Willow Creek Critters

Studying the Macroinvertebrates of the Willow Creek Ecosystem

The waters of a healthy creek teem with a rich variety of life. Ducks swim through emergent vegetation, skirting algal growths. Swallows perform acrobatics in the air, just above the creek's surface. The water itself ripples with the movement of fish, and as aquatic insects travel the banks, a flurry of wings makes the shoreline sparkle.

An essential component of this ecosystem is the *macroinvertebrate* population. Macroinvertebrates are small invertebrates, or animals without backbones, less than 600 microns in size that are still large enough to be seen with the naked eye. These tiny organisms are often hidden in the activity of larger critters that make the creek their home. Yet, the dynamics of these species are key to understanding the overall ecological condition of a freshwater environment due to the vital role macroinvertebrates play in the food chain of an aquatic ecosystem.

Macroinvertebrates consume phytoplankton, zooplankton, and other small organisms, and are in turn eaten by insects, birds, and fish. They are found all over the world and live in a variety of microhabitats within a creek, including the surface film, the *littoral zone*, open water, and *benthic sediments.* The littoral zone refers to the waters of a freshwater body in which rooted plants grow, and benthic sediments are the soils, rocks, and organic materials found at the bottom of the creek bed (Figure 1). A few species even migrate between these microhabitats throughout the day while others are only present during a specific life stage. All add to the great diversity of organisms and a rich and varied diet for animals in the higher *trophic* levels, or those with a higher position in the food chain.

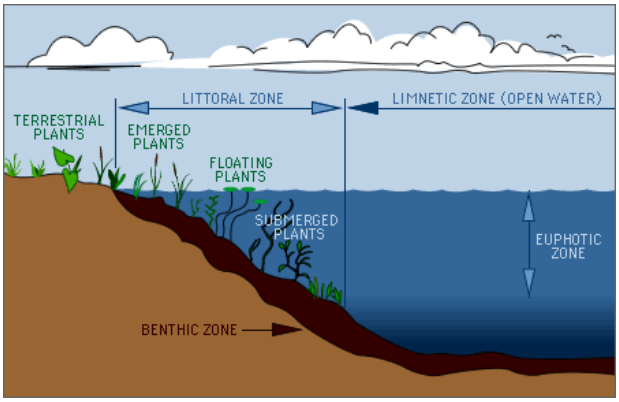

Figure 1: An image describing the microhabitats of an aquatic ecosystem (Source: McDaniel College).

These invertebrate species are not highly mobile and therefore susceptible to pollution events, habitat loss, and other physical, chemical, and biological conditions. Some are more sensitive to environmental change than others. The abundance and variety of these organisms are consequently good indicators of water quality. Biosurveys that study macroinvertebrate species richness and diversity are often used by researchers and conservationists to determine the biological health of creek ecosystems.

The following pages describe the sampling technique of a biosurvey designed specifically to study macroinvertebrate species richness and diversity in Willow Creek, an urban stream located in Madison, Wisconsin. These methods are targeted for a general audience and intended for use as part of an outreach program.

Bottle Biology and the Macros Kit

The *Willow Creek Critters* biosurvey was created in partnership with the University of Wisconsin—Madison *Bottle Biology* team. Bottle Biology is a program designed to get students of all ages interested in exploring science and the environment using recyclable materials. The goal is to make research a sustainable activity that any student can engage in by building tools from everyday household items that would otherwise be thrown away.

This biosurvey exercises the use of the "Macros Kit," a BottleBio-inspired set of tools developed specifically for the study of macroinvertebrates in Willow Creek. The Macros Kit includes the following items:

- 1 large bin
- 1 collection cup
- 5 small containers
- 1 mini-net
- 2 ice cube trays
- 2 plastic spoons
- 2 pipettes
- Magnifying glass
- Macroinvertebrate identification guides
- *Pond Life* by George K. Reid
- Notebook
- Pencil

Follow these step-by-step instructions to prepare your Macros Kit.

1. Obtain the following materials:

- Large (70 to 80 oz.) plastic container (~2 to 2.3 kg)
- 7 small (5 to 8 oz.) deli containers (~140 to 240 g)
- Window screen material
- Rubber band
- Scissors
- Permanent marker

2. Wash the large plastic container with soap and warm water and allow the container to dry. This will serve as the large bin in the *Willow Creek Critters* sampling protocol.
3. Wash the deli containers with soap and warm water. When they are dry, set one container aside and label the remaining six as "Collection Cup," "1," 2", "3", "4", and "5," respectively.
4. With the scissors, cut out a small square of window screen material, approximately 5" x 5" (~13 cm x 13 cm). Cut out the bottom of the remaining deli container. Lay the window screen square flat over the original, larger opening. Make sure it is centered and secure it with the rubber band. This apparatus will be used as the mini-net throughout macroinvertebrate sampling.
5. Recycle two ice cube trays and two plastic spoons. Rinse them out and add these new tools to your Macros Kit.
6. Obtain two 5 mL pipettes, a magnifying glass, a notebook, and a pencil. Try to recycle these materials if possible. (Try contacting a local laboratory or university to request a donation of these materials, especially from supplies that would otherwise be thrown away. These materials can also be purchased online or from local office supply stores.)
6. Obtain a copy of *Pond Life* by George K. Reid and print the macroinvertebrate identification guides, available at the following links:

Bland, Jim. "A Selection of Aquatic Macroinvertebrates of Illinois, USA."
idtools.fieldmuseum.org/sites/default/files/rapid-color-guides-pdfs/381_AquaticMicrovert_1.pdf

Gautsch, Jacklyn. "IO Water Volunteer Water Quality Monitoring: Photographic Benthic Macroinvertebrate Identification Guide."
www.iowadnr.gov/Portals/idnr/uploads/watermonitoring/iowater/Publications/IOWATERBenthicPhotographicGuide.pdf

Kohl, Patrice. "Monitoring Your Wetland."
http://wetlandmonitoring.uwex.edu

The Biosurvey

Before beginning the biosurvey, identify the locations of the five sampling sites along Willow Creek using the following map and site descriptions (Figure 2).

Figure 2: Map of Willow Creek from Campus Drive to Lake Mendota. The blue line represents the creek and the pink lines show the storm sewers that drain into the urban stream. The gray boxes indicate the locations of bridges along the transect.

Site 1: Upstream Rocks
This site is located on the east bank next to the Veterinary Hospital at the end of the rocky culvert leading into the creek. This location is shaded and the bottom sediments are rocky.

Site 2: Midstream Rocks
This sampling location is found on the east bank downstream of site one at the bottom of the rocky riparian zone just past the first bridge. The site is in full sun and bottom sediments are covered in rocks. Samples should be taken from the gap in the vegetation.

Site 3: Midstream Shore

A bench on the west bank of the creek marks this site. The bench is located downstream of site two alongside the rain gardens, just past the fourth bridge facing north. The bottom sediments at this location are sandy and rich with organic debris, and the site is in full sun.

Site 4: Downstream Waters

This site is found farther downstream on the east bank of the creek just upstream of the Willow Creek Bridge. This sampling location is easily identified as the spot where the bank transitions from grass to dirt. The bottom sediments contain sand, gravel, and organic debris, and the site is in full sun.

Site 5: Bay Outlet

This sampling spot is located at the outlet of Willow Creek into University Bay. To reach this location, walk to the lawn area just east of the Willow Creek Bridge and find the west trail that leads to Lake Mendota. After a short distance, the trail opens up to the bay. This site is highly vegetated and completely shaded. The bottom sediments are sandy and contain lots of organic matter. A few large rocks are scattered close to the shoreline.

After identifying the locations of the five sites, follow these step-by-step instructions to complete the biosurvey.

Data Collection:

1. Begin sampling at site 5 and move upstream. At each site, collect samples by standing or sitting on the shoreline to minimize disturbance of surface waters.
2. It is essential to assess habitat in conjunction with ecological biosurveys to give context to findings. **Before collecting a sample, make some observations and snap a few photos of the site (if possible).** Take note of the **date and time, weather,** including temperature, cloud cover, photo period, and precipitation, and **water conditions,** such as how fast or slow the current is moving, the clarity of the water, and descriptions of any organisms at or near the surface waters. (If you do not have a thermometer handy, use your past experience to estimate the air temperature.) Record all observations in your notebook. **These notes will help you understand your data later.**
3. To collect a sample, take the collection cup and hold it in your hand. From a sitting or standing position, submerge the container to the creek bottom and pull the cup toward you. **Be sure to scrape the bottom rocks and sediments.** Transfer collected

sample into the site 5 container. Continue to collect samples using the collection cup until the water level in the site 5 container reaches the bottom lip.

4. Repeat steps 1 through 3 at each site, moving upstream, to obtain a sample from each location. **The goal is to obtain the same volume of water from each site.**
5. Find a spot to sort and identify the macroinvertebrates collected, working site-by-site.
6. Begin by examining the contents of the site 5 container. Remove any large organisms collected. Using a pipette or a plastic spoon, transfer the organisms to an ice cube tray. Keep all organisms of the same species in the same section of the ice cube tray to make identification easier.

7. After removing the large organisms, filter the water collected through the mini-net into the large bin.
8. Use a pipette or plastic spoon to sift through the captured organic debris to find any additional organisms. Transfer these organisms into the ice cube trays and keep them separated by species. Carefully look at the filtered water and make sure the only organisms present are *microorganisms*, animals whose identifying features cannot be seen with the naked eye. If any larger organisms are seen, use the pipette or plastic spoon to transfer them to the ice cube tray as well.
9. Identify all isolated organisms using the magnifying glass, the macroinvertebrate identification sheets, and *Pond Life*. Keep track of the species identified and the number of organisms collected that belong to each species in your notebook.
10. Repeat steps 6 through 9 to count and identify the macroinvertebrates collected at sites 4, 3, 2, and 1, in that order.
11. When finished, return all samples to Willow Creek.

Data Analysis:

1. Calculate species richness and species diversity at each site.

- *Species richness* is the number of species found in a specific location and can be easily totaled in the field during data collection.
- *Species diversity* is a measurement of both species richness and *species evenness*, the distribution of species in an ecological community. There are several methods used to compare species diversity between locations, but the most commonly used diversity index is the Shannon-Wiener Index. To calculate Shannon-Wiener Index values, use the equation below. You can use an Excel spreadsheet to help you calculate these values.

$$H' = -\sum p_i \ln p_i, \text{ where } p_i = \text{the proportion of individuals of species i.}$$

2. Double check your calculations and enter the data into an Excel spreadsheet. Graph species diversity and species richness by site to compare the macroinvertebrate population along Willow Creek.
3. Enter the data into the *Willow Creek Critters* Google Docs spreadsheet and upload your photographs of each site to the "Photos" tab. This will allow other students, researchers, and conservationists to look at long-term trends in the macroinvertebrate population of Willow Creek and assess habitat change over time.

Further Study

The *Willow Creek Critters* biosurvey introduces students of all ages to the importance of macroinvertebrates in creek ecosystems and offers a simple way to engage students in a brief study of these organisms in Willow Creek. To add to this experience, there are many opportunities for further study.

1. *Adding replicates*

This biosurvey only studies the species richness and species diversity found in one sample from each of the five sites along Willow Creek. A greater number of replicates increases the reliability of the data collected and allows researchers to use statistical analyses that are more powerful than simply generating scatterplots. To increase confidence in the trends supported by the data, take multiple replicates from each site along the creek during sampling and average the results before creating graphs of species richness and species diversity.

2. *Assessing pollution*

Increased organic pollution to aquatic ecosystems decreases dissolved oxygen concentrations and increases water temperatures. These changes are often accompanied by more extreme fluctuations in both oxygen and temperature as well as increased plant growth. The response of macroinvertebrates to these effects of pollution varies by species, and some are more sensitive than others. In Wisconsin, macroinvertebrates are grouped into four categories based on tolerance to lowered dissolved oxygen concentrations: *sensitive, semi-sensitive, semi-tolerant,* and *tolerant.* Species from all four categories are found in healthy ecosystems, but in a polluted body of water semi-tolerant and tolerant macroinvertebrates are more abundant than species that are sensitive to changes in dissolved oxygen concentrations.

Wisconsin Macroinvertebrates

Pollution Tolerance by Species

Sensitive: dobsonfly, alderfly, water snipefly, stonefly
Semi-sensitive: caddisfly larvae, damselfly larvae, cranefly larvae, water penny larvae, mayfly larvae, riffle beetle, freshwater mussel, fingernail clam, dragonfly larvae, crayfish
Semi-tolerant: black fly, non-red midge larvae, orb snail, gilled snail, and amphipods (such as scuds)
Tolerant: isopod, pouch snail, bloodworm midge larvae, leeches, tubiflex worms

To further explore the data obtained with the *Willow Creek Critters* biosurvey, sort the species found at each site into the four categories listed in the box above. After sorting the macroinvertebrates by tolerance, determine whether the data suggests that any or all of the sites along Willow Creek suffer from organic pollution.

Remember that while the study of macroinvertebrates can identify a pollution event, the results cannot determine what caused it. Additional biosurveys, habitat assessments, and further tests of water quality are needed to investigate the source of organic pollution to aquatic ecosystems.

4. Looking at habitat and seasonal variation

The *Willow Creek Critters* biosurvey focuses on studying the macroinvertebrates found in surface waters and benthic sediments along the shoreline of Willow Creek, yet there are many other microhabitats that are home to these organisms. Grab a pair of waders and explore the littoral zone and open water to investigate how species composition changes between each site's microhabitats.

Because Willow Creek is located in a temperate climate zone, the ecosystem and its habitats are also affected by seasonal variation. Macroinvertebrates are most active in summer, especially from early June through mid-August, but few organisms survive the winter. To further understanding of the macroinvertebrate population of Willow Creek, studies should be conducted year-round.

5. Using the Citizen Monitoring Biotic Index

To compare the water quality of Willow Creek to other Wisconsin streams and rivers, check out the Citizen Monitoring Biotic Index. This index was developed by the Water Action Volunteers or WAV, a program run in collaboration with the University of Wisconsin – Extension and the Wisconsin Department of Natural Resources to improve the quality of Wisconsin's streams and rivers. The Citizen Monitoring Biotic Index allows researchers and conservationists to compare the water quality of these Wisconsin ecosystems using the WAV macroinvertebrates biosurvey at each sampling location. The biosurvey calls for data to be collected twice each year, once in spring and again in fall, so it is possible to establish long-term trends across the state and identify when an organic pollution event may have occurred in streams like Willow Creek.

Sources

For a complete list of resources used in the development of this biosurvey for the Willow Creek Community Project, see the Works Cited page.