Overview

This activity will teach students how human impacts to the environment affect water quality and indicator species.

Estimated Time

60 minutes

Vocabulary

- Watershed
- Indicator Species
- Water Quality
- Erosion
- Sedimentation
- Leaching
- Groundwater

Lesson Objective

Students will be able to define the term watershed and water quality as well as understand how human impacts affect watersheds and their associated wildlife.

Required Materials

- Watershed game board (pdf)
- Human Impact Cards (pdf)
- Indicator species cards (pdf)
- Vocabulary worksheet (pdf)
- Beads to represent pollution
- Tippecanoe Watershed overhead (pdf)
- Mighty Mussel game pieces (one per player)
- Clear 3 oz. cups to hold water (1 per student)
- Dice, two per playing group
- Freshwater Mussel photos (pdf)
- Freshwater Mussel distribution maps (pdf)

Targeted Grade-Level Standards (5th)

English

EL 5.1; ELP 5.1, ELP 5.2, ELP 5.7

Science

SC 5.2, SC 5.4, SC 5.6; SCI 5.3

Reference Materials

All files (pdf) are available for download at www.heartofthetippy.org

See teacher's notes.

Authors

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Acknowledgments

The authors would like to thank Ellen Kapitan, Suzy Lyttle, and Rod Williams for permission to take inspiration from the Hellbender Lesson Plan. The authors would also like to credit Anastasia Makridakis for the Watershed Gameboard and Brant Fisher (Indiana DNR) for the Species pictures.

How to Play

Present to entire group:

1. Begin the lesson by asking questions such as: *What do you think a watershed is? What is the size of a watershed? What types of water are included within a watershed?*
2. Define the term watershed for the students.
3. Ask students *what watershed do they live in*? Use the Tippecanoe Watershed as an example for the class. Display the image provided in the Teacher's Notes section and discuss the size of the watershed, flow of water and how the surrounding area can influence these dynamics. If available, include information about your local watershed.
4. Ask the students: *what kinds of animals live in streams, rivers, and ponds and why they may live there*? Introduce the term **indicator species**. Indicator species have certain qualities that make them important for scientists to study. Explain that the presence or absence of an indicator species reveals the environmental condition, such as water quality. Invertebrates, such as mayflies and crayfish, are excellent indicator species for aquatic habitats. Explain to students why an invertebrate's unique characteristics make them good indicator species for a watershed (see teacher's notes for examples).
5. Introduce the **freshwater mussel** to the class and explain that they serve as an indicator species in rivers. Mussels are found in clean, fast flowing water. The presence of mussels in streams and rivers serves as an indicator of high water quality (more information in teacher's notes)
6. Shift the discussion to **water quality**. Ask the students: *what are ways in which water quality can be affected, both positively and negatively*? Ask students: *what might happen if the water quality were to change? What if the water quality became worse- what would happen to the freshwater mussels in the river*?
7. Pass out the **Vocabulary Worksheet** and review the terms with the students. Define the ways pollution travels into and through the watershed.
   - Soil Erosion
   - Sedimentation
   - Leaching
   - Groundwater

Directions for Activity and Game Rules

The goal of the **Mighty Mussel Journey through the Watershed Game** is to travel through the watershed and see how humans impact the water quality.

Game Set-Up: Split the class into groups of 4-5 students. Each group should have:

a. One cup per student half filled with water
b. One watershed game board (pdf)
c. Two dice
d. Game player piece for each student (options: Mighty Mussels, cubes, etc.)
e. Three stacks of human impact cards: forestry, agriculture, and urban (pdf)
f. Beads to represent pollution (optional: using black/grey/brown beads)
g. One set of indicator species cards (4-5 of each species; 8-10 total cards). Cards include mussels and crayfish. They serve as a prize for winning the game. There can be multiple winners at the end. A freshwater mussel represents the high water quality, a crayfish represents moderate water quality,

and low water quality receives no invertebrate indicator species.

1. **Game Play**: Each student starts with a clean cup of water. One by one, each student will **roll both dice** to determine how many spaces they will travel on the watershed game board.
2. The students will **pick up a human impact card every time they land on a new spot** on the game board. The human impact cards correspond with the three areas on the game board: f**orestry**, **agriculture**, and **urban**. The boundaries of the watershed are color coded with the corresponding area: *green is forestry, yellow is agriculture, and gray/white is urban*. When in the forestry area, students are to pick up a forestry human impact card, the same goes for the other two areas.
3. After the human impact card is drawn, the **students will read the human impact card aloud and follow the instructions listed**. Each card either has a negative or positive impact. **Negative impacts** require students to add pollution beads into their cup of water. **Positive impacts** allow students to remove pollution beads from their water. If they get a positive impact before they have any beads in their cup, then no action is needed.
4. **Repeat steps 3-5 until each student has reached the end of the river**. The river splits once in the urban area, but it does not matter which trail they follow.
5. **Winning the Game**: To determine the winner, have **students count the final number of pollution beads in their cup**. The student(s) with the cleanest water (fewest beads) wins.
   a. **0-5** beads receive the mussel indicator species card meaning they have the cleanest water and win the highest honor.
   b. **6-9** beads receive a crayfish indicator species meaning they have moderate water quality.
   c. **10+** beads receive no indicator species meaning that their water quality is unfit for an invertebrate to live in.
6. **End of game**: Review the terms **watershed** and **water quality**. Ask students: *What did your water look like before the game started? What did your water look like after? Would you drink your water after the game was over?* Ask students for examples of some positive and negative human impacts on watershed water quality they experienced during the activity.
   a. Review the terms they encountered in these experiences: **soil erosion**, **sedimentation**, and **leaching**.
   b. Review the term **indicator species**. Ask how many students' water quality allowed them to have freshwater mussels, crayfish, or no invertebrates at all. Ask them what factors caused them to receive the particular indicator species.
   c. Ask the students if they personally have done any of the positive or negative impacts and how they can impact the water quality in their daily lives.

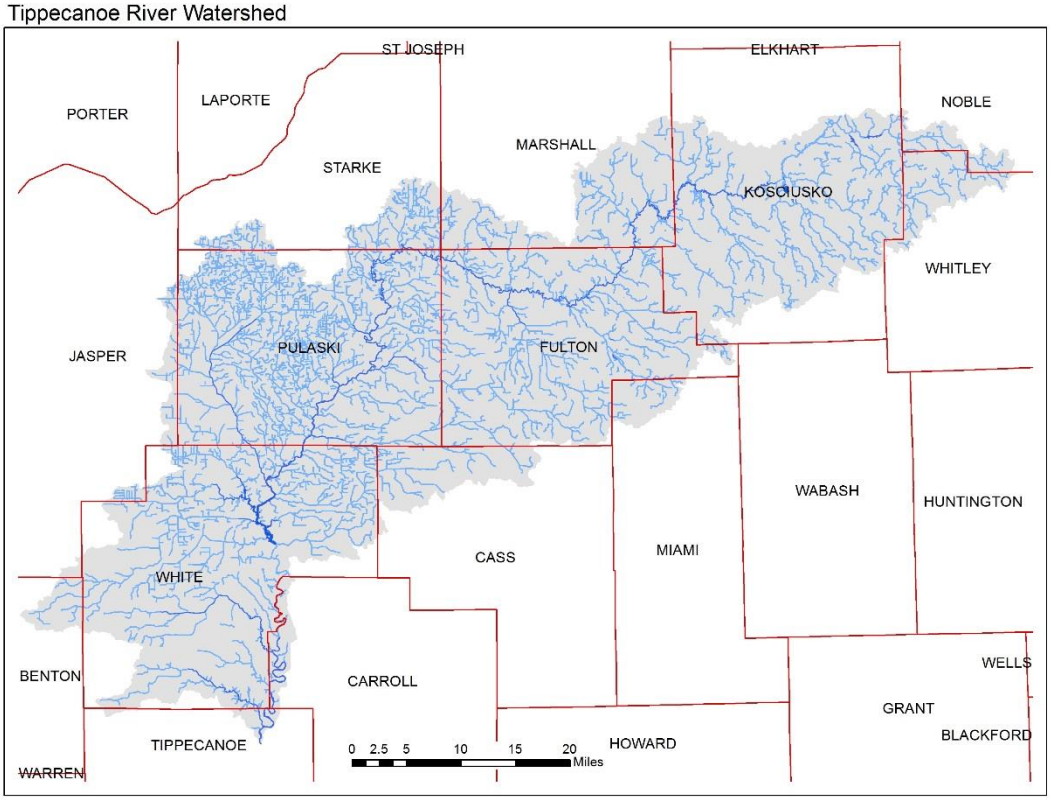
Teacher Notes

Watershed

A **watershed** is an area of land where all of the water drains into the same location. Watersheds can include creeks, streams, rivers, ponds, lakes, wetlands, groundwater, and oceans. Everyone lives in a watershed!

An example of a watershed is The Tippecanoe River Watershed, in north central Indiana. The Tippecanoe River Watershed is approximately 1,890 square miles, which is roughly the size of Grand Canyon National Park. All lakes and streams within this watershed drain to the Tippecanoe River. The actual Tippecanoe River is 166 miles long, but the river's watershed is a larger area because multiple sources of water form a watershed.

Tippecanoe River Watershed



Water Quality

Water quality is the measure of the chemical, biological, and physical characteristics of water in relation to a standard of use, such as drinking water for humans or habitats for aquatic and riparian animals. A watershed's water quality can be affected by multiple factors, including human impacts.

- **Soil Erosion and Sedimentation**: These are the primary sources of pollution in Indiana. Erosion and sedimentation result from poorly managed construction sites and logging sites, as well as non-environmentally conscious agricultural practices. **Erosion**

occurs when the topsoil is removed from the land's surface. **Sedimentation** occurs when wind or water carry soil particles away from the land, and deposits the soil somewhere else, which results in less productive, less healthy land. Together, erosion and sedimentation can transport unwanted nutrients and pollutants such as organic nitrogen, phosphorus, and pesticides into the watershed.

- **Leaching**: The natural process by which chemicals, minerals, animal waste, or pharmaceuticals are washed out from soil and enter the groundwater. **Groundwater** is the water that fills the empty spaces beneath the soil. For example, after pesticides are sprayed on crops the chemicals can leach or move through the soil and into groundwater, which ultimately ends up in waterways throughout the watershed.
- **Runoff**: Occurs when water, containing chemicals such as fertilizers, flows over land instead of being absorbed into groundwater or instead of being lost by evaporation. For example, after a landowner applies fertilizer to their yard, rainfall can carry some of the fertilizer into the street drains that flow directly to streams and rivers, thereby contaminating local water supplies.

One way to control the effects of erosion and sedimentation is by **planting more trees near streams and rivers**. Removing natural vegetation or buffers for development purposes, however, would increase the effects of erosion and sedimentation. Converting acres into cropland takes away the land's natural ability to stabilize soil, resulting in additional erosion of the land. Many agricultural practices, such as tilling, can increase erosion and sedimentation. To combat the effects of erosion and sedimentation, farmers can adopt no-till farming, which leaves the soil undisturbed and increases the amount of water and nutrients available while decreasing erosion. Other positive impacts include the proper disposal of chemicals and oils, and applying the recommended amount of fertilizer on your lawn to reduce leaching.

Indicator Species

An **indicator species** is an organism whose presence, absence, and abundance reveals a specific environmental condition, whether it be a positive or negative condition. Assessing the presence or absence of an indicator species can help determine the health of a watershed and aid in diagnosing a specific problem. Invertebrates serve as important indicator species in aquatic habitats due to their unique life history traits.

Invertebrates as Indicator Species

There are two categories of invertebrates: microinvertebrates and macroinvertebrates. Macroinvertebrates are invertebrates that are visible with the naked eye. Microinvertebrates can only be seen through a microscope. Invertebrates are unique compared to vertebrates, as they often have multiple life-stages before they reach adulthood. However, not all invertebrates are dependent on water sources to start their lifecycle. Those that are dependent on water sources to start their lifecycle, aquatic invertebrates, make exceptional indicator species to determine water quality. Like many other organisms, macroinvertebrates are sensitive to changes in water quality,

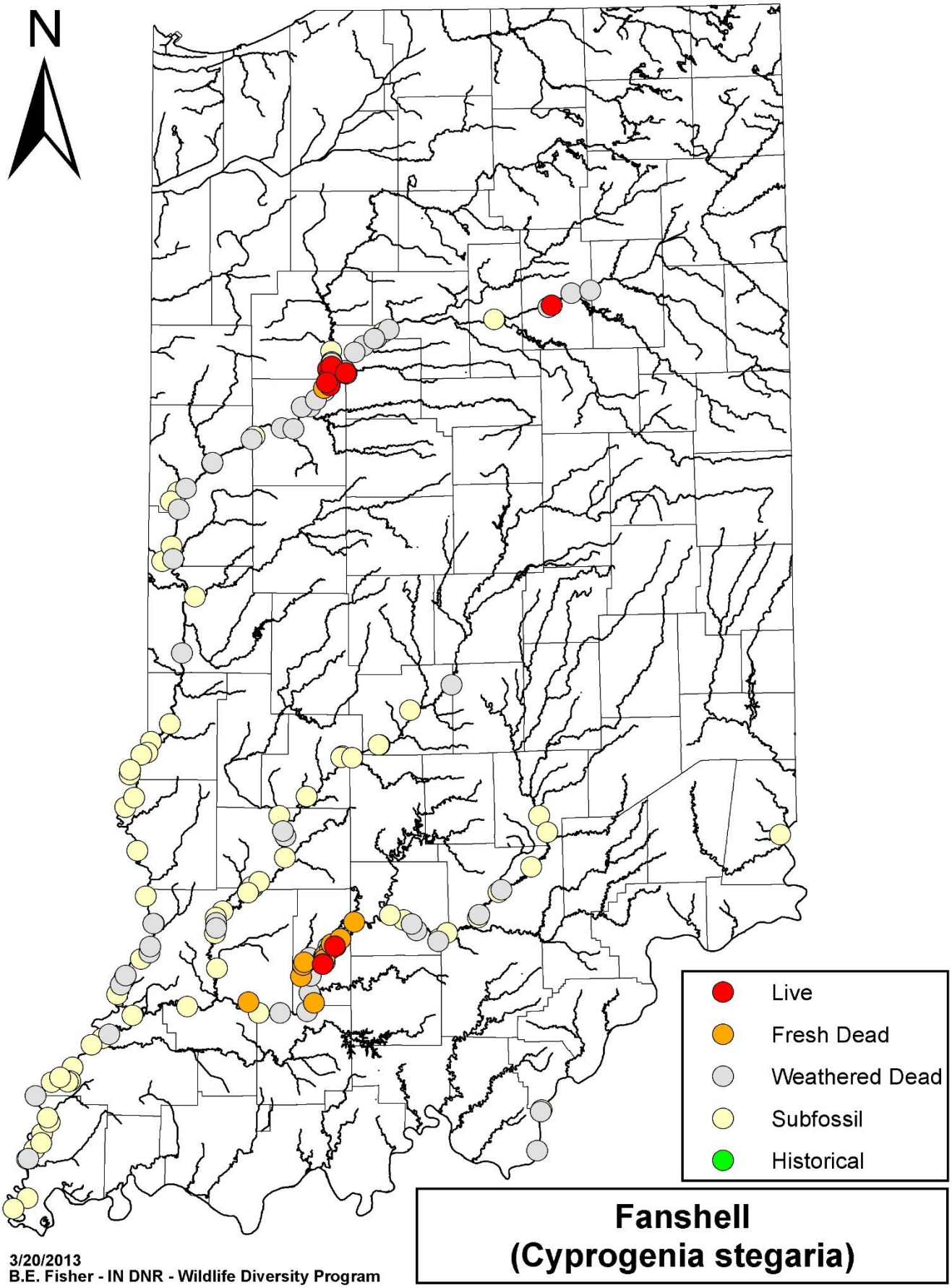
such as changes in the amount of oxygen or water temperature that pollutants can make once in the water. At the beginning of their lifecycle, the pollutants can be absorbed into the invertebrates' eggs because, unlike reptiles, invertebrates lack the hard outer shell to protect them from their environment. Absorbing pollution during the egg stage of an invertebrate's life cycle can result in mortality or a large number of complications in the offspring. If the offspring develop in the absence of pollutants, they are still vulnerable to changing water quality conditions as they continue through their life cycle. Whether through filter feeding or feeding on plants/other invertebrates that have been contaminated, the pollutants will be taken into the aquatic invertebrate and decrease its health.

Freshwater Mussels

One particular group of invertebrates is declining due to poor water quality. Freshwater mussels are invertebrates that are so inconspicuous that they are often mistaken for rocks at the bottom of the riverbed. Due to their lack of limbs, freshwater mussels spend most of their adult life sitting in one area, only moving if outside influences act upon it or if their species has specifically adapted to be able to move, albeit very slowly. Even though they cannot move very much or very fast, mussels have developed an incredible way to make sure their offspring disperse to new parts of the river. Mussels reproduce through a special "mobile nursery." Once a female mussel's eggs develop into the juvenile stage, called glochidia, she will draw in a predator fish close to her with an adaptive lure that looks eerily similar to a small fish. Once the predator fish strikes the female mussel, the female mussel will release her offspring onto the fish where they will attach to the fish's gills (though not harming the fish), where they develop into their adult stage and then drop off the fish gills. Once in their adult stage the mussels will filter feed on microscopic food particles, cleaning the water in the process. This is how mussels serve as a great indicator species for water quality. If any pollutants are in the water, it will be taken into the tissues of the mussel and decrease its health and possibly cause mortality. Therefore, if a scientist looks at the quality (size and reproductive capabilities) of the mussel populations in a river, the scientist can tell how clean the water is. And with North America (including Indiana) harboring some of the highest diversity of reproducing freshwater mussel populations in the world, many mussels are being affected by poor water quality. For more information about mussels and what you can do to improve their health and improve water quality, please visit heartofthetippy.org

Distribution Maps

Once found in virtually every river in Indiana, there are very few live populations of freshwater mussels remaining in Indiana. See the maps below for current distribution of freshwater mussels as of 2013.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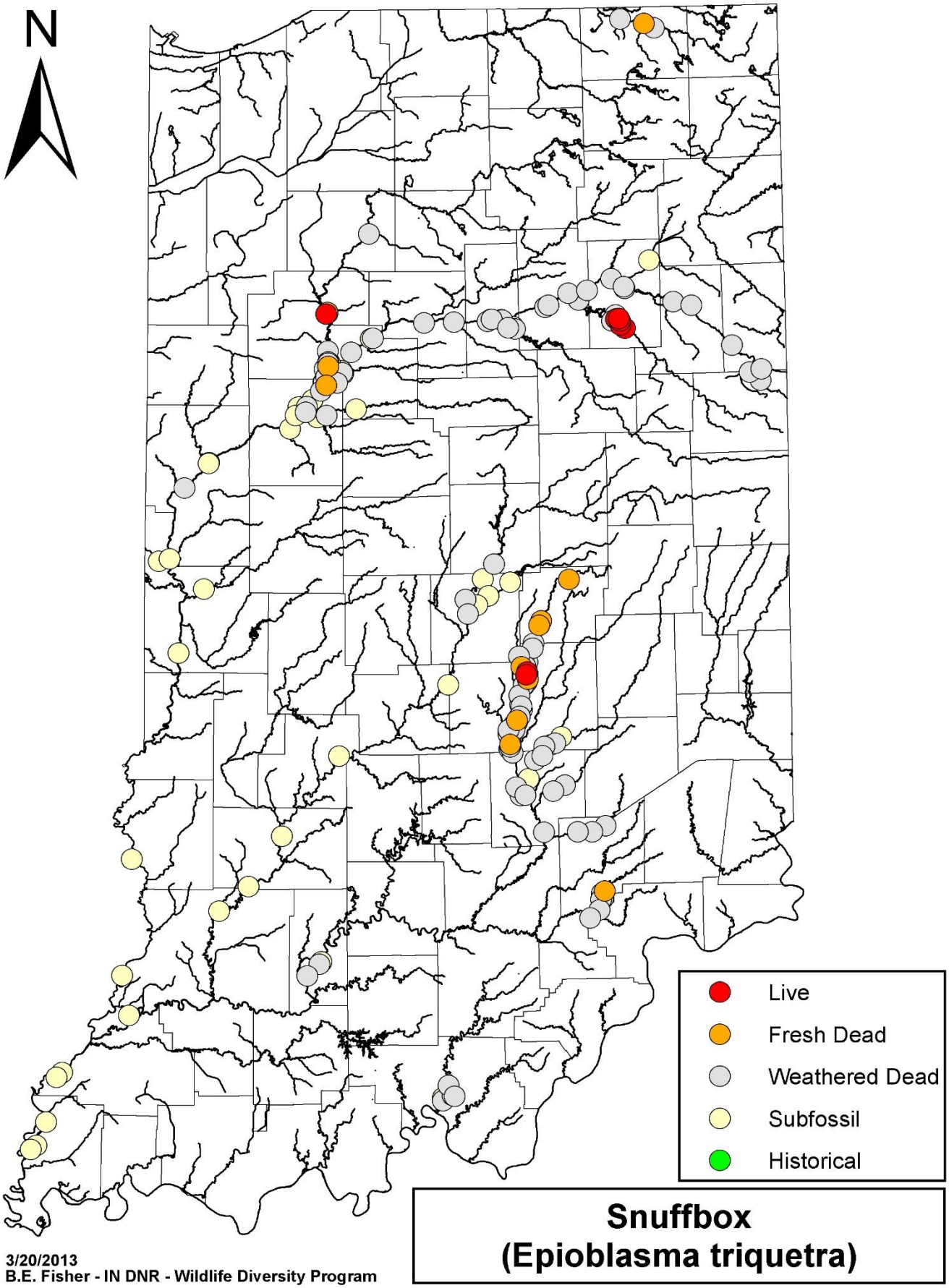
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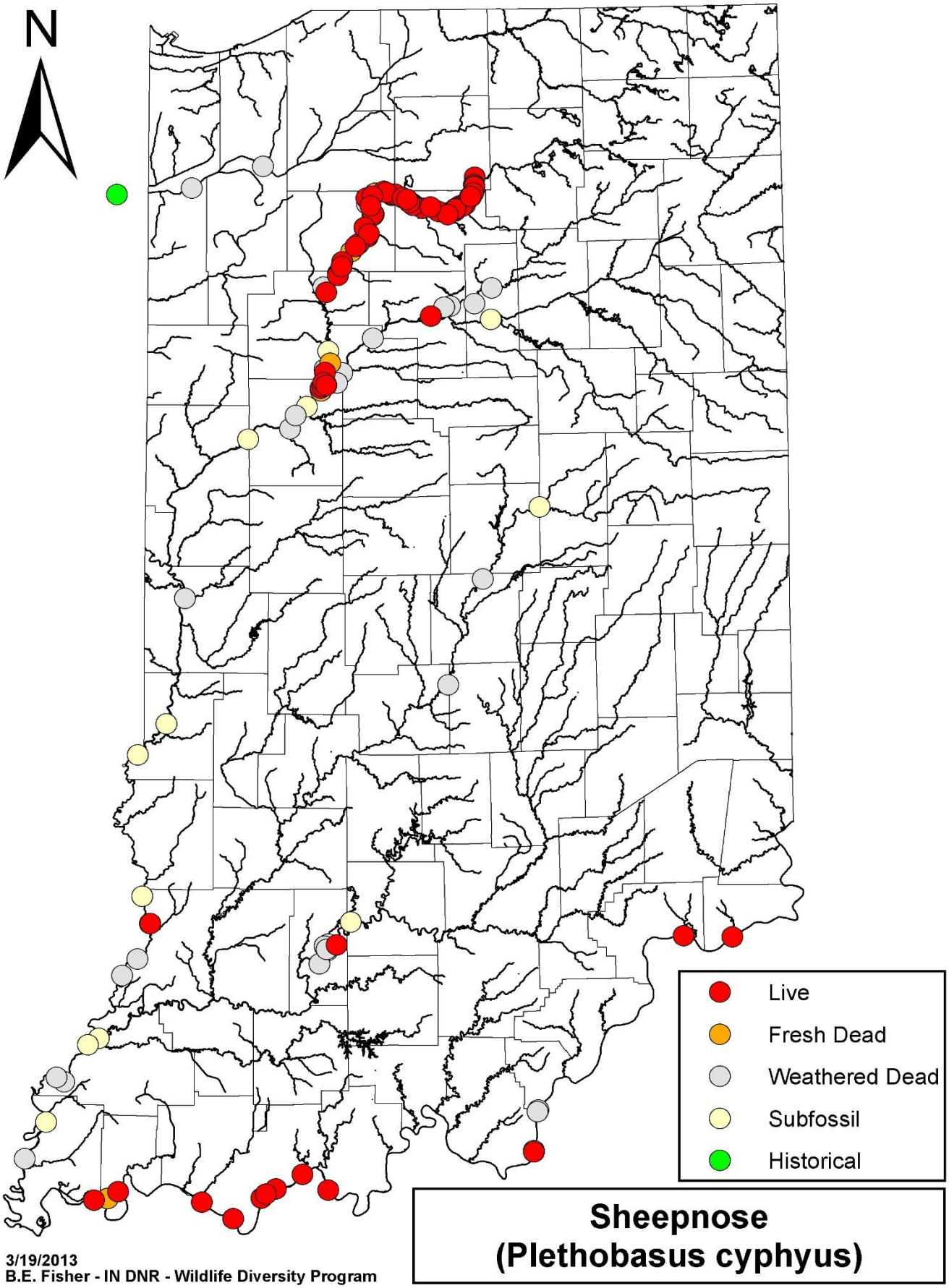
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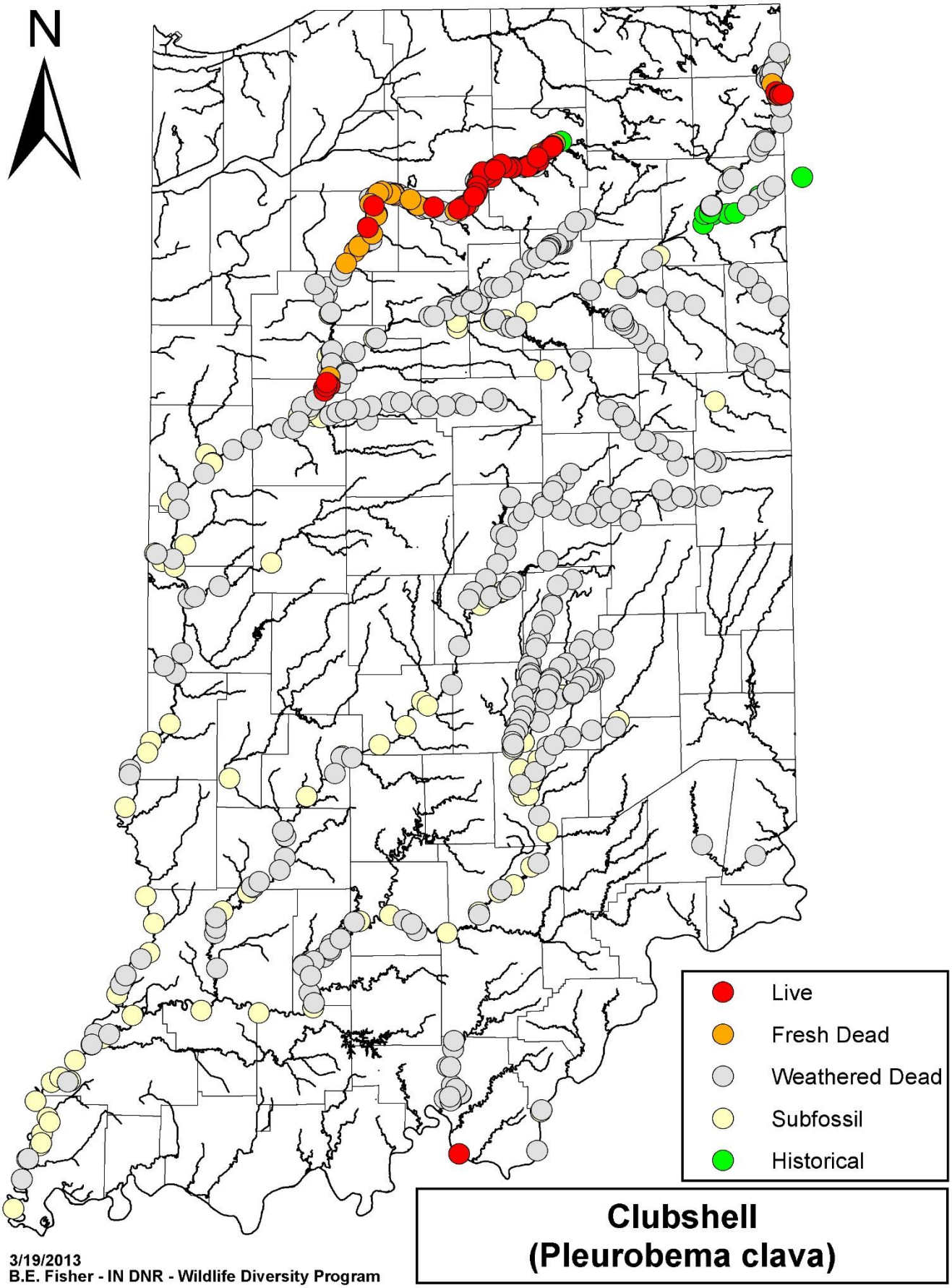
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Further Reading

To locate and learn facts about your local watershed, click the link below to visit Surf Your Watershed by the US Environmental Protection Agency: http://cfpub.epa.gov/surf/locate/index.cfm

Hoosier Riverwatch: http://www.hoosierriverwatch.com/

Heart of the Tippy Freshwater Mussel Outreach and Education: http://heartofthetippy.org

United States Fish and Wildlife Service:
http://www.fws.gov/midwest/endangered/clams/mussels.html

Human Impact Cards

Forestry (print on green paper)

John decides to restore a wetland to help filter and clean rainwater before entering the watershed. Remove 3 beads.	Tim decides to drain a wetland, causing unfiltered water to drain into the watershed. Add 4 beads.
Tom doesn't allow his crew to take machinery through the streams while harvesting trees. The streams are in good condition. Remove 1 bead.	Brian allows his crew's machinery to cross multiple streams while harvesting trees. The equipment hurts the habitat. Add 1 bead.
Nancy followed the proper instructions when applying pesticides. No chemicals entered the watershed. Remove 1 bead.	Mark did not follow the guidelines while applying pesticides. Chemicals entered into the watershed. Add 2 bead.
Along the watershed there is woody debris which provides a great habitat for indicator species. Remove 1 bead.	Along the watershed there is no woody debris which is poor habitat for indicator species. Add 1 bead.
Maria takes out all dams, causing less fragmentation throughout the watershed. Remove 1 bead.	Nick decides to keep the dam in his stream, causing fragmentation. Add 1 bead.
The local community plants trees along the river, causing less erosion. Remove 2 beads.	There are no trees left along the river, causing erosion. Add 3 beads.
Cody restores the forest's streams by adding plants to help prevent sedimentation and erosion. Remove 2 beads.	Jarred removes vegetation along the forest's streams which causes sedimentation and erosion. Add one bead.
Zach has been volunteering to pick up trash in the forest to help clean polluted streams. Remove 1 bead.	Curtis sneaks in the forest to dump his trash. The forest and its streams are polluted. Add 3 beads.
Harmon allows all terrain vehicles to only be driven on trails, keeping the streams undisturbed and clean. Remove 1 bead.	Sally allows all terrain vehicles to drive through streams. Drivers cause sedimentation and damage to the environment. Add 1 bead.
Seth practices sustainable timber harvesting to ensure healthy forests and streams. Remove 2 beads.	Ethan does not regulate his timber harvesting, causing unhealthy forests and streams. Add 3 beads.

Agriculture (print on yellow paper)

Megan practices no till farming that minimizes soil erosion. Remove 2 beads.	Matt tills his farmland and increases soil erosion. Add 3 beads.
Shem installs wind breaks to prevent sedimentation and erosion. Remove 1 bead.	Bart does not have any wind breaks on his farm, increasing the sedimentation carried to the watershed. Add 1 bead.
Connor enrolls his land into the Conservation Reserve Program to help stop erosion and protect the watershed. Remove 2 beads.	Kelly does not enroll his land into the Conservation Reserve Program, increasing erosion and less protection of the watershed. Add 3 beads.
Anders installs a two ditch system to filter sediment before it reaches the watershed. Remove 1 bead.	Anton does not install a two ditch system which causes more sedimentation to enter the watershed. Add one bead.
Staci installs a wetland by her cattle ranch to filter out waste before it drains into the watershed. Remove 2 beads.	The cattle's waste from Johanna's ranch leaches into the watershed because there is no wetland to filter the water. Add 2 beads.
Anne installs a retention pond to manage runoff while preventing erosion. Remove 2 beads.	Mike does not install a retention pond causing erosion and polluted runoff to enter the watershed. Add 3 beads.
Randy uses cover cropping by planting a seasonal crop to prevent erosion. Remove 2 beads.	Anthony does not use a cover crop which leads to erosion. Add 3 beads.
Barney fenced off his cattle to prevent pollution and disturbance to the stream. Remove 1 bead.	Patrick does not have a fence for his cattle and they pollute and disturb the nearby stream. Add one bead.
Betty follows all regulations and limits on fertilizers to prevent pollution. Remove 1 bead.	Carolyn does not read the limits on fertilizers and the extra chemicals cause pollution Add 2 beads.
Reuben properly disposes all pesticides and herbicides, preventing any polluted runoff into the watershed. Remove 1 bead.	Thomas does not properly dispose his pesticides and herbicides causing pollution in the watershed. Add 2 beads.

Urban (print on gray or white paper) page 1 of 2

Daniel follows the label limits on the fertilizers which prevents many chemicals from entering the watershed. Remove 1 bead.	Karen applies more fertilizer than the label recommends and the chemicals leach into the watershed. Add 1 bead.
Rob's car shop properly disposes oil and keeps it out of the watershed. Remove 1 bead.	Andre's car shop pours oil down the drain and oil enters the watershed. Add 5 beads.
Lily's construction crew has installed sediment fences on their construction site which prevents sedimentation and runoff. Remove 2 beads.	Peter's construction crew does not install sediment fences on their construction site which causes sedimentation in the local streams. Add 3 beads.
The Smith family installed rain barrels to capture rainwater and reduce pollution and runoff into their local river. Remove 1 bead.	The Johnson family has not installed rain barrels. All the water runs across their property and adds pollutants to the river. Add 1 bead.
Bill maintains his septic system to prevent waste from leaching into the water. Remove 2 beads.	Louis fails to maintain his septic system and the waste leaches into the groundwater. Add 3 beads.
There is a pipe with clean, treated water flowing from it. There are no unwanted chemicals entering the river. Remove 1 bead.	There is a pipe draining into the river with many chemicals and unhealthy substances entering the water. Add 2 beads.
A superstore is built on top of a wetland and causes habitat reduction and pollution to the wetland. Add 3 beads.	A superstore tries to build a new store in town. The locals don't allow it to be built and protect the wetland habitat. Remove 1 bead.
Tom makes sure that none of his fishing bait escape into the river. The bait species won't compete with the indicator species. Remove 1 bead.	Adam releases his fishing bait into the river. The bait species outcompete the indicator species and causes many to die. Add 1 bead.
Lauren properly disposes her unused medication. No harmful chemicals enter the watershed. Remove 1 bead.	Lana dumps her unused medication down the toilet which causes many chemicals to enter the watershed. Add 3 beads.
Shelly goes to her local car wash to have her car cleaned. The soap used isn't put directly into the water. Remove 1 bead.	Rod drives his truck down into the local river and washes his car there. The soap he uses pollutes the water. Add 2 beads.

Urban (print on gray or white paper) page 2 of 2	
People from the community join Hoosier Riverwatch and help clean debris and pollutants from their local river. Remove 1 bead.	There are no local volunteer groups to help clean the river. Pollution and garbage remain in the river. Add 2 beads.
The factories monitor and clean their waste-water to make sure no pollutants enter the local watershed. Remove 1 bead.	The factories allow their wastewater to be dumped straight into the watershed. Many harmful chemicals enter the watershed. Add 4 beads.
Maggie relies on the rain to water her lawn. Water is preserved and there is no cause of sedimentation. Remove 1 bead.	Carl waters his lawn every morning and every night. This use of water causes sedimentation and runoff from his lawn into the watershed. Add 1 bead.
Linda makes sure her family only uses phosphate free soaps for laundry and dishes. This prevents leaching into the groundwater. Remove 1 bead.	Julie uses dangerous chemicals in her household which then leach into the groundwater. Add 1 bead.

Human Impact Vocabulary Reference Sheet

Cover crop - a crop planted during the off-season to hold soil in place, reducing erosion, and to help move nutrients back to the surface using long root systems, reducing fertilizer use on agricultural fields. Some common examples of cover crops are grasses or legumes such as ryegrass, wheat, crimson clover, and radishes.

No till farming - This type of farming involves planting a crop into the undisturbed soil that still contains the previous season's crop residue. In other words, there is no plowing the cropland before planting. This planting technique increases the amount of water and nutrients in the soil while decreasing erosion.

Two-stage ditch system - This is a type of agricultural drainage that closely mimics the function of natural streams. A two-stage ditch incorporates “benches” (or floodplains) on either side of the stream instead of the usual “V” shaped ditch. Using a two-stage ditch system reduces flooding and sedimentation by decreasing the energy of the water allowing deposition of sediments on the “benches” instead of carrying them to the stream/river.

Low head dam - Low head dams are a type of barrier installed in rivers to alter the stream flow and prevent flooding. Because it is a barrier, dams can prevent various water dependent species from moving through the river.

Conservation Reserve Program (CRP) – A United States Department of Agriculture program that provides farmers annual rental payments and cost-share assistance for conserving resources on eligible farmland. CRP protects millions of acres of topsoil from erosion, reducing sedimentation in streams. By reducing sedimentation, CRP protects groundwater and helps improve the condition of the local watershed.

Retention pond – A small body of water designed to manage stormwater runoff. Retention ponds are useful because they catch the unabsorbed water (runoff) and help to remove pollutants before they can enter the watershed. These ponds are often created in urban areas because there is less land available to absorb water due to buildings and pavement.

Sediment fences - A temporary device, usually make of fabric, that is installed at a construction site to protect water quality by controlling sedimentation and runoff to nearby streams.

Windbreaks - A linear planting of trees or other vegetation to reduce soil erosion caused by wind.

Rain barrels - A system used to collect and store rainwater from roofs using downspouts. Installing rain barrels helps to conserve water and reduce erosion.

Habitat fragmentation - The reduction of large, continuous habitats into smaller, more isolated areas.

Vocabulary

Word Bank

Watershed **Water Quality** **Indicator Species** **Erosion**
Sedimentation **Groundwater** **Leaching**

1._____-An organism whose presence or absence reveals the environmental condition.

2._____-When soil is removed from the land's surface.

3._____-The area of land where all of the water drains off into the same place.

4._____-When soil particles are carried by water and deposited somewhere else.

5._____-The measure of the chemical, biological and physical characteristics of water.

6._____-The natural process by which chemicals, minerals, or particles are washed out of the soil and enter the groundwater.

7._____-Water located beneath the ground that fills the empty spaces.

Vocabulary- Key

Word Bank

Watershed **Water Quality** **Indicator Species** **Erosion**
Sedimentation **Groundwater** **Leaching**

1. **Indicator Species** -An organism whose presence or absence reveals the environmental condition.

2. **Erosion** -When soil is removed from the land's surface.

3. **Watershed** -The area of land where all of the water drains off into the same place.

4. **Sedimentation** -When soil particles are carried by water and deposited somewhere else.

5. **Water quality** -The measure of the chemical, biological and physical characteristics of water.

6. **Leaching** -The natural process by which chemicals, minerals, or particles are washed out of the soil and enter the groundwater.

7. **Groundwater** -Water located beneath the ground that fills the empty spaces.

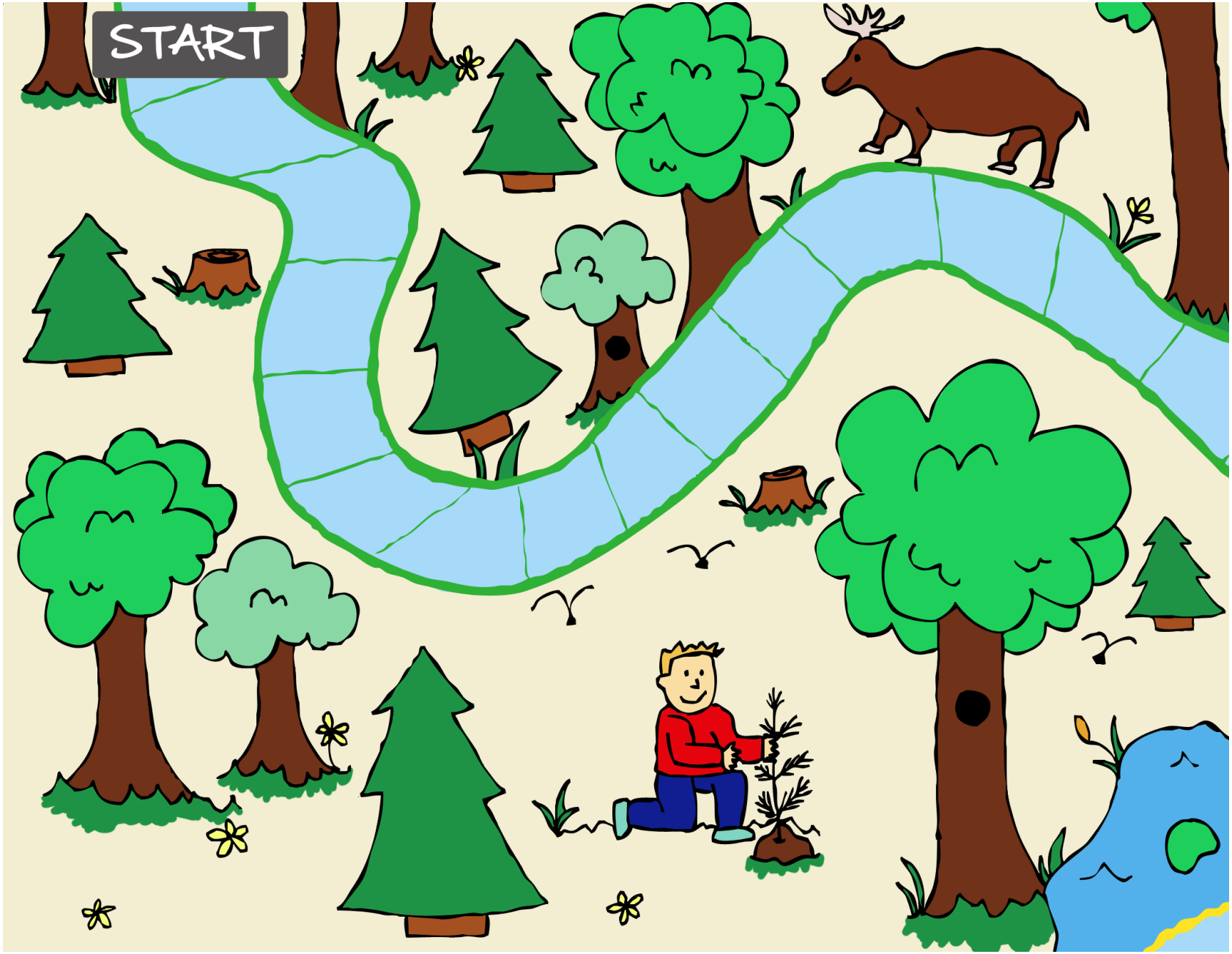
Lesson Plan: Mighty Mussels Journey through the Watershed

Six of the Tippecanoe Rivers' most endangered mussels. From right to left: Clubshell, Fanshell, Rabbitsfoot*, Rayed Bean, Sheepnose, and the Snuffbox. *Threatened species, not yet classified as endangered

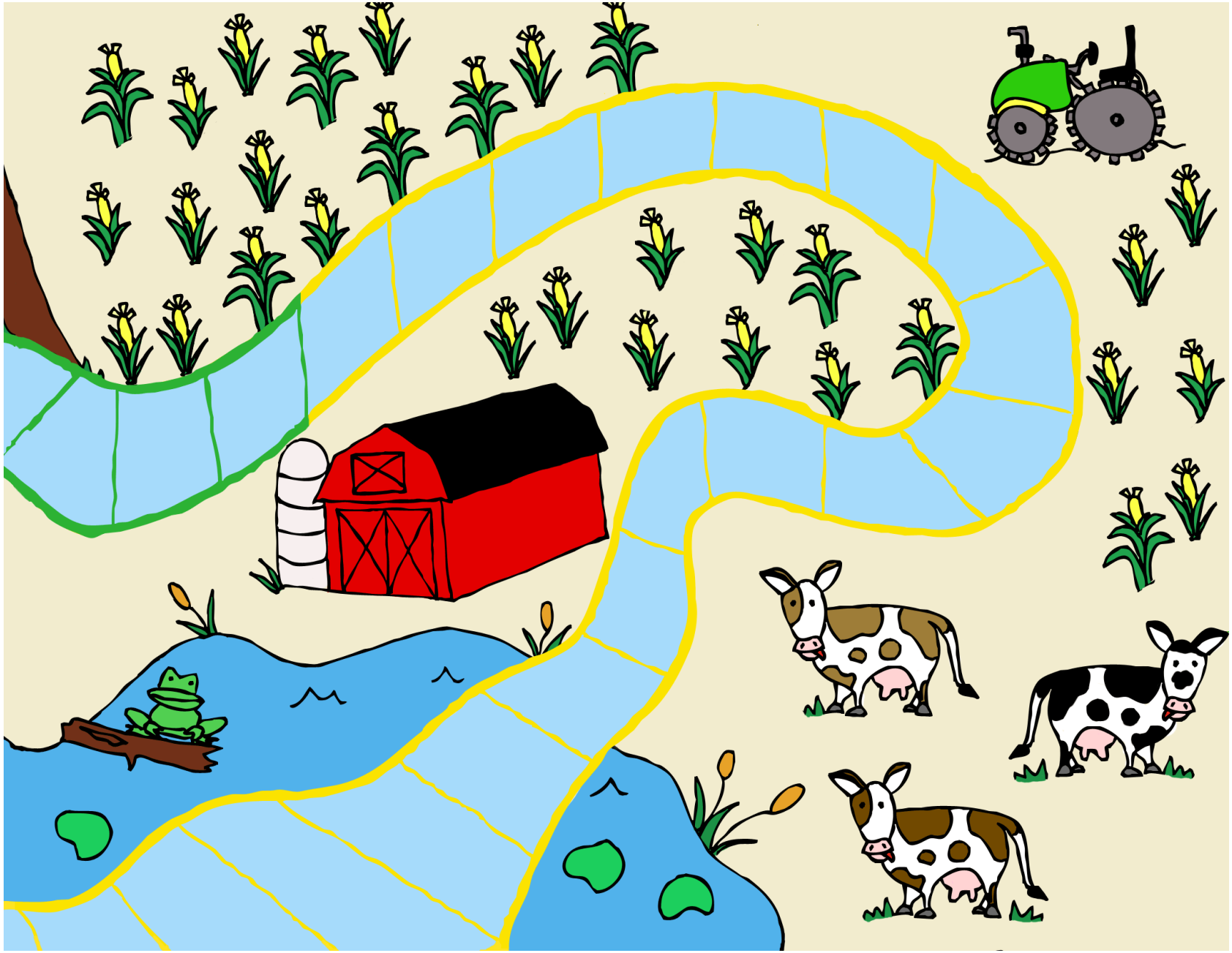
Photo Credit: Brant Fisher (Indiana DNR)

Complete Game Board Credit: Anastasia Makridakis

Game Board Part 1

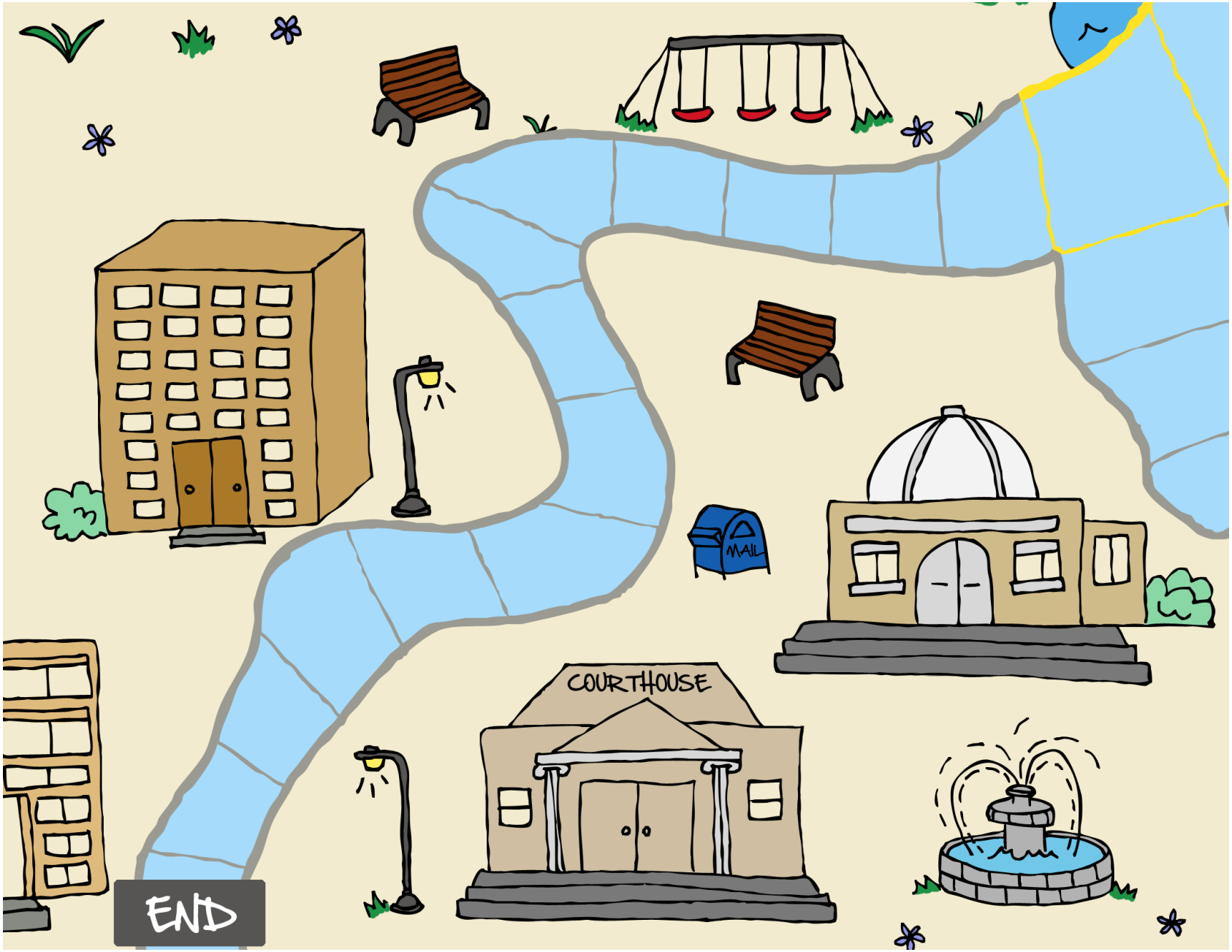


Game Board Part 2

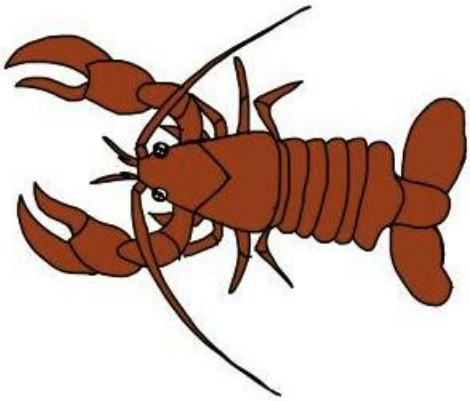


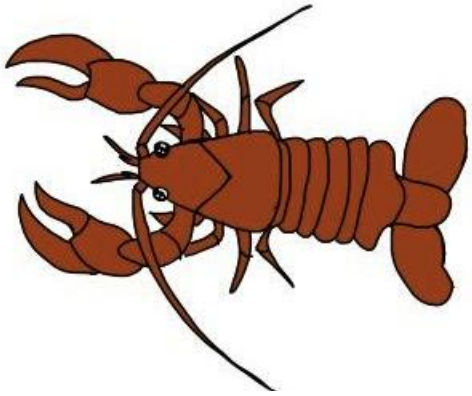
Game Board Part 3

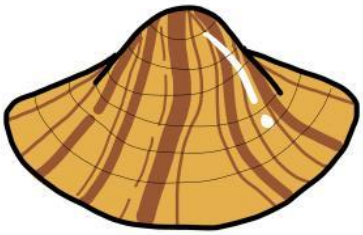
Game Board Part 4

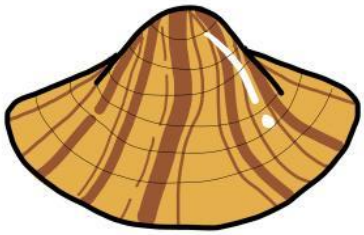


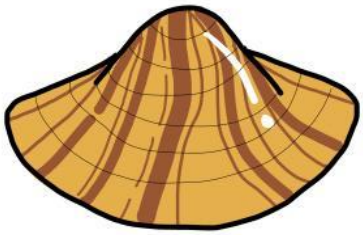
Indicator Species Cards Credit: Jaclyn O'Connor

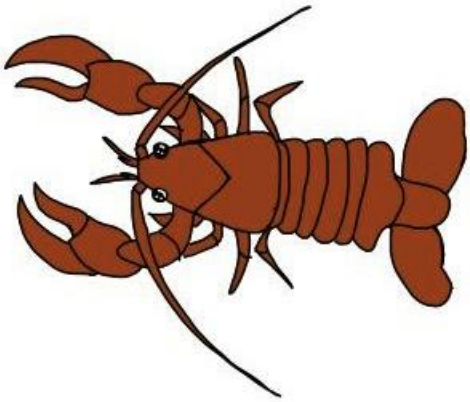


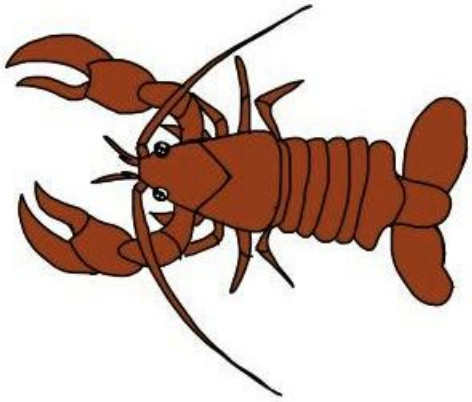


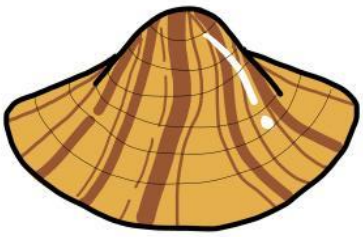


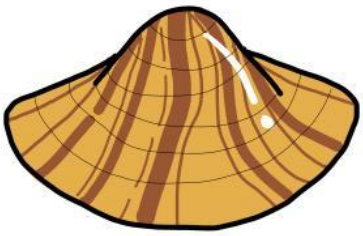


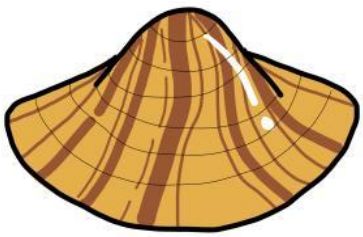












Character Pieces (optional) Credit: Tony Pawli