STREAMS

A National Heritage Worth Preserving

Alabama Cooperative Extension System, Alabama A&M and Auburn Universities ANR-911

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Johnie Crance, U.S. National Biological Service, Southeastern Biological Science Center, Auburn Field Station
Michael Masser, *Extension Fisheries Specialist*, Associate Professor, Fisheries And Allied Aquacultures

The sound of water bubbling over a stony riffle?

The adventure and excitement of a float trip?

Fun associated with jaunts to the swimming hole?

Days relaxing with a fishing pole and can of worms?

A string of fish and a tale to tell about the big one that got away?

The beaver dam, or otter slide, or muskrat trail?

Kingfishers stalking prey, or a red-winged blackbird nest suspended from a cattail stem?

Many of us have enjoyed these pleasures and the fond memories evoked in the words *creek, river, brook, branch, slough, and stream*. However, population pressures and industrial growth have severely reduced these opportunities and negatively impacted many of our nation's waterways. The number of streams is limited, and the total miles of free-flowing streams has been reduced throughout the United States. Of the nation's 3.5 million miles of rivers, more than one-sixth (600,000 miles) have been dammed and converted to reservoirs. Because of the continuing degradation of our streams we, as a society, need to develop measures to ensure that opportunities for quality experiences and memories of unspoiled streams are available to future generations.

The physical, chemical, and biological characteristics of streams vary greatly, and there are many different types of streams in Alabama and throughout the Southeast. Some terms used to describe these differences are *large, small, deep, shallow, fast flowing, slow flowing, clear, turbid, rocky, sandy, coldwater, warmwater, and meandering.* Such physical features are generally brought about by a combination of factors including rainfall, geology, slope, temperature, stream-side vegetation, and human activities. Alabama has about 77,000 miles of streams. However, many of these water resources have deteriorated and are in need of help.

A study by Auburn University indicates that Alabamians are willing to pay about $76 million per year to maintain the state's remaining free-flowing rivers in their natural condition.

Exploitation of Alabama waterways began 9,000 years ago when Native Americans first came to the state. These early people were few in number and had relatively little impact on rivers and streams. The state's founding fathers saw the importance of rivers and streams. The state seal, adopted in 1819 when Alabama gained statehood, features a map of her river systems. Alabama has 1,438 miles of navigable waterways—more than any other state. Population growth and industrialization over the past century have created multiple competing uses and increased demands for these limited water resources. Development along the Coosa-Alabama river system, the state's longest river system, illustrates the multi-uses and demand for this resource. Located along the Mobile-Alabama-Coosa river system are 23 dams, 28 locks, nearly 200 industries, more than 40 mining operations, 70 sewage treatment plants, thousands of farms and private timber lands, and dozens of cities and towns.

There is growing awareness and concern over the accessibility and quality of stream resources, but time may be running out for saving or restoring the ecological integrity and functional values of some streams. Corrective actions where needed to restore and protect stream systems must be taken by governments, industries, citizen groups, concerned individuals, and all other responsible sectors of society. We hope that this publication will enlighten readers on the importance of streams and lead them to develop stronger stream awareness. Streams are valuable assets that enrich our lives and are worth sustaining for present and future generations as part of our state and national heritage.

Stream Components

Watershed

A watershed is the land area from which water, sediment, and dissolved materials drain to a common watercourse or river system. All land is part of a watershed; therefore, our houses or apartments are within watersheds, and we spend all of our land-locked lives within watersheds. There are fourteen rivers encompassing ten major watershed areas in Alabama (Figure 1A). Five of Alabama's major river systems have their origins in adjoining states.

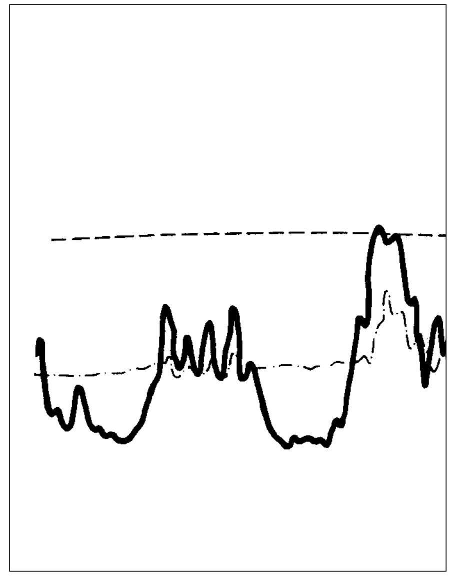


Figure 1A. Alabama's river systems including their tributaries consist of 47,000 miles of perennial and 30,000 miles of intermittent streams. There are 1,438 miles of navigable waterways in the state—more than any other state.

The smallest streams in a watershed have no tributaries or feeder streams and are called "first order streams." When two first order streams join, they form a "second order stream," and so on up to the largest—"tenth order streams." In general terms first, second, and third order streams are considered headwater streams, fourth through sixth order are called mid size streams, and seventh through tenth order are called large streams or rivers. The Mobile and Alabama rivers are tenth order streams (Figure 1B).

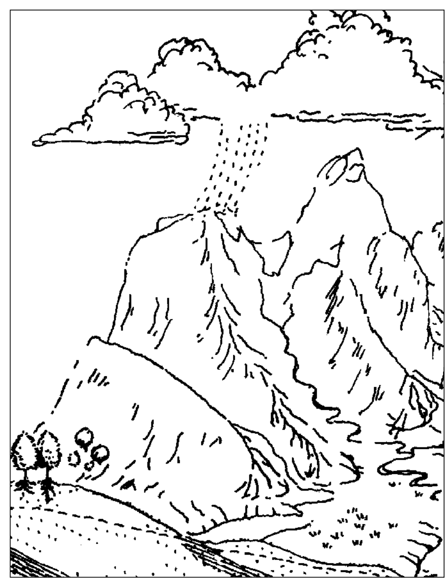


Figure 1B. Streams are classified by order. Small streams with no feeders or tributaries are first order streams. Large rivers such as the Mobile River with many tributaries are tenth order streams.

Streams such as the Tennessee River, the Mobile-Alabama-Coosa system, and the Chattahoochee River drain watersheds encompassing thousands of square miles in adjoining states. Streams that originate within or near the coastal zone, such as Alabama's Fowl River and Dog River, have small watersheds and a flat gradient, and they are warm, slow-flowing streams. Streams in upland areas, such as the Little River in northeast Alabama, generally have higher gradients or steep slope and are cooler and faster-flowing than streams in lowland areas. Rainfall, stream gradient, vegetation, and soil type generally determine if a stream flows constantly **(perennial streams)** or only occasionally **(intermittent streams)**. Of Alabama's 77,000 miles of streams, 47,000 miles are perennial and 30,000 miles are intermittent. A hydrograph (Figure 2) shows the volume and pattern of streamflow and

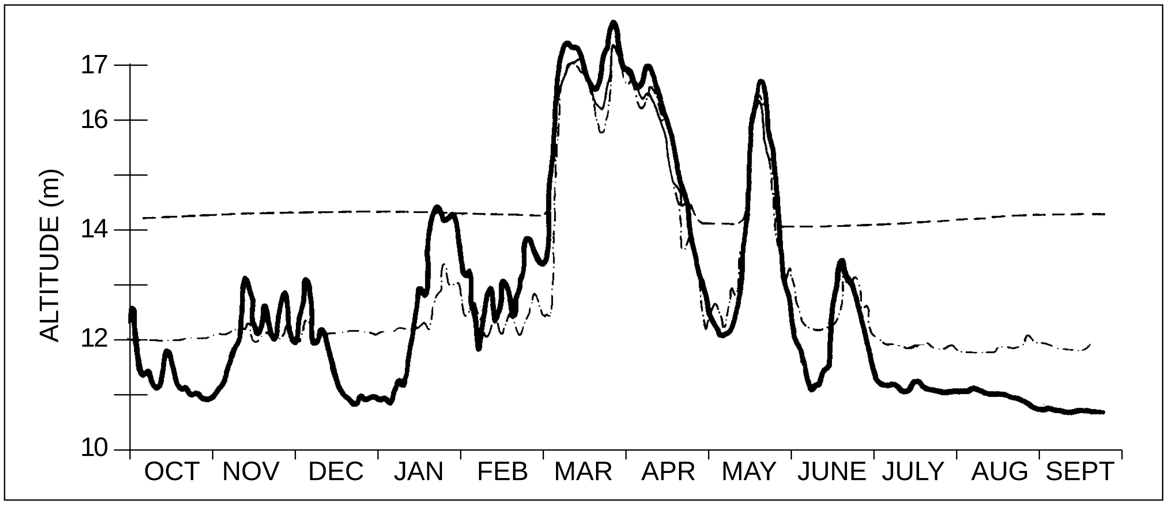
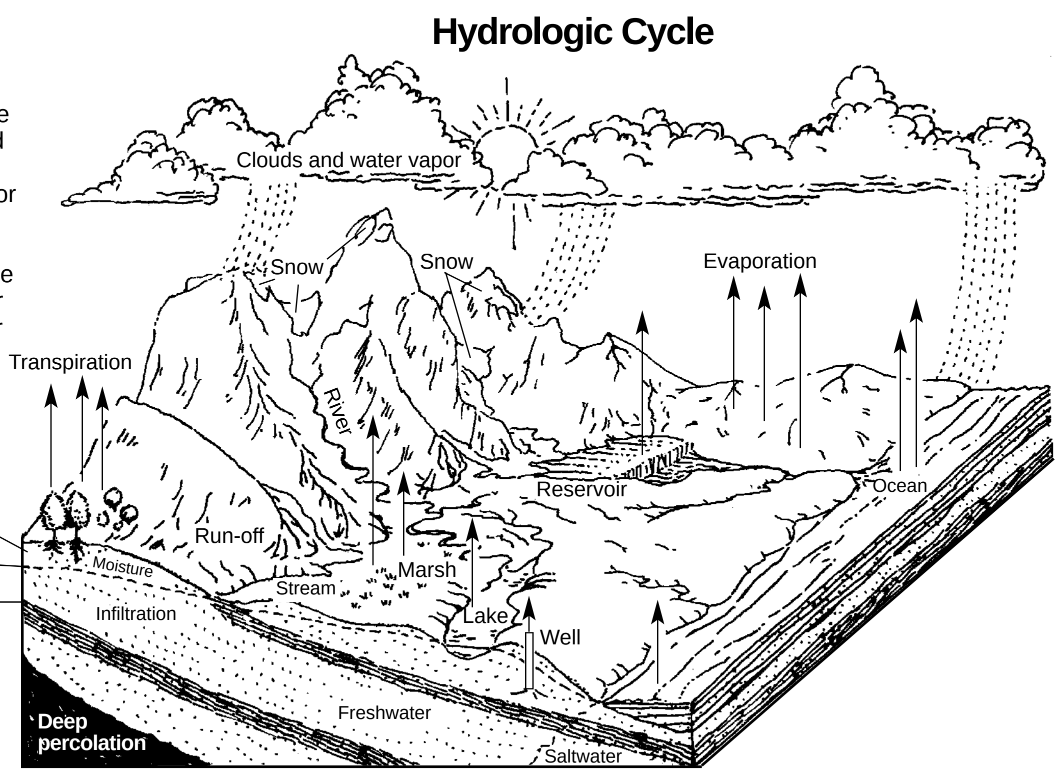


Figure 2. Example of hydrographs from the Apalachicola River, Florida (solid line), at river mile 86, and from two nearby floodplain sites along the river during the water year 1980. Floodplain site 1 (dashed line) was located 1 mile east of the river in a large tupelo-cypress swamp that was permanently ponded with 1 to 2 feet of water. Floodplain site 2 (dotted line) was located about ½ mile west of the river in a floodplain with high flow velocities during floods, but which was ponded during low flows.

serves as a historical account of the amount of streamflow at a specific location over time.

The hydrologic cycle (Figure 3), geomorphology, and watershed practices generally determine the condition of a stream and its plant and animal life (biota). When rain falls on the watershed some moisture evaporates immediately, and some is taken up by plants where it is either incorporated into plant tissue or released back into the atmosphere by water loss from leaves (transpiration). Much of the remaining water moves downslope as surface runoff or filters through the soil. Forested watersheds hold large amounts of water and release it slowly into nearby streams. As water moves through the watershed into streams, it takes with

Figure 3. Highly simplified schema of the hydrologic cycle showing how the sun powered system constantly circulates water from lower elevations (for example the sea, estuary, stream, or lake) to higher elevations in the watershed. In the water's return journey to lower elevation, wetlands may occur and be sustained where there are suitable hydrological and geological conditions.



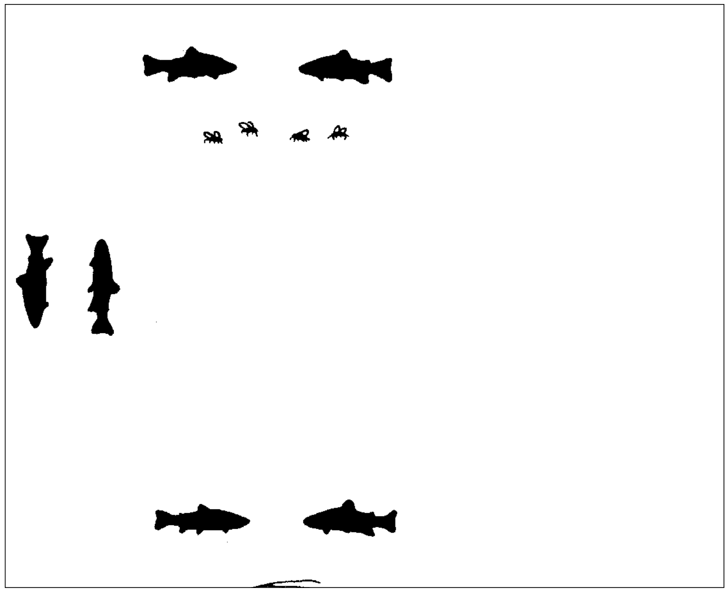
it dissolved nutrients (for example, nitrogen and phosphorous) and decaying leaves, sediments, and other forms of organic and inorganic particulate materials, which are major energy sources for bacteria, plankton, insects, and other organisms low on aquatic food chains. These organisms provide food for fish and other stream-dwelling animals higher on the food chain.

Streams deposit sediments and nutrients in their floodplains on their way to the sea. It is this deposition of enriched sediments that makes stream floodplains such fertile and productive lands, which explains why floodplains have been used extensively for agriculture. Some sediments and nutrients contributed by watersheds are carried all the way downstream to estuaries. Here, fresh water from the stream and saltwater from the sea circulate the nutrients, providing enrichment to the food supply of shrimp, fish, birds, and other organisms that use estuaries. The solar-powered hydrologic cycle (Figure 3) constantly circulates or recycles water evaporated from the lower components of the stream system to higher elevations in the watershed where it begins its return journey downstream.

Riparian Floodplain

Riparian floodplains are lands adjacent to streams. These portions of stream ecosystems accommodate high flows and are among the most productive and valuable of all lands. They help to maintain water quality, store and release flood water, produce timber and agricultural products, and provide habitat for fish and wildlife. Spotted sunfish, flier, and pirate perch are some species of fish that rely heavily on riparian wetland habitat.

Riparian floodplains are usually dominated by plants that have adapted to the specific environmental conditions, and some floodplain plants are strongly influenced by flooding. For example, the bald cypress requires periodic flooding to produce seedlings. Overbank flooding provides for the interchange of nutrients and aquatic organisms between a stream and its floodplain. Impoundments reduce flooding but interfere with the natural exchange that occurs in free-flowing systems.



Aquatic lilies are attractive and locally abundant along some streams. Siltation, pollution, and altered stream flow may destroy the habitat of some stream plants and other aquatic organisms.

Stream Channel And Flowing Water

The stream channel with its flowing (lotic) water is the most obvious part of a stream ecosystem. Parts of any stream channel include the stream with its pools and riffles, the stream bottom with its bed material, and the stream banks. Deeper and slower moving pools are important habitat for fish. Riffles, because of the general turbulence and associated aeration, are productive stretches for aquatic insects and as fish spawning areas. The channel bed or substrate is used as habitat by many bottom dwelling **(benthic)** fish and invertebrates that provide food for fish. The upstream and local channel conditions (that is, slope) greatly influence the quantity and composition of bed material. The channel banks and riparian vegetation influence sediment entering the stream. Sodded stream banks can be sufficient to stop erosion in slow-moving (low gradient) streams but, if exposed to high flows, will usually erode. Woody vegetation, with its thick root system, provides better protection along the shoreline against channel erosion in most streams, particularly those prone to high-water flows.

Water flow within the channel or floodplain (instream flow) is a basic requirement for all streams. Instream flow has a variety of values and uses:

- Keeps water transportation lanes open.
- Turns turbines that produce electricity.
- Supplies water for domestic and industrial uses.
- Dilutes and helps assimilate natural and man-made wastes.
- Provides the conditions needed for the incubation of eggs and young of many aquatic organisms.
- Flushes fine sediments from the stream bed, making it more suitable for fish spawning and bottom-dwelling organisms.

Stream Ecosystems—Functional And Economic Values

An ecosystem is an ecological community of plants and animals together with its physical environment. An important ecological principle is that no one part of an ecosystem operates independently of any other part. This principle is clearly evident in stream ecosystems. Functional values of stream ecosystems include sediment and contaminant retention and transformation, improved water quality, groundwater recharge, food chain support, fish and wildlife habitat, and maintenance of biological diversity. To examine the functional values and uses of a stream, we need to look at more than just its channel of flowing water. Functional values of streams extend from their headwaters to the sea.

Streams are linked either directly or indirectly to adjacent floodplains, which are linked to upland watersheds. Streams are linked to groundwater and help to recharge aquifers that provide water (wells) for many people. Ultimately, streams are linked to estuaries and the sea. By virtue of this continuum and coupling, along with the capability of water to dissolve and transport materials and the mobility of fish and other aquatic and terrestrial organisms, there are exchanges among components of a stream ecosystem (Figure 4). In lower order streams, most of the food enters from overhanging vegetation (leaf fall) directly into the water.

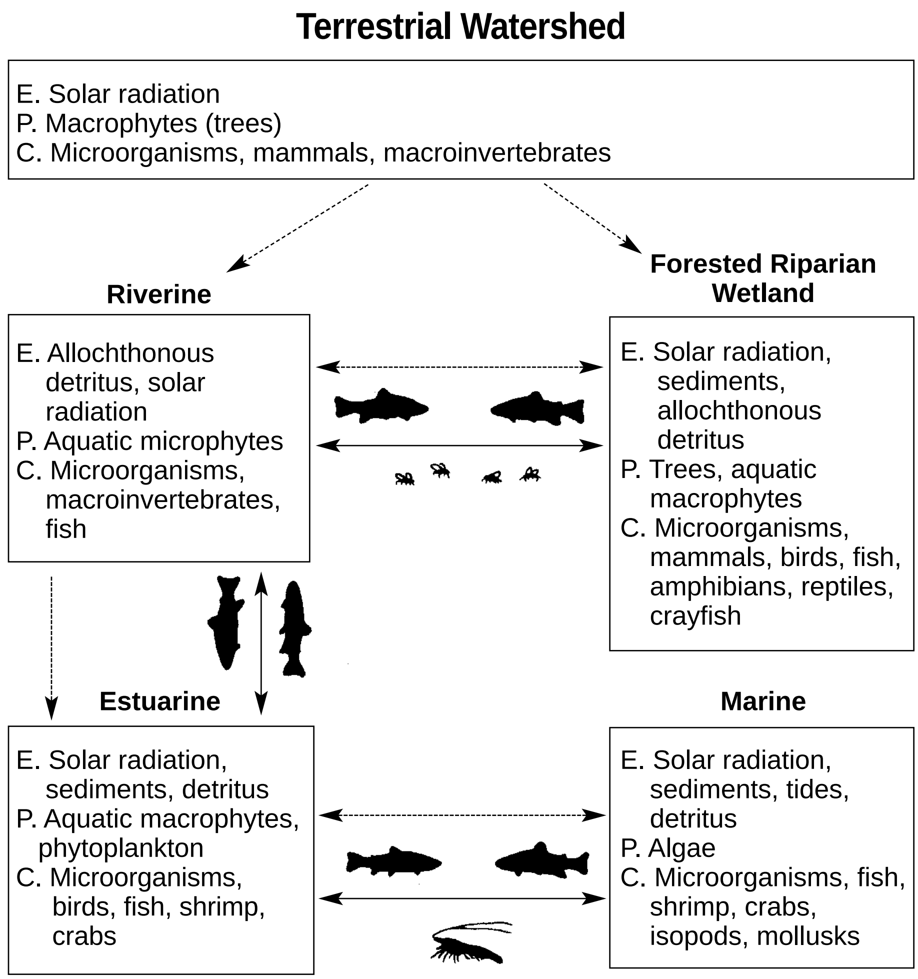


Figure 4. Schema showing the potential for transfer of materials between a palustrine wetland of a forested riparian floodplain and other systems linked directly or indirectly to the wetland. For each system (that is, terrestrial watershed, riverine, forested riparian wetland, estuarine, and marine), examples are given of major sources of energy for the system (E), some major primary producers for the system (P), and some major consumers for the system (C). Arrows with broken lines indicate direct linkage and direction of transfer of water, detritus, nutrients, and sediments. Arrows with solid lines indicate direct linkage and direction of movement of fish and other primary consumers.

• Organic matter (leaves) decaying in the watershed releases nutrients into groundwater.

• Groundwater flows into streams as seeps or springs.

• The nutrients released into the stream promote the growth of bacteria, algae, and rooted plants.

• These are eaten by aquatic insects, snails, and other organisms that become food for fish.

• Small fish become prey for larger fish, turtles, otters, birds, and man.

• Wastes and decay after death from all of these organisms release more nutrients that stimulate other food chains farther downstream (nutrient spiraling).

• These nutrients may become incorporated into soils with annual floods and cycle into various terrestrial food chains or be released back in groundwater into streams.

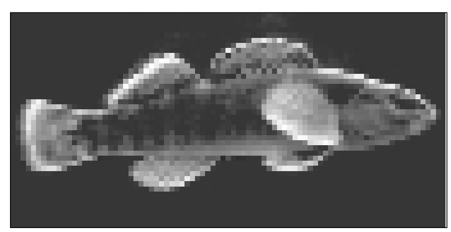
Eventually, as nutrients reach the sea, they are cycled into marine food chains, where they stimulate growth of estuarine and marine organisms. The crawfish, red snapper, or tuna you eat tomorrow received nutrients and possibly pollutants originating from the watershed, including your lawn, garden, field, or parking lot in previous years!

The functional aspects of this stream continuum depend on the rise and fall of flowing water necessary for the production of plants and animals along the floodplain, in the stream channel, and, ultimately, in the receiving waters of the coastal zone. Because no one part of a stream ecosystem operates independently of its other parts, we must consider the entire system or all of its parts to visualize the “big picture” (Figure 4).

Scientists have long known that trees help clean the air. Now they know that trees are effective water cleansers too. Riparian forests along streams serve as filters in two ways. First, nutrients from a watershed are soaked up by roots of trees in the floodplain and used for growth. Second, pesticides and other pollutants from the watershed are filtered as they seep through layers of soil in the floodplain. Some of the chemicals are retained in the floodplain until decomposed by natural biological processes **(biodegraded)**, lessening their toxicity before reaching the stream. High levels of pesticides or other pollutants jeopardize the use of streams for swimming, irrigation, livestock water, drinking water, and as a source of food fish. Artificial water treatment to remove contaminants from water and render it safe for fish, livestock, or human use can be very costly. Therefore, the rational approach is to prevent streams from becoming contaminated in the first place.

Imperiled Stream Species

The natural food supply and wide variety of habitats that healthy stream ecosystems provide are basic ingredients needed to support many types of animals and plants. Some stream systems, such as the Tennessee or Alabama river systems, support more than 150 species of fish and more than 100 species of a less conspicuous group of creatures, freshwater mussels. Some Alabama streams are home to several species of fish and mussels found nowhere else in the world. Unfortunately, a few species of mussels and fish that once lived in Alabama streams in modern times have become extinct. Several other species (11 fish species in Alabama by 1994) are so scarce that they have been placed on the Endangered or Threatened Species list. While the Endangered Species Act continues to be controversial, there can be no denying that the number of native species inhabiting our streams has declined, and this decline appears to be continuing. Destruction and loss



More than 300 species of fish are found in Alabama streams. Many species such as this darter and numerous other darters and minnows are inconspicuous but are an important component of stream ecosystems.

of habitat because of siltation and stream alteration resulting from dams is the major cause for the loss or decline of many species.

The pronounced decline in diversity and abundance of freshwater mussels serves as an indicator of the overall health of our streams. Although mussels have a substantial commercial value (more than $1 million annually in Alabama), they have an inherent worth that is difficult to measure in dollars and cents. Mussels are particularly sensitive to human-caused changes in streams. They serve as excellent water quality watch dogs, and they represent an untapped source of genetic material that may provide valuable medicines in the future. The introduction of the zebra mussel has further complicated native mussel depletions. The zebra mussel was accidentally introduced from Europe and first found in Lake St. Clair, Illinois, in 1988. Since that time it has spread into the Mississippi, Ohio, and Tennessee river basins, and predictions are that it will eventually inhabit most of the U.S. and southern Canadian river systems. The zebra mussel has caused extensive damage by clogging industrial and municipal intake pipes, but it also attaches to and smothers native mussels. The zebra mussel will undoubtedly cause ecological changes in our river systems, but its total impact will not be known for years.

The next nonindigenous species that will impact our native stream inhabitants is unknown, but other introductions will likely occur. One way in which introductions occur is through the release of aquarium species. Most aquatic plants, fish, and invertebrates sold in aquarium shops are not native to the southeastern United States. They have the potential to cause ecological problems and **should not be released into natural waterways.**

Economic Value Of Streams

The value of streams can be measured in economic terms by the value of navigation, hydropower, sewage assimilation, water supply, and recreation and tourism. These resources have an economic value exceeding several billion dollars annually. Fishing, boating, swimming, and other recreational uses of streams combined have a significant economic value, too. In sport fishing alone, anglers spend more than $1 billion annually fishing in streams in a fifteen-state area of the Southeast.

The aesthetic value of streams is difficult to measure in dollars. However, streams are being valued more and more for their beauty and versatility for photography, nature watching, and other outdoor experiences. As the number of relatively undisturbed streams decreases, the value—both aesthetic and economic—of those that remain will increase. A study completed in 1987 by Auburn University showed that more than a half-million Alabamians use free-flowing rivers for recreation. The same study showed that Alabamians were willing to pay about $57 per year per household if necessary to maintain the state's free-flowing rivers in their natural condition. This translates into an estimated value of about $76 million per year.

The aesthetic value of streams is difficult to measure. Streams are being valued more and more for their beauty and versatility.

Stream Problems

Many changes that altered the natural flow and scenic beauty of our streams were deliberate to provide for transportation, flood control, water supplies, hydroelectric power, and other economic benefits. These changes are usually associated with economic development activities that help us enjoy a comfortable life style. Today, with a better understanding and appreciation for ecological values, we need to consider the long-term effects of deteriorating stream ecosystems and to look for methods to conserve, restore, or enhance streams through management.

Watersheds

Healthy streams depend on healthy watersheds. Few if any watersheds are spared the influence of human use. Farming, forestry, mining, urban development, and road building are major watershed activities that—if not carried out properly—can degrade streams. Silt from excessive erosion in watersheds can settle in stream beds, suffocating aquatic organisms and destroying fish spawning and nursery habitats. Improper use of pesticides and fertilizers on farms, lawns, and gardens, and run-off from city streets and parking lots can result in unacceptable levels of chemicals in run-off water. Today specific industrial or municipal discharge sites ("point" source pollution), can be easily documented, and they are usually regulated. Non-point source pollution—those difficult to trace diffuse pollutants from general agriculture and forestry practices and urban run-off—have substantial impact and do **not** have simple solutions.

Channelization

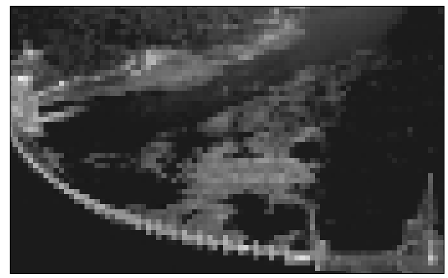
Channelization of streams is done to reduce the impacts of flooding or to make water transportation lanes more navigable. A channelization project may remove trees along the stream bank, deepen and widen the stream channel, and eliminate meandering, resulting in a free-flowing stream being changed to a straight-running ditch. This process speeds up the transport of surface run-off from the watershed and may reduce local flooding. However, local flood water is only transferred more rapidly downstream and often becomes a problem in another area. Channelization, along with the removal of riparian trees and vegetation, causes excessive siltation, destabilizes streamflow, reduces habitat and species diversity, and destroys fishery resources over large segments of a stream or estuary.

Dams And Reservoirs

The world's first hydroelectric dam was completed in 1892 on the Fox River at Appleton, Wisconsin. Since then, hydroelectric power has played a significant role in our homes and in the industrialization of our nation.

The Yellowstone River in Montana is the only major river in the contiguous 48 states that has not been severely altered for navigation or hydropower. In the past, Alabama's major rivers were free flowing too. Today, all of the state's major rivers except the Cahaba River have impoundments. Sections of the Little River have been designated Little River Canyon National Preserve.

Dams are built to provide domestic and industrial water supplies, to aid navigation, and to help prevent flooding. Many reservoirs also provide important recreation sites.



All of Alabama's major rivers except the Cahaba River have been impounded for hydropower, navigation, water supply, or other purposes.

Most dams built in recent decades have hydropowered generators to produce electricity. Hydropower does not release pollutants into the air as do fossil-fuel powerplants. Damming a river, however, dramatically alters a stream ecosystem by replacing a flowing water system with a relatively still water system, by creating a migration barrier for many aquatic species, and by changing the hydrology of the stream. Flowing water generally absorbs more oxygen than the calmer water of reservoirs or lakes. Without flowing water, many species of fish, mussels, and aquatic insects cannot survive, and these species are replaced by species that tolerate standing water (lake) conditions. The operation of some hydropower dams result in a wide range of water releases from very high flow when generating to almost no flow when generators are off-line. The frequency and wide variation in flows can adversely impact fish and other aquatic organisms below the dam.

Another type of ecological problem may arise if reservoir water is transferred to a stream located in a different basin or watershed. Interbasin transfer increases the supply of water in the receiving basin while depleting the quality and quantity of water in the donor stream. Aquatic organisms in the donor stream are deprived of the flow patterns to which they were adapted. Stream-flow depletion can destroy the habitat of many aquatic species, as well as reduce other stream values. Most states legally recognize instream flow needs of fish as a beneficial use of water. As of 1994, Alabama has not enacted such instream flow legislation.

Stream Management

There may be little that individuals can do to protect or improve large streams already developed for hydropower, navigation, or flood control. Where reservoirs exist, citizens and conservation groups should become involved in management decisions and activities. However, land owners and other concerned individuals or groups can become active in stream surveillance and serve as spokespersons for stream resources. Stream resources can be protected by joining or forming coalitions designed to protect stream ecosystems and by voicing concern and giving input to regulating agencies at public hearings. Individuals or families can become involved by joining citizen groups like Adopt-a-Stream or the Alabama Water Watch Program (see page 19, Where To Get Help).

A stream inventory is a good place to start if citizens are seeking to strengthen statewide stream-use legislation. This is not an anti-development approach; instead, it helps citizens manage development for the benefit of the entire community. South Carolina has completed an inventory that describes how the various sections of that state's waterways are used. This inventory provides citizens with information needed to make decisions about their stream resources, helping them understand and manage their waterways. An important part of South Carolina's streams assessment, completed in 1988, brought together the many economic, environmental, and recreational interests that use stream resources. Representatives from electric utilities, foresters, environmental organizations, landowners, recreational users, and other groups worked together. Various users of the streams had an opportunity to discuss which streams are crucial to their industries or economic interests and which streams are in need of protection.

Pollution

Both point and non-point sources of pollution impact streams. Point source pollution is effluent entering streams through pipes or other types of conduits. These sources are usually industrial or municipal and are typically wastes discharged from treatment facilities. Progress made in waste treatment technology over the past 20 years has made it possible to greatly reduce the amount of pollution from point sources and the damage caused by them. New pollution control and waste recycling technologies—and a keener awareness and support by the public of stream water quality needs—are expected to be the driving forces for continued improvements in point source pollution abatement.

Non-point source pollution (NPS) originates from fields, forests, streets and highways, construction sites, parking lots, lawns, gardens, and numerous other sources. Non-point source pollution is associated with rainfall run-off that moves over or through the ground and eventually enters streams. Agriculture, forestry practices, and urban run-off are major sources of NPS pollution. Land clearing and grading for construction projects, activities associated with timber harvesting and the mining of sand, gravel, and other minerals, septic tanks, garbage disposal sites, and urban run-off from streets, driveways, lawns, and gardens all contribute to NPS pollution. Run-off from these sources may contain chemicals, heavy metals, fertilizers, sediments, bacteria, or other pollutants that can lower the quality of stream water, kill fish, or reduce the quality or quantity of riverine habitat. Excessive sediments settling in stream beds can smother organisms and destroy aquatic habitat, including fish spawning beds. Siltation, resulting from erosion, is the single greatest threat to aquatic ecosystems in Alabama. In the short term, commercial fertilizer or animal and human wastes entering streams may cause an increase in available food to stream inhabitants. Too much of these materials, however, can change the delicate balance of nutrients and cause excessive growth of algae and aquatic plants. When these plants die, the process of decay uses up oxygen needed by fish and other stream inhabitants.

Bioaccumulation

Some pesticides and other chemicals in run-off may be toxic enough to kill aquatic organisms directly. Lesser amounts of such materials may not be toxic immediately but may accumulate in the flesh of creatures and later present health risks to fish, wildlife, and human beings that eat the fish.

Riparian Vegetation

Grass, shrubs, and trees adjoining streams can serve as filter strips that provide a natural buffer between a stream and its watershed. Vegetation slows down and filters run-off, retaining most of the dangerous material before it reaches the stream. Filter strips, like wetlands, and bottomland hardwood forests, not only improve water quality but also reduce soil erosion, provide habitat for wildlife, and serve as a corridor for wildlife movement. They are aesthetically pleasing. Trees adjacent to and hanging over the stream cool the water and provide or improve habitat for everything from insects to amphibians, fish, birds, and mammals. In the American West, 80 percent of all wildlife species are dependent on streams and their riparian areas. Plowing fields right up to stream banks (leaving no vegetated strip) or allowing cattle to graze freely on stream banks will impact stream quality through the destruction of the riparian zone.

Trees along streams serve an important role in helping to reduce the level of nutrients and pollutants from the watershed entering the stream.

Best Management Practices

Many agriculture and forestry enterprises are already implementing or starting to develop best management practices (BMPs). Benefits provided by filter strips are only part of the prescription or one of several management practices needed for keeping streams healthy. Best management practices in this sense are the most practical, effective, and economical means for preventing or reducing NPS pollution. “An ounce of prevention is worth a pound of cure” is generally applied to our health, but it applies to the health of streams too. Best management practices carried out in watersheds help prevent or reduce NPS pollution before it reaches the riparian zone or stream. Best management practices can differ from one watershed to the next, depending on variables, such as soil type, slope, and average rainfall. The following are some generally recognized BMPs that help maintain stream flow and integrity; however, they may not be effective in all situations.

- Maintain a minimum 50-foot wide vegetation zone (filter strip) along stream banks; use wider zones in areas of steep slope.
- Encourage the growth of native riparian trees in the vegetation zone.
- Stabilize eroding banks by anchoring logs or brush against the bank to redirect and slow the stream current around the erosion zone (these areas should fill with sediment and be recolonized by native vegetation).
- Routinely inspect the stream, looking for problems and noting changes.

Assessing Stream Quality

The natural variety and ever changing conditions of streams make it impossible to come up with one set of guidelines for determining the condition of each stream or the best management options for each stream. The following discussion is based on scientific research conducted on streams in the Southeast and should be considered as only a guide to assessing streams. This type of assessment is often done as an ecological teaching tool by “water watch” organizations to get concerned individuals acquainted with streams and to look at general stream conditions.

The two most common ways to assess streams are based on (1) water quality and (2) the number and kinds of aquatic invertebrates. These stream quality assessments are only “snapshots” at a point in time and streams are best understood by repeated assessments or by carefully following stream conditions over a long time so that trends can be identified.

The Stream Quality Assessment Form (page 19) and Figure 5 (page 14) are examples of stream assessment methods. Note that information like canopy cover, vegetation type, riffle size, and substrate composition are also important to stream assessment but are beyond the scope of this publication.

Water Quality

Water testing to determine the presence or absence of pollution can be complicated and expensive. Only a few federal, state, university, or private laboratories have the sophisticated equipment to test for pesticides or heavy metals. A few simple tests, however, can help anyone better understand the general quality of the stream water and, over time, to note changes. Many of these water quality tests can be done using relatively inexpensive test kits that can be easily mastered by anyone with a minimum of training. Many water watch programs across Alabama are actively involved in stream monitoring. If you are interested in joining one of these groups or in learning more about water quality testing, contact the Alabama Department of Environmental Management (ADEM) or your county Extension office.

The water quality tests that are commonly done by citizen groups include tests for temperature, pH, turbidity, dissolved oxygen, total alkalinity, and total hardness. These tests must be performed with care and records of these data must be kept to study the long-term trends of the stream quality. The following is a general discussion of why these water quality parameters are important and what they may indicate.

Temperature affects feeding behavior, growth, and reproduction of all aquatic organisms. Temperature also affects how much oxygen water can hold, how fast decay occurs and nutrients are recycled, and even the density of water. Changes in water temperature follow but lag behind those of air temperatures. Air temperature, spring flow, sunlight striking the water, rain events, depth of the water, and other factors all affect water temperature. Long-term trends of altered water temperature may indicate that vegetation in the watershed has been reduced, that spring flow into the stream has been altered, or that surface flow rates have increased.

A **pH test** is a measure of the hydrogen ions. A pH of 7 is neutral, while a pH below 7 is acidic and above 7 is basic. Most aquatic organisms can tolerate a pH range from 6 to 9, although a rapid change of even 2 units can be harmful to some. A pH below 5 or above 10 would be a condition in which very few organisms could survive. A consistently high or low pH may indicate pollution, possibly from mining or industrial sites.

Turbidity is a measure of suspended substances in the water that make the water cloudy. Turbidity usually is a combination of suspended soil particles, organic matter, and microscopic plankton. Turbidity blocks sunlight needed by underwater plants and algae, and it generally increases the absorption of heat from sunlight, slowly raising the temperature of the water. Soil particles can settle to the bottom and suffocate benthic organisms. High turbidity levels could indicate heavy soil erosion, drainage from swamps and forests bringing in particles from the decay of vegetation, or heavy nutrient inputs from urban or agricultural run-off.

Like land creatures, aquatic organisms need **oxygen** to live. The amount of oxygen that will dissolve in water is very small and is measured in parts per million (ppm). Oxygen concentrations in a stream can range from 0 to more than 15 ppm. A dissolved oxygen concentration (DO) between 5 and 10 ppm is sufficient to support a healthy stream environment. Oxygen dissolves directly into the water from the air through water turbulence created by wind, riffles, and waterfalls and from underwater plants and algae that produce oxygen as a by-product of photosynthesis. The amount of DO in a stream will vary, depending on the amount of water movement, bottom structure, amount of sunlight, water temperature, and number of organisms (plants, animals, and bacteria) that use oxygen. More oxygen can dissolve in cool water than in warm.

As temperature increases in summer, less oxygen can be dissolved into the water, particularly at night, when underwater plants and all other organisms are using oxygen in respiration. Most aquatic organisms survive best at DO concentrations above 5 or 6 ppm, will become severely stressed at DO below 3 ppm, and may die if DO concentrations fall near 1 ppm. Low DO readings generally indicate high rates of respiration from dense algal blooms or high decomposition rates, both of which could be associated with organic or nutrient pollution.

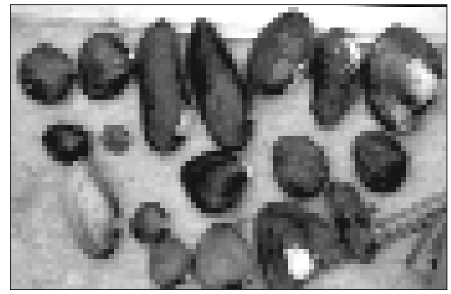
Total alkalinity and **total hardness** are closely associated measures of dissolved solids. Alkalinity is a measure of carbonate and bicarbonate bases in water and is therefore related to pH. Hardness is a measure of calcium and magnesium ions dissolved in water. Alkalinity and hardness can range from 0 to more than 500 ppm. Sandstone and granite bedrock and their associated soils will usually result in surface waters of low alkalinity and low hardness. Limestone bedrock and alkaline soils will produce run-off water with moderate to high alkalinity and hardness. Alkalinity and hardness concentrations below 20 ppm are considered soft waters with limited plant and animal productivity, while concentrations above 20 ppm are more productive. Sufficient alkalinity (more than 50 ppm) buffers or resists pH changes.

Aquatic Invertebrates

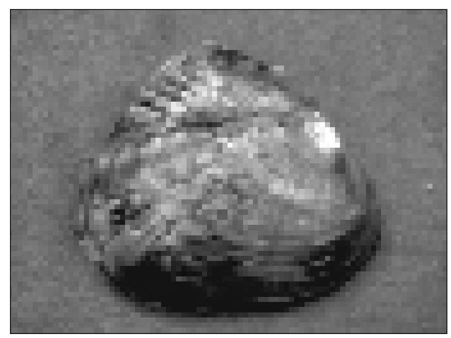
Organisms survive and prosper in any environment because it meets their needs. Therefore, a look at the organisms inhabiting an environment tells us much about that environment and its stability. In streams we could look at higher plants, plankton, insects, worms, mollusks, crustaceans, or fish. Recent research suggests that the larger invertebrates (macroinvertebrates—insects, worms, mollusks, and crustaceans) may be the most reliable indicators of a stream's health. This reliability stems from the fact that these invertebrates do not readily move around and so cannot leave or return quickly to avoid poor stream conditions. They are also abundant, and their diversity spans the ecological range of aquatic environments. So, macroinvertebrates that inhabit a stream are a profile of the overall health of that stream. Some of these creatures tolerate only pristine environments and die-off quickly if conditions decline; others tolerate limited pollution, particularly if it is temporary or intermittent; and some will survive even in very polluted environments. Macroinvertebrates present must tolerate whatever the conditions of their stream, so the species present do not change rapidly, and they are good indicators of stream quality.

Aquatic biologists are the only group truly qualified to interpret macroinvertebrate ecology, but even a novice can sample these creatures and get a feel for their diversity and habitat needs. The following discussion may not apply to stream quality in all cases, but it will provide those interested individuals with an example of how these kinds of ecological data are collected and evaluated.

The best place to sample these organisms is in riffle areas. These shallow areas, where the water flows over boulders, cobble, gravel, and woody debris, usually have high DO and many microhabitats. The most diverse and sensitive macroinvertebrates live in many microhabitats of riffle areas. Sample or capture macroinvertebrates using a fine mesh (less than 1mm) net held on edge on the stream bottom and placed facing upstream so that the current flows into the bag of the net. Then disturb the stream bottom upstream from the net, using hands or feet. The current sweeps the macroinvertebrates into the net. Collect samples from the bottom of the riffle upstream until you have at least 100 creatures.



A unique combination of native freshwater mussels, many of which are found nowhere else in the world, depend upon Alabama streams for survival.



Mussels are particularly sensitive to human caused changes in streams. The decline in both the diversity and abundance of native freshwater mussels in many streams serves as an indicator of the overall ill health of our streams.

Compare the macroinvertebrates captured to those in Figure 5 to assess the general condition of the stream. The specific types of macroinvertebrates found and the number of different groups (taxa) indicate the overall condition of the stream. The more taxa found and more organisms from Group 1 identified, the better the quality of the stream. Conversely, fewer taxa and large numbers of Group 3 organisms indicate poor water quality or polluted conditions. In other words, as stream habitat quality declines, intolerant species disappear, and tolerant species prosper in large numbers because they do not have many competitors.

The results of stream water quality tests and observations of macroinvertebrate populations over time will provide useful information on the quality of a stream and changing trends in stream conditions. The data can provide a starting point from which informed decisions about stream impacts and management can be made by water quality professionals.

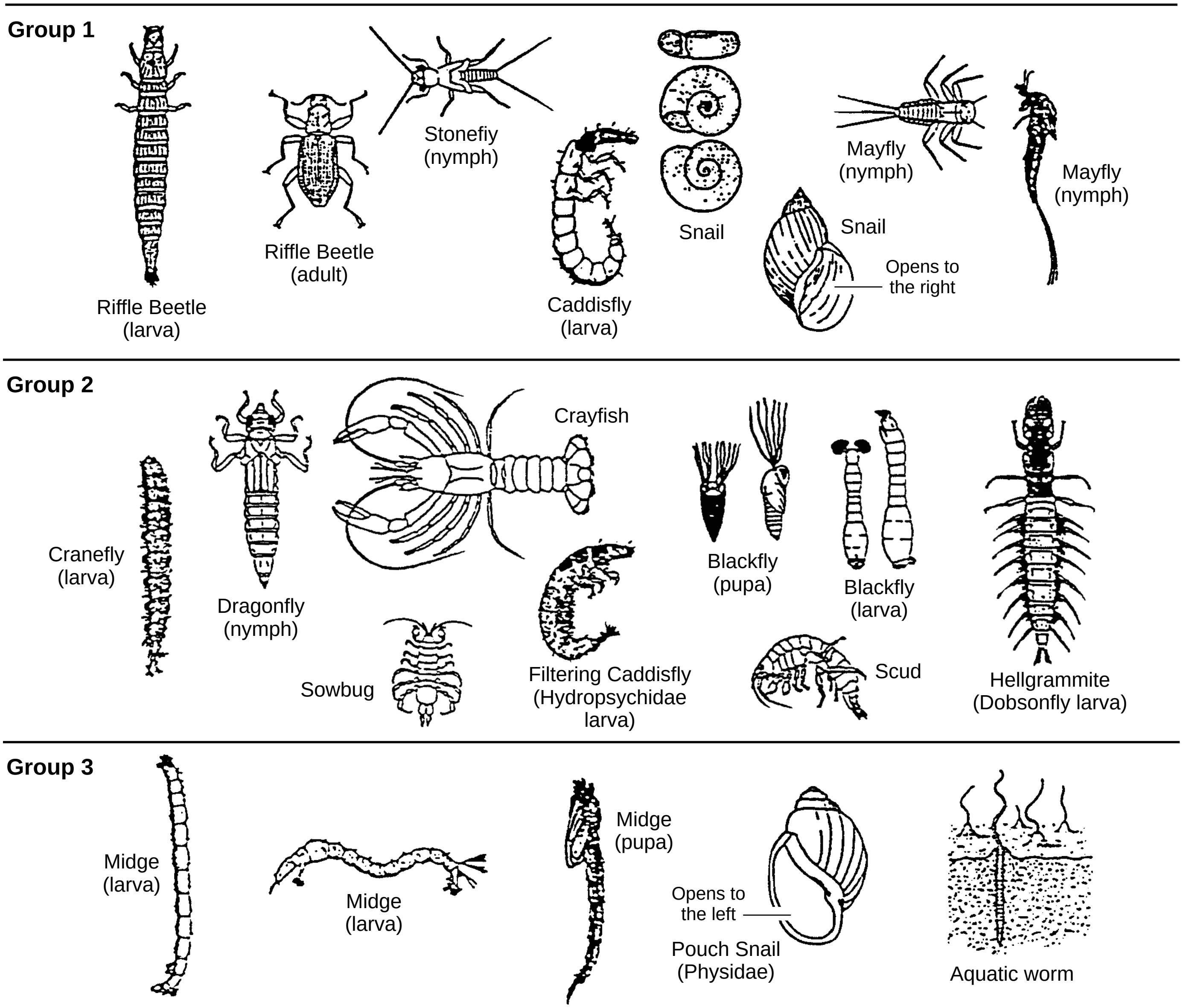


Figure 5. Macroinvertebrate groups picture key. **Group 1** organisms are generally pollution intolerant. Their dominance generally signifies excellent to good water quality. **Group 2** organisms exist in a wide range of water quality conditions. **Group 3** organisms are generally tolerant of pollution. Their dominance usually signifies fair to poor water quality. Courtesy Bio-Assess, Auburn University.

What Else Can Be Done

National And Local Governments And Water And Management Authorities Can:

1. Support ecosystem and watershed research and management programs. Encourage the restoration or maintenance of the ecological functions of streams.

2. Support efforts to minimize soil erosion. Less erosion means higher productivity and profits for agricultural enterprises and less sediment in run-off. Less sediment in run-off reduces losses of fish habitat and reduces the frequency of disturbances to streambeds where dredging is required.

3. Encourage energy conservation. Reduced demand for electricity can limit or postpone the need to build new dams or to extract fossil or nuclear fuels.

4. Support research and education programs related to stream management and best management practices for land and water resources.

Developers And Contractors Can:

1. Install silt fences, hay bales, sediment basins, or other appropriate sediment controls before clearing a site (Alabama law requires that any disturbance greater than 2 acres must have a permit from ADEM and must follow best management practices).

2. Take corrective actions immediately, if erosion problems occur.

3. Minimize tree and vegetation disturbances. Retain natural vegetation around drainage areas. Revegetate disturbed areas immediately.

4. Maintain the natural drainage of the site to the fullest extent possible.

5. Avoid diverting concentrated run-off into natural streams or gullies.

6. Design drainage systems to maximize infiltration into the soil and minimize concentrated flows that may require curbs and gutters.

7. Post signs educating the public as to where run-off goes when it leaves the immediate area (for example, a sign on a storm drain that says, "Water entering this drain flows into the Cahaba River").

Industries Can:

1. Develop and use safer chemicals.

2. Support and develop ways to recycle and use wastes.

3. Abide by water pollution laws.

4. Employ and train certified operators of pollution control facilities.

5. Retain credible and well-trained "in-house" environmental specialists (biologists, hydrologists, engineers).

Farmers, Foresters, And Other Land Owners Can:

1. Adopt and carry out pesticide and soil best management practices and soil conservation measures.

2. Where applicable, adopt integrated pest management strategies to reduce or eliminate pesticide use.

3. If pesticides are used, follow manufacturers' label directions for rate and time of application and disposal of containers and tank rinse water. Become a certified pesticide applicator and keep up-to-date by attending professional meetings, enrolling in short courses.

4. Manage nutrient inputs, including fertilizers, manure, and nitrogen from legumes, so that they meet, but do not exceed, crop nutrient needs.

5. Use a wide variety of soil and water conservation practices such as no-till or minimum till, terracing, crop rotation, and contour planting.

6. Keep livestock out of streams so their wastes cannot pollute the water and their activities cannot cause bank erosion.

7. Keep water used to wash out animal confinement areas out of streams.

8. Dispose of dead animals according to state regulations—burying 4 feet deep, rendering, or incinerating.

9. Apply animal wastes or compost for fertilizer at rates suggested by a soil test.

10. Practice logging and erosion control on forest lands according to BMPs for logging and construction and maintenance of logging roads and stream crossings.

11. Leave a buffer strip of trees and shrubs or grass along the edges of streams or drainage channels. Fifty feet of trees along some streambanks is the minimum buffer-width needed to filter pollutants (Alabama Forestry BMPs suggest only 35 feet).

12. Manage the land with the interest of long-term profits and with future generations in mind.

Civic Groups And Schools Can:

1. Become educated about stream ecology and best management practices for land and water resources.

2. Encourage other civic, environmental, educational, business, and governmental groups to join in sponsoring sound pollution preventive measures.

3. Encourage local public officials to develop sound erosion control ordinances at construction sites.

4. Organize, promote, and participate in "stream sweep days" and "adopt-a-stream" programs.

5. Sponsor a tour to identify potential causes of and remedies for non-point source pollution and stream system deterioration.

6. Sponsor and promote a household chemical waste collection day to allow people to bring in unused containers of paint, oil, and other chemicals for disposal (see Circular HE-623, "Disposal Of Household Chemical Wastes"). Encourage local government officials to establish a continuing program for collecting and disposal of household chemical wastes. Contact your county Extension office for disposal of pesticides classified as hazardous wastes.

7. Become informed about local threatened or endangered (or indicator) species identification, distribution, life history, habitat requirements, values.

Homeowners, Gardeners, You, And I Can:

1. Follow manufacturer's label directions when using fertilizers, pesticides, or other chemicals. Do not overtreat for pests or overfertilize lawns and gardens.

2. Recycle or dispose of used oil, antifreeze, paints, and other household chemicals by wrapping in newspaper and then in plastic before you add it to household refuse. Do not place such materials in storm sewers, drains, or streams.

3. Plant trees, shrubs, grasses, or other ground cover to help filter out pollutants and reduce run-off.

4. Compost grass and leaves. If placed in streets they will wash into storm sewers and into streams or lakes.

5. Construct septic tanks and filter lines at least 50 feet from stream banks or wells and make certain that the soils have good drainage. Maintain the septic tank and field line. Periodically call a septic service to pump out solids and dispose of them according to Department of Health regulations.

6. Give away or euthanize live pet fish or other aquatic animals and allow aquatic plants to die. Do not release them into streams, lakes, or wetlands.

7. Become informed about stream ecology. Attend a seminar or workshop or read a book. Attend a lecture or visit a museum.

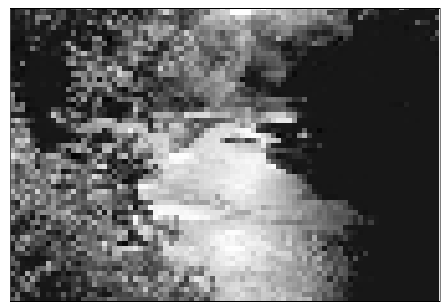
8. Become informed about and encourage enforcement of regulations and laws pertaining to pollution and stream care.

9. Call your local stream or water resource management agency, watershed board, or community action network and ask what you can do to help.

10. Conserve water in the home and in the yard. Use water-saving faucets and toilets; plant low-maintenance shrubs and grass and mulch flower beds.

11. Conserve electricity in the home and gasoline on the road.

12. Join a water watch, adopt-a-stream, or other community organizations that protect and enhance stream environments.



Trees, shrubs, and grass along streams serve as filter strips that slow down run-off and help reduce erosion, improve water quality, and provide habitat for wildlife.

Where To Get Help

Alabama Cooperative Extension System (offices in each Alabama county) provides information on the best farm and garden plants for local conditions, integrated pest management, pesticide and herbicide use, pesticide certification, best management practices in agriculture and forestry, composting, youth projects and can put you in touch with local citizen groups interested in environmental concerns.

National Resources Conservation Service (NRCS, formerly Soil Conservation Service—offices in most Alabama counties).
665 Opelika Road
Auburn, AL 36930
(334-887-4506)

Alabama Forestry Commission
513 Madison Avenue
Montgomery, AL 36130
(334-240-9300)

Alabama Department of Environmental Management
1751 W. L. Dickinson Drive
Montgomery, AL 36130
(334-271-7700)

Alabama Department of Conservation and Natural Resources
J. E. Folsom Administration Building
Montgomery, AL 36130
(334-242-3471)

Alabama Nature Conservancy
2717 7th Avenue South, Suite 201
Birmingham, AL 35233
(205-322-3126)

U.S. Fish and Wildlife Service
P.O. Drawer 1190
Daphne, AL 36526
(334-441-5181)

U.S. Army Corps of Engineers
P.O. Box 2288
Mobile, AL 36628-0001
(334-694-3861)

Tennessee Valley Authority (TVA)
TVA Aquatic Biology Department
Norris, TN 37828
(615-632-1782)

Geological Survey of Alabama
420 Hackberry Lane
Tuscaloosa, AL 35486-9780
(205-349-2852)

Cahaba River Society
2717 7th Avenue South, Suite 205
Birmingham, AL 35233
(205-322-5326)

American Rivers
801 Pennsylvania Avenue, SE,
Suite 303
Washington, DC 20003
(202-547-6900)

American Fisheries Society
5410 Grosvenor Lane
Bethesda, MD 20814
(301-897-8616)

U.S. Forest Service
1765 Highland Avenue
Montgomery, AL 36107
(334-832-4470)

Alabama Water Watch, Coordinator
Department of Fisheries
203 Swingle Hall
Auburn University, AL 36849-5627
(334-844-4786)

Adopt-a-Stream
340 N. Hull Street
Montgomery, AL 36104
(800-252-7257)

Acknowledgment

We would like to acknowledge the following colleagues who provided photographs used in this publication: Mary Freeman, Frank Boyd, Cliff Webber, and Monty McGregor.

There is growing awareness and concern over the accessibility and quality of stream resources. Time may be running out for saving or restoring the ecological values of some streams.

Stream Quality Assessment Form

Monitoring Group

Name ______________________________

Stream Name ______________________________

Site Location ______________________________

____

Date ____________ Time (military) ____________

County ______________________________

Town/City ______________________________

Chemical Assessment

(Please convert °F to °C: °C = (°F - 32) × 5/9)

Air temperature °C _____ Water temperature °C _______

(Please convert feet to centimeters: cm = ft. × 30.48)

Water depth (cm) ______ Secchi depth (cm) ________

Alkalinity (mg/l) ________ Hardness (mg/l) __________

Dissolved Oxygen (mg/l) ________ pH (SU) _________

Turbidity (JTU) _________

Organic substrate components: ____________________

Canopy cover:

open partly open partly shaded shaded

Streamside vegetation type: ______________________

Turbidity: clear slightly turbid turbid opaque

Describe Water Conditions: (Color, odor, bedgrowths, surface scum, etc.) ______________________________

Width Of Riffle: _____________

Bed Composition Of Riffle (%)

Silt: _______

Sand: _____

Gravel (1/4" to 2"): _______

Cobbles 2" to 10"): _______

Boulders (>10"): ________

Macroinvertebrate Tally

Letter Code For Tally

R = 1 to 3 individuals (Rare)
C = 4 to 9 (Common)
A = 10 or more (Abundant)

GROUP 1 TAXA	Letter Code	GROUP 2 TAXA	Letter Code	GROUP 3 TAXA	Letter Code
Mayfly		Hellgrammite		Aquatic Worm	
Stonefly		Dragonfly		Midge	
Caddisfly		Crane Fly		Pouch Snail**	
Riffle Beetle		Filtering Caddisfly*			
Snail		Crayfish			
		Asiatic Clam			
		Sowbug			
		Water Penny Beetle			
		Blackfly			
Number of Taxa = ________		Number of Taxa = ________		Number of Taxa = ________	
Multiply by 3 = ________		Multiply by 2 = ________		Multiply by 1 = ________	
(Index Value)		(Index Value)		(Index Value)	

* Filtering Caddisflies are in the Family Hydropsychidae (gills on abdomen; most common caddisfly).

** Pouch snails are in the Family Physidae (shell opens to the left; air-breathing snail).

Total Number of Taxa
(Sum of number of taxa in each group) ☐

Cumulative Index Value
(Sum of index values for each group) ☐

Stream Quality Assessment:

(Check box corresponding to Cumulative Index Value)

Excellent (>22) ☐ Good (17-22) ☐

Fair (11-16) ☐ Poor (<11) ☐

For more information, call your county Extension office. Look in your telephone directory under your county's name to find the number.

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