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 rusticiformes)* 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.

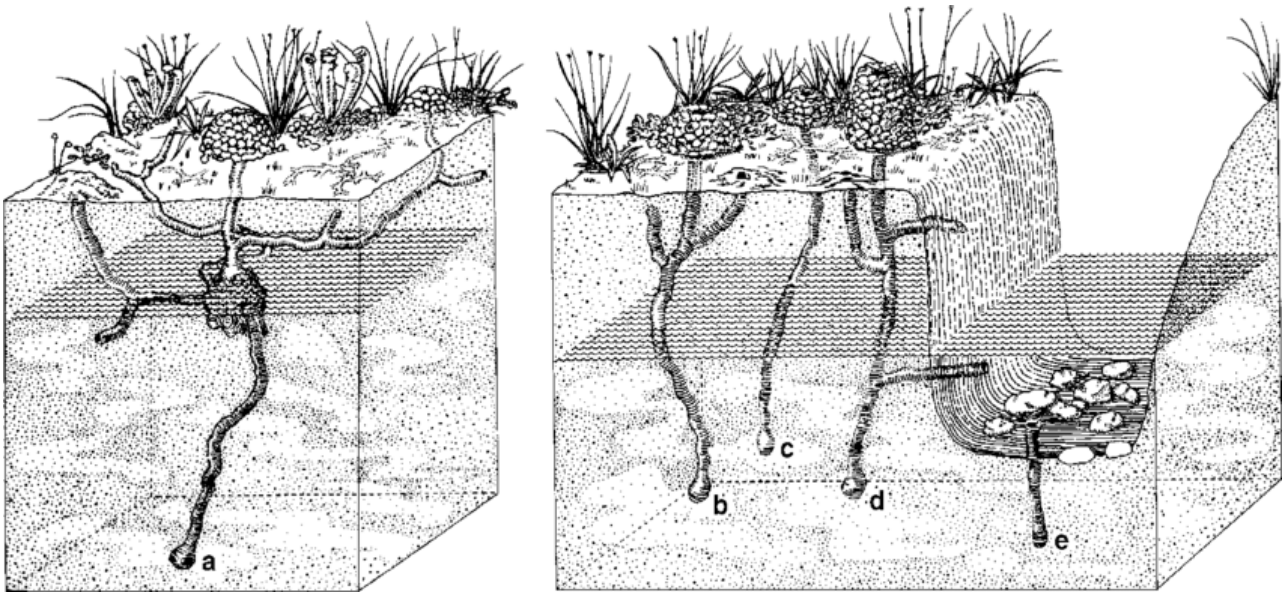
- **Detritus**: Crayfish can consume large amounts of detritus, primarily in the form of leaf litter and other decaying plant material (Huryn & Wallace, 1987; Schofield et al., 2001). The processing of large amounts detritus by crayfish, such as dead animals and plant matter, can help keep freshwater 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 "45% of North American crayfish species are considered to be at risk of extinction" ("Menace to the West: Crayfish"). 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.