NRCS Natural Resources Conservation Service

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# Warmwater Streams

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## Introduction

Streams and the corridors through which they flow are valued resources across the United States. Streams and stream corridors also support many recreational opportunities including fishing, canoeing, kayaking, swimming, and hiking. Stream corridors have tremendous economic value as agricultural and forest lands and provide some of the most desirable sites for real estate development, highways, and railroads. Less well understood, but equally important, are the ecological values stream corridors provide including water quality protection, water supply, flood pulses, nutrient cycling, and biological diversity. Warmwater streams provide habitat not only for popular game fish such as bass and catfish, but also for non-game fish such as darters and minnows, amphibians, aquatic insects, some reptiles, and many species of mussels, clams, and crayfish.

This leaflet focuses on small warmwater streams. The average water temperature of a warmwater stream during the summer is usually greater than 75° F. This temperature generally excludes trout and other coldwater species that require cooler temperatures and higher oxygen levels. Readers of this leaflet will become more familiar with the physical, biological, and chemical processes that characterize warmwater stream systems and how these processes influence habitat conditions both within the stream and the adjacent riparian zone. In addition, methods, resources, and funding sources available to landowners wishing to conserve, improve, or restore warmwater stream habitats are identified.

## Warmwater stream systems

A stream corridor consists of a stream, its adjacent riparian zone, and its floodplain. The riparian zone is the portion of the terrestrial landscape from the high water mark towards the uplands, where vegetation may be influenced by elevated soil moisture. The floodplain is the land alongside the stream that is susceptible to flooding. Intact stream corridors are

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**Clear Creek in California is an example of a warmwater stream.**

among the most diverse, dynamic, and complex habitats and ecosystems in North America. Their riparian zones account for less than 2 percent of the land area of the U.S., yet more vertebrates depend on these areas during some part of their life cycle than any other habitat type. Streams and their floodplains have historically served as town sites and have been used for irrigation, transportation, water supply, hydroelectric power, industrial development, and even waste disposal sites. These human activities cause increased surface erosion, excessive sedimentation, water pollution and altered hydrologic conditions, which significantly degrade or eliminate stream and riparian habitats.

A warmwater stream and its riparian zone is an integrated ecosystem, such that the effective functioning of one component affects the health of the others. For example, the seasonal flooding of streams enriches the soil of riparian areas with nutrient-rich alluvium. Alluvium is material (sand, gravel, silt, topsoil) that is deposited in the floodplain of a river or stream during flood events. Alluvium is created as a result of erosion. Alluvium can significantly alter floodplains, as is the case in the Mississippi River Delta, which began forming from alluvium millions of years ago. Alluvium from the Mississippi River has created rich, agricul-

Billy Teels, NRCS

**Riparian buffers protect and improve stream habitat.**

tural land in the lower Mississippi Delta. These deposits, along with increased soil-moisture from flooding, increase plant productivity in riparian zones and floodplains. Likewise, the stream benefits from the riparian plant community—overhanging vegetation provides shade and important cover for fish; tree roots stabilize banks; the input of leaf litter and other organic material feeds microbes and invertebrates that are at the base of the food chain; large wood provides instream cover and habitat complexity for aquatic species; and dense understory vegetation helps filter surface water that runs off the land during storms. Due to the interdependence of warmwater streams and their riparian zones, the degradation of either of these components adversely affects the flora and fauna of the others.

## Warmwater stream fauna

### Fish

There are hundreds of different species of fish found in warmwater streams in the U.S. The most complete guide available on freshwater fishes is *The Atlas of North American Freshwater Fishes* (Lee et al. 1980), which documents some 775 species. Table 1 lists some common native warmwater fishes.

To learn which fish species are likely to occur in a particular watershed, contact the local state fish and wildlife agency, or visit *http://www.fishbase.org/search.cfm* to search for the information on the internet. The distribution of fish throughout the U.S. depends on their particular habitat needs and their ability to colonize a given stream. Barriers to the dispersal of fish can be as large as a mountain range and can be as small as a road culvert or a 10-foot waterfall. While some barriers to migration can easily be identified, others are difficult to detect. For example, a stream may be too steep for a fish to swim up, or a short segment of stream may have such poor water quality that a fish will avoid it.

### Factors affecting fish distribution

The distribution of fish within a stream is affected by physical factors including water temperature, gradient or steepness, substrate, and flow. Temperature variations occur both seasonally and longitudinally (in an upstream and downstream direction), and different fish species tolerate or prefer different temperature ranges. Some species seek different temperatures at different stages of their life cycles. The gradient of the stream channel influences not only fish distribution, but also water velocity, substrate size, and pool formation.

Many natural factors cause variations in the chemical make-up of streams that in turn affect the distribution of fish. Hardness of the water (level of dissolved mineral concentration), dissolved oxygen, pH, salinity, and the concentrations of heavy metals and chlorine all affect the distribution and abundance of fish and other aquatic species.

Billy Teels, NRCS

**The satinfin shiner (*Notropis analostanus*) is one of a number of species of shiner found in warmwater streams across North America.**

Blly Teels, NRCS

**The largemouth bass (*Micropterus salmoides*) prefers clear, quiet waters with lots of vegetation and can be found in warmwater streams in most regions of the United States.**

**Table 1** Common native warmwater fishes[1]

| Common name(s) | Genus | Range in North America |
|---|---|---|
| rock bass, shadow bass, Roanoke bass | *Ambloplites* | eastern U.S., Great Lakes Region |
| central stoneroller, largescale stoneroller, Mexican stoneroller, bluefin stoneroller | *Campostoma* | eastern and central U.S., northern Mexico |
| suckers (many different species) | *Catostomus* | most of continental U.S. and Canada, northern Mexico |
| redside dace, rosyside dace | *Clinostomus* | Great Lakes Region, eastern U.S. |
| banded pygmy sunfish, Okefenokee pygmy sunfish, everglades pygmy sunfish | *Elassoma* | souteastern U.S. |
| blackbanded sunfish, bluespotted sunfish, banded sunfish | *Enneacanthus* | eastern U.S. |
| chain pickerel, grass pickerel, redfin pickerel, muskellunge | *Esox* | eastern U.S., Mississippi Valley, Great Lakes Region |
| smoothbelly darters (many different species) | *Etheostoma* | central and eastern U.S. |
| topminnows (many different species) | *Fundulus* | eastern U.S., Mississippi Valley |
| bigeye chub, highback chub, lined chub, rosyface chub, clear chub | *Hybopsis* | eastern U.S., Mississippi Valley, Great Lakes Region |
| channel catfish, blue catfish | *Ictalurus* | central U.S., southern Canada |
| redbreast sunfish, green sunfish, orangespotted sunfish, bluegill, dollar sunfish, longear sunfish, redear sunfish, spotted sunfish | *Lepomis* | most of continental U.S. |
| white shiner, crecent shiner, striped shiner, warpaint shiner, common shiner, duskystripe shiner, bleeding shiner, bandfin shiner | *Luxilus* | eastern U.S. and Great Lakes Region |
| largemouth bass, redeyebass, smallmouth bass, Suwannee bass, spotted bass, Guadaloupe bass | *Micropterus* | continental U.S. |
| striped bass, yellow bass, white bass, white perch | *Morone* | most of continental U.S. |
| redhorse suckers, redhorses (many different species) | *Moxostoma* | central U.S., Mississippi Valley, central Canada |
| bull chub, bigmouth chub, river chub, bluehead chub, redtail chub, hornyhead chub, redspot chub | *Nocomis* | eastern U.S., Mississippi Valley, Great Lakes Region |
| shiners (many different species), redeye chub, silverjaw minnows, Ozark minnows | *Notropis* | most of continental U.S., central Canada |
| madtoms (many different species) | *Noturus* | eastern U.S., Mississippi Valley, Great Lakes Region |
| roughbelly darters (many different species) | *Percina* | eastern and central U.S., central Canada |
| creek chub, fallfish, Sandhills chub | *Semotilus* | eastern and central U.S. |

[1]For specific habitat information about these fish, visit *www.fishbase.org/search.cfm*.

Several biological factors also affect fish distribution, not only longitudinally, but also vertically in the water column, and according to specific habitats within a reach of steam. Biological factors affecting fish distributions include predation, competition, and behavioral differences. For a given species to exist in the presence of one of its predators, it must have access to hiding cover in the form of large bottom substrate, woody material, or overhanging banks and vegetation.

Behavioral differences among fish include choice of substrate for spawning (laying eggs) and feeding behavior. Some fish use sandy stream bottoms to spawn, some spawn on vegetation or in the water column, some require gravel or crevices to build their nests, and others bear live young. Feeding behaviors differ greatly among species and vary according to where in the water column a fish finds food, the time of day it feeds, the type of food eaten, and the size of food items selected. Many species can be found in close proximity due to only slight differences in feeding behavior. For example, it is not uncommon for more than 20 species of fish to occupy a relatively short reach of many southern streams (approximately 100 meters).

Whereas many natural influences affect the distribution of fish and other aquatic organisms, human disturbances are often equally influential. For example, acidic water drainage from mines and roadfills (soil material used in road embankments) has reduced aquatic fauna and caused water quality problems in many streams of the eastern U.S. Hydroelectric dams and water supply impoundments can dramatically alter a stream's flow regime and habitat quality and act as physical barriers to fish dispersal, while sewage and industrial wastewater outflows often create chemical barriers. In addition, human intervention has significantly expanded the range of many fish species, both intentionally and unintentionally, to areas where they did not naturally occur. The introduction of nonnative species has contributed to the decline and extinction of many native fish that were not able to survive in the face of new competition or predation.

The combined effect of human influences has been a dramatic decline in native freshwater fauna. About one-fourth of native freshwater fish species, three-fourths of native freshwater mussel species, one-fourth of native amphibians, and one-third of native crayfish species are considered to be imperiled or extinct. In 1998, at least 40 percent (by length) of streams of the U.S. were listed as impaired by the Environmental Protection Agency (EPA). This effect is most pronounced in warmwater streams where the greatest faunal diversity and most extensive disturbances occur.

## Aquatic macroinvertebrates

Aquatic macroinvertebrates including insects, crustaceans, mollusks, and worms are an important part of the aquatic food web, feeding on organic material (algae or leaves) and other organisms, and serving as food for larger animals, such as fish. Aquatic macroinvertebrates can serve as indicators of water quality. Because these aquatic animals differ in their sensitivities to water pollution, their presence or absence is a good indication of the quality of the water in which they are found. Table 2 identifies various macroinvertebrates and their sensitivities to contamination. By examining the macroinvertebrates living in a particular stream reach, the water quality and overall stream health can be inferred.

Freshwater mussels make up a large group of aquatic macroinvertebrates. Nearly 300 species and subspecies of freshwater mussels are present in the U.S. The south-central U.S. has the highest diversity of freshwater mussels in the world. Like many other aquatic macroinvertebrates, freshwater mussels are highly sensitive to habitat disturbances. Of the 297 known native mussel species in the U.S., 72 percent are considered endangered, threatened, or of special con-

Blly Teels, NRCS

**Giant stoneflies (*Pteronarcys californica*, above) and leeches (*Clitellata, Subclass: Hirudinea*, below) are aquatic macroinvertebrates found in streams. Giant stoneflies are very sensitive to water contaminaton, while leeches are tolerant of it.**

cern. Only 70 species are considered to have stable populations, although many of these also have declined in abundance and distribution. Freshwater mussels benefit from intact, well-managed stream reaches. When stream reaches become degraded as a result of human activity, mussel populations suffer.

### Amphibians and reptiles

Many amphibians (frogs, toads, salamanders, and newts) require access to warmwater streams to complete various stages of their life cycles (breeding), as well as to keep their glandular skin moist. Amphibians are most frequent and abundant in floodplain wetlands and riparian zones during their breeding seasons. Some species of reptile including turtles, lizards, alligators, and snakes also depend on riparian areas adjacent to streams for feeding, basking, and egg-laying. Riparian areas can be critical for reptiles and amphibians by providing avenues for dispersion to new habitats.

## Stream assessment

Landowners wishing to improve stream habitat should first evaluate the existing conditions. The health of a stream ecosystem depends on the interaction of several physical, chemical, and biological processes that can be relatively easy to evaluate. However, many factors such as streamflow, water quality, and sediment transport are affected by processes occurring upstream or at other places in the watershed and so cannot be adequately addressed by the evaluation of a small reach. On the other hand, there is much that a landowner can do to protect and/or improve stream and riparian habitat quality on the property. A quick visual assessment will often yield clues about the general health of a stream reach. A simple evaluation of canopy cover in the riparian area, bank stability, water clarity, and other easily recognizable features often suggest actions that can be taken to improve stream and riparian habitat.

**Table 2** Aquatic macroinvertebrate sensitivity to pollution

| Very sensitive | Somewhat sensitive | Tolerant |
|---|---|---|
| Caddisflies | Damselflies | Aquatic worms |
| Mayflies | Dragonflies | Black fly larvae |
| Stoneflies | Crayfish | Midge fly larvae |
| Riffle beetles | Scuds | Leeches |
| Water pennies | Sowbugs | Pouch snails |
| Gilled snails | | Other snails |
| Hellgrammites | | |
| Freshwater mussels | | |

The Stream Visual Assessment Protocol (SVAP) developed by the Natural Resources Conservation Service (NRCS) is a simple tool that requires little specialized equipment or experience. Table 3 summarizes some of the components and characteristics of streams evaluated by the SVAP. Using SVAP, the landowner can evaluate and score each stream habitat component separately and then average all the scores together to determine an overall rating of stream condition. If the landowners do not feel that they have the expertise to make this assessment, they can solicit assistance from the local NRCS biologist. Individuals interested in obtaining a copy of the SVAP can visit *http://www.nrcs.usda.gov/technical/ECS/aquatic/svapfnl.pdf*.

## Conserving and restoring instream and riparian habitats

Once a reach of stream has been assessed, the landowner may focus on actions that can be taken on the property that will benefit the stream and its flora and fauna. Techniques to improve instream cover, such as placing large wood in the stream, are often successful at increasing the diversity and abundance of fish. For long-term maintenance of good aquatic habitat, establishment of riparian vegetation that will naturally fall into the stream may be all that is required. Other approaches to stream corridor restoration are described in the multi-agency Stream Corridor Restoration Handbook available online at *http://www.nrcs.usda.gov/technical/stream_restoration/*.

Larger-scale stream habitat improvements should be planned in partnership with other land users who manage lands adjacent to streams. Before designing and implementing a stream habitat project, consider the known or expected problems within the watershed such as non-point source water pollution land management activities such as logging, farming, or development; and other watershed-related concerns. Non-point source pollution comes from many diffuse sources. It is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into streams and other bodies of water. The pollutants in non-point source pollution include: excess fertilizers, herbicides, and insecticides from agricultural lands and residential areas; oil, grease, and toxic chemicals from urban runoff and energy production; and sediment from improperly managed construction sites, crop and forest lands, and eroding streambanks.

Any stream habitat management project is most effective when applied within the context of overall watershed conditions and with clear objectives for stream management goals. There are several options that can be used singularly or in combination to improve stream habitat:

- Through watershed planning, establish soil conservation, nutrient management, pesticide management, and other management practices to minimize non-point sources of water pollution.
- Manage excessive surface runoff with grassed waterways.
- Restore or protect riparian and floodplain vegetation and associated wetlands.
- Maintain enough water in the stream to allow fish species to swim upstream and downstream.
- Maintain physical habitat components important to aquatic species such as sediment-free spawning gravel, boulders, large wood, resting pools, overhead cover, and stable banks.
- Eliminate fish migration barriers such as improperly installed stream crossings.
- Provide barriers/screens to exclude fish and other aquatic species from water pumps, diversion ditches, or any area where unintentional entrapment could occur.
- Improve floodplain-to-stream channel connectivity including off-channel habitats by

**Table 3** SVAP components of stream health

| | High score | Above average score | Below average score | Low score |
|---|---|---|---|---|
| **Channel condition** | natural channel; no evidence of erosion | evidence of past channel alteration | altered channel | channel is actively downcutting or widening |
| **Hydrologic alteration** | flooding every 1.5-2 years | flooding every 3-5 years | flooding every 6-10 years | no flooding |
| **Riparian zone** | natural vegetation extends >2 active channel widths on each side | natural vegetation extends 1 active channel width on each side | natural vegetation extends 1/3 of active channel width on each side | natural vegetation extends <1/3 the active channel width on each side |
| **Bank stability** | stable | moderately stable | moderately unstable | unstable |
| **Water appearance** | very clear or clear, but tea-colored | occasionally cloudy | considerable cloudiness | very turbid or muddy |
| **Nutrient enrichment** | clear water | slightly greenish water | greenish water | pea green, gray, or brown water |
| **Barriers to fish movement** | no barriers | water withdrawals limit fish movement | drop structures <1 foot | drop strucutres >1 foot |
| **Instream fish cover** | >7 cover types available | 5-6 cover types available | 2-3 cover types available | 0-1 cover type available |
| **Pools** | deep and shallow pools abundant | pools present but not abundant | pools present but shallow | pools absent |
| **Riffle embeddedness** | gravel or cobble particles are <20% covered with fine sediment | gravel or cobble particles are 20-40% covered with fine sediment | gravel or cobble particles are >40% covered with fine sediment | riffle is completely covered with fine sediment |

setting back or eliminating berms, levees, and dikes.

- Limit streamside access for recreational use, livestock, and equipment.
- Use irrigation waters as efficiently as possible, maximizing the amount of water left in the stream for aquatic fauna.

**Maintain or restore riparian buffers**

By far the most important factor affecting stream conditions and aquatic habitats on a local scale is the presence of an ecologically functional riparian buffer. Vegetated stream buffers serve numerous functions including filtration of sediments, nutrients, and toxins; contribution of woody material to the stream channel; contribution of organic matter that forms the base of the food chain; floodwater storage; bank stabilization and erosion reduction; shading and consequent stabilization of water temperatures; and provision of habitat for terrestrial invertebrates, amphibians, reptiles, birds, and mammals. The benefits of riparian buffers on both aquatic and terrestrial wildlife vary dramatically based on the types of vegetation planted and the width of the area planted. In general, benefits increase with increasing width and complexity, and the wider and more ecologically complex the buffer the more value it will have for wildlife and other aquatic species in the stream.

In naturally forested landscapes, the ideal riparian buffer zone has mature trees spaced sufficiently to allow an understory of grasses, forbs, and shrubs. Trees should be close enough to the stream so that exposed roots supply cover and allow stable undercut banks to develop. This proximity to the channel assures that some trees will fall into the stream when they die, providing habitat complexity in the channel. Grasses, forbs, and shrubs should have deep root systems, dense top growth, and an ability to recover and grow subsequent to inundation of water and sediments during floods.

Kathryn Boyer, NRCS

**Vegetated riparian buffers serve valuable ecological functions.**

Landowners can take an active role in maintaining and restoring riparian buffers by planting native woody species as seedlings or saplings. On the other hand, the landowner may choose to take a passive approach to restoration, and simply allow natural recruitment of woody species along the streambank. If the landowner takes the more active approach, there are a number of factors to consider.

Before beginning, a landowner should examine the surrounding plant community and learn about native plant species and current and projected flooding of the stream. With this information, the landowner is better equipped to restore native vegetation in such a way as to maximize growth based on flooding and/or drought. It is not practical to plant the full complement of vegetation desired in the riparian area. Rather, a landowner should plant dominant species, or those species unlikely to colonize readily, and let the others establish themselves over time. Typically, vegetation at the outside edge of the stream corridor is very different from the vegetation that occurs within the interior of the corridor. The topography, aspect, soil, and hydrology of the corridor provide several naturally diverse layers and types of vegetation. An edge that gradually changes from the stream corridor into the adjacent landscape features will soften environmental gradients, minimize any associated disturbances, encourage species diversity, and buffer nutrient and energy flows.

**Leave woody material in place**

Woody material in the form of fallen trees, limbs, and branches plays a major role in both aquatic and terrestrial components of ecosystems and should be maintained within the riparian buffer. Woody material helps trap sediment that may otherwise enter the stream. In addition, woody materials create seedbeds for additional recruitment of woody species, help retain moisture during droughts, and provide an important habitat component for many invertebrates, amphibians, reptiles, birds, and mammals. Along the stream bank, branches and fallen trees can help to stabilize streambanks and provide moist cover for amphibians such as salamanders. Within the stream channel, large wood provides important cover for many fish and other organisms and traps fine sediments. Large logs extending above the water are often used as perch sites for wading birds while reptiles such as turtles and snakes often use them to bask in the sun.

Billy Teels, NRCS

**Woody material plays a major role in both aquatic and terrestrial ecosystems.**

Allowing fallen tree limbs, branches, and even entire trees to stay in-place can significantly improve both instream and riparian habitat. To maintain the ecological integrity of the stream and riparian area, it is not essential that every piece of woody material be left in place, but rather that the landowner takes into consideration the value of woody material to wildlife rather than hastily clearing the ground to a manicured and unnatural state. Through informed decisions, ecological benefits and personal preferences for aesthetic appearance can be well balanced.

### Construct fishways and replace culverts

Instream barriers, such as dams, weirs, and road culverts, can reduce the ability of many fish to move freely upstream and downstream to spawning, rearing, and feeding areas. While some barriers are man-made, others are natural, such as cascades or waterfalls. If possible, man-made fish barriers should be removed or modified to allow fish passage. Replacing culverts to conform to the gradient of the stream and allow free fish passage can be done efficiently by working with conservation partners and state agencies. For example, bottomless arch culverts can replace perched culverts to make fish passage easy. Fishways can be built to allow fish to migrate through or over barriers. Fishways are constructed by creating a series of pools and small steps over or around the barrier, usually with rocks. Fish are able to move up or down the fishway by swimming into a pool, resting, and then swimming up or down the step into the next pool, until they have cleared the barrier. For more information on fish passage techniques, see *http://wdfw.wa.gov/hab/engineer/habeng.htm* or *http://www.stream.fs.fed.us/fishxing/index.html*.

### Manage livestock access

Livestock using riparian areas and streams for forage or water often trample streambanks and riparian vegetation. Grazing prescriptions that minimize access to these vulnerable areas are an effective way to protect stream corridors. Fences can be built to limit livestock access to riparian areas where damage is extensive. If livestock need access to the stream for water, a fenced chute can be installed to allow access to only a small portion of the stream. Funding for fencing to manage livestock access in streams and riparian areas is available to landowners through the USDA Wetland Reserve, Wildlife Habitat Incentive, and Environmental Quality Incentive Programs, and the U.S. Fish and Wildlife Service Partners for Fish and Wildlife Program (table 4).

### Use pesticides and fertilizers safely

Fertilizers and pesticides (including herbicides and insecticides) can have serious detrimental effects on stream habitat and water quality. Fertilizers are tak-

Washington Department of Fish and Wildlife

**Bottomless arch culverts (left) can replace perched culverts (right) to make fish passage easy.**

Billy Teels, NRCS

**Fences can be built to keep livestock away from streams, protecting streambanks.**

en up by algae in stream waters, a process that uses up valuable oxygen and can produce poisonous methane, ammonia, and sulfur gases, which can kill fish and other aquatic animals. Pesticides can be toxic to humans, animals, and plants and they are one of many factors contributing to the decline of fish and other aquatic organisms. Insecticides are used to kill destructive crop and forest insects, but they can also kill beneficial stream insects and fish. Similarly, herbicides used to kill land weeds can also kill oxygen-producing water plants and reduce the food supply for aquatic animals.

Homeowners, farmers, ranchers, and land managers using fertilizers and pesticides can use these chemicals wisely and minimize their effects on warmwater streams.

- Avoid fertilizing near streams or on steep slopes, particularly during rainy weather or when the ground is frozen or covered with ice and snow.
- Apply pesticides only when and where necessary, using those that are short-lived, avoiding applications near streams or drainage ditches, using soil conservation practices to limit runoff, and properly disposing of old or unused pesticides and their containers.
- Read and follow the directions on fertilizer or pesticide labels.
- Consider Integrated Pest Management (IPM) when managing insects and other pests.

IPM is a system of using a variety of methods, including pesticides, to reduce pest populations to acceptable levels. IPM strategies include agricultural control (crop rotation and selected planting dates to avoid pests), host resistance (using plants and livestock that are resistant to pests), mechanical control (uprooting, weed harvesting, cultivation, and use of insect traps), biological control (introducing a pest's natural predators), and chemical control (using pesticides).

**Address streambank conditions**

Severely eroding streambanks are often the first sign that a stream and its habitat are in poor condition. Landowners wishing to stop erosion of streambanks should seek technical assistance in evaluating the cause of the severe erosion and methods to minimize further damage that are compatible with conservation of fish and wildlife habitat. Newer approaches to streambank stabilization especially suitable for small streams involve using natural materials such as logs, boulders, live trees, and/or branches to temporarily arrest erosion until riparian vegetation can be reestablished. These approaches, referred to as bioengineering, usually employ live cuttings of readily sprouting species that are set deep into the bank.

Streambank restoration has proven most successful in slowing bank erosion when the flow regime is relatively unaltered or controlled to mimic natural conditions. Decisions regarding whether and how to use stabilizing techniques should be based on local site conditions, as well as watershed conditions, such that no standard approach can be outlined in this leaflet. Successful implementation of bioengineering techniques requires professional design, installation, and long-term monitoring. However, in many cases bioengineering is the most effective solution available to restore streambanks to healthy conditions, so landowners should consider contacting local state agencies for assistance with streambanks that have been severe-

Billy Teels, NRCS

**The instability and erosion apparent in this stream are signs of an unhealthy streambank.**

Federal Interagency Stream Restoration Working Group, 1998

***Bioengineering employs live cuttings of readily sprouting species that are set deep into the bank to increase streambank stability.***

ly eroded. In such cases, professional opinions will be invaluable in determining what solutions are likely to be most cost effective, if indeed a feasible option does exist. For additional information and guidelines for implementation, see *http://plant-materials.nrcs.usda.gov/technical/publications/riparian.html.*

## Assistance programs

Financial and technical assistance for maintaining and improving warmwater stream habitat is available from an array of government agencies and public and private organizations. Table 4 lists organizations that can provide technical and/or financial assistance to landowners for warmwater stream management and other natural resource projects, and describes their associated conservation incentive programs.

## Conclusion

Human activity has had a significant impact on warmwater streams and the fish, aquatic invertebrates, birds, mammals, reptiles, and amphibians that live in and around them. However, warmwater streams can be managed in such a way to protect, improve, or restore stream habitats. A stream assessment, followed by habitat management practices such as maintaining and restoring riparian buffers, managing woody material, reengineering stream crossings, managing livestock access, limiting and properly using fertilizers and pesticides, and addressing streambank conditions can greatly benefit the habitats and biota of warmwater streams. The resultant healthier streams provide many ecological and economic benefits, including recreational opportunities and increased water quality and biodiversity.

**Table 4** Assistance programs

| Program | Land eligibility | Type of assistance | Contact |
|---|---|---|---|
| Conservation Reserve Program | Cropland (including field margins), riparian pastureland, highly erodible land. | 50% cost-share for establishing permanent cover, annual rental payments in return for establishing long-term, resource-conserving covers, additional financial incentives are available for some practices. | NRCS or FSA state or local office |
| Environmental Quality Incentives Program | Cropland, rangeland, grazing land, and other agricultural land in need of treatment. | Up to 75% cost-share and incentive payments to implement conservation practices to a maximum term of 10 years. | NRCS state or local office |
| Partners for Fish and Wildlife Program | Most degraded fish and/or wildlife habitat. | Up to 100% financial and technical assistance to restore wildlife habitat under minimum 10-year cooperative agreements. | U.S. Fish and Wildlife Service local office |
| Waterways for Wildlife | Private land. | Technical and program development assistance to coalesce habitat efforts of corporations and private landowners to meet common watershed level goals. | Wildlife Habitat Council |
| Wetlands Reserve Program | Previously degraded wetland and adjacent upland buffer, with limited amount of natural wetland and existing or restorable riparian areas. | 75% cost-share for wetland restoration under 10-year contracts and 30-year easements, and 100% cost-share on restoration under permanent easements. Payments for purchase of 30-year or permanent conservation easements. | NRCS state or local office |
| Wildlife at Work | Corporate land. | Technical assistance on developing habitat projects into a program that will allow companies to involve employees and the community. | Wildlife Habitat Council |
| Wildlife Habitat Incentives Program | High-priority fish and wildlife habitats. | Up to 75% cost-share for conservation practices under 5- to 10-year contracts. | NRCS state or local office |

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