Leaf Pack Network®

Background Information

Linking Trees To Streams

(Also available online at www.stroudcenter.org/lpn under the *Learning Center*. All images and drawings are copyright Stroud Water Research Center unless otherwise noted.)

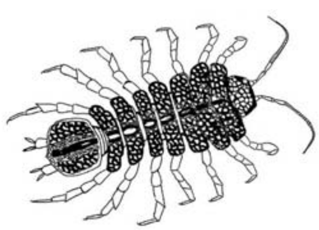
Historically, most small streams in the eastern United States were forested. Leaf fall from the forest canopy was the dominant food resource for small streams. All ecosystems rely on a steady supply of energy. Solar energy drives photosynthesis that supplies carbon (chemical energy) for the rest of the system. In many headwater streams, however, sunlight cannot reach the water's surface due to shading of the forest canopy. Therefore, most headwater streams rely on autumn leaf fall to supply much of the carbon needed to support the stream throughout the year.

The leaves that fall into streams accumulate in packs behind branches, rocks and other obstructions in the stream, forming natural leaf packs.

Leaves, falling in or near the stream, leach out organic molecules creating a "watershed tea" that flows downstream providing nourishment along the way. On the leaf surface, there is a diverse assemblage of microbes (fungi and bacteria) and macroinvertebrates (insect larvae, crustaceans, etc.) which "process" leaves and facilitate the flow of energy through the system. Macroinvertebrates are often referred to as "canaries of the stream" because they function as living barometers that indicate changes in water quality.

Benthic freshwater macroinvertebrates can be defined as the following:

Benthic	=	inhabit bottom areas/substrates
Freshwater	=	streams, rivers, lakes, ponds
Macro	=	relatively "large" (> 0.2-0.5mm)
Invertebrate	=	animal without vertebrae



Aquatic macroinvertebrates play important roles in the food webs of the stream ecosystem (Figure 1). Macroinvertebrates can be classified not only by traditional taxonomy but also by how they function in the ecosystem. This method of classification based on feeding adaptations and/or food preferences is known as functional feeding groups (Figure2).

Figure 1. *Food web in small streams.*

Image provided by "Stream Corridor Restoration: Principles, Processes, and Practices, 10/98, by the Federal Interagency Stream Restoration Working Group (FISRWG)."

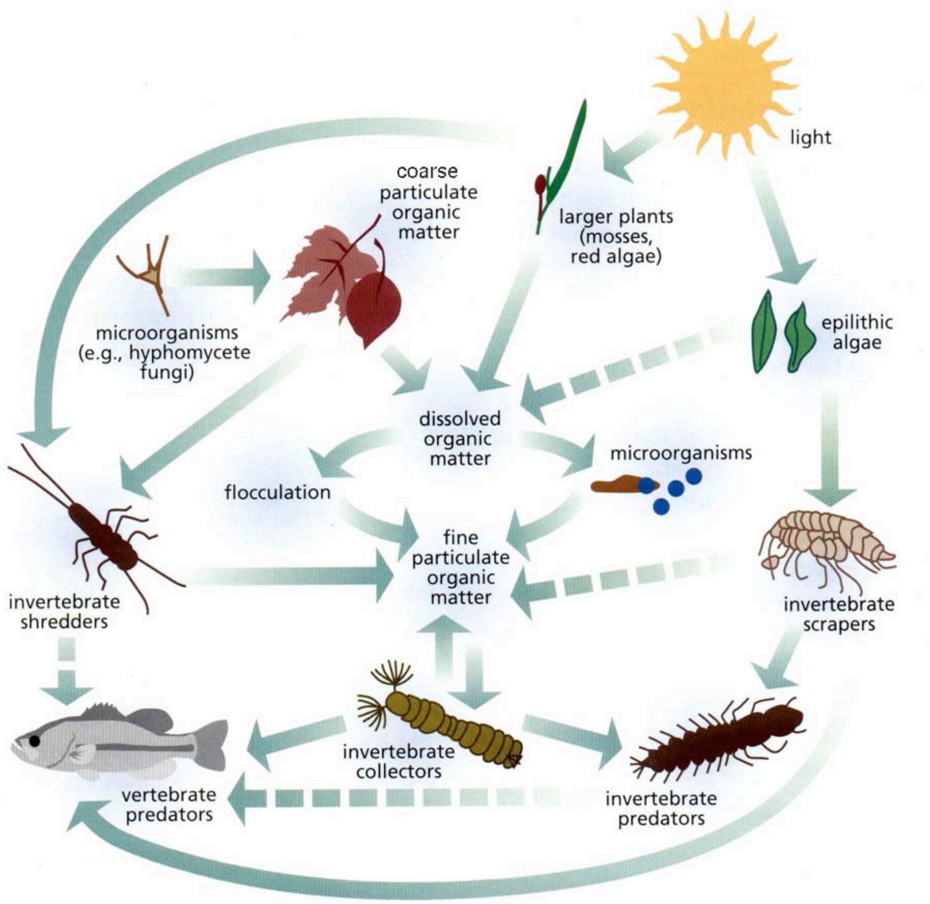
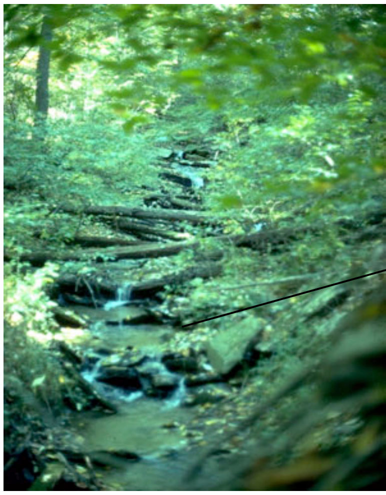


Figure 2. *Functional Feeding Groups*

Feeding Strategy	Food Category
I. Shredders	dead leaves/live macrophytes
II. Collectors	fine organic particles (live/dead)
filter feeders	particles in water column
miners	buried particles
browsers	bottom surface deposits
III. Scrapers	live benthic algae (diatoms)
IV. Piercers	live filamentous algae
V. Predators	other invertebrates + small fish

Leaf fall from the forest canopy in small streams are used by shredders (Figure 3). Shredders get nutrition primarily from the fungi and bacteria that colonize the leaf surface. Craneflies, stoneflies, caddisflies and aquatic sow bugs are important members of this group. Small fragments of leaves and feces from shredders are captured by another group of macroinvertebrates called collectors. Netspinning caddisflies and blackflies are examples of this group.



Leaves accumulate in leaf packs in streams. The animals adapted to feeding on leaves are called "shredders."

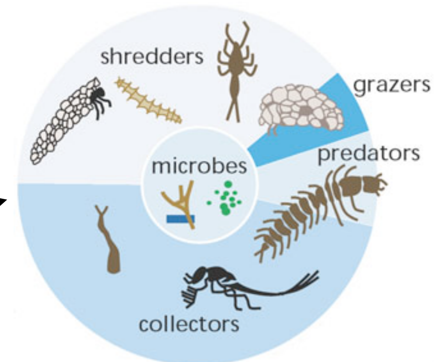


Figure 3. *Shredders and collectors form the major proportion of stream macroinvertebrates.*

Image provided by "Stream Corridor Restoration: Principles, Processes, and Practices, 10/98, by the Federal Interagency Stream Restoration Working Group (FISRWG)."

As the stream widens, exposing more of the water's surface to sunlight, in-stream photosynthesis plays a more important role. Leaf litter reaching the stream decreases and algae, due to the increased sunlight, becomes more abundant. As the food base shifts so does the type of invertebrates. Grazers/Scrapers who utilize the abundant algal resource increase while shredders decrease (Figure 4). Snails, limpets, certain mayflies and case-building caddisflies are adapted to feeding on the algae growing on rock surfaces.

More sunlight reaches this mid-sized stream.

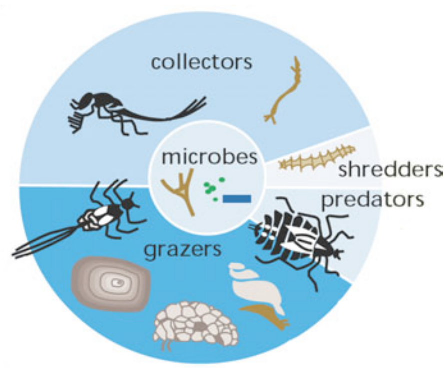


Figure 4. *Collectors gather or filter plant fragments, feces, and plankton. Grazers, also known as Scrapers, browse on algae.*

Image provided by "Stream Corridor Restoration: Principles, Processes, and Practices, 10/98, by the Federal Interagency Stream Restoration Working Group (FISRWG)."

Further downstream the river channel widens and deepens. Trees shade only the edge of the river and sunlight, although abundant, does not penetrate to the river's bottom due to turbidity. The food base is dominated by phytoplankton and fine, suspended organic particles generated further upstream and from the river's floodplain. Filtering collectors (Figure 5) such as mussels and clams are adapted to filtering these fine particles from the water column. To complete food web ecology, a diverse group of predators are found throughout the entire stream length feeding on all other feeding groups.

Large river

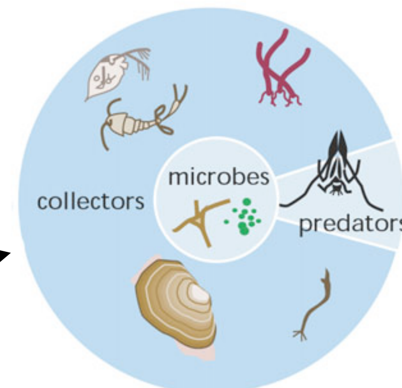


Figure 5. *Filtering collectors such as mussels are found in greater abundance in larger streams.*

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Physical conditions vary greatly in small headwater streams compared to large rivers. In general width, depth, temperature, and discharge increase further downstream. The **River Continuum Concept** (Figure 6) seeks to correlate this continuum of physical changes with biological changes throughout a river system and provides a conceptual model to compare with stream systems throughout the world.

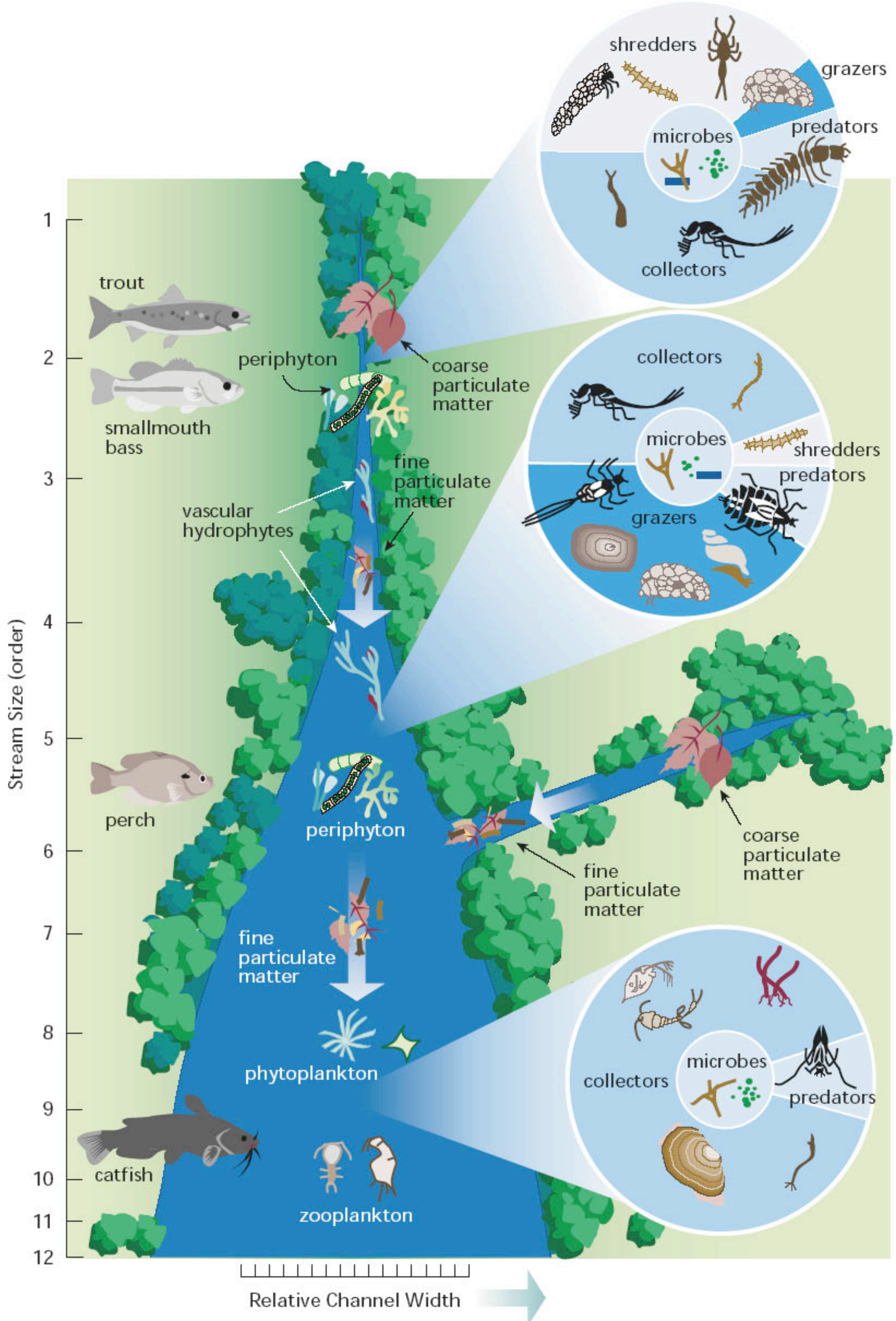

Figure 6. *River Continuum Concept.*

(Source: Vannote, R. L., Minshall, G. W., Cummins, K. W., Sedell, J. R., & Cushing, C. E. (1980). The river continuum concept. *Canadian Journal of Fisheries and Aquatic Sciences*, *32*, 130-137. Reprinted with permission from NRC Research Press. Image provided by "Stream Corridor Restoration: Principles, Processes, and Practices, 10/98, by the Federal Interagency Stream Restoration Working Group (FISRWG)."

Linking the Leaf Pack Experiment to Stream Ecology

The Leaf Pack Experiment Kit and Leaf Pack Network® are designed to enhance student understanding of stream ecosystems and to demonstrate the importance of streamside forests. Historically streams and the life in those streams, evolved and developed under forested conditions. Researchers at the Stroud Water Research Center have been studying the connection between streamside forests and stream ecosystems for the past 30 years.

In the mid-seventies, the Stroud Center's first director had an innovative idea of studying an entire watershed opposed to a section of stream as had been done in the past. Not only does a stream change physically as it flows downstream but also biologically. The River Continuum Concept, developed by scientists from the Stroud Center and other colleagues, was the first unified hypothesis about how streams and their watersheds work. A river is a single continuum that flows ceaselessly from its source to the sea. To understand it, you must know what is happening upstream and what is entering it from the watershed. Today, the River Continuum Concept is still the most widely sited study in the field of stream ecology.

Early research conducted for the River Continuum laid the foundation for more recent studies linking streamside forests and stream ecosystems. Since the mid-1980's, it has been well known that streamside forests can function as filters for pollution. On-going research at the Stroud Center has determined that in addition to acting as buffers for pollution, streamside forests are an integral and essential part of the stream ecosystem that affect the physical, chemical and biological aspect of streams.

As part of its research, Stroud Center scientists have used leaf packs to better understand the stream ecosystem. In Costa Rica, for example, leaf packs have been used to study how tropical streams differ from temperate streams. Leaf packs in the Flint River, Georgia, were used to assess effects of industrial effluents.

Conducting a leaf pack experiment by placing artificial leaf packs in the stream, replicates the natural process of leaves forming packs in streams. Participants learn scientific principles, gain an understanding of how streams function as ecosystems and are given an opportunity to communicate their data to the global community through the Leaf Pack Network®.

Natural leaf pack.

Artificial leaf pack.