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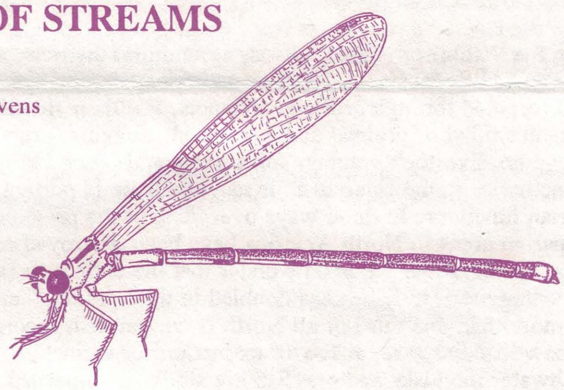
CONSCIOUSNESS OF STREAMS

by Gretchen Stevens



"...by means of water We give life to everything."
The Koran

Water is essential to many human enterprises and also to fundamental processes that maintain ecosystem functions. Without sufficient quantities of clean, unregulated water, streams and wetlands cannot provide the ecological services on which we depend. In our studies of Hudson Valley streams, Hudsonia has found depauperate fish and invertebrate fauna in formerly rich streams, extreme turbidity in streams of agricultural watersheds, and dramatically elevated pollution levels in streams of rural, suburban, and urban settings.

The biological diversity and ecological integrity of a region are closely tied to the vitality of the freshwater streams embedded in the landscape. The well-being of each stream, moreover, is inextricably linked to the condition of its watershed. Because streams and other waterbodies are down-gradient of most human activities, they receive a disproportionate burden of pollution and disturbance in developed regions. In this article I outline some of the direct and indirect effects of human activities that are damaging to streams, and offer suggestions for minimizing the impacts of certain land uses, and for restoration of damaged streams to functional communities of native stream organisms.

Riparian Corridors and Natural Disturbance

The riparian corridor (i.e., the stream, its floodplain, and proximate upland areas) is of critical importance to terrestrial and aquatic ecosystems. The continuous exchange of energy, nutrients, and organisms among aquatic, riparian, and upland communities makes those communities ecologically inseparable.[6] Indeed, many stream ecologists insist that a stream and its floodplain can be understood and managed only as a single ecosystem.[3] Riparian meadows, shrublands, and forests provide habitats for a great variety of wildlife, provide an ecological buffer for the stream itself, and serve a multitude of crucial functions: for example, removal of nutrients, sediments, and other pollutants from stream floodwaters, and from surface runoff and shallow groundwater entering the stream; stabilization of streambank and floodplain soils; maintenance of stream flows during drought periods; contribution of herbaceous and woody debris to the aquatic habitat and food web; and filtering of noise, visual disturbance, and intrusion of human activities from the habitats of sensitive biota.

Riparian areas may be the most diverse and complex of all non-marine habitats.[11] The physical and biological diversity of stream corridors is largely maintained by periodic and aperiodic disturbances associated with flowing waters, e.g., floods, droughts, ice scouring, sediment and debris deposition, and channel migration. By such mechanisms, a natural riparian corridor develops a complex mosaic of habitats which enables a large variety of plants and animals to coexist in a relatively small area. When humans attempt to reduce the irregularities of a stream system, or reduce the impact of natural disturbances by straightening channels, installing riprap and artificial walls, constructing dams, removing woody debris, and filling and paving floodplains, the resulting simplification of habitats can be devastating to the stream ecosystem.

Approximately 10 km of the Wallkill River (the Cheechunk Canal in part) in Orange County, New York, have been straightened and riprapped to facilitate drainage of the Black Dirt croplands and to reroute the river around two landfills. Large woody debris has been removed from the channel to

ALSO IN THIS ISSUE: *Technical Assistance projects p. 6, Natural History Courses p. 7, Sponsor & Donor Lists p. 8*

prevent the formation of debris dams and hasten drainage of floodwaters. During a fish survey in 1992,[8] Hudsonia found very few species and individuals of fishes at a sampling station in a channelized segment of the Wallkill, in marked contrast to our eight other stations upstream and downstream of that segment. A 1978 survey of another channelized segment of the Wallkill had similar results. The biologist observed "...the Cheechunk Canal is an excellent example of how a productive stream can be destroyed by stream channelization."[17] Debris removal has further depleted the Wallkill of valuable habitats. Trees and large branches (snags) that lodge in stream channels, and the debris dams that snags create, provide food and cover for stream invertebrates. Removal of snags, particularly in the sandy Wallkill where good benthic habitat is scarce, can drastically reduce fish food productivity.

Human Impacts on Streams

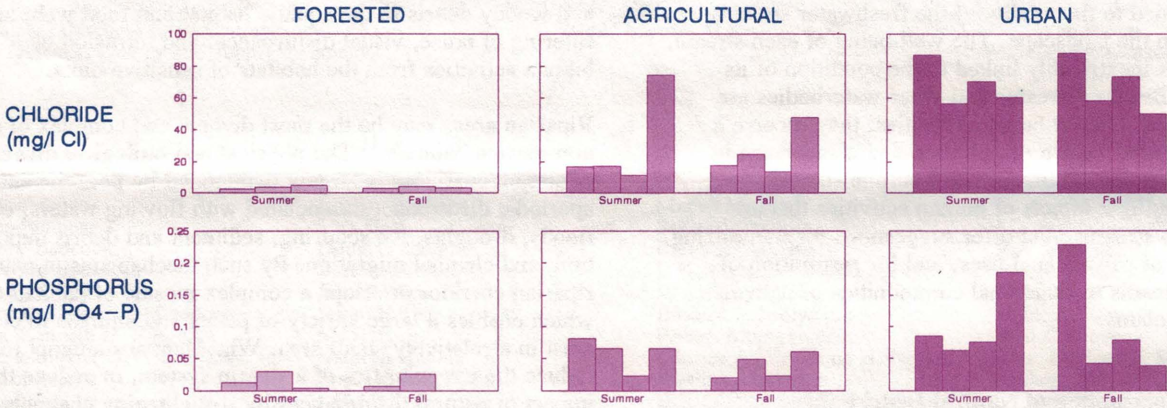
As in the Wallkill, in cities, towns, agricultural districts, and other areas of concentrated human activities, streams are often rerouted through artificial channels, and their floodplains are filled or drained and developed. Logging, crop cultivation, livestock grazing, soil mining and other disruptive activities in the riparian zone can eliminate important riparian functions. In these ways over 70% of the pre-colonial riparian areas in North America have been destroyed or seriously degraded.[11] It is no wonder that the extinction rate of North American fishes has doubled in this century,[23] and that more than one-third of all North American fish species are now listed as rare, at risk of extinction, or extinct. Freshwater mollusks and crayfish are similarly imperiled. Habitat destruction, water pollution, and pressure from introduced species are the primary causes of these declines and extinctions.[4,10] The brook trout is an example of a once common native species that has been extirpated from many streams in the Northeast due to habitat degradation and, in some cases, competition from non-native species.

Urban, suburban, and rural residential development are attended by increased intensity of land uses, volume of wastes, and demands for water. Sediment-laden runoff from construction sites; chloride, heavy metals, hydrocarbons, and sand in road and parking lot runoff; biocides and fertilizers from lawns, gardens, and other manicured grounds; nutrients[13] and perhaps pathogens[2] from septic leachate; and nutrients, chloride, and toxins from sewage treatment plant effluent are all likely to increase in streams located in developing landscapes. Storm runoff from urban streets can be more highly contaminated than treated sewage effluent.[1] Increased withdrawals of groundwater and surface water for household water supplies can lower the regional water table, and deplete the water supply to wetlands and streams.

Stream Assessment

Stream water chemistry is affected by the bedrock and surficial geology of the watershed, the nature and timing of point and non-point pollution discharges, atmospheric deposition, and the biological influences in the watershed and stream. Stream water chemistry may change dramatically from day to day or from season to season due to both natural and anthropogenic causes. Because water is continuously moving through a stream, the water chemistry at any particular time and place reflects only momentary conditions. Pulses of pollutants are easily missed by infrequent water sampling. Stream organisms, on the other hand, especially those that are relatively sedentary such as diatoms (glassy-walled, single-celled algae) and invertebrates (insects, crustaceans, mollusks), tend to integrate pollution effects and thus they reflect to some degree the pollution status of the stream over time. Using diatoms, invertebrates, and fishes, stream ecologists have developed various biological indices to the water quality and habitat quality of streams which can reveal aspects of stream ecosystem function not detectable in water chemistry data alone.

(continued on p.4)

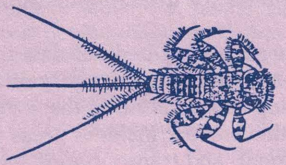


stream codes: 1 2 3 | 4 5 6 7 | 8 9 10 11

1=Cascade Brook; 2 = Breakneck Brook; 3 = Doodletown Brook; 4 = Chase Road Brook; 5 = Mud Creek; 6 = Klein Kill; 7=Moodna Creek; 8 = Casper Creek; 9 = (unnamed Ossining stream); 10 = Sparta Brook; 11 = Quassaic Creek

Fig. 1. Concentrations of chloride and phosphate−phosphorus in 11 Hudson River tributaries with watersheds of predominantly forested (streams 1−3), agricultural (streams 4−7), and urban (streams 8−11) land uses. Data are from W.C. Nieder (unpublished data), Parsons and Lovett (1993), and Stevens et al. (1994). Summer concentrations are means of monthly samples taken June−August; fall concentrations are means of monthly samples taken September through December.

Stream Management Problems and Possible Remedies

Problems	Remedies
Excessive nutrients added to streams in runoff from fertilized agricultural lands, lawns, pastures, golf courses and urban roads, in leachate from septic systems, and in discharges from sewage treatment plants can lead to excessive growth of aquatic weeds, and blooms of algae in streams. The decomposition of large amounts of plant material can lead to decreased oxygen levels in sluggish streams; extremely low dissolved oxygen can be lethal to fishes and aquatic invertebrates.	Upgrade sewage treatment to remove nutrients, and increase setbacks for residential septic systems. Adopt low-input agricultural, landscaping, and turf management practices which rely on reduced applications of slow-release fertilizers, and strategic timing and methods of application. Direct all runoff from roads, pastures and fertilized lands into vegetated detention ponds where nutrients can be taken up by plants, broken down into elemental forms, or incorporated into the sediments before drainage water enters streams. Nutrient-rich sediments can be dredged from detention ponds and returned to the land.
Sediment pollution is one of the most widespread, damaging, and neglected forms of stream pollution. The primary sources are runoff from croplands, disturbed soils on construction sites, and roads, parking lots, and other paved surfaces that receive sand applications. Sediment deposition in streams can smother plants, mollusks, fish eggs, aquatic insects, and other stream organisms, and can hinder the buildup of large populations of invertebrates, a basic food source for many freshwater fishes.	Use Best Management Practices for cropland tillage to reduce the volume of soil carried away by wind and runoff. Direct all cropland runoff into vegetated detention ponds where sediments can settle out before drainage water enters streams. Install and maintain rigorous erosion control measures on all construction sites. Reduce road sanding and salting near streams, and direct all runoff from roads and other paved areas into detention ponds.
Removal of trees and shrubs from stream banks can lead to bank erosion, loss of stream bank habitats supported by woody root systems, and increased summer water temperatures. Elevated temperatures can alter the metabolic and reproductive activity of stream organisms, and cause shifts in invertebrate dominance. Temperature alterations exert the greatest influence on specialized species with narrow thermal tolerances. Brook trout, for example, are restricted to cool streams in part because they require high levels of dissolved oxygen; warm water holds less dissolved oxygen than cool water.	Plant native woody vegetation wherever possible on non-wooded stream banks to create shade for the stream and to foster bank stability. 
Biocides (herbicides, fungicides, rodenticides and insecticides) are present in runoff from cropland, golf courses, gardens, and lawns. Many turf chemicals are listed by the U.S. EPA as known or probable human carcinogens, and many are also toxic to aquatic invertebrates, fish, birds, amphibians, reptiles and other wildlife. The common misuse of pesticides by homeowners, golf course managers and others can lead to dangerous concentrations of toxins in groundwater and streams.[14,18]	Use pest-resistant turf grasses, and adopt Integrated Pest Management (IPM) practices which rely on monitoring of pest conditions; mechanical, cultural, and biological treatments where appropriate; and minimal use of least-toxic chemical treatments only as a last resort.[14]
Stream banks that are trodden or grazed by livestock are sources of sediments, nutrients, and pathogens. Grazing and trampling destroys plant cover and soil stability, leading to bank erosion, destruction of stream bank habitats (e.g., undercut banks and muskrat burrows), widening of stream channels, and siltation of stream beds. Livestock feces contain high levels of nitrogen, coliform bacteria, and sometimes other pathogens.	Fence all pasture areas adjacent to streams to prevent livestock from grazing, trampling, and defecating in or near the stream. If there is no other drinking water source for pastured livestock, construct a narrow, hardened, fenced ramp to permit access to the stream without compromising soil stability.
One of the greatest threats to North American fisheries may be the loss of spawning and nursery areas.[15] Tributaries appear to be very important to spawning fishes of the Hudson River estuary,[20,21] but many tributaries have dams in their lower reaches that prevent the passage of spawning fishes (none have fish ladders).	Fish ladders have been successfully installed on most tidal streams in New England.[19] Installation of fish ladders on certain Hudson River tributaries could substantially increase the spawning runs of anadromous (marine to freshwater) and potamodromous (freshwater to freshwater) fishes.[20]
Construction, paving, logging, soil mining, clearing vistas, creating lawns, and other disruptive activities in and near riparian areas can eliminate riparian functions essential to both streams and uplands.	Establish and maintain buffer zones of substantially undisturbed soils and vegetation along streams wherever possible. A buffer zone should encompass the entire riparian corridor and a protective upland zone. Buffer zones can be maintained by landowner agreement, by conservation easement, by land purchase, or by the authority of local zoning ordinances.
The introduction of non-native fish species to a stream can threaten native populations by competition for food, predation, genetic swamping, and habitat alteration. Brown trout, bluegill, and common carp are all non-native to this region, but have been widely introduced into northeastern streams. Pressure from introduced species is a significant contributor to the nationwide population declines and extinctions of many listed rare fish species.[4]	Discourage further introductions of non-native fishes; restore high quality stream habitats and native fish communities wherever possible.

Because fish are dependent on the health of the entire aquatic community, as well as on physical and chemical aspects of stream habitats, they may be the best biological indicators of the condition of the system as a whole. Certain fishes, such as brook trout and slimy sculpin, require clean, cool streams, while others such as common carp and common sunfish can tolerate warmer stream temperatures and considerable organic pollution. Stream macroinvertebrates are less mobile (cannot easily move away from pollution), so they may reflect local conditions more accurately than the fish community. Invertebrates are important food for fishes and birds, and are one of the most important ecological components of streams because they process the dead plant matter that forms the base of the stream food web. The environmental tolerances and sensitivities for certain macroinvertebrate taxa are well known. For example, abundant stoneflies, mayflies, and caddisflies are usually indicative of clean water. Abundant chironomids (midges) and oligochaetes (aquatic earthworms) are usually associated with organic pollution and nutrient enrichment. Attached diatoms are less mobile than fish or macroinvertebrates, so they may be the most reliable indicators of local habitat quality. Because diatoms are short-lived and reproduce rapidly, diatom populations adjust quickly to water quality modifications.[5] Thus if sampled with sufficient frequency, diatoms may be more useful than fishes or macroinvertebrates for detecting intermittent pollution.

There is a growing body of data indicating that the water quality and biological integrity of streams decreases with increasing urbanization of the watershed.[1,7,9,13,16] (Urbanization in this context includes areas in residential, industrial, institutional, and transportation uses.) A study of the water quality of 17 streams in southeastern New York found that small increases in urbanization resulted in a disproportionate deterioration of stream water quality.[16] In one Hudsonia study we found that even low levels of common pollutants (phosphorus, chloride, sulfate) were correlated with marked depressions in the quality of the macroinvertebrate and diatom communities in three Hudson River tributaries.[22] Another Hudsonia study of 16 Hudson River tributaries found that urbanization of a stream's watershed was associated with conspicuous declines in the spawning success of anadromous fish.[9] Figure 1 illustrates some differences in the water quality of Hudson Valley streams of forested, agricultural, and urban watersheds. The inset on page 7 of this issue lists several stream reaches under particular stress.

* * *

Population pressures will continue to increase in the Hudson Valley and in the Northeast in general. We are already beginning to suffer from drinking water shortages, and we have used up the waste assimilation capacity of many streams. Stream degradation has tangible consequences to public welfare, and to regional economics (e.g., the expense of upgrading to tertiary sewage treatment, the expense of water purification for drinking water supply, and loss of tourism revenues). We all reside and work in the watersheds of streams and rivers, and it is our own personal and institutional practices that determine the health of those waterways.

Streams are endowed with a remarkable capacity for self-renewal if the causes of ecological stress are eliminated and floodplain functions are restored. The obstacles to stream restoration are rarely insurmountable, and many restoration projects can be accomplished on a piecemeal basis. Rene Dubos observed

"There is phenomenal resiliency in the mechanisms of the earth. A river or lake is almost never dead. If you give it the slightest chance...then nature usually comes back" (1971).

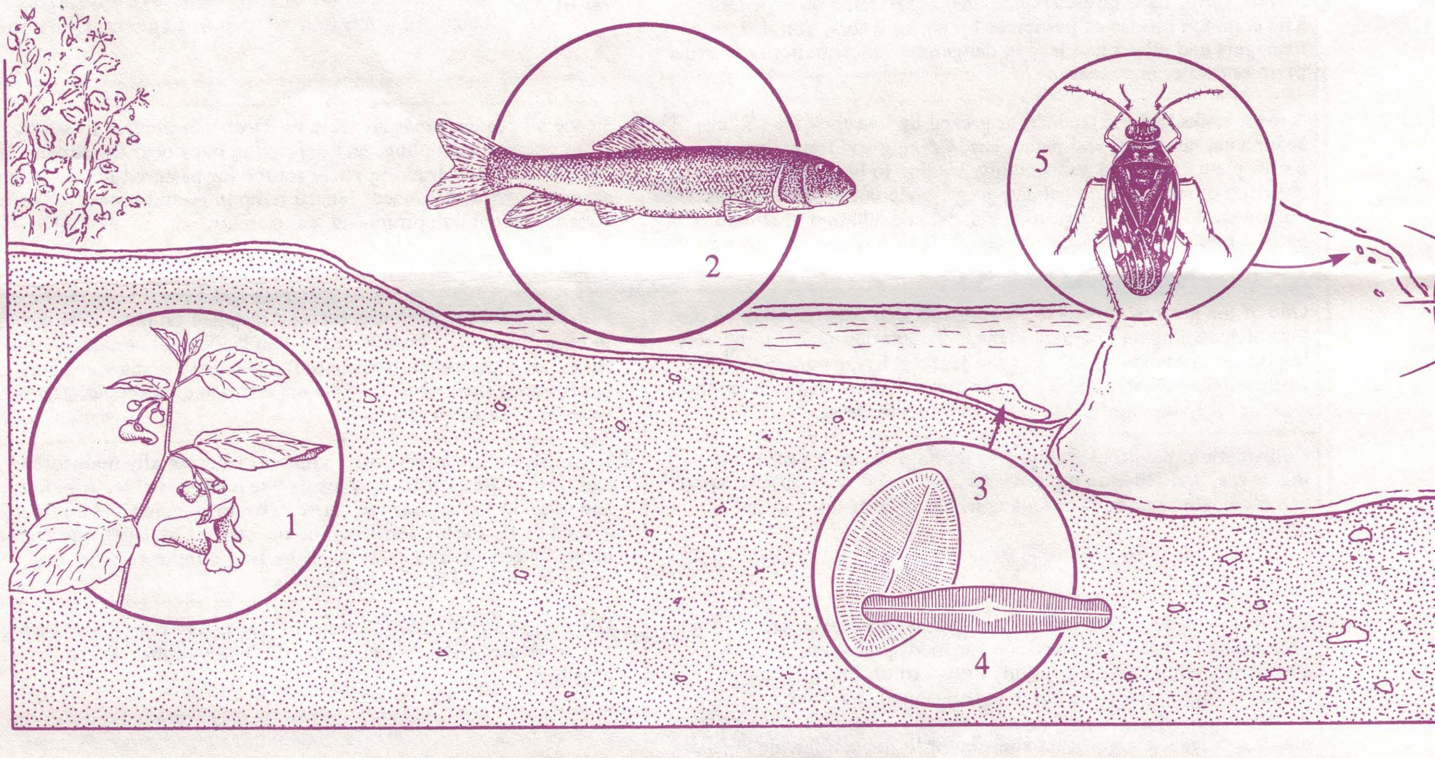


Fig. 2. Cross-section of a freshwater stream. **1.** spotted jewelweed (*Impatiens capensis*), 12 dm; **2.** white sucker (*Catostom*
8. the damselfly *Argia moesta*, 3.5 cm; **9.** blacknose dace (*Rhinichthys atratalus*), 6 cm; **10.** brown trout (*Salmo trutta*), 38 c

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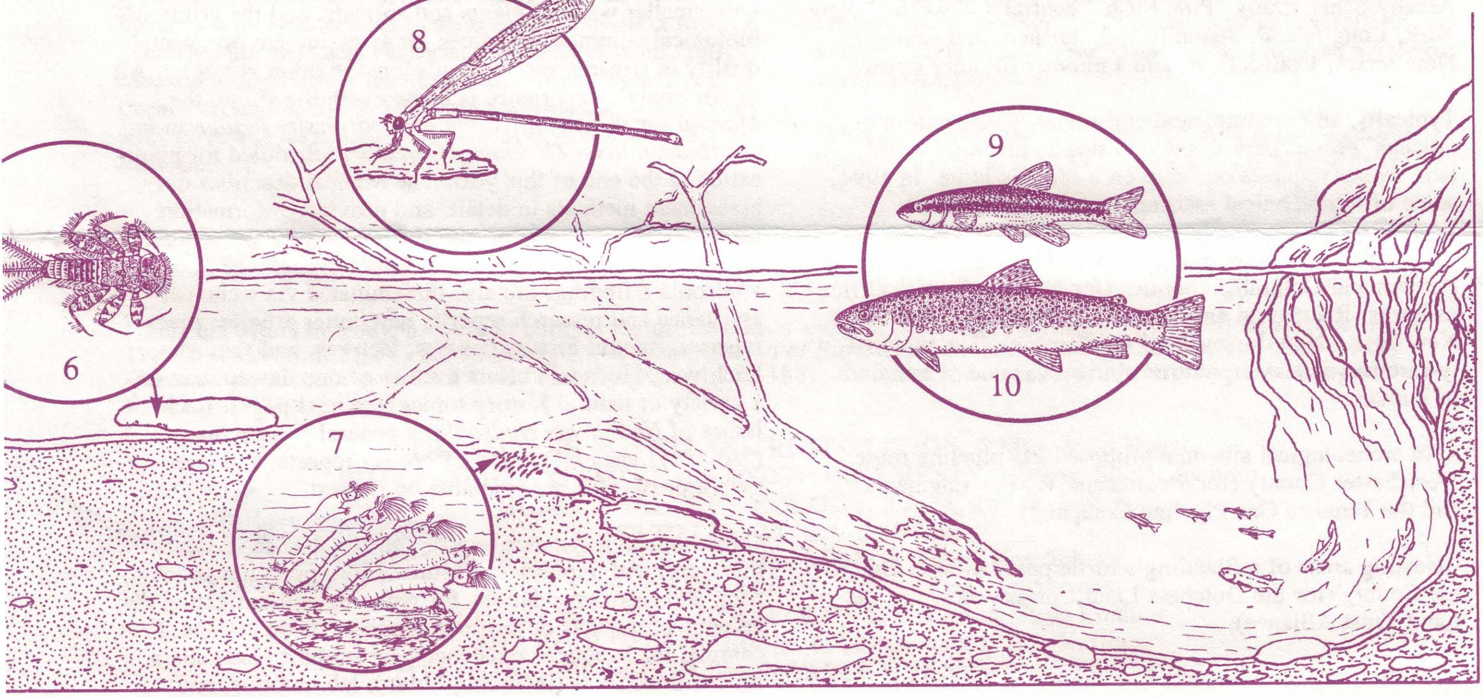


ommersoni), 35 cm; **3.** the diatom *Cocconeis placentula*, 0.05 mm; **4.** the diatom *Achnanthes minutissima*, 0.02 mm;
. the aquatic bug *Pentacora ligata*, 8 mm; **6.** a mayfly (*Stenonema* sp.), 12 mm; **7.** black fly larvae (*Simulium* sp.), 8 mm;

Hudsonia Technical Assistance Projects

by Erik Kiviat

Why is Hudsonia concerned about the kinds of sedges in a wet meadow, the locations of prickly-pear populations, the texture of soils in bog turtle wetlands, and materials discarded by previous human inhabitants? These kinds of information can be used to assess the biological diversity, ecological integrity, and cultural resources of a wetland, a park, a development site, a golf course, a landfill or mine site, a watershed, or a town - and identify sensitive features in need of conservation.

Owners, managers, developers, regulators, and protectors of land make decisions affecting the biology and ecology of a site, yet complete information upon which to base these decisions is rarely available. Because land use changes can result in economic loss, legal actions, or ecological damage, decision makers often seek technical assistance and better information. Hudsonia is equipped to provide accurate, up-to-date, site-specific information on many environmental issues including wetland boundaries, wetland ecology, stream and lake ecology, the Hudson River, rare species, significant habitats, wild plant and animal pests, archeological resources, opportunities and needs for environmental restoration, and resources for environmental education. In addition to the Hudson Valley region, we have experience in the Catskills, the Shawangunks, the Berkshires, eastern Massachusetts, the Adirondacks, the Albany-Schenectady "Pine Bush," central and western New York, Long Island, Staten Island, northern and southern New Jersey, Connecticut, and a number of other states.

Typically, an environmental consultant, conservation or citizens' group, park agency, business, planning board, or land owner requests our help on a specific issue. In 1994, some of our technical assistance projects addressed:

- Biological resources along proposed hiking trail routes in Putnam and Columbia counties (for New York State Office of Parks, Recreation and Historic Preservation, and the New York - New Jersey Trail Conference). The regionally-rare worm snake (pictured above) was one of our finds in Putnam.

- An archeological site on a proposed gas pipeline route in Westchester County (for Stearns and Wheler Engineers, and the Tenneco Gas Pipeline Company).

- Nesting areas of a Blanding's turtle population in Dutchess County (for the Dutchess Land Conservancy, and the Land Trust Alliance).

- The training of volunteers to monitor the spread of common reed, and the population of a rare plant, in a nature reserve in Connecticut (for the Salisbury Land Trust).

- The flora, big trees, wildlife, and aquatic communities of a Westchester park that will be altered for highway improvements (for the County Department of Planning).

- Wetland boundaries at a potential development site in Sullivan County (for Pawling Savings Bank) and a proposed landfill site in Oneida County (for Adirondack Communities Advisory League).

- Rare plants of a river in Ulster County (for the Shawangunk Valley Conservancy).

- Suggested sites for a sewage treatment plant in Dutchess County (for the Town of Rhinebeck).

- Environmental considerations of the proposed Hudson River Park, Manhattan (for Quennell Rothschild Associates, and the Hudson River Park Conservancy).

Hudsonia was asked to do these projects because of our knowledge of the region and the specific natural and cultural phenomena involved, as well as our reputation for non-advocacy. The interweaving of research and technical assistance, we believe, helps to maintain objectivity and high standards. We analyze and publish data from studies such as these as part of ongoing research on the conservation biology of the Blanding's turtle, the interaction of reed with smaller wetland plants and animals, and the utility of biological community indices for assessing environmental quality in streams and wetlands (among other subjects). All of Hudsonia's experience is being synthesized into the *Manual for the Identification of Biodiversity Resources in the Hudson River Greenway Corridor*, scheduled for publication at the end of this year. The Manual describes our assessment methods in detail, and provides information necessary for recognizing significant ecological features.

Hudsonia's findings are also disseminated via technical assistance and research reports, newsletter articles, press releases, natural history courses, lectures, and seminars. Each year, Hudsonia offers a series of one-day courses on a variety of natural history topics (see next page). Back issues of *News from Hudsonia*, a general prospectus ("About Hudsonia"), a list of project reports, and a research prospectus are available on request.

Our technical assistance reports include data from the field, literature, and unpublished sources; interpretation of the data; and recommendations for reducing and mitigating development impacts or improving conservation actions. Fees charged for technical assistance help support Hudsonia's staff and facilities (including library, laboratories, and herbarium) as well as the upkeep of the Bard College Field Station which we share with the college and the Hudson River National Estuarine Research Reserve.

Some Mid-Hudson Valley Stream Reaches Needing Attention

Dutchess County

** The lower **Stony Creek** where phosphate concentrations are higher than we have seen in any other stream in the Hudson Valley.
** A tributary to the lower **Saw Kill** where chloride, sulfate, phosphate and nitrate are elevated where the stream passes through a residential subdivision.
** **Wiccopee Creek** above Route 52, where the fish diversity has declined dramatically since 1985.

Orange County

** The lower **Quassaic Creek** and tributaries, where chloride and phosphate concentrations were extremely high (in 1988-1989 samples), and where inadequate flows are released from the dam at Chadwick Lake.
****Moodna Creek** and the **Otter Kill** where the poor macroinvertebrate and fish communities indicated habitat stress, and chloride levels were extremely high (in 1988-1989 samples).

Rockland County

** **Sparkill Creek** where chloride levels are high, and massive sediment deposition has severely damaged macroinvertebrate and fish habitat.

If you observe pollution discharges into streams, unauthorized construction in riparian areas, or siltation of streams from eroded construction sites, 1) talk to the transgressor, if appropriate, and explain the potential for stream damage. If the activity persists, 2) contact the regional office of the New York State Department of Environmental Conservation, for example, Region 3 (mid- & lower Hudson Valley, (914) 255-3000, or Region 4 (Columbia, Greene, Albany counties etc.), 518-382-0680.

Design and production by Kathy Anne Schmidt. Drawings Copyright © Kathleen A. Schmidt 1994. Special thanks to the Bard College Library and the Hudson River National Estuarine Research Reserve. Dennis Mildner and Laura Pilkington commented on drafts. This issue was underwritten by the Hudson River Improvement Fund. Donors, organizations, and individuals acknowledged do not necessarily agree with the concepts and opinions expressed in *News from Hudsonia*.

Hudsonia News

On the evening of Friday 9 June, Mohonk Consultations, Inc. will present an award to Hudsonia. If you are interested in attending, please contact us. Mohonk Consultations provides a forum for shaping a clearer understanding of the earth, nurturing harmonious relationships with the environment, and facilitating reconciliation among people.

Recent Reports Available from Hudsonia
(postage included)

Millbrook Marsh Watershed: Conservation of Biological Resources. 75 p. $8

Environmental quality of the Wallkill River in Orange County, New York. 44 p. $6

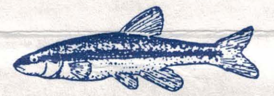
Bronx River Reservation Environmental Studies for the Woodlands Viaduct Reconstruction. 44 p. $6

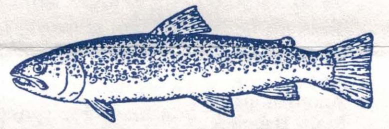
Baseline Assessment of Tributaries to the Hudson: Water Quality, Fishes, Macroinvertebrates, and Diatoms in Fishkill, Quassaic, and Moodna Creeks. Vol. 1 (text), Vol. 2 (data). $25 (both volumes) or $15 (Vol. 1 only).

DONORS OF GOODS AND SERVICES

Sumru Aricanli, books; Patrick Baker, microwave oven; Paul Barten, book; Joseph T. Bridges and Steve Clemants, identifying specimens; Lin Fagan, herbarium work; Stuart Findlay, review of manuscript; Laura Haight, book; C. Barre Hellquist, identifying specimens; Dave Hill, book; IBM (Kingston), file cabinets; Jerry Jenkins, book, loan of computer; Esther Kiviat, magazines; Gary Lovett, review of manuscript; Heinz Meng and Peter Morin, identifying specimens; Barbara O'Hare, a painting; Richard S. Ostfeld and Peter J. Petokas, loan of equipment; John Porcella, computer assistance; Kathleen A. Schmidt, use of drawings; Jim Stapleton, printing labels; David Strayer, identifying specimens; Dusan Tynek, herbarium work; Peter Warny, books, periodicals.

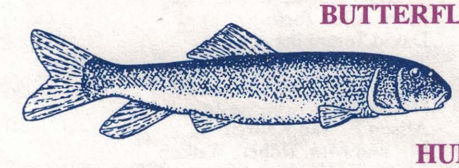
Office and Herbarium Assistants: Patti Austin, Flavia deJesus, Dwayne Linville, Rebecca Miller, Dusan Tynek, Naomi Yoder.





1995 NATURAL HISTORY COURSES

Hudsonia offers one-day, non-credit courses for professionals and amateurs with a strong interest in field science. Most 1995 courses are linked to our *Manual for the Identification of Biodiversity Resources in the Hudson River Greenway Corridor* (in preparation). Call Laura Pilkington, 914-758-1881, for information or registration (payment is required 10 days in advance).



STREAMBANK & WETLAND RESTORATION, 6 May, Sven Hoeger
BUTTERFLIES ON SHALE & SANDSTONE CRESTS, 20 May, Spider Barbour
HUDSON VALLEY GEOLOGY, 3 June, Roy Budnik
TURTLES, 17 June, Erik Kiviat
DRAGONFLIES & DAMSELFLIES, 8 July, Ken Soltesz
WETLAND DELINEATION, 22 July, Gretchen Stevens
HUDSON VALLEY ARCHAEOLOGY, 5 August, Chris Lindner
THE ECOLOGY OF BOGS, to be announced, Eric Karlin
MYCOLOGY OF MID-HUDSON VALLEY, 16 September, Bill Bakaitis

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Erik Kiviat, Executive Director

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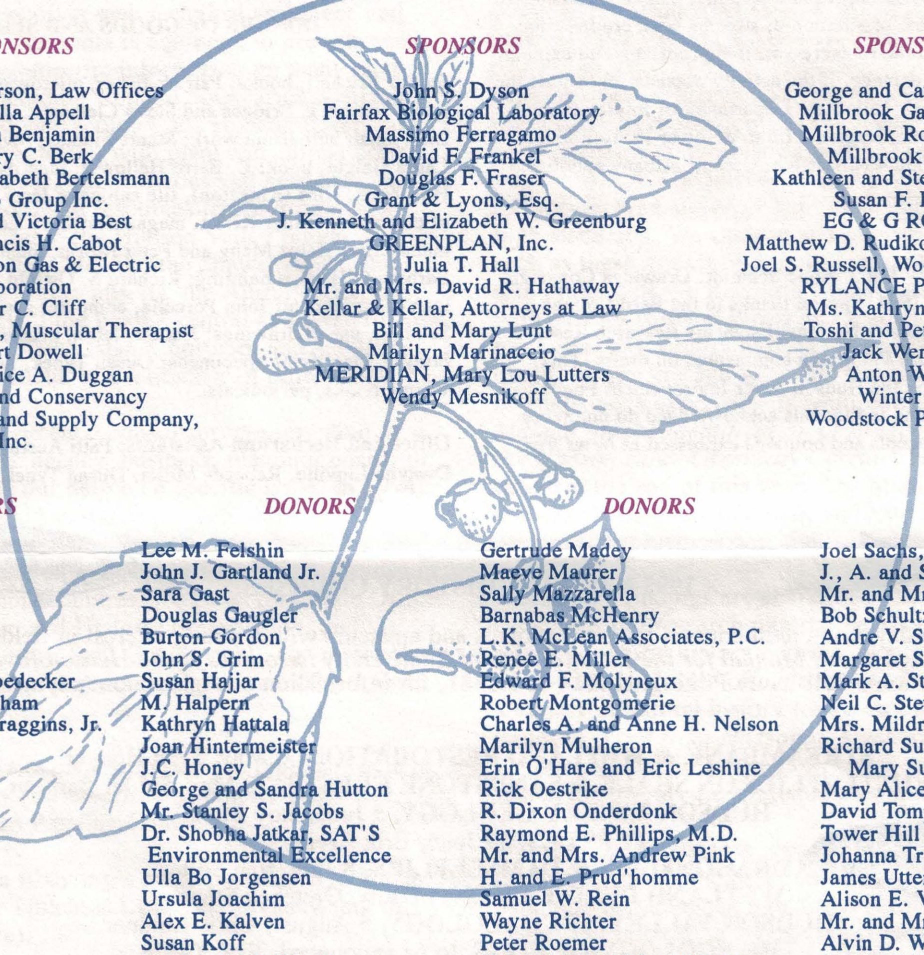

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