aquatic plants used by young fish as cover (Wilson et al., 2004).

Invasive crayfish may also reduce the breeding success of fish by eating their eggs (Dorn & Mittelbach, 2004).

Impact of Invasive Crayfish:
Negative Impacts on Amphibians

A northern leopard frog
Photo: Brian Gratwicke CC BY 2.0

Invasive crayfish have reduced native amphibian species around the world.

- For example, red swamp crayfish have contributed to the decline of some amphibian species by eating their eggs (Gamradt & Kats, 1996).
- In ecosystems where native crayfish are present, red swamp crayfish can consume amphibian eggs at a higher rate than native crayfish species (Renai & Gherardi, 2004).
- Invasive crayfish can also reduce food availability, which could impact amphibian growth and survival (Cruz et al., 2006).

Impact of Invasive Crayfish:
Destruction of Aquatic Plants

Duckweed: a tiny but important aquatic plant
Photo: Mokkie CC BY-SA 3.0

Aquatic plants provide habitat for fishes, amphibians, and aquatic macroinvertebrates.

- Crayfish can reduce biomass and biodiversity of aquatic plants (Lodge & Lorman, 1987; Wilson et al., 2004; Rosenthal et al., 2006).
- Invasive crayfish consume plant material at a faster rate than some native crayfish species.
- Such changes can strongly affect ecosystem structure and function. This could result in the decline or displacement of other species in freshwater ecosystems.
- Invasive crayfish can also reduce the density of aquatic plants used for cover by young fish (Wilson et al., 2004).

Impact of Invasive Crayfish: **Disease Transmission**

Signs warning of the dangers of disease transmission by invasive crayfish in Europe
Photo: Kevin Higgins CC BY-SA 2.0

- Invasive crayfish can transmit diseases to native crayfish species. For example, crayfish plague *(Aphanomyces astaci)* has caused major population declines and range reductions in native European crayfish. The disease was introduced to Europe through invasive North American crayfish *(Lodge et al., 2000a)*.
- While introduced diseases have not yet been reported for native crayfish in the Great Lakes, the potential for disease transmission exists.
- A study in California showed that invasive crayfish lead to more mosquitoes and risk of mosquito-borne diseases: newsroom.ucla.edu/releases/invasive-crayfish-lead-to-more-mosquitoes-and-risk-of-disease-in-southern-california

Introduction Pathway of Invasive Crayfish: **Bait**

A bucket of live invasive red swamp crayfish
Photo: Defense Visual Information Distribution Service CC 0

- Invasive crayfish sometimes spread when they are used as bait.
- Live crayfish that are left over after fishing are sometimes released.
- These “bait bucket” introductions are one of the ways non-native crayfish invade new areas (Ludwig & Leitch, 1996).

Introduction Pathway of Invasive Crayfish: **Aquariums**

A young blue crayfish in an aquarium
Photo: xcalibur8OP CC BY 3.0

- Crayfish and other freshwater crustaceans have become increasingly popular as pets *(Chucholl, 2013)*. This is partly due to their striking colors.
- Live crayfish are transported across state borders, and even internationally, for the pet trade.
- Some crayfish can grow to a large size quite rapidly, leading to overcrowding or aggression towards other organisms in a tank. For this reason, crayfish pets are often released into nearby water bodies.

Introduction Pathway of Invasive Crayfish: **Aquaculture**

A crayfish farm
Photo: Natalie Maynor CC BY 2.0

- Crayfish are grown and sold for a variety of purposes, including for food or for use as bait in recreational fishing.
- Aquaculture facilities that supply crayfish to food and bait vendors can spread invasive species such as red swamp crayfish.
- Facilities farming non-native crayfish can accidentally spread these species to nearby water bodies by overland migrations or during flood events.
- Even facilities that raise other organisms, such as fish in ponds, can risk transporting invasive crayfish if crayfish make their way into the ponds and then are accidentally included with shipments of live animals.

Introduction Pathway of Invasive Crayfish: **Classrooms**

Students hold invasive rusty crayfish in a classroom.
Photo: Jennifer England

- Crayfish are used in classrooms as pets or as tools to enrich learning. This can lead to accidental or intentional release of live organisms, negatively impacting local environments.
- Red swamp and rusty crayfish are common in biological supply kits provided to teachers for science lessons. It is estimated that 25% of elementary schools in the US purchase and use live crayfish in their science classes (Patton, 2011).
- It is important to be aware of the alternatives to releasing classroom animals and plants into the wild. Even native crayfish species that are caught in the wild and brought into the classroom should never be re- released into the wild.