IV-4. Introduction to Biological Monitoring

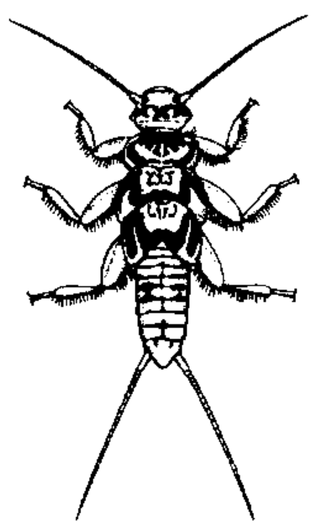
How would you know if a barrel of chemicals spilled into your stream? If you hadn't seen it spill you would have to sample the water for its effects. Chemical data would tell you a lot about the water at the particular time you sampled. But, if the barrel spilled a week ago, the chemicals might have flushed through without you knowing. Luckily, we can examine the biological components of a stream to gain information on the history of our stream's water quality. Since the plants, insects and other critters of the stream live in that environment all the time, they can tell us a lot about what has happened to the water in days, weeks, or years past. If we don't find the amounts or types of aquatic insects that are supposed to be there, then we know something is wrong and we can investigate further. It can be said that chemical monitoring provides a snap shot of water quality while biological monitoring provides a video. In this manner, the two complement each other well.

This chapter will help students examine biological components of a stream from both a classroom and field setting. A variety of sampling techniques are outlined for each biological parameter. Identification keys will help you collect your data and information provided at the end of each chapter will help you interpret your results.

Sections included:

a. Macroinvertebrates

b. Riparian Vegetation



Source: Tennessee Valley Authority

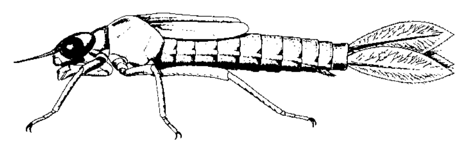
V-4a. Macroinvertebrates

Key Terms

Collectors	functional feeding groups	nymphs	shredders
dichotomous key	larvae	piercers	substrate
engulfers	macroinvertebrates	predators	Water Quality Rating Index
EPT Value	metamorphosis	scrapers	species

What is a macroinvertebrate?

The tiny animals that live in streams are called aquatic **macroinvertebrates**. These macroinvertebrates include many types of insects as well as other animals such as worms, molluscs and tiny crustaceans.

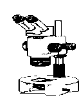


1

Where do we find them?

Most of the macroinvertebrates you will sample make their home in the rocks, leaves and sediment of stream beds. These organisms have many special adaptations that allow them to live in demanding environments. When you sample from riffles and fast-moving areas, look closely for features that help the animals hold on in the current, such as hooked feet, suction cups, and flat bodies. Animals that live deep in the mud may have adaptations for a low oxygen environment. For example, some are red because of hemoglobin in their tissues.

Figure IV-13, "Macroinvertebrates In Your Stream," illustrates some of the areas in a stream where macroinvertebrates live. Consider the unique environmental conditions of each area and how macroinvertebrates might deal with those conditions.



The name says it all. "Macro" means large (or large enough to be seen with the naked eye). "Invertebrate" means lacking an inside skeleton, like we have. Instead, they have an exoskeleton – a protective, supportive case on the outside of the body.

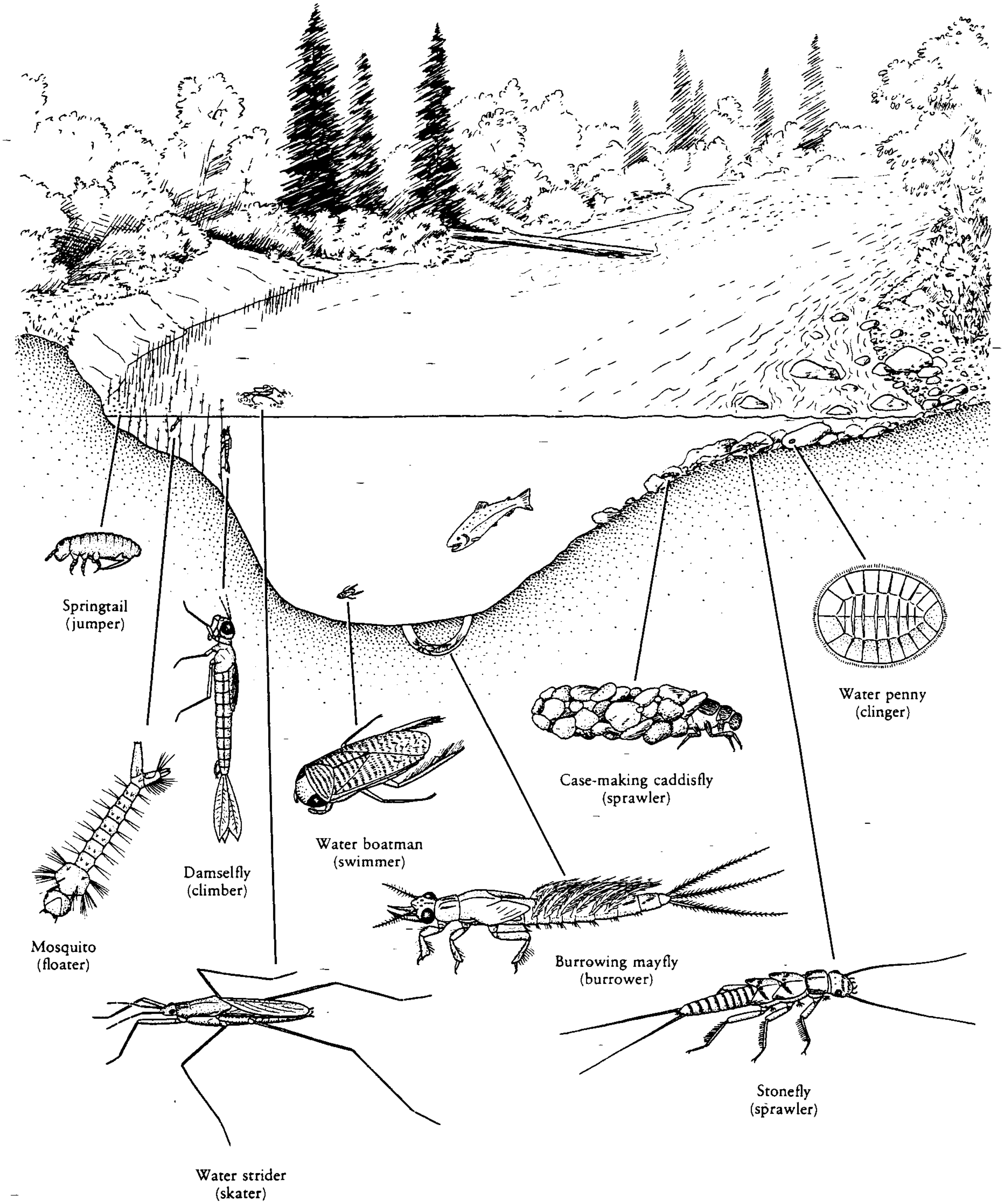
Do they spend their whole life in water?

Some macroinvertebrates complete their lives in a few weeks; others may live for several years. Usually, just the immature phases of insects' lives (**larvae** and **nymphs**) are spent in the water but some insects, such as water boatmen and backswimmers, spend their whole lives in the water. Most non-insect macroinvertebrates, such as amphipods (scuds), gastropods (snails) and bivalves (clams and mussels) spend their entire life in the water. Some mussels have been found to live for 100 years!

Young their whole life

Some mayflies live as nymphs for 2-3 years in water. But, when they hatch into adults, they have just 24 hours left. In that time they must find a partner, mate and lay their eggs before they die. They don't even have time to eat.

Figure IV-13 Common macroinvertebrates found in your stream

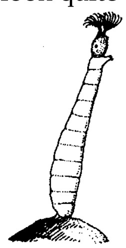


Provonsha in McCafferty, Aquatic Entomology, 1998: Jones and Bartlett Publishers, Sudbury, MA. www.jg[ub.com. Reprinted with permission

Do they change as they grow?

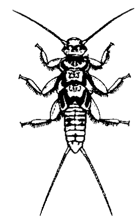
All aquatic macroinvertebrates start life as eggs. Some animals, such as water beetles and leeches, don't change much as they grow – they only get bigger, much as humans do. Some insects, however, may change (**metamorphose**) quite dramatically as they grow. After hatching, the insect may go through several stages before reaching adulthood. Depending upon the species, it may go through a larval stage, a nymph stage or both (see Figure IV-14).

Larvae do not show wing buds and usually look quite different than adults.



blackfly larva

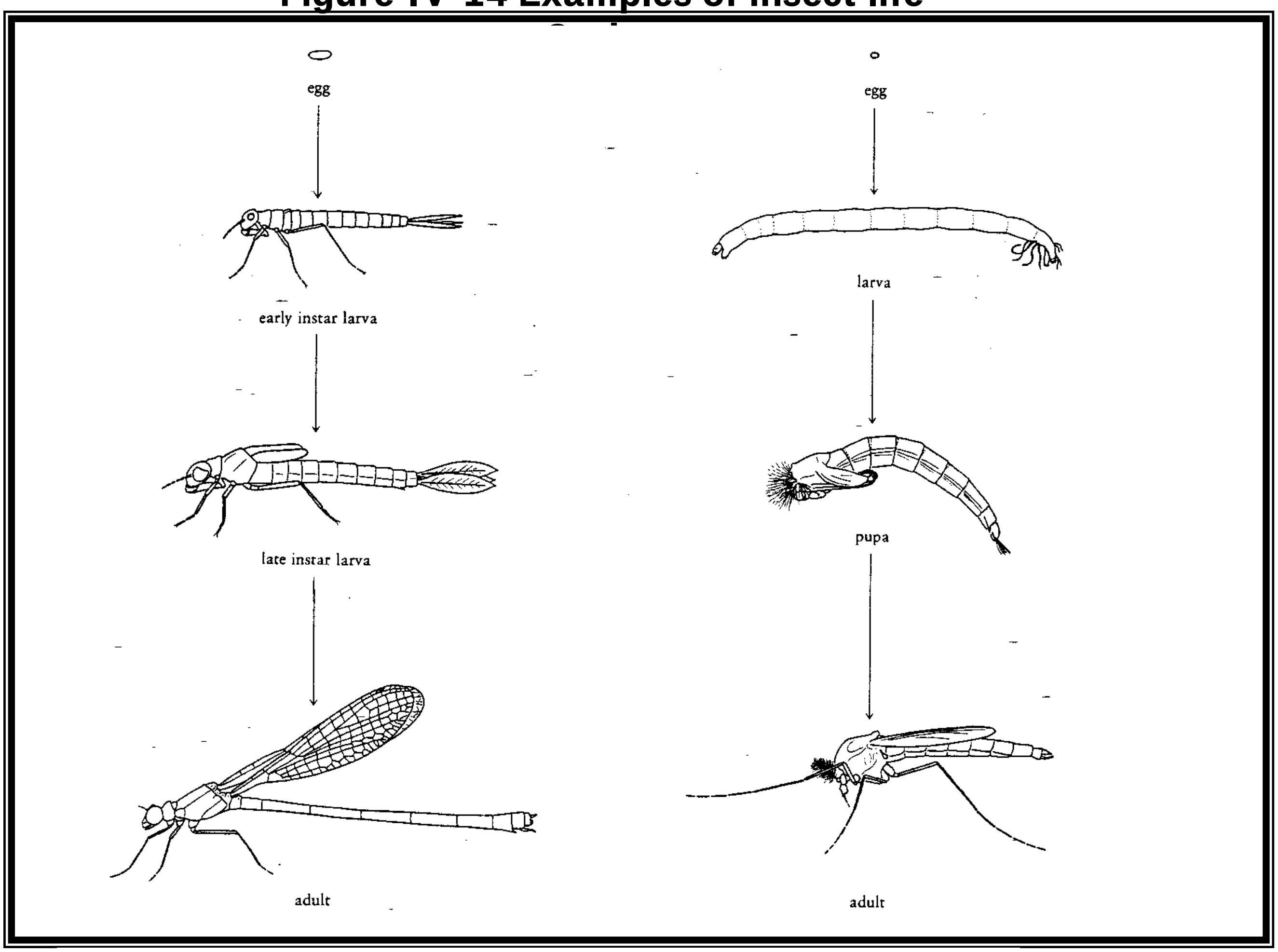
Nymphs usually resemble adults, but are smaller and have no wings.



stonefly nymph

Source: Tennessee Valley Authority (TVA)

Figure IV-14 Examples of insect life



Provonsha in McCafferty, Aquatic Entomology, 1998: Jones and Bartlett Publishers, Sudbury, MA. www.jg[ub.com. Reprinted with permission

What natural influences cause macroinvertebrate populations to change?

Seasons

Macroinvertebrate populations change through the year. You will find different types of macroinvertebrates during different seasons. The life histories of these invertebrates is tied to food availability. For example, **scrapers** (macroinvertebrates that eat microscopic plants called algae from the surfaces of rocks and leaves) are most abundant during the summer when algae production is highest. In general, the greatest diversity of organisms is found in autumn because there is a lot of organic matter such as fallen leaves in the stream.

Dissolved Oxygen

Aquatic macroinvertebrates breathe oxygen that is dissolved in the water. Immature stages of species such as stonefly nymphs, mayfly nymphs, and water pennies (beetle larvae) require high levels of dissolved oxygen. Look for the fluttering gills on the abdomen (sides) of mayfly nymphs. If dissolved oxygen is low, even for a short while, these insects may not survive.

Substrate

The **substrate** in your stream will greatly influence what macroinvertebrates are present. Expect to find the greatest variety and abundance of species in rocky or gravelly substrate. Because of the abundance of fine food particles, you can find many **collectors** (macroinvertebrates that eat tiny food particles from the water or stream bottom) in slow, murky waters with sandy or muddy bottoms.

What human influences cause macroinvertebrate populations to change?

Nutrient enrichment

Nutrient enrichment in a stream or lake may result from introductions of human sewage, manure or fertilizer. These substances can enter the water directly or be delivered by runoff from the surrounding watershed. Added nutrients may greatly accelerate the growth of algae and other plants. When these plants die, decomposition by microorganisms can use up much of the dissolved oxygen in the water, which is harmful to the macroinvertebrates.

pH

Acid precipitation, runoff from mining activities and dumping of industrial pollutants can lower pH. Low pH can weaken shells and exoskeletons, disrupt egg laying and reduce food availability. A pH below 4.5 will kill many macroinvertebrates in a short time. Water boatmen are one of the most resistant, surviving at a pH as low as 4.0.

Stream bank vegetation

Removal of vegetation in the riparian area eliminates important insect breeding grounds. It also deprives many types of macroinvertebrates of an important food source. These **shredders** feed on fallen sticks and leaves.

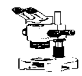
Why do we care about macroinvertebrates?

The types and abundance of macroinvertebrates in your stream are important to know for two reasons:

1) They are indicators of water quality.
   - Different macroinvertebrates tolerate different types of stream conditions. Depending on what we find, we can make predictions about water quality.
2) They are an important part of aquatic and terrestrial food chains.
   - Each macroinvertebrate plays a role, or function, in a stream. These roles are combined into "Functional Feeding Groups," such as shredders, collectors, scrapers and predators.

Pollution tolerance levels

Sometimes it's easy to tell if a stream is in trouble. Strange colors and dead fish are indicators of poor water quality. But, biologists need to know about water quality problems long before they reach such a severe point. Some of their most effective partners in detecting declining trends in water quality are macroinvertebrates because they respond so rapidly to changes in water quality.



Chemical samples provide a "snapshot" of the water quality at a particular moment. Macroinvertebrates provide a "video." Because they remain in the same area over a long period of time they enable biologists to assess both recent and more historic water quality.

To evaluate the health and productivity of a stream, biologists look at the types of species that live there. Different species have different tolerances to pollution. If many pollution-intolerant species, such as stonefly and caddisfly nymphs, are present then the water quality is probably quite good. Although the presence of certain species indicates good water quality, the absence of these species does <u>not</u> necessarily indicate bad water quality. Other factors besides pollution may account for their absence. For example, they may have metamorphosed (changed) into adults and flown away.

We can classify macroinvertebrates into three groups based on pollution tolerance.

Group 1 - *Sensitive or Intolerant Species*
Organisms that are easily killed, impaired or driven off by bad water quality: these include stonefly, dobsonfly and mayfly nymphs, caddisfly larvae, water pennies and snails.

Group 2 - *Somewhat Tolerant Species*
Organisms that have the ability to live under varying conditions. You may find them in good or poor quality water. These organisms include amphipods, scuds, beetle and cranefly larvae, crayfish and dragonfly nymphs.

Group 3 - *Tolerant Species*
Organisms capable of withstanding poor water quality: these include leeches, snails, aquatic worms, midge larvae and sowbugs.

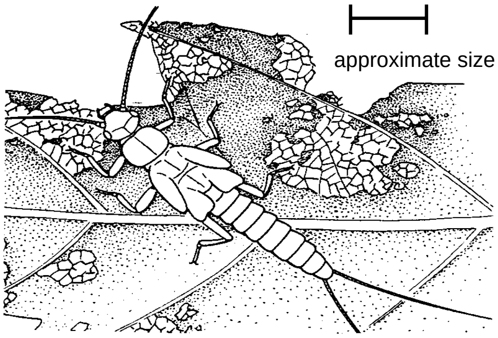
? *What would the following species distributions suggest to you?*

- A community with many species from Group 1, some from Group 2 and a few from Group 3. – Indicates good water quality.
- A community with no species from Group 1, a few from Group 2 and a lot from Group 3. – May indicate poor water quality but we can't be sure (better do some chemical and physical monitoring, too)

Functional Feeding Groups

Macroinvertebrates are a critical link in the food webs of streams and riparian areas. They graze on algae that grows in the stream, they help break down leaves and sticks that fall in the water, they are an important food source for fish and much more.

One way to study and classify macroinvertebrates is to look at their role in the food web. Biologists categorize their food web roles into 4 groups - the **Functional Feeding Groups** (Figure IV-15):

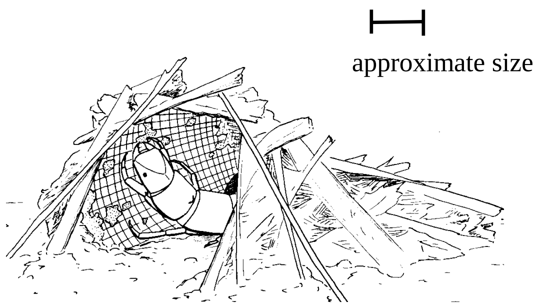


Shredder (stonefly nymph)
Provonsha in McCafferty, 1998

1) **<u>Shredders</u>** feed by biting or cutting on leaves and wood that has fallen into the stream. The shredding action is an initial step in the decomposition process. The shredded particles become food for smaller macroinvertebrates and microscopic decomposers. Shredders, such as stonefly, cranefly and mayfly larvae and nymphs, are found mainly in small, upper stream reaches that receive large amounts of leaves and wood from the riparian zone.

2) **Collectors**, which feed on particles 1 mm or less in size, further the decomposition process. They feed on fragments of shredded organic material or feces cast-off by shredders as well as on algae and bacteria. To get their meal, collectors often use a variety of specialized methods.

- Some, such as the blackfly larvae, spread out fan-like mucous-covered body parts to trap particles that float by.
- Others, such as this caddisfly nymph, spin webs to filter their food from the water.
- Some species of caddisfly larvae are picky. They spin webs of different mesh sizes to collect specific-sized particles.



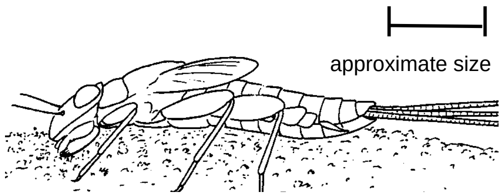
Collector (caddisfly nymph)
Provonsha in McCafferty, 1998

Collectors are abundant in medium and large stream sections. These sections are slower and contain a lot of small (less than 1 mm in diameter) pieces of leaves and wood.

? *Would you expect to find a lot of collectors in a stream if there were no shredders?*
No. Without shredders, collectors would not have enough small food particles to eat.

1) **Scrapers** harvest material that adheres to rocks, such as algae and bacteria. Scrapers need to stay close to the rock surface to feed. Special adaptations, such as flat bodies and suction disks, allow them to do this. Scrapers, which include certain mayfly and caddisfly larvae, and water pennies, are found mainly in

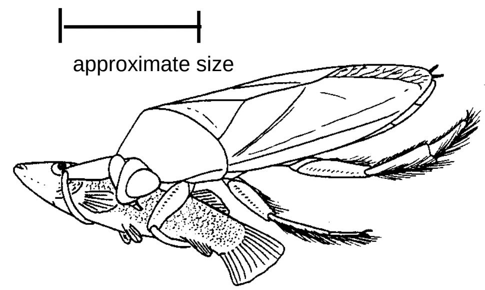
middle-sized stream sections. These stream sections receive greater sunlight which increases the abundance of algae – a major food source for scrapers.



Scraper (mayfly nymph)
Provonsha in McCafferty, 1998

? *What time of year would you expect to find a lot of scrapers and grazers in your stream?*
Summer and fall, when the most sunlight reaches the stream and algae production highest.

4) Fish, birds and reptiles all prey on macroinvertebrates, as do other macroinvertebrates. We call these **predators**. Just like shredders, collectors, and grazers, predators have unique mechanisms for obtaining a meal. Odonates (dragonflies and damselflies) often bury themselves in the sand with only their eyes protruding and wait to spring their retractable mouthparts at unsuspecting prey. Some predators, such as predacious stoneflies, are more active and pursue their prey.



Predator (water boatman)
Provonsha in McCafferty, 1998

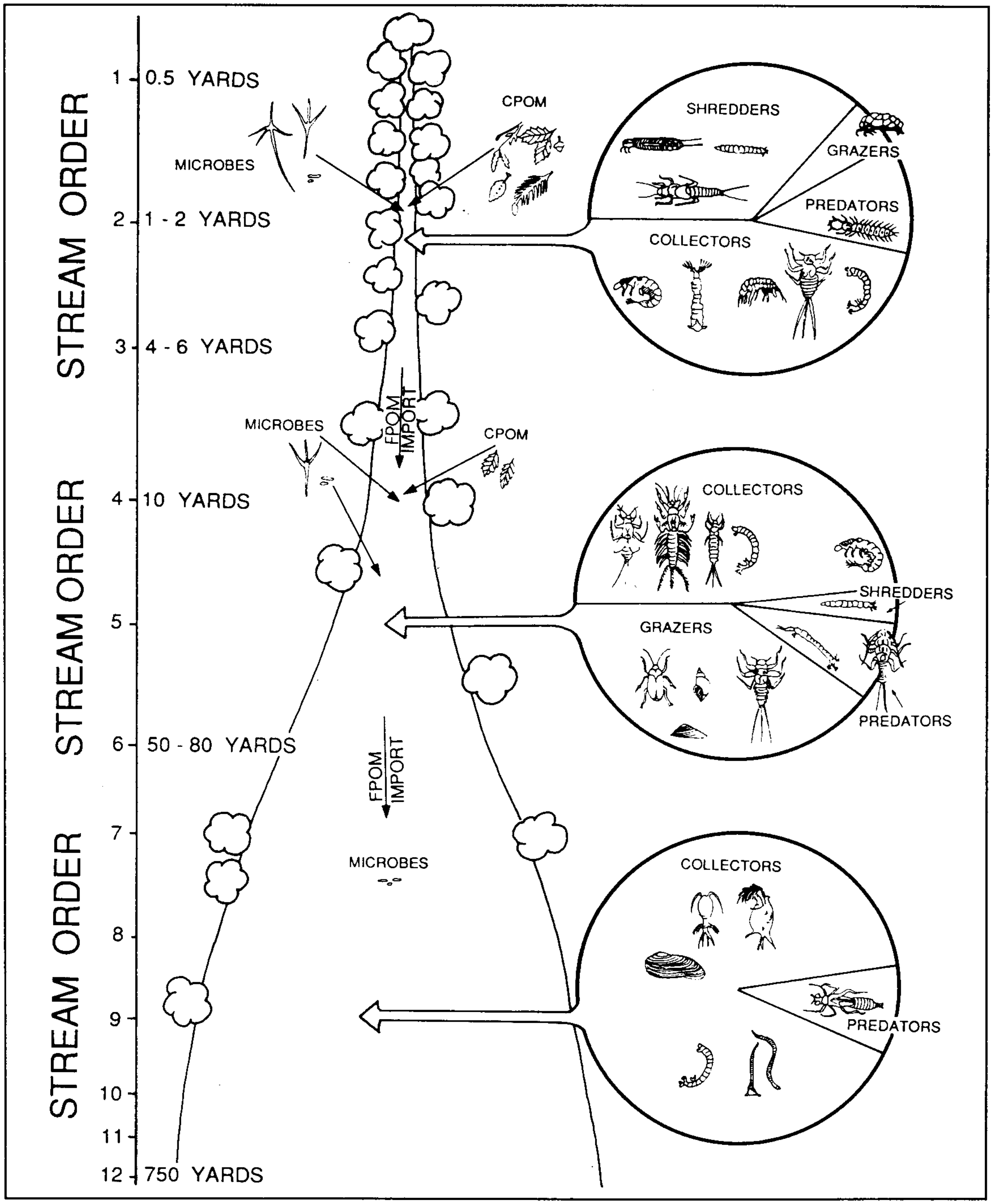
We classify predators into two groups.

- **Engulfers** swallow their prey whole.
- **Piercers** inject a mouth part into their prey and suck out the body fluids. This giant water bug is an example of a piercing predator.

? *Would you expect to find predators in areas without shredders,collectors and grazers?* No. Predators depend upon them for food.

? Look for different "Functional Feeding Groups" in Figure IV-17. Consider how the size and location of the stream section affects the type of food available and how the available food affects the location of the different functional feeding groups.

Figure IV-15. **Functional Feeding Groups** Note how the types of macroinvertebrates change in a stream as the stream gets larger.



Source: Ken Cummins, "From Headwater Streams to Rivers," *The American Biology Teacher*.

CPOM (coarse particular organic matter) – plant material (leaves, needles and wood)
FPOM (fine particulate organic matter) – feces and tiny bits of plant materials

How do we sample macroinvertebrates?

The *Utah Stream Team* provides a standard method for collecting macroinvertebrates. This method is detailed in the Field Directions at the end of the chapter. Once you have collected your sample, you may want to simply observe the animals. If you want to use the sample to evaluate water quality, calculate one of the indexes described below.

When do we sample?
Anytime is a good time to look at bugs. Fall is an especially good time to sample since many macro-invertebrates will be large and more easily studied. Also, lower stream levels in the fall make sampling easier and safer.

Making Observations:

Many groups choose to simply collect and look at their macroinvertebrates without quantifying them. Encourage your students to use the hand lenses to look at the animals closely. This is easiest if they to transfer individual animals into the small petri dishes with a little water.

- Investigate the insect body parts. The head, abdomen and thorax are easy to see, and the students can count the legs on insects compared to other animals they find. Students can investigate the different types of mouth parts and the large eyes some of these insect have.
- Consider how the animals breath. Mayflies have distinctive gills on their abdomen, stoneflies have gills under their legs, damselflies have gills on plates at the end of their thorax. Try to see what they do when they need more oxygen. For example, stoneflies do "push ups" to pass more water over their gills.
- Watch for animal behavior. Look for differences in how they move and watch how they interact with other animals. Look for evidence of predation. Encourage your students to think about how these animals experience their world, how they see, or how they might detect chemical signals in the water.
- Have students draw the animals. Some are beautiful while others resemble monsters.

Quantifying Samples

Two methods are provided for quantifying (indexing) your sample: 1) the **EPT Value** and 2) the **Water Quality Rating Index**. If you wish to quantify and interpret your results using either of these two indexes, read the next section before you start to sample. A Data Collection Sheet is included for each of these indexes.

EPT Value

This biotic index is one way to interpret water quality in your stream using the types and amounts of macroinvertebrates you collect. The EPT value – **E**phemeroptera (mayflies), **P**lecoptera (stoneflies) and **T**ricoptera (caddisflies) – is a sum of the total number of "species" of these three orders in the sample. These insect groups contain many species that cannot tolerate poor water quality. Generally, the more EPT species you find, the better your water quality. The **EPT Value** is simpler than the Water Quality Rating Index and will take the least amount of time to conduct (about 1 hour for a trained group of three students).

Water Quality Rating Index

The Water Quality Rating Index requires more extensive identification of different types and more time to conduct (about 2 – 3 hours). However, it will provide a more accurate assessment of your water quality. The Water Quality Rating Index operates in a similar manner as the EPT. Species are collected and identified – the more pollution-intolerant individuals collected, the higher the value and the better the water quality rating. With this index, however, all the different types of organisms in your sample must be identified and totaled. Note that this can be difficult for younger students, especially when very small organisms are present. Intolerant and Somewhat Tolerant species have higher values than Tolerant species.

What is a "species"?

Species is a term used by scientists to identify groups of animals that are uniquely different from other groups. If animals can potentially reproduce with each other, they are in the same species.

In this section we use this term somewhat loosely. In the *Utah Stream Team*, "species" refers to animals that are related but have enough different physical characteristics that they can be easily divided into separate groups. For example, caddisflies have different body widths and shapes, different gill sizes and make different kinds of cases. For our purposes, we consider these different caddisflies to be different "species."

How do we interpret our results?

Pollution tolerance indexes provide a relatively quick means for assessing stream quality and help students to understand pollution tolerance ranges for organisms. However, they need to be considered along with physical and chemical data in order to provide a comprehensive picture of water quality.

EPT Value

Compare your calculated EPT Value with the water quality ratings below. If your stream does not score well, refer back to the "Natural and Human Influences" sections in this chapter as well as your physical and chemical data to help you determine why. You may want to share your rating with a local aquatic biologist (consult the UT Division of Wildlife Resources or UT Division of Water Quality) to help you interpret it.

EPT Value:

[] >10 not affected (excellent water quality) [] 2 – 5 moderately affected (fair water quality)

[] 6 – 10 slightly affected (good water quality) [] < 2 severely affected (poor water quality)

Water Quality Rating Index

Compare your calculated Water Quality Rating Index with the water quality ratings listed below. If your stream does not score well, refer back to the "Natural and Human Influences" sections in this chapter as well as your physical and chemical data to help you determine why. You may want to share your rating with a local aquatic biologist (consult the UT Division of Wildlife Resources or UT Division of Water Quality) who can help you interpret it.

Water Quality Rating Index

[] Excellent (> 79) [] Fair (40-59)

[] Good (60-79) [] Poor (< 40)

Resources for Further Investigation

Guide to Macroinvertebrate Sampling - The River Watch Network's guide offers a user-friendly picture key, methodology and various indices such as the Percent Composition of Major Groups, the Modified Family Biotic Index, and Organism Density per Sample (these indices are excellent opportunities to weave math into your monitoring program). The manual is available for $5 from RWN, 153 State St., Montpelier, VT 05602.

Monitor's Guide to Aquatic Macroinvertebrates by Kellogg, L.L. 1994. 60 pages. A pocket-sized guide including a key (with some important fly families), descriptions of major invertebrate groups, sampling protocols for both rocky bottoms and muddy bottoms, and sample data sheets with excellent illustrations. Contact: Save Our Streams, Izaak Walton League of America, 707 Conservation Lane, Gaithersburg, MD 20878; (800)BUG-IWLA. $5.

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Macroinvertebrate Sampling

Time – 40 minutes
Persons – 2
Materials -
- 1 kick net
- 1 plastic pan
- transfer pipettes
- plastic4 petri dishes
- magnifying glasses
- dichtomous key

OPTIONAL
- paint brushes (for transferring)
- 5 gal plastic bucket (for decanting)
- waders (for sampling in cold or deep water)

Step 1 - Choose your sample site

- Select sampling reaches that are safe and easily accessed by everyone in your group. A riffle will offer the best variety of organisms.
- You may also want to collect samples from other habitats such as pools, aquatic vegetation and stream margins. Compare the different results you obtain from these areas and discuss why (think about Functional Feeding Groups, different flows, or available oxygen).

Step 2 – Collect your sample.

Note: Follow these directions if you are sampling in *flowing* water.

1. Wade into the stream and place your net so the mouth of the net is perpendicular to and facing the flow of water.
2. Stand upstream of the net and disturb the stream bottom with your feet and hands.
3. Carefully pick up and rub stones directly in front of the net to remove attached animals. The stream bottom material and organisms will be carried by the current into the net. If the rocks are lodged in the stream bottom, rub them vigorously, concentrating your effort on any cracks or indentations.
4. After removing all large stones, disturb the sand and gravel to a depth of about 3 inches by raking and stirring with your hands.
5. Continue this process until you can see no additional animals or organic matter being washed into the net.

Note: Follow these directions if you are sampling in *pools or highly-vegetated* areas.

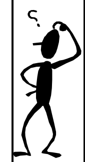
1. Scoop material from the stream bottom.
2. Push and pull the net through aquatic vegetation.
3. Hand pick organisms from sticks and other structures.

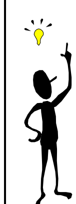
Step 3 – Empty your sample

1. Hold your sampling net over a plastic pan and use a bucket of stream water to wash the material into the pan.
2. If your sample contains a lot of rocks or debris, stir the sample in the pan to suspend the animals, then pour the suspended material back into your net. Rinse the debris from the pan, then wash the animals in the net back into the pan.

Step 4 – Sort out the bugs

1. Use plastic transfer pipettes, small paint brushes or your fingers to remove bugs from pans. For easier observation, place the animals into smaller water-filled containers (plastic ice cube trays or petri dishes work well).
2. Use the keys provided in this section to identify the bugs.





Macroinvertebrate Indices

Subsample to simplify EPT Value or Water Quality Rating Index

To calculate either index, you need to sort approximately 100 animals. It is very difficult to "randomly" select animals from a large sample, because we tend to choose the most obvious, largest or most active animals. This will bias the results. Subsampling gives you a representative selection from your larger sample.

Time – 60+ minutes
Persons – 3 or more
Materials -

- Macroinvertebrate sample
- 1 plastic pan
- transfer pipettes
- plastic petri dishes or ice cube trays
- magnifying glasses
- ruler for subsampling
- dichotomous key
- Macroinvertebrate Index Data sheet

1. Place entire macroinvertebrate sample into flat plastic pan.
2. Pour off most of the water from the pan, so material and animals are no longer floating. Distribute material evenly on the bottom of the pan.
3. Distribute material evenly on bottom of pan. Take a ruler and divide the material in the pan in half. Remove one half of the material from the pan.
4. Redistribute the material again over the bottom of the pan and divide this material again with a ruler.
5. Continue this process until you have a sample with about 100 total organisms.
6. Add some stream water back into the pan for easier sorting.

EPT Value

1. Find all the mayflies, stoneflies and caddisflies in your subsample using the identification key.
2. Separate these into as many distinct species by looking for differences in body shape, color and markings. Place all members of each species into separate containers.
3. Count the total number of species of mayflies, stoneflies and caddisflies. This total is the EPT Value.

Remember: A separate "species" in this case refers to animals that are related (e.g. all mayflies) but have enough different physical characteristics that they can be easily divided into separate groups.

Water Quality Rating Index

1. Separate each different type of macroinvertebrate in your subsample into a different container.
2. Use the identification key to identify each different type. Look at the body shape, color and markings.
3. Separate these different types into pollution tolerance categories, using picture guides on data sheet.
4. Multiply the number in each category by the pollution sensitive weighting found on the data sheet.
5. Sum the number of animals in each category and the weighted values for each category. Add up the total number of animals, and the total weighted values.
6. Divide the total weighted values by the total number of animals. This will give you the Water Quality Rating Index.

	EPT Value	Water Quality Rating Index
Time –	45 minutes	60 minutes
Persons –	3+	3+

Materials (needed for either sampling method)

- 1 plastic pan
- 4 plastic petri dishes
- 4 transfer pipettes
- 1 kick net
- 4 magnifying glasses
- dichotomous keys
- 1 pair waders (for cold and/or deep water)

EPT VALUE

Aquatic invertebrate Group	**Number of different “species” found**
MAYFLIES	
STONEFLIES	
CADDISFLIES	
TOTAL	

Total “species” equals EPT Value

[ ] >10 not affected (excellent water quality)

[ ] 6 – 10 slightly affected (good water quality)

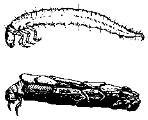
[ ] 2 – 5 moderately affected (fair water quality)

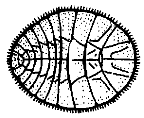
[ ] < 2 severely affected (poor water quality)

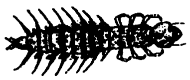
Water Quality Rating Index

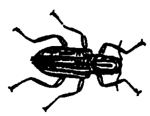
(Circle each category found)

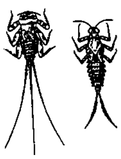
Group 1: Pollution Sensitive


Caddisfly larva


Water penny


Dobsonfly larva adult


Riffle Beetle


Mayfly nymph

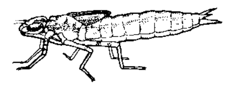

Gilled Snail

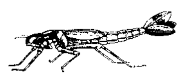
Group 3: Fairly Tolerant

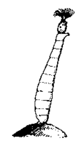

Scud


Clams, Mussels

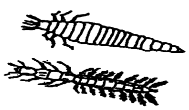

Crayfish nymph

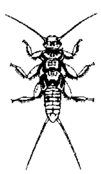

Dragonfly

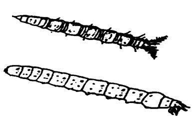

Damselfly nymph


Blackfly larva

Group 2: Slightly Tolerant

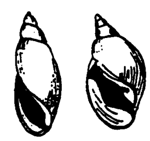

Beetle larva

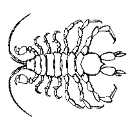

Stonefly nymph

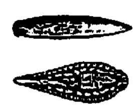

Cranefly larva

Group 4: Very Tolerant


Midge larva


Pouch (left hand) Snail


Sowbug


Leech

Total # categories of Pollution Sensitive Group 1	________	X	100	=	____________
Total # categories of Slightly Tolerant Group 2	________	X	80	=	____________
Total # categories in Fairly Tolerant Group 3	________	X	60	=	____________
Total # categories in Very Tolerant Group 4	________	X	30	=	____________
COLUMN TOTALS	_________	(a)			____________ (b)

Divide (b) by (a) ___________ / ___________ = Water Quality Rating Index _______________

Water Quality Rating Value:

[ ] > 79 Excellent [ ] 60-79 Good [ ] 40-59 Fair [ ] < 40 Poor

IV-4b. The Riparian Zone

Key Terms		
aquatic zone	greenline	sedges
emergents	groundwater recharge	shrubs
forbs	niches	swale
floodplain	ocular tube	uplands zone
grasses	rushes	water table

What is the Riparian Zone?

The riparian zone is the green ribbon of life alongside a stream. This ribbon is a mixture of vegetation types, which varies greatly from place to place. Riparian vegetation along a desert stream may be small and sparse while the vegetation along a mountain stream may be tall and lush.

The riparian zone is critical to the health of every stream and its surrounding environment. It connects the **uplands zone** to the **aquatic zone**, controlling the flow of water, sediment, nutrients, and organisms between the two. Without a proper functioning riparian zone, the other zones suffer. Riparian zone functions are discussed (Figure IV-16) in detail below.

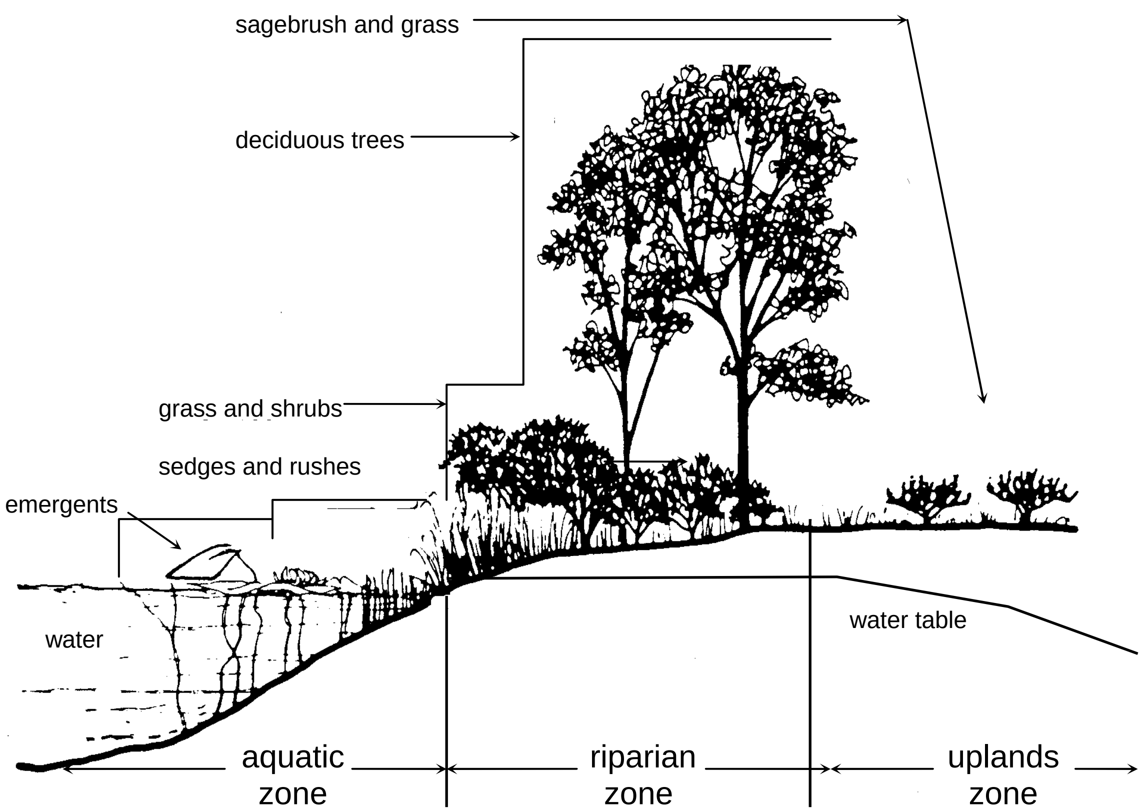


Figure IV-16. The Riparian Zone Connects the Stream (Aquatic Zone) to the Upper Part of the Watershed (Uplands Zones)

Adapted from "The Riparian Zone," Utah Riparian Management Coalition

1) Is the riparian zone wetter than the uplands zone?

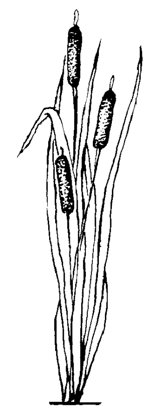
- Yes, because it receives regular flooding and is closer to the **water table**.

2) How do riparian plants and trees affect the stream?

- Riparian vegetation contributes shade, food and shelter for aquatic organisms. The riparian zone is also home to many animals that move between land and water, such as insects, amphibians and waterfowl.
- Riparian vegetation and litter reduces erosion and regulates the overland flow of water to the stream (uplands vegetation serves this function, too).
- The riparian zone acts as a natural sponge, soaking up water as it runs off the land, and slowly releasing that water back into the stream.

3) How does the variety of species differ between each zone?

- The riparian zone generally has a greater variety of species than the other zones. It is also denser and more structurally complex (plants have a greater variety of shapes and heights).
- Some plants, such as **sedges** and **rushes** are not found in most areas of the upland zone because they require a lot of water.
- Other plants, such as sagebrush, are not found in the aquatic zone because they cannot tolerate a wet environment.
- **Emergents** which are found only in the aquatic zone grow up through the water and expose their leaves at the surface. Submerged and floating vegetation are also found in the aquatic zone.



Cattail

Utah riparian areas

- Riparian zones constitute less than 3% of Utah's land area. However, 75% of the 360 bird species found in Utah depend on riparian zones for some part of their life cycle.
- The cottonwood/willow forest is a type of riparian zone common in Utah. The cottonwoods form a tall canopy and the willows create a thick understory. A variety of birds and other animals fill the niches created by this complex structure.
- Many other riparian vegetation types can be found in the varied landscapes of Utah. Look for saltgrass and cattail in western salt marshes; alkali bullrush and coyote willow in the sagebrush country; and even subalpine fir and Engleman spruce in high mountain areas.

The western cottonwood willow forest, an exclusively riparian forest type, is the most threatened of the 106 forest types found in North America.

What natural influences affect riparian zones?

Water supply

Water supply is the major factor that regulates the growth of riparian vegetation. Flood waters transport nutrients, sediment and new seeds from upstream. Floods also strip away larger, established vegetation and allow new seedlings to establish.

Unlike floods, groundwater offers a steady source of water for the stream and riparian zone. In fact, it may be the only source of water for a stream in winter when precipitation is frozen (groundwater remains at a relatively constant 50 degrees). The closer you get to the stream, the closer the water table (the top of the groundwater) is to the surface of the soil. Groundwater comes to the surface at the edge of a stream.

Soils
The type of soil in the riparian zone influences the amount of water and nutrients available. Organic-rich soil holds water and provides abundant nutrients to plants, with out releasing these nutrients to the water. We can expect to find denser vegetation in these soils than in a gravely soil with little water-holding capacity and few nutrients.

Topography
The shape of the land affects the location and abundance of plants in the riparian zone. See figure IV-17 to find out how.

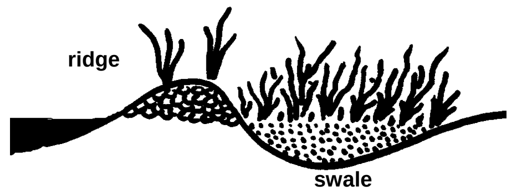


Figure IV-17. The shape of the land near a stream affects the plants which grow there.

The gravelly composition of this ridge allows fine sediment and organic matter to filter through and collect in the swale. These materials, which have high water-holding capacities, keep the swale wetter than the ridge; even though it is further from the stream. Notice the thicker vegetation that results. Why else might we find thicker vegetation in the swale? Think about access to the *water table*.

Climate
Riparian zones in different climates have different appearances. In the deserts of southern Utah riparian zones are "green oases" in sparse, dry surroundings. In the mountains, where precipitation is more abundant, the upland vegetation remains relatively lush. It is usually less structurally and visually different than the riparian vegetation.

What human influences affect riparian zones?
Humans, just like animals, are attracted to riparian zones. Unfortunately, many of our activities can have a negative influence on the riparian zone and reduce its value both for the ecosystem and ourselves. Through respect and good planning we can help to avoid many of these problems.

Road building
Riparian zones, which tend to be flatter than the surrounding land, are attractive routes for road builders. Roads, however, may cause accelerated erosion, introduce oil and other pollutants to the stream, cut off subsurface water flow to the stream and threaten wildlife.

Farming
Farmers often clear riparian zones to increase the amount of available farmland. However, without the stabilizing effect of riparian vegetation, the banks of a field may erode during floods. Farmland is lost where the erosion occurs and sedimentation increases downstream. More and more farmers now maintain the health of their riparian areas to ensure long-term sustainability of their land.

Grazing
Just like other animals, cattle are attracted to cool, lush riparian zones. If managed correctly – herded or fenced out after a short time – cattle can be part of a healthy riparian zone. However, mismanagement, or overgrazing of the riparian zone can cause changes in the types of vegetation and the amount of cover and forage, increase erosion, and introduce increased amounts of nutrients and fecal coliform bacteria to the stream through manure.

Development
The aesthetic value of riparian zones makes them prime targets for housing and commercial development. However, construction often removes vegetation and alters the stream banks and may even result in concrete lined banks. These changes can increase the intensity of floods, increase the direct input of pollutants to water, and decrease wildlife.

Logging
Logging operations today realize the importance of healthy riparian zones and rarely log them. However, logging roads continue to be built through these zones, creating the same problems that all roads do. When we strip away upland vegetation, we allow too much water to flow down into the stream at one time, which can lead to bank erosion, deep and narrow channels and shrunken riparian zones. Along with the increased water flow may come increased loads of sediment.

Dams
Dams reduce downstream flooding. While this serves the people who live downstream in the **floodplain** it degrades riparian zones. Natural flood cycles are critical to healthy riparian zones. Floods bring essential supplies of water, nutrients and sediment. They also help to create backwaters that serve as critical fish nurseries.

Why do we care about riparian zones?
Well-functioning riparian zones are critical to a healthy watershed. Plants and animals depend on their unique, diverse and productive habitats. Humans, as well, depend on riparian zones; they provide the following services.

Erosion control
The tough, tangled roots of sedges, shrubs and trees provide structure to streambanks and reduce soil loss to the stream.

Filters
As surface runoff flows through the riparian zone to the stream, vegetation traps much of the sediment it carries which reduces turbidity levels in the stream. Riparian vegetation also pulls nutrients out of the soil before they can reach the stream.

Groundwater recharge
Riparian zones supply water to underground reservoirs. We call this process **groundwater recharge**. Well-vegetated areas trap the overland flow of water, allowing it to infiltrate the soil and percolate downward. Underground stores provide the primary and sometimes only source of water for streams during dry periods. Without this supply, the aquatic ecosystem would collapse. Recharge is equally crucial for humans who depend on groundwater for drinking and other purposes.

Flood control
Riparian zones serve as reservoirs for flood waters. The vegetation and soil absorb overbank flow then releases it over time. This decreases the amount and energy of water flowing through the stream at any one time. People who live in floodplains benefit from the regulating effect of healthy upstream riparian zones.

Wildlife
Riparian zones concentrate water and nutrients from the stream and the surrounding uplands. In response, the vegetation grows dense and structurally complex – it takes on a variety of shapes and sizes. This greater complexity translates into more **niches** for organisms to fill.

- The diversity and production of riparian zones surpass all other terrestrial (land) ecosystem types.
- Riparian zones in the Southwestern United States have a higher breeding diversity of birds than all other western habitats combined.
- Aquatic organisms are just as dependent upon riparian zones for their survival. The leaves, sticks and bark that fall into the water may provide up to 99% of the energy for organisms in a small headwater stream (the other 1% comes from **photosynthesis**).

Southwestern willow flycatcher

The southwestern willow flycatcher breeds throughout southern Utah (and elsewhere). It migrates up from Central America and Mexico in mid-May and nests mainly in the understory of cottonwood/willow riparian forests. As these types of riparian zones have been lost or changed, the 6-inch, green and yellow insectivore has decreased in number. In fact, so many have disappeared that in 1995 it was placed on the endangered species list. The southwestern willow flycatcher had historically been found in Utah along Kanab Creek and the Virgin, Colorado and San Juan rivers. However, only three sightings have been confirmed in the last five years.

How can you help the southwestern willow flycatcher and other birds that depend on riparian zones? Contact your local Fish and Wildlife Department to learn more about these birds. Ask if there are riparian zone restoration projects you and your class can participate in.

How do we sample the riparian zone?

This section provides three ways to monitor the riparian zone:

1) Greenline Transects,
2) Ground Cover Transects and
3) Canopy Cover Transects.

Each activity measures a different characteristic of the riparian zone.

NOTE: Step-by-step "Sampling Directions" can be found at the end of this section along with the "Riparian Zone Data Collection Sheet."

Greenline transects

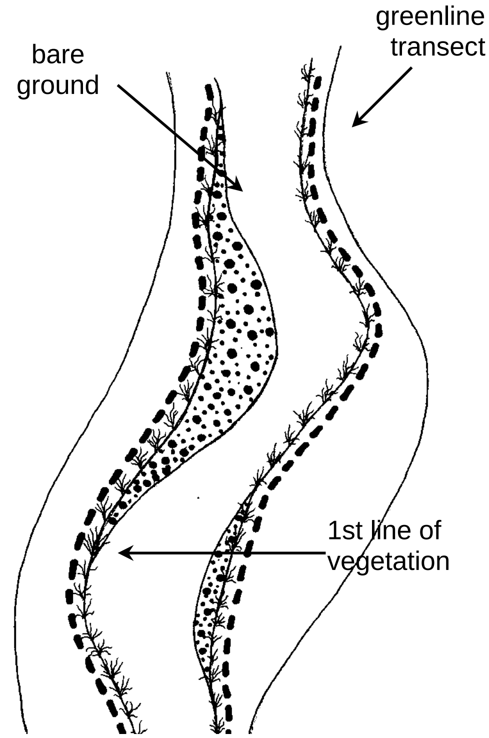
The **greenline** consists of the first plants you encounter as you move away from the water (see Figure IV-18). The greenline may at times closely parallel the stream and at other times it may head a considerable distance away from the stream.

- The greenline gives us a measurement of bank stability, which is the ability of banks to withstand erosion. We determine stability by calculating the percent composition of five different vegetation types along the banks. These are: 1) grasses, 2) forbs, 3) sedges and rushes, 4) shrubs and trees, and 5) bare ground (see Figure IV-19) for help identifying different vegetation types). Each vegetation type has a different ability to stabilize the bank, due primarily to the depth and density of their roots or whether they are annuals (die back after one year) or perennials (survive through the winter). Stability ratings are found on the "Riparian Zone Data Collection Sheet."

- Before sampling work with your students to correctly identify the different vegetation types and to locate the greenline. This can easily be done in your schoolyard in an area where vegetation meets bare soil. The more practice students have before they visit the stream site the more successful they will be.

- The greenline will take two students 30 minutes to complete if they are familiar with the different vegetation types.

Figure IV-18. The Greenline transect (line of vegetation nearest the stream) as seen from below



Canopy cover transects

- The canopy cover transect measures the percentage of overhead area covered by leaves or branches. This tells us the amount of shading the stream receives.

- The canopy cover transect runs along the greenline transect and can be measured at the same time. The canopy cover transect will take two students 15 minutes to complete.

- Students can simply look up to determine whether the overhead space is covered or they can use an **ocular tube** for a more precise measurement. One student looks through the tube, pointing it straight up. A second student tells him/her when the tube is vertical, at which time, the observation is made ("covered" or "open"). To make an occular tube refer to the appendix "Make Your Own Monitoring Equipment."

Ground cover transects

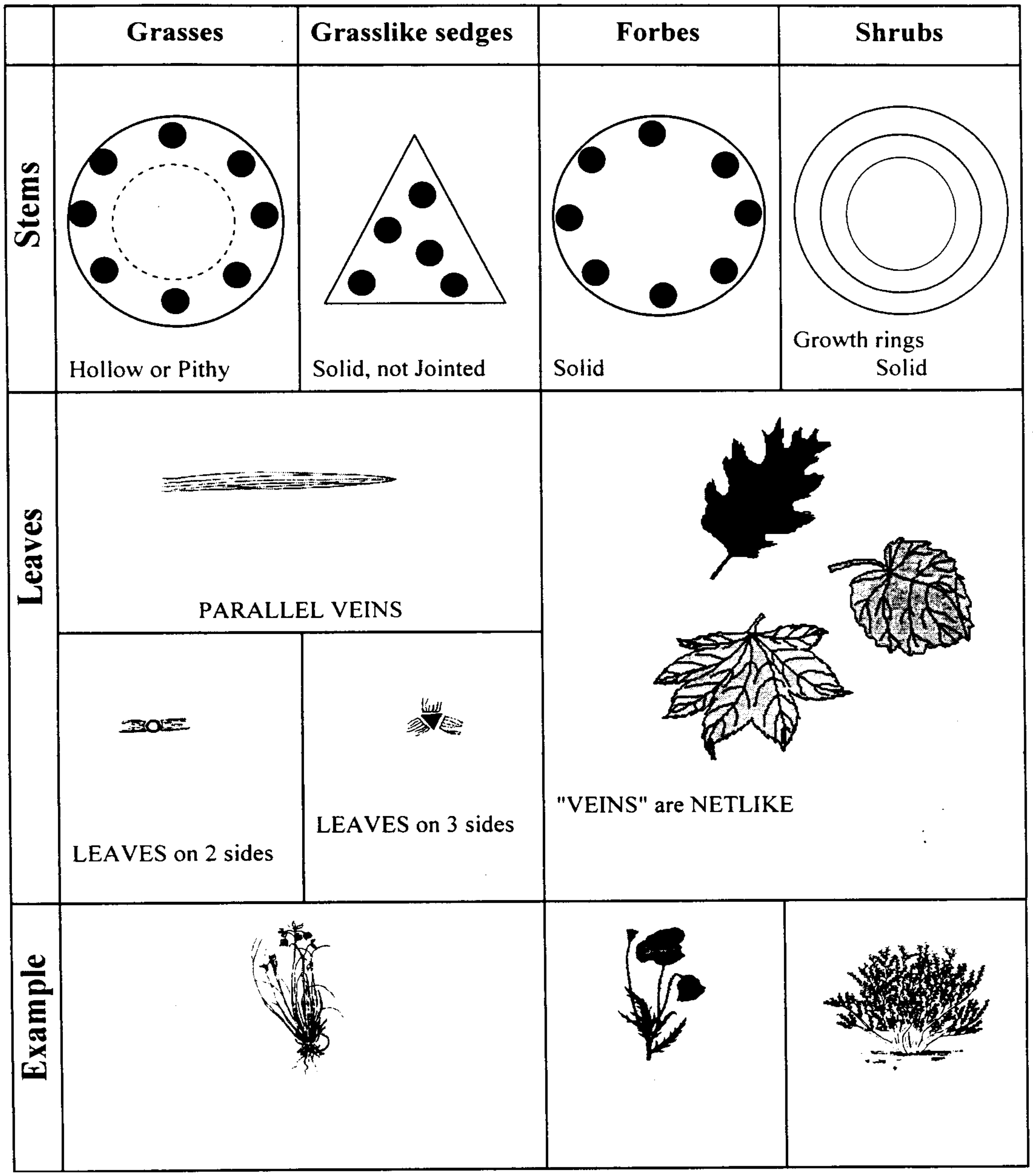
- Measuring ground cover tells us how well the riparian zone prevents erosion and filters runoff before it enters the stream.

- Riparian ground cover transects are set up perpendicular to the greenline. They begin at the stream's edge and extend approximately 30 feet away from the stream. Generally, five transects are run per stream stretch.

- Students count paces to measure the ground cover transect. Along each transect students will record four possible categories: 1) live vegetation; 2) litter (dead plant or tree material); 3) rock; and 4) bare ground. These different cover types provide varying degrees of protection from erosion. The cover type found at each sampling point should be tallied on the data sheet.

- One ground cover transect will take two students 10 minutes to complete (60 minutes to complete all five).

Figure IV-19 Different types of vegetation. Note the differences in stems and leaves.



Grasses – These have hollow stems that are jointed and leaves with parallel veins. The leaves come off the stem in opposite directions.
Grasslikes sedges – These resemble grasses but they have solid, triangular stems with no joints. The leaves have parallel veins but they come off the stem in three directions. This group also includes rushes which have round, hollow stems with very small or no leaves.
Forbs – These generally have broad leaves with net-like veins. The stems are solid or spongy and they die back to the ground every year.
Shrubs and trees – These have woody stems that remain alive all year. The leaves tend to have net-like veins. Rarely do shrubs grow taller than 13 feet. Trees are similar to shrubs in that they generally have a single woody stem but they grow taller than 13 feet.

How do we interpret our results?

- When interpreting your transect data, remember that a considerable amount of natural variability exists within and between different riparian zones. Not all riparian zones have naturally abundant plant/tree growth. Simply because your study area does not have 100% canopy or ground cover does not necessarily mean that it is unhealthy or that it was impacted by humans.

- To use your transect data to accurately assess riparian zone health you must establish long-term trends. Regular and continual sampling will show if changes are occurring over time. Consult with local land owners, local land management personnel or historic photos to determine past conditions.

Greenline

The higher the greenline score, the better the riparian zone can control erosion and stabilize the bank.

Canopy cover

The greater the percentage of overhead cover, the more shading your stream receives. Shading helps lower water temperature. Overhead material also adds organic matter to the stream which is an important food source for aquatic **macroinvertebrates**.

Ground cover

The materials that comprise riparian zones naturally vary according to their individual watersheds. Riparian zones in the Uinta Mountains may be primarily rock, while lower lying areas may be completely vegetated. As a general rule, though, a healthy riparian zone will be covered by a mixture of litter, rock and vegetation (many desert streams, which have very sandy banks, are an exception). A mixture of cover types is ideal because each provides a different service. Vegetation functions well as a filter and also buffers against erosion. Rock does little to filter erosion but acts as an excellent buffer against erosion. Litter serves both functions.

Resources for further investigation

River Corridors and Wetlands Restoration – Consult this web site if you want to involve your group in a riparian restoration project. It contains information on restoration projects, proposals, ideas, and contacts.
www.epa.gov/owow/wetlands/restore

Enviroscape: Riparian Kit – This plastic waterflow model offers an accompanying activity guide that focuses on the Riparian Zone. Contact : Your local [county] Cooperative Extension Service – or – Utah State University Extension, 1500 N 800 E, ASTE Dept, Utah State University, Logan, UT 84322-2300, (435) 797-3389. www.ext.usu.edu/natres/wq/index.htm. See the "Resources" appendix for ordering information.

Rocky Mountain Flower Finder : A Guide to Wildflowers Found Below Tree Line in the Rocky Mountains by Janet L. Wingate. Publishers - Berkeley : Nature Study Guild, ©1990.
This field guide will help students identify common grasses, plants, shrubs and flowers in Utah. More importantly, it provides easy-to-understand techniques for identifying plant families. This is an excellent guide for student field trips.

Rocky Mountain Tree Finder : A Pocket Manual for Identifying Rocky Mountain Trees by Tom Watts. Publishers – Berkeley: Nature Study Guild, ©1972. This made-for-students field guide makes an excellent compliment to the Rocky Mountain Flower Finder.

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Riparian Zone

Greenline

Time – 30 minutes
Persons – 2
Materials –

- Flagging
- Tape measure
- Riparian Zone Data Collection Sheet
- Plant guide (optional)

NOTE: The “greenline transect” can be done at the same time as the “canopy cover transect.” To save time have your directions and data sheets ready for both.

1. Measure a 100 ft stretch along your stream. Place a flag near the water at the beginning and end points.

2. Standing at the first flag, look toward the water. Note the vegetation type that is closest to the water and record it in row (1) of the data sheet.

3. Take one pace toward the other flag and stop. A pace is a normal stride you would take while walking. Look toward the water and record the vegetation type closest to the water.

4. Repeat these steps until you reach the other flag.

5. Add up the total number of steps you took and record in row (2).

6. Sum up all the observations and record in row (3)

7. For each vegetation category, divide the number in row (2) by the number in row (3), multiply by 100 and record in row (4). This will give you the percentage of the greenline that is made up of that vegetation category. For example, if you took 50 steps and found grass at 20 of them then 40% of your greenline consists of grasses.

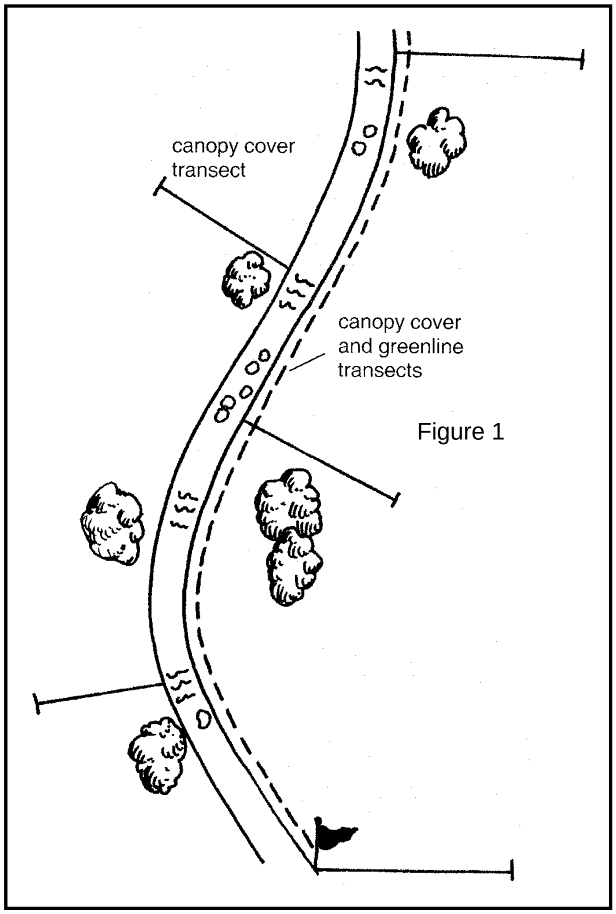

Figure 1

8. For each vegetation category, multiply the number in row (4) by the factor in row (5) and record in row (6). This will give you the “site score” for each vegetation category. Because sedges and rushes have the strongest roots and prevent erosion the best they receive the highest factor - “9.” Bare ground doesn’t prevent erosion so it receives the lowest factor – “1.”

9. Add the individual site scores in row (6) together to get the “total site score” for that stretch of stream.

Canopy Cover

Time – 30 minutes
Persons – 2
Materials –
- ocular tube
- measuring tape
- Riparian Zone Data Collection Sheet

Note: At each point where you record greenline data you will also record canopy cover data.

1. Point the ocular tube straight up in the air (90 degree angle) and look through it with one eye. Your partner who is recording data can help you adjust the tube until it is as straight as possible.
2. Tell the recorder whether the “X” at the end of the tube points at sky (a “miss”) or a part of a tree or bush (a “hit”). Record this on your “canopy cover data chart.”
3. Repeat these steps for the rest of the greenline.
4. Add up the total hits and misses and record in the second row.
5. Add the two scores recorded in row 2. This will tell you the “total number of steps” you took along the transect (the greenline). Record this total in row 3.
6. Divide the number of “hits” in row 2 by the total observations in row 3 and multiply by 100. This will give you the percent canopy cover for the transect.

Ground Cover

Time – 35 minutes
Persons – 2
Materials –
- Measuring tape
- Riparian Zone Data Collection Sheet

Note: Riparian ground cover transects start at the stream edge and extend 15 paces away from the stream, into the riparian vegetation. A pace is a normal stride you would take while walking.

1. You will collect data along five separate transects in your stream stretch, spaced out at approximately equal distances along your stream reach. If possible, you should run two transects on one side of the stream and three on the other to get a better picture of the total riparian zone. Refer to the figure on page 1 of these instructions for help locating these transects.
2. Starting at the stream’s edge take one pace away from the stream. Touch your finger to the ground at the tip of your front foot.
3. Note the ground cover type that your finger touches. The categories are: bare ground, live vegetation, litter (dead vegetation or sticks) or rock. Record the type with a slash in the appropriate box on the “ground cover data chart.” Note that each column on the data chart is for a separate transect.
4. Repeat steps 2 – 3 for 15 paces. Then move on to the second transect. Repeat.
5. When you’ve finished with all five transects, add the totals for each row or cover type. Record your totals for each ground cover category in the category total column. In the next column, divide the categoy total by 75 (your total number of steps) and multiply by 100. This will give you a percentage of ground cover for each type in the riparian zone. To check your math, add up your percentages for each ground cover type. They should total 100%.

* The percentage of each ground cover type provides a measure of ground cover that can be compared to other sites or to compare changes over time (between different years or seasons). As a general rule, though, a healthy riparian zone will be covered by a mixture of litter, rock and vegetation. An important exception to this are desert streams, which have very sandy banks.

Greenline

	Vegetation Categories				
	Deep Rooted Plants		Shallow Rooted Plants		Bare Ground
	Sedges and Rushes	Shrubs and Trees	Grasses	Forbes	
Row 1: Record each observation as a slash mark in the appropriate box.					
Row 2: Total # of observations for each category					
Row 3: Total number of observations for the entire greenline (sum of all observations in Row 2):					
Row 4: % of each category (divide row 2 values by total in row 3. Multiply by 100)					
Row 5: Multiply each value in row 4 by this factor.	X 9	X 8	X 6	X 3	X 1
Row 6: Site score for each category					

Total Site Score (add up all site scores in Row 6)**:**_____________________

The higher your score the stronger your plant roots are and the more your stream banks will resist erosion.

Notes:

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Canopy cover

	"Miss" (Open sky)	"Hit" (Vegetation)
At each step along green line, record with a slash whether you see a "miss" (open sky) or a "hit" (vegetation) in your ocular tube.		
Total # of slash marks for each category		
Total number of observations		
% Canopy cover: Divide total "hits" by total observations and multiply by 100		

The more "covered" area you have the more shading your stream receives (this keeps the water cool and provides food for aquatic organisms).

Ground cover

	Transects Perpendicular to the Greenline						
	1	2	3	4	5	Category Total	**Percent of each category** (divide category total by 75 and multiply by 100)
Live vegetation							
Litter							
Rocks							
Bare ground							