United States
Department of
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Natural
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National Biology Handbook

Aquatic and Terrestrial Habitat Resources

Subpart C Technical Resources

United States
Department of
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**Natural
Resources
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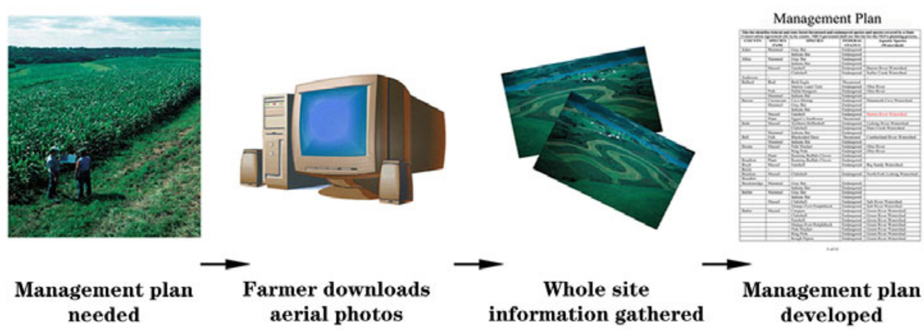
National Biology Handbook

Part 620

Technical References for Integrating Fish and Wildlife Considerations into Conservation Planning



(190-VI-NBH, November 2004)

Part 620 Technical References for Integrating Fish and Wildlife Considerations into Conservation Planning

Contents:

Subpart C — Technical Resources

Part 620 — Technical References for Integrating Fish and Wildlife Considerations into Conservation Planning

620.00 Introduction

Keeping up with all of the technical information pertaining to terrestrial and aquatic resources is a tremendous challenge in the information age. All of us have been stymied by the inability to find and access new or old information. Indeed, nothing is more frustrating than being unable to locate a resource you know is buried somewhere in your office.

Assembling and organizing a library containing all of the technical resources needed to achieve fish and wildlife conservation goals simply is not feasible for most of us. Thanks to the Internet, however, much of the information needed to plan, implement, and monitor conservation actions is now available online. Sorting through all of potential sources of information available online can be every bit as challenging as trying to find a needed publication in a busy office. Moreover, information resources keep changing, with new sites constantly coming online.

Part 620 lists online resources containing information potentially helpful to NRCS field staffs for planning, implementing, and monitoring projects. To improve the usefulness of this electronic toolbox, links were organized into the NRCS planning framework. The quality and usefulness of information clearly is better for some subjects (e.g., birds) than it is for others (e.g., reptiles and amphibians), but electronic access to needed resources improves daily.

Because of the dynamic nature of online resources, the electronic toolbox provided here needs to be updated frequently. For the latest version of the electronic toolbox, go to the Wildlife Habitat Management Institute's Web site at **www.whmi.nrcs.usda.gov**.

620.01 Electronic toolbox

How does the electronic toolbox work?

Example: The goal is to design a WRP site near Ames, Iowa, to benefit migratory birds. Ames is in the tallgrass prairie physiographic area:

www.natureserve.org/explorer

Bird conservation priorities identified by bird conservation groups for the tallgrass physiographic area are displayed at the Partners-in-Flight Web site:

www.partnersinflight.org/pifbcps.htm

The relative abundance of these and other birds observed breeding near the project site is available at the Breeding Bird Survey's Clickable Abundance Map:

www.mbr-pwrc.usgs.gov/geotech/bbsmaps3.html

See **www.mbr-pwrc.usgs.gov/bbs/** for their breeding and wintering distribution in North America. The occurrences and population trends for birds also can be determined at the Breeding Bird Survey's Web site:

www.mbr-pwrc.usgs.gov/bbs/

For detailed information on habitat requirements of priority species, see *The Birds of North America—Life Histories for the 21st Century* or

www.natureserve.org/explorer/

Additional resources on bird life histories and habitat requirements of individual species of North American birds are identified at

www.partnersinflight.org/birdacct.htm#Table

For information on the conservation status of area plants and animals, see The Nature Conservancy at **www.natureserve.org/explorer/**, the state GAP at **www.gap.uidaho.edu/**, or the U.S. Fish and Wildlife Service at **http://endangered.fws.gov/wildlife.html#Species**.

Guidance on designing a bird-monitoring program for birds on the site is available at

www.mp2-pwrc.usgs.gov/powcase/

620.02 Planning

(a) Conservation priorities established by conservation partners

(1) Birds

Songbirds—Partners in Flight bird conservation plans identifying species priorities by physiographic (vegetative) region:

www.partnersinflight.org/pifbcps.htm

Waterfowl—North American Waterfowl Management Plan:

http://northamerican.fws.gov/NAWMP/nawmphp.htm

Shorebirds—North American Shorebird Management Plan:

www.manomet.org/USSCP/index.htm

Waterbirds—North American Waterbird Management Plan:

www.nacwcp.org/

(2) Threatened or endangered species

Federally listed plants and animals:

http://endangered.fws.gov/wildlife.html#Species

See section 620.01(b)(4) for links to *Conservation Status of Fish and Wildlife Species* Web sites.

Specific information on aquatic/wetland species at risk is available from

www.epa.gov/iwi/1999april/iii8_usmap.html

(3) Habitats

(i) General—The Society for Ecological Restoration's Primer on Ecological Restoration provides general information concerning restoration of habitats by restoring ecological processes:

http://ser.org/Primer.pdf

(ii) Aquatic—Web sites giving general aquatic information are

- USDA Forest Services Stream System Technology Center provides links for downloading information on hydrology, fluvial geomorphology, and stream habitat improvements, including fish passage:

  www.stream.fs.fed.us/

- EPA's *Surf Your Watershed* Web site defines boundaries of watershed, identifies political jurisdictions, and provides links to environmental databases:

  http://cfpub.epa.gov/surf/locate/index.cfm

- NatureServe Explorer has information on ecological communities in the United States and Canada:

  www.natureserve.org/explorer/

Some aquatic Web sites are specifically for streams and stream corridor. They include

- NRCS' Stream Corridor Restoration: Principles, Processes, and Practices provides resources for planning, implementing, and monitoring restoration projects within a watershed context.

  www.usda.gov/stream_restoration/

- EPA's River Corridor and Wetland Restoration Web site:

  www.epa.gov/owow/restore/

- Know your watershed Web site:

  www.ctic.purdue.edu/KYW/Brochures/GetToKnow.html

(iii) Terrestrial—The NatureServe Explorer is a source for information on ecological communities in the United States and Canada:

www.natureserve.org/explorer/

USGS's Gap Analysis Program (GAP) was undertaken to provide regional assessments and to facilitate the application of this information to land management activities. When completed, this program will provide a searchable database for landcover, indices of biodiversity, and distribution and conservation status of terrestrial vertebrates:

www.gap.uidaho.edu/

Check your state for GAP status and access to database.

(4) Plants

The NRCS PLANTS database is a single source of standardized information about plants. This database focuses on vascular plants, mosses, liverworts, hornworts, and lichens of the United States and its territories. The PLANTS database includes names, checklists, automated tools, identification information, species abstracts, distributional data, crop information, plant symbols, plant growth data, plant materials information, plant links, references, and other plant information:

http://plants.usda.gov

(b) Inventory of terrestrial and aquatic resources

(1) Species distributions and abundance

The Web sites giving general information for all fish and wildlife species/groups follow:

- NatureServe Explorer is the source for information on distribution, conservation status, life histories, and habitat requirements for over 50,0000 plants, animals, and ecological communities in the United States and Canada:

  www.natureserve.org/explorer/

- The Gap Analysis Program (GAP) was undertaken to provide regional assessments of the conservation status of native vertebrate species and natural land cover types and to facilitate the application of this information to land management activities. When completed, this program will provide a searchable database for landcover, indices of biodiversity, and distribution and conservation status of terrestrial vertebrates:

  www.gap.uidaho.edu/

Check your state for GAP status and access to database.

Specific reference sites for species distribution and abundance are listed below:

- Birds:
  - Breeding Bird Survey Clickable Abundance Map can be used to determine what species are in the chosen area and their relative abundance.

    www.mbr-pwrc.usgs.gov/geotech/bbsmaps3.html

  - Christmas Bird Count (CBC) is an annual survey organized by The Audubon Society and conducted by volunteers since 1900. The Website maintained by Patuxent Wildlife Research Center provides background information on the survey and distribution maps for wintering birds based on CBC data.

    www.mp2-pwrc.usgs.gov/birds/cbc.html

- Mammals
  - Information on systematics, distribution, fossil history, genetics, anatomy, physiology, behavior, ecology, and conservation of 631 species of mammals is provided by the American Society of Mammalogists at

    www.science.smith.edu/departments/Biology/VHAYSSEN/msi/default.html

  - Lists of mammal species for selected states:

    www.mammalsociety.org/statelists/index.html

  - Bats—Photos, distribution, and life history information for selected species. Go to **Bat Links**, then to **Detailed Species Information** on the following site:

    www.batcon.org/

- Amphibians
  - Searchable database for occurrences of amphibians:

    www.mp2-pwrc.usgs.gov/cvs/ampcv

  - Northern Prairie Wildlife Research Center Web site provides information on identification, distribution, and habitat associations for selected amphibian species:

    http://frogweb.nbii.gov/

- Fish
  - National Biological Information System's National Fish Strain Registry Web site contains information on managed fish strains, populations, and broodstocks located throughout the United States:

    http://159.189.37.201/

  - North American Native Fishes Association's Web site has links to taxonomically structured indices of the freshwater fishes of North America:

    www.nanfa.org/resources.htm

  - FishBase is a relational database that is available for purchase. However, considerable species account information is available for downloading from the Web site:

    www.fishbase.org/home.htm

  - Butterflies—Butterflies of North America Web site contains distribution maps, photos, species accounts (information on size, identifying characteristics, life history, flight, caterpillar hosts, adult food, habitat, species range, conservation status, and management needs), and species checklists for each county in the United States and each state in northern Mexico:

    www.npwrc.usgs.gov/resource/distr/lepid/bflyusa/bflyusa.htm#maps

(2) Plants, plant communities

Plants—Comprehensive list of online plant and vegetation maps organized by state, region, country, and continent:

www.lib.berkeley.edu/EART/vegmaps3.html#noamer

Physiographic regions/vegetative alliances—NatureServe Explorer is source for information on ecological communities in the United States and Canada:

www.natureserve.org/explorer/

Landcover—Gap Analysis Program (GAP) was undertaken to provide regional assessments of the conservation status of native vertebrate species and natural land cover types and to facilitate the application of this information to land management activities. When completed, this program will provide a searchable database for landcover, indices of biodiversity, and distribution and conservation status of terrestrial vertebrates:

www.gap.uidaho.edu/

Check your state for GAP status and access to database.

Trees by state—The Dendrology homepage at Virginia Tech provides tree identification fact sheets on over 450 species of trees as well as other tree information:

www.cnr.vt.edu/dendro/dendrology/map/zonemap.htm

(3) Habitats

Riparian—Assessing condition of riparian wetland corridors at area-wide level using Proper Functioning Condition methodology:

www.wcc.nrcs.usda.gov/watershed/products.html

Corridors or buffers—Designing conservation buffers for wildlife at the landscape scale (see subpart B, part 613).

Streams—NRCS Stream Visual Assessment Protocol (see 630 Exhibits, exhibit H)

(4) Conservation status of fish and wildlife species

General references:

- NatureServe Explorer is a source for information on distribution, conservation status, life histories, and habitat requirements for over 50,000 plants, animals, and ecological communities in the United States and Canada:

  www.natureserve.org/explorer/

- Gap Analysis Program (GAP) was undertaken to provide regional assessments of the conservation status of native vertebrate species and natural land cover types and to facilitate the application of this information to land management activities. When completed, this program will provide a searchable database for land cover, indices of biodiversity, and distribution and conservation status of terrestrial vertebrates:

www.gap.uidaho.edu/

Check your state for GAP status and access to database.

Aquatic species:

- North American Native Fishes Association's Web site has links to taxonomically structured indices of the freshwater fishes of North America:

  http://www.nanfa.org/resources.htm

(5) Invasive species

General:

- USGS Web site provides links to resources on nonindigenous plants and animals:

  http://nas.er.usgs.gov/links/links.html

Specific:

- Aquatic—A central repository for accurate and spatially referenced biogeographic accounts of nonindigenous aquatic species is available at the following Web site. It provides scientific reports, online/realtime queries, spatial data sets, regional contact lists, and general information:

  http://nas.er.usgs.gov/

(c) Fish and wildlife habitat requirements

(1) General

NatureServe Explorer is source for information on distribution, conservation status life histories, and habitat requirements for over 50,000 plants, animals, and ecological communities in the United States and Canada:

www.natureserve.org/explorer/

Gap Analysis Program (GAP) was undertaken to provide regional assessments of the conservation status of native vertebrate species and natural land cover types and to facilitate the application of this information to land management activities. When completed, this program will provide a searchable database for land cover, indices of biodiversity, and distribution and conservation status of terrestrial vertebrates. Check your state for GAP status and access to database.

www.gap.uidaho.edu/

Northwest Habitat Institute's Web site provides matrices for fish and wildlife habitat relationships for species in Oregon and Washington. The site also includes an interactive Biodiversity Information System (IBIS):

www.nwhi.org/nhi/

(2) Specific

Birds:

- Partners-in-Flight provides a table showing availability and includes links to online species accounts for North American birds:

  www.partnersinflight.org/birdacct.htm#Table

- *Birds of North America—Life Histories for the 21st Century* provides detailed life history accounts for all North American birds. The following Web site describes the information contained in species accounts. Note that BNA accounts currently are available only in printed format.

  www.birds.cornell.edu/birdsofna.org

- Wildlife Habitat Management Institute and Wildlife Habitat Council's Fish and Wildlife Habitat Management Leaflets are available for selected species, species groups, and habitats at

  www.whmi.nrcs.usda.gov/technical/leaflet.htm

Amphibians:

- Partners of Amphibian and Reptile Conservation fact sheets for selected species are available at

  www.parcplace.org/education/educational_materialsposters.htm

Fish:

- North American Freshwater Fishes Index includes images, distribution maps, and life history information:

  www.tmm.utexas.edu/tnhc/fish/na/naindex.html

(d) Additional ecological datasets for planning

(1) Watershed boundaries

Hydrologic unit boundaries define the areal extent of surface water drainage to a point. The goal of this initiative is to provide a hydrologically correct, seamless, and consistent national geographic information system (GIS) database at a scale of 1:24,000, that has been extensively reviewed and matches the USGS topographical 7.5 minute quads. The new levels are called **watershed (5th level, 10-digit)** and **subwatershed (6th level, 12-digit)**.

The watershed level is typically 40,000 to 250,000 acres, and subwatershed level is typically 10,000 to 40,000 acres with some as small as 3,000 acres. An estimated 22,000 watersheds and 160,000 subwatersheds will be mapped to the 5th and 6th level. The GIS coverages will be available by the Internet to any person, including researchers, private companies, utilities, environmental groups, concerned citizens, and Federal, State, and local government agencies. The database will assist in planning and describing water use and related land use activities:

www.ftw.nrcs.usda.gov/huc_data.html

(2) Soil surveys

SOILS is part of the National Cooperative Soil Survey, an effort of Federal and State agencies, universities, and professional societies to deliver scientifically based soil information. The USDA Natural Resources Conservation Service leads the National Cooperative Soil Survey and hosts this site:

http://soils.usda.gov

(3) Spatial data

http://fgdc.ftw.nrcs.usda.gov/NRCSgateway.html

620.03 Establishment and management of habitats

(a) Terrestrial habitat

(1) General references:

Printed sources:

- Bookhout, T.A. 1994. Research and management techniques for wildlife and habitats, 5th edition. The Wildlife Management Institute, Washington, D.C., 740 pp, ISBN 0933564-10-4.
- Payne, N.F. 1992. Techniques for wildlife management of wetlands. McGraw-Hill, New York, 549 pp, ISBN 0070489564.
- Payne, N.F., and F.C. Bryant. 1994. Techniques for wildlife management of uplands. McGraw-Hill, New York, 840 pp, ISBN 0070489637.

Specific references:

- Riparian habitats
  - Riparian Management Systems—A management approach for environmental enhancement of intensively modified agricultural landscapes:

    www.buffer.forestry.iastate.edu/

  - Riparian Ecosystem Creation and Restoration: A Literature Summary—Riparian ecosystem information from 92 records (primarily published papers or reports) in the U.S. Fish and Wildlife Service's Wetland Creation/Restoration database was used to develop a literature summary of creation and restoration of riparian ecosystems. The summary provides an overview of the status of riparian ecosystems in the United States, a description of several riparian functions, and a review of some techniques used for planning, implementing, monitoring, and measuring project success of riparian ecosystem creation/restoration efforts. Case studies of various riparian ecosystem creation or restoration projects are used to demonstrate these techniques:

    www.npwrc.usgs.gov/resource/literatr/ripareco/ripareco.htm

- The National Academies Press. 2002. Riparian areas: functions and strategies for management. Washington, D.C., 428 pp, ISBN0309082951. Downloadable at

  www.nap.edu/books/0309082951/html/

(3) Technical notes and pamphlets

NRCS sources:

- Establishment of warm-season grasses pamphlet (Indiana):

  ftp://ftp-fc.sc.egov.usda.gov/IN/technical/biology/NATIVEGRASSPAMPHLET98.pdf

- Establishment and Management of Forbs in Grass Plantings (Illinois). Go to **Technical Notes** in Technical Resources section of NRCS-IL Web site:

  www.il.nrcs.usda.gov

- Buffers for wildlife job sheets for filter strip, riparian forest buffers, windbreaks and shelterbelts, grassed waterways, and field borders (Illinois). Go to **Wildlife** in the **Information On** section of NRCS-IL Web site:

  www.il.nrcs.usda.gov

- Attracting Iowa wildlife—a guide for providing habitat on private lands (Iowa):

  www.iowadnr.com/wildlife/files/plhabitatguide.htm

- Recommendations for the establishment of vegetation on restored wetlands in the lower Mississippi River Alluvial Valley) based upon recent research and publications:

  www.wli.nrcs.usda.gov/products/index.htm

Extension publications:

- Assortment of publications on Iowa's wildlife and natural resources:

  www.extension.iastate.edu/pubs/wi.htm

- Links to all state extension Web pages:

  www.ext.colostate.edu/links/linkexte.html

(b) Aquatic habitat

(1) General references in print

- Rehabilitation of Rivers for Fish: A study undertaken by the European Inland Fisheries Advisory Commission of FAO. I.G. Cowx and R. L. Welcomme, editors. 1998. ISBN 92-5-104018-4 (FAO), 260 pp.
- Restoration of Aquatic Ecosystems. Science, Technology, and Public Policy. National Research Council. 1992. National Academy Press, 552 pp.

(2) Specific references

- Amphibians and reptiles—Center for Amphibian and Reptilian Management and Conservation site provides habitat management guidelines for amphibians and reptiles of the Midwest:

  http://herpcenter.ipfw.edu/Outreach/MWHabitatGuide/

(3) Technical notes and pamphlets

NRCS publications:

- Shallow water management job sheet (IN):

  ftp://ftp-fc.sc.egov.usda.gov/IN/technical/biology/646_jobsheet.pdf

- Using Micro and Macrotopography in Wetland Restoration. Go to **Technical Notes** in Technical Resources on NRCS-IL Web site:

  www.il.nrcs.usda.gov

- Trout Management leaflet at:

  http://policy.nrcs.usda.gov/scripts/lpsiis.dll/TN/TN_B_10_a.pdf

Extension publications:

- Assortment of publications on Iowa's wildlife and natural resources:

  www.extension.iastate.edu/pubs/wi.htm

- Links to all state extension Web pages:

  www.ext.colostate.edu/links/linkexte.html

620.04 Monitoring and evaluation of terrestrial and aquatic resources

(a) Designing a monitoring program

(1) General

Patuxent Wildlife Research Center's Web site provides basic information regarding the design of a monitoring program:

www.pwrc.usgs.gov/monitoring2/

(2) Specific

Terrestrial:

- Birds
  - U.S. Forest Service publication, *A Land Managers Guide to Point Counts of Birds in the Southeast*, provides techniques for inventorying and monitoring populations of birds in southeastern forest habitats:

    www.srs.fs.fed.us/pubs/viewpub.jsp?index=1594

  - U.S. Forest Service publication, *Monitoring Bird Populations by Point Counts*, reviews technique for inventorying and monitoring populations of birds:

    www.fs.fed.us/psw/publications/documents/wild/gtr149/gtr_149.html

  - U.S. Forest Service publication, *Handbook of Field Methods for Monitoring Landbirds*, provides general summaries of techniques for inventorying and monitoring populations of landbirds

    www.psw.fs.fed.us/psw/publications/documents/gtr-144/gtr-144-cover.pdf

    www.psw.fs.fed.us/psw/publications/documents/gtr-144/gtr-144-content.pdf

- Butterflies—Recently established census (since 2000) carried out by members (volunteers) of the North American Butterfly Association to monitor occurrences of North American butterflies:

  www.naba.org/4july.html

Aquatic:

- Amphibians—EPA publication describing methods for evaluating wetland condition using amphibians:

  www.epa.gov/waterscience/criteria/wetlands/12Amphibians.pdf

- Fish and fish habitat monitoring protocol developed by the State of Oregon:

  www.oregon-plan.org/monitoring/status.html

(b) Monitoring methods

(1) Aquatic

The Wetlands Division of EPA's Office of Wetlands, Oceans, and Watersheds site provides introduction to why and how people monitor wetlands. The following sites also include handbooks and manuals that offer detailed information on wetlands monitoring for the layperson.

- A volunteer's guide for documenting quality assurance methods, project organization, goals and objectives with examples and references:

  www.epa.gov/owow/monitoring/volunteer/qappcovr.htm

- Estuary monitoring methods:

  www.epa.gov/owow/estuaries/monitor/

- Lake monitoring methods:

  www.epa.gov/owow/monitoring/lakevm.html

- Stream monitoring methods:

  www.epa.gov/owow/monitoring/volunteer/stream/

- An introduction and resource guide for wetland monitoring:

  www.epa.gov/owow/wetlands/monitor/volmonitor.html

- Methods, case studies, glossary, and publications for wetlands bioassessment:

  www.epa.gov/owow/wetlands/bawwg/

- Sampling Amphibians in Lentic Habitats. D.H. Olson, W.P. Leonard, and R.B. Bury, editors. Northwest Fauna Number 4. Society for Northwestern Vertebrate, Biology, 1997, 134 pp.

(c) Ongoing monitoring programs

(1) Terrestrial

Birds:

- Project FeederWatch:

  http://birds.cornell.edu/pfw/

- Raptor Monitoring:

  http://srfs.wr.usgs.gov/research/narms1.html

- Breeding Bird Survey Summary and Analysis:

  www.mbr-pwrc.usgs.gov/bbs/bbs.html

- Bird Banding Laboratory:

  www.pwrc.usgs.gov/bbl/

Butterflies—Recently established census (since 2000) carried out by members (volunteers) of the North American Butterfly Association to monitor occurrences of North American butterflies:

www.naba.org/4july.html

(2) Aquatic

Amphibians—EPA publication describing methods for evaluating wetland condition using amphibians:

www.epa.gov/waterscience/criteria/wetlands/12Amphibians.pdf

Fish—The Multi-State Aquatic Resources Information Systems database provides long-term data on fish populations. In 2002, data were limited to lake fisheries. Beginning in 2003, stream fish population data were available on a state-by-state basis:

http://fwie.fw.vt.edu/www/spp.htm

620.05 Additional resources

Scientific journals—Links to environmental sciences journals

www.esd.ornl.gov/journals.html

Directories—State conservation agencies links to fish and wildlife departments:

www.lib.washington.edu/fish/fandg/fandglist.html

Glossaries—Links to online dictionaries and glossaries for science and technology

www.nbii.gov/datainfo/onlineref/dictionaries.html

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Part 621 Technical Guidance Documents

Part 621 Technical Guidance Documents

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Subpart C Technical Resources

Part 621 Technical Guidance Documents

621.00 Introduction

Many technical guidance documents are available to field personnel and conservation planners. NRCS state offices manage Web sites with links to state- and region-specific technical information regarding conservation of aquatic and terrestrial habitats.

Other technical documents useful to field office personnel for integrating biodiversity, fisheries, and wildlife considerations into the conservation planning process are *technical notes* and *job sheets.* These guidance documents are NRCS directives originating at the national, regional, state, and area office level. They are generally prepared entirely or in part by NRCS biologists or other technical specialists. Examples of these types of guidance documents are provided in Part 630, Exhibits.

621.01 Technical notes

The fundamental purpose of a biology technical note is to provide information related to improving wildlife and fisheries habitat when assisting with conservation planning on private lands. Technical notes have been developed on many subjects important to field office staff. In many instances the technical notes are developed specifically at the request of the field office to address a specific need. Generally, technical notes fall into five categories:

Tech notes that highlight tools designed to restore, create, or enhance habitat:

Exhibit A—Idaho Plant Materials Technical Note on the Waterjet Stinger.

Tech notes that take national guidance and develop it for use in a particular state:

Exhibit B - Hawaii Biology Technical Note and Transmittal Letter providing state instructions for implementing national guidance on the Stream Visual Assessment Protocol.

Tech notes that provide technical information, for example, state heritage databases or threatened and endangered species lists to the conservation planner:

Exhibit C—Hawaii Biology Technical Note demonstrating the use of ArcView and Toolkit to access the state heritage database.

Exhibit D—Kentucky Biology Technical Note listing threatened and endangered species by county.

Exhibit E—Kentucky Biology Technical Note listing FOTG practice effects on threatened and endangered species.

Tech notes that highlight techniques designed to restore, create, or enhance habitat:

Exhibit F—Indiana Biology Technical Note on developing macrotopography and microtopography in wetland restoration.

Technical notes that provide guidance on how to evaluate habitat conditions.

Exhibit G—Fish Assemblages as Indicators of the Biological Condition of Streams and Watersheds, Technical Note 190-16

Exhibit H—Stream Visual Assessment Protocol

621.02 Job sheets

The purpose of a biology job sheet is to provide the "how-to" information necessary to create, restore, or enhance the fish and wildlife habitat when developing a conservation plan for the landowner. Job sheets, in general, are associated with standards and specifications for specific conservation practices in the FOTG and become a part of the landowner's conservation plan.

Although development of biology job sheets is the responsibility of the NRCS biologist, interest in fish and wildlife habitat development on working lands is important to many conservation partners. Involving these partners in the process of developing job sheets can improve the content and enhance the partnership.

The Wildlife Habitat Management Institute undertook a pilot project to evaluate this technique in six states (Illinois, Maryland, North Carolina, South Dakota, Texas, and Utah) in 1998. Each of the states hosted a facilitated workshop to gather the information and design the job sheets that would work for the NRCS state office as well as include components important to our conservation partners. The process, although challenging, was supported by all and viewed as a commitment to considering fish and wildlife habitat in conservation planning. Although such extra effort is often viewed as unnecessary to develop the technical document, it is extremely valuable for gaining support.

The following job sheet examples are for the same practice from different states. They illustrate the multitude of options available to accomplish the same task across the varied landscape in the United States.

Field Border—Practice Code 386

Exhibit I—Field Borders Wildlife, Illinois

Exhibit J—Wildlife Habitat in Field Borders, North Carolina

Exhibit K—Buffers for Wildlife Field Borders, Texas

Exhibit L—Field Borders as Wildlife Habitat, Georgia

Exhibit M—Field Borders for Wildlife, Utah

Exhibit N—Field Border Buffers for Wildlife, Maryland

621.03 Other technical guidance references

NRCS State Offices and National Institutes and Centers develop technical guidance materials for internal and external use by partners and clients. In particular, the following NRCS Web sites provide excellent technical information for aquatic and terrestrial habitat considerations:

Wildlife Habitat Management Institute:
www.whmi.nrcs.usda.gov

Watershed Science Institute:
www.wcc.nrcs.usda.gov/watershed/

Soil Quality Institute:
http://soils.usda.gov/sqi/

Wetland Science Institute:
www.wli.nrcs.usda.gov

NRCS Plant Data Center:
http://plants.usda.gov/

NRCS New Hampshire is a good source of information regarding salt marsh/estuarine ecosystems of New England:
www.nh.nrcs.usda.gov

NRCS Minnesota:
www.mn.nrcs.usda.gov/mnres.html/

NRCS Montana (see especially "Creating Native Landscapes"):
www.mt.nrcs.usda.gov

For additional sources of technical guidance documents, see part 620 of this handbook.

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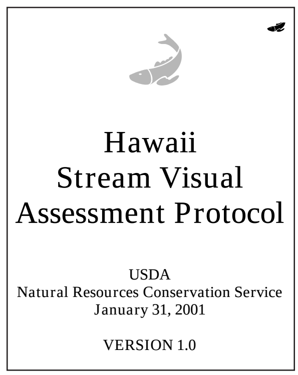
Part 630 Exhibits


Hawaii
Stream Visual
Assessment Protocol

USDA
Natural Resources Conservation Service
January 31, 2001

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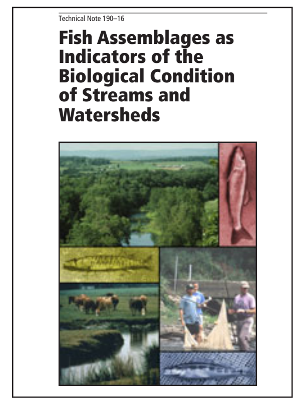
January, 2001

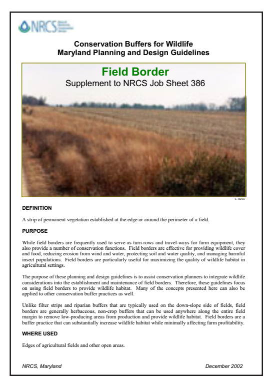
Waterjet Stinger:
A tool to plant dormant unrooted cuttings of willows, cottonwoods, dogwoods, and other species


Technical Note 190–16

Fish Assemblages as Indicators of the Biological Condition of Streams and Watersheds


USDA Field Borders
Wildlife Job Sheet Insert

Natural Resources Conservation Service (NRCS)—Illinois


Conservation Buffers for Wildlife
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June, 2001

Waterjet Stinger:

A tool to plant dormant unrooted cuttings of willows, cottonwoods, dogwoods, and other species

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Introduction

Opportunities for riparian revegetation around the nation are numerous. Planting dormant unrooted cuttings often called pole plantings, post plantings, or live stakes is one technique that is often recommended for streambank stabilization and riparian buffer planting. This method is limited to species that can easily sprout from hardwood cuttings, such as: willows, cottonwoods, and dogwoods. There are other species that will sprout from hardwood cuttings, but do not root as readily.

Dormant unrooted cuttings are used because they are easy to harvest, easy to plant, inexpensive, and effective. In the arid and semi-arid West, it is extremely important that any plant that is installed in a riparian zone have its roots in the lowest watertable of the year. This is often difficult when using bareroot or containerized plants especially when the riparian zone has been dewatered to the point that the water table may be several feet below the soil surface. Unrooted cuttings have been planted as deep 12 ft (average depth is about 5-6 ft) by the Riparian/Wetland Plant Development Project at the Aberdeen PMC using a long bar attached to a backhoe (Hoag and Ogle 1994). Most riparian and stream protection projects require planting depths of 3-6 ft. The biggest problem we faced was finding a method and developing equipment that could dig a hole more than 3-4 ft deep quickly and efficiently. The Waterjet Stinger is the result of this equipment development effort.

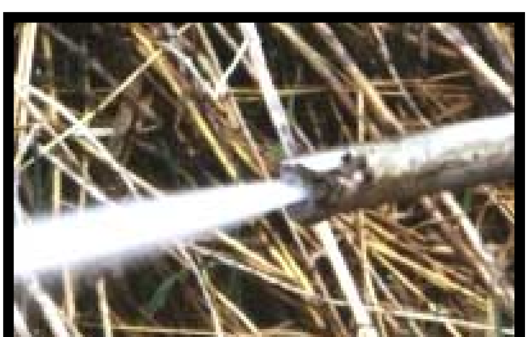
To plant unrooted cuttings successfully, the bottom of the cutting should be placed about 8-12 in into the lowest watertable of the year. The top of the cutting should extend out of the ground at least 10-12 in or high enough to be out of the shade cast by surrounding vegetation such as grasses or forbs. This allows the bottom of the cutting to act like a straw and pull water up the cutting keeping the roots, stems and leaves hydrated. In some riparian zones, the lowest water table of the year can be several feet deep.

Waterjet Stinger

The Waterjet Stinger was specially designed to use high-pressure water to hydrodrill a hole in the ground to plant unrooted hardwood cuttings into riparian revegetation. This is not new technology, in fact, it has been around for a long time. Oldham (1989) described a water drill that he used to drill holes in the ground to plant stem and pole cuttings 4-5 ft deep. His hydrodriller was a steel pipe that was beveled at the bottom and was hooked up to a "water tank (spray rig) or portable pump." Drake and Langel (1998) reported using a water jet tool to plant willow cuttings. They designed a nozzle that is made out of stainless steel welded to a steel pipe. They used a high-pressure pump and the nozzles to plant cuttings over 2 meters deep. An engineering technician in Manitoba, Canada (Andrews, personal communication) described working with a water jet to drill holes for geotechnical test holes ten years ago. He indicated that they had taken a steel pipe and pounded the end flat to increase the water pressure. These earlier jets did not last very long because the pounding tended to weaken the steel.

The advantages of using the waterjet stinger to drill a hole for planting unrooted willow and cottonwood cuttings are:

1) simple to operate and transport
2) little training necessary to operate
3) hydrodrilling the planting hole is fast
4) plant large number of cuttings in a short period of time
5) allows cutting to be planted directly into a wet environment
6) allows for saturated soil conditions to surround the cutting for a longer period of time
7) liquefied soil will settle around the cutting eliminating air pockets in the rooting zone



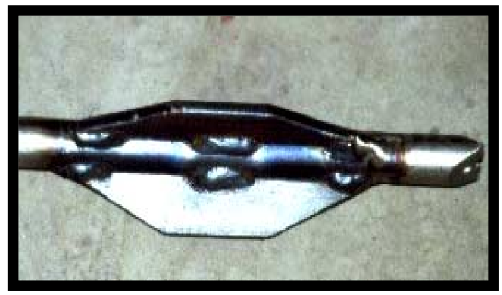
Waterjet Nozzle

Based on a request from Scott Henderson, an Idaho NRCS Field Office employee, and others, Boyd

Simonson, PMC Biological Technician, used the paper written by Drake and Langel (1998) and attempted to modify their design to better fit the coarse soils in the Intermountain West. He started with the actual probe itself. A local machinist used the detailed drawing to build the nozzle out of stainless steel and welded it to a ½ in steel pipe. Boyd added a T-handle at the top to help with the planting operation and a ball valve at the handle to turn the water on and off (see Appendix A).


Handle with ball valve

After testing in the field, we decided to add a set of vanes to be bottom on one of the probes. Three vanes were welded to the probe pipe directly above the stainless steel tip. The individual vanes were about four inches long, tapering down to the nozzle, and about 5/8 inch tall. The vanes provide several benefits. They open the hole up all the way down to accept wider diameter cuttings. This is especially true in compacted layers like clay. They also allow the user to nudge rocks slightly out the way in the hole. With the smooth pipe, it is almost impossible to get any leverage on rocks. For silt soils, the vanes are a real help. With cobbly soils, it does not provide a major advantage. We work in a combination of silts and gravels so we put vanes on one probe and left the other without vanes.



It took quite a bit of research to come up with the right size pump. . Drake and Langel (1998) describe a “cube” pump, but we had difficulty finding anything with that name. We determined that the basic specifications for the pump were:

1) gasoline powered
2) small enough to fit on the back of an ATV
3) output of at least 80 psi or higher
4) 120 gallons/minute output
5) vertical lift of at least 18 ft

There are many different pumps that meet these specifications available on the market.

We did try a 1600-psi pressure washer thinking that it was ready made for this type of application. The main problem is that pressure washers do not put out enough water volume for this application. The pressure washers typically put out about 2-3 gpm while the high-pressure pump puts out 120 gpm (about 12-15 gpm at the nozzle). Pressure washers have more than enough water pressure, but they tend to blow all the soil out of the hole for the first couple of inches making it pretty messy. After the hole is drilled, there is very little water left in the hole to hydrate the willow cuttings. We do not recommend using a pressure washer for this application.

Next, Boyd felt that for safety’s sake, a pressure relief valve should be installed so when both waterjets were shut off, the water from the pump would bypass back into the stream or other water source. This would decrease the pressure on the pump and eliminate turning the pump on and off. A manifold was designed to fit on the pump to allow the water to flow from the stream to either the waterjet stingers or to the bypass hose. When a certain internal pressure is reached inside the manifold, the water will divert to the bypass hose and back into the stream automatically. An additional benefit to the pressure relief valve was that it allows one to release air out of the system. This made the priming go much faster.

Garden Hose Quick Coupler Manifold

The garden hose quick coupler manifold allows two waterjets to run simultaneously. It is attached to the main manifold just past the pressure relief valve. Quick couple attachments (available at most lawn and garden stores) are used to keep the connections simple, reduce the possibility of stripping the treads on the hose ends, and to allow the hoses to be hooked up in either direction. Water is delivered through heavy-duty 5/8 in garden hoses with a pressure rating of 100 psi that are 100 ft long. The hoses run from the garden hose quick couple manifold to the waterjets.

At the planting site, the hoses are laid out parallel to the stream channel. The two waterjets can be operated with two separate crews. One crewmember runs each waterjet and the other crewmembers transport the cuttings and push them into the holes after they are hydrodrilled. As the holes are hydrodrilled and planted in the 200 ft length, the ATV with the waterjet stinger pump is driven further down the streambank and the process starts all over again. If the streambank is too high and the lift is too great to get water from the stream to the pump, the pump can be dismounted from the ATV and placed on a flat shelf that is cut right into the streambank. This way the pump is placed closer to the water, lift is reduced, and pressure increased at the nozzles.

Planting Process

Once the pump is set up and pushing water to the waterjets, hydrodrilling holes can begin. Planting sites with vegetation are scalped down to mineral soil to get rid of competing above ground biomass. The waterjet is placed in the center of the scalp and the ball valve is turned on. At this point most beginning users get nervous about being splashed with water. We have found that water rarely splashes up, rather it tends to bubble as it liquefies the soil. Splashing might occur if the hydrodrilling is attempted on soils that are crusted or have a hard layer. However, as soon as the waterjet goes through the surface layer of soil, the splashing is eliminated (except in rocky soils).

After turning on the ball valve and the water starts jetting out of the nozzle, the waterjet will slowly start sinking into the ground. If a hard layer is encountered, the waterjet will stop. If the user leaves the waterjet in place and let the water work on the layer, eventually it will go through it. We have demonstrated this with several demonstration projects from a site with a 6 in hard calcic layer to a site with a 2 ft thick layer of decomposed granite. If medium sized rocks (with lots of fines around them) are encountered, the user must wiggle the jet back and forth until the water can find a way around it. This does make a larger hole below the surface, but the liquefied soil will normally settle back into place after the cutting has been installed.

As the waterjet liquefies the soil, it will continue down until it hits something it cannot cut through, the T-handle hits the ground, or the user stops. We have held the waterjet at a stationary point to have the water cut further into the soil. We have been able to duplicate Drake and Langel's (1998) depth of 6.6 ft (2 m). The depth the waterjet will penetrate depends mainly on the soil texture and the length of the probe.

As the user pulls the waterjet back up out of the hole, the nozzle should be rotated back and forth to increase the size of the hole. The rotation should continue the entire length of the hole from the bottom to the ground surface. The waterjet probe is ½ in diameter and the user should be planting at least ¾ in diameter or larger cuttings (Bentrup and Hoag 1998, Hoag 1993). In order to get larger diameter cuttings in the hole, the soil needs to be liquefied all the way to the soil surface.

Once the hole has been hydrodrilled, the single cutting or a bundle of three to four cuttings can be pushed into the hole. The longer one waits to shove the cutting into the hole, the higher the chance there is to for the suspended sediment to settle to the bottom of the hole. This will limit the depth that the cutting can be pushed to.

An alternative option is to start the hole with the waterjet and then place the cutting or bundle right next to the waterjet pipe and push both the waterjet and the cuttings into the hole at the same time. If done properly, the cutting or bundle will go down as the waterjet liquefies the soil. If the cutting hits a tight spot, the operator will immediately know it and he can spiral the nozzle around a little to loosen the obstruction. A word of caution - make sure that the cutting does not extend past the nozzles or the pressurized water will cut the bark off.

One problem that we have observed is that if there is a coarse soil layer under a layer of fine textured soil, when the waterjet drills into this coarse layer, the water in the hole will drain out into the coarse layer. This will defeat the purpose of planting the cuttings into a slurry to eliminate air pockets. Pulling the waterjet nozzle up to just above the layer will allow sediment to settle back into the bottom of the hole and seal it again.

We have found that a three-person team per waterjet works very well for the planting process. One member of the team runs the waterjet, the other two members haul the cuttings and shove them in the holes. The team members can rotate jobs through the planting day to keep everyone fresh and interested in the planting job. An extra person to transport the cuttings from the soaking location to the planting location with another ATV will speed the process up. The speed of the entire planting process will depend upon the soil, the labor force, and the cutting or bundle sizes.

Once the cutting is shoved into the hole to the depth of the low water table, the sediment will start to settle around the stem. It is important that the operator not allow significant amounts of sediment to bubble up out of the hole while drilling. The more sediment that is allowed to bubble out, the more sediment that will have to be replaced after the water moves out into the surrounding soil. After planting, the planting team needs to return to each of the stems and replace soil that bubbled out and created a depression around the stem. The depression is cause by the sediment settling in and compacting around the stem. By replacing soil around the stem, it is possible to provide more opportunity for root development in the upper part of the soil profile. When replacing the soil, use a mud slurry or tamp shoveled soil around the stem to prevent air pockets.

In cobbly soils, the waterjet stinger has the same problems as most of the other techniques that one would use to plant hardwood cuttings. In our experience, the waterjet stinger will cut down through he silt layer on top of the cobble layer and stop as it hits the cobbles. In some cases, when there are a lot of fine soils around the cobbles, the waterjet will liquefy the soil around the cobbles and allow the cobbles to shift slightly so the user can get the probe around the side of the cobble. In most cases however, it is very difficult even with the waterjet to go very deeply into a cobbly soil profile. Several other methods can be successful on cobbly soils. See “The Practical Streambank Bioengineering Guide” (Bentrup and Hoag 1998) for detailed instructions on how to install these treatments.

Safety

We would be remiss if we did not mention safety. Before the start of each planting session, safety concerns should be discussed with the planting team members. This ensures that proper safe working conditions are fresh in everyone’s mind before starting to work. Potential safety problems that might occur can be discussed. The proper response to these problems can then be considered. This helps everyone know what to do if problems actually occur.

The water coming out of the waterjet nozzles is concentrated and under extremely high pressure. If the waterjet nozzle were ever pointed at a foot or hand, it could cut through a boot or glove and into the skin. Severe damage could occur if the nozzle were pointed at the face, eyes, or any unprotected part of the body. The waterjet stinger is not a toy and should always be operated by, or at least supervised by, an experienced, mature adult. Caution should always be exercised around the pump. Inspect the hoses regularly to ensure that they are not kinked, cut, or abraded. The quick couple hose attachments should be tested several times during the operation of the waterjet stinger to ensure they are firmly attached. If for some reason the hoses are disconnected from the waterjets, shut the pump down immediately to ensure the metal tipped ends do not whip around and hurt one of the team members. It is much better to anticipate and discuss safety concerns than to heal the wounds caused by a mistake or faulty equipment.

Summary

The waterjet stinger is easy to operate and transport. Very little training is necessary to operate the waterjet stinger. The pump intake should be placed in a fairly sediment free location in the streambed to operate properly. Hydrodrilling a planting hole with the waterjet stinger is fast and relatively splash-free. A large number of cuttings can be planted in a short period of time with very little effort compared to conventional planting methods. Planting into a hole filled with water allows each cutting to be planted directly into a wet microenvironment. The liquefied soil will settle around the cutting eliminating air pockets in the rooting zone that prevent root growth. In addition, the waterjet stinger creates saturated soil conditions around the cutting for a longer period of time. This means the cutting is in the best microenvironment to produce the largest and most desirable root mass possible, which in turn means that the establishment success rate will increase.

Overall, the waterjet stinger is relatively inexpensive when compared to other planting methods. The PMC prototype waterjet stinger cost about $1000 for parts (see Appendix B) and labor to build it was about $500 for a total of about $1500. The design layout was planned to make the entire piece of equipment as simple as possible to build and operate. The most complicated part is putting the manifold together and this only takes about a half-hour. All of the parts can be ordered or purchased locally, except the pump. An experienced machinist can build the waterjet nozzle in a couple of hours with the plans provided in this paper. Once the parts are purchased and delivered, the entire waterjet stinger can be assembled in less than a day.

The waterjet stinger is not new technology, but we have taken it to another level. We have included all the information necessary for a person to build one. After it has been built, it will take some experimentation and experience in your particular soils and conditions to figure out the best way to hydrodrill your planting holes.

More information can be obtained by calling Chris Hoag at 208-397-4133 or Boyd Simonson at 208-397-4501. For those people who have access to the Internet, email messages can be sent to choag@id.usda.gov.

Brent Cornforth demonstrates the Waterjet Stinger at a training session

Acknowledgements

The development of the Waterjet Stinger would not be possible without the support and the generous financial assistance provided by the South Bingham Soil and Water Conservation District, Gem Soil and Water Conservation District, Squaw Creek Soil and Water Conservation District, the Camas Soil and Water Conservation District and Dick Scully (Regional Fisheries Biologist), Southeast Region, Idaho Department of Fish And Game.

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Andrews, D. 1999. Personal Communication. Denis Andrews Consulting, Manitoba, Canada.

Bentrup, G. and J.C. Hoag. 1998. *The Practical Streambank Bioengineering Guide — A User's Guide for Natural Streambank Stabilization Techniques in the Arid and Semi-Arid Great Basin and Intermountain West*. USDA NRCS Plant Materials Center, Interagency Riparian/Wetland Plant Development Project, Aberdeen, ID.

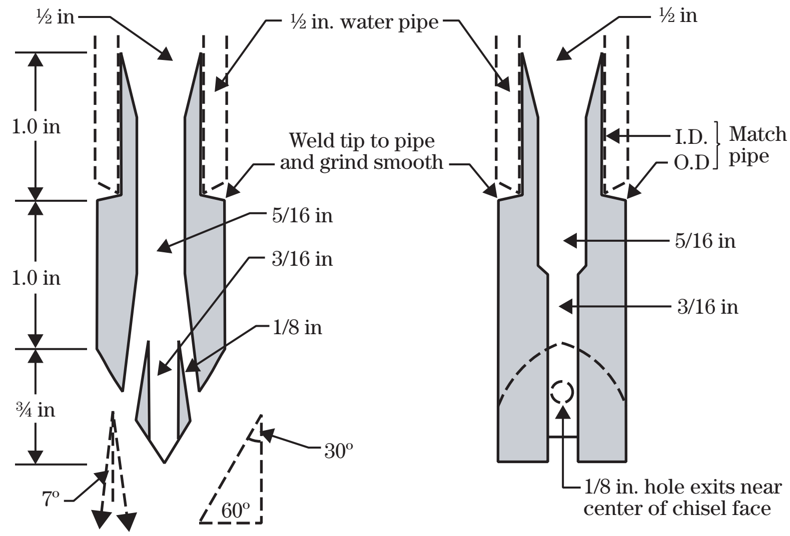
Drake, L and R Langel. 1998. Deep-planting willow cuttings via water jetting. ASCE Wetlands Engineering & River Restoration Conference, Denver, CO. March 22-27, 1998.

Hoag, JC and D Ogle. 1994. *The Stinger, a tool to plant unrooted hardwood cuttings of willow and cottonwood species for riparian or shoreline erosion control or rehabilitation*. USDA Natural Resources Conservation Service, Idaho Plant Materials Technical Note No. 6, Boise, ID. 13 pp.

Hoag, JC. 1993. *How to plant willows and cottonwoods for riparian rehabilitation*. USDA Natural Resources Conservation Service, Idaho Plant Materials Technical Note No. 23, Boise, ID. 12 pp.

Oldham, JA. 1989. The hydrodriller: an efficient technique for installing woody stem cuttings. Society of Ecological Restoration and Management annual meeting, Oakland, CA. Jan. 16-20, 1989. 6 pp.

APPENDIX A: DETAILED DRAWING OF THE WATERJET NOZZLE TIP FROM DRAKE AND LANGEL (1998).



Pictures of the stainless steel nozzles that were welded to ½ in steel pipe. The stainless steel is expected to increase the life of the waterjet. A machinist built the pipe, handle, and nozzles as a single unit. The ball valve is added by the end user.

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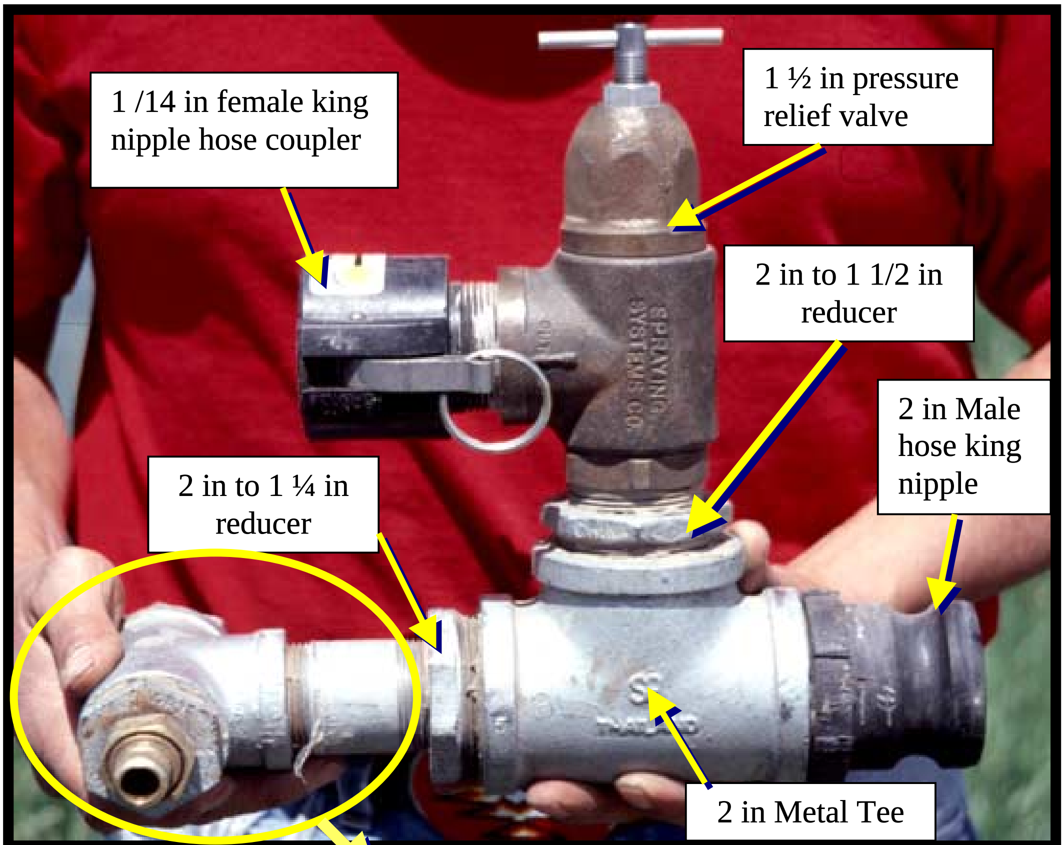
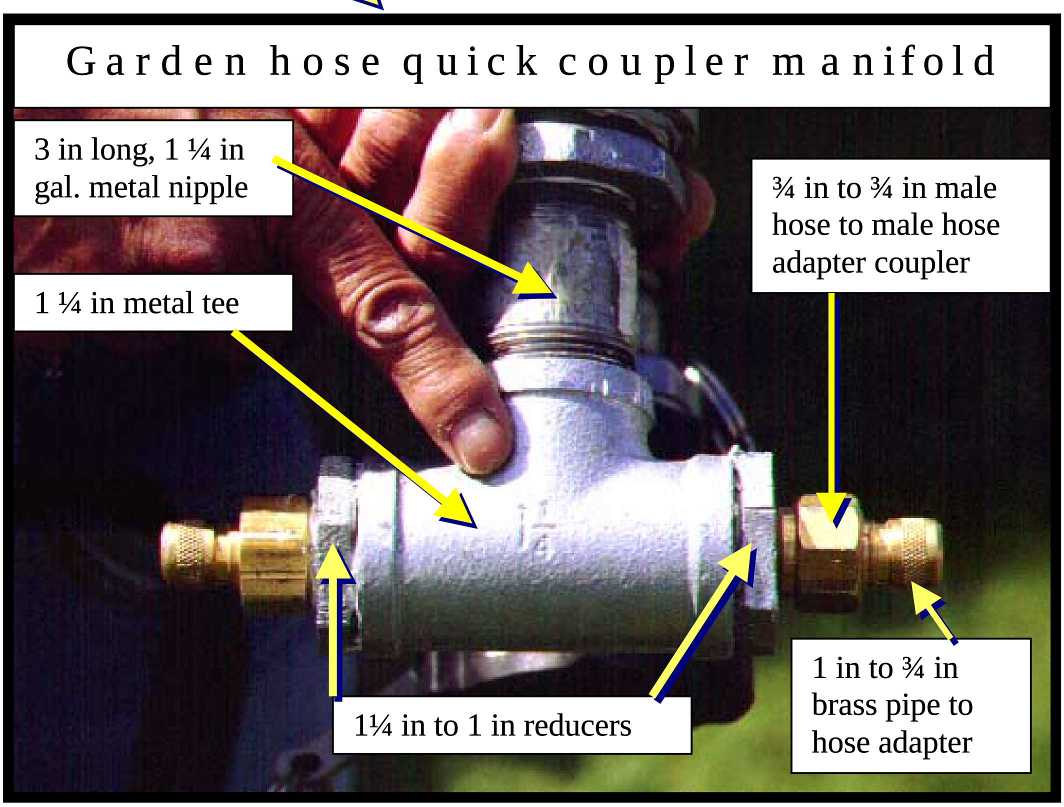
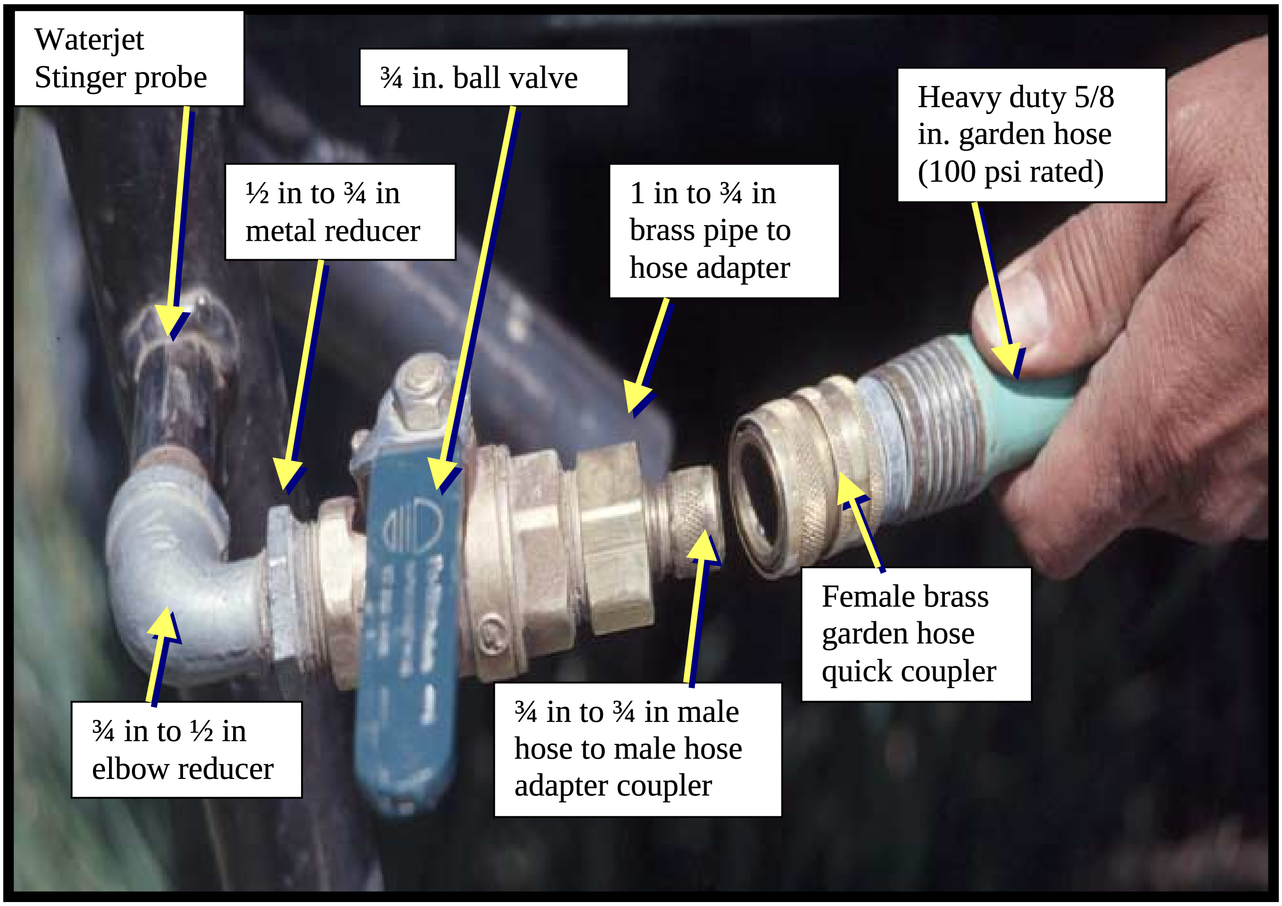
APPENDIX B: LIST OF MATERIALS FOR THE ENTIRE WATERJET STINGER.

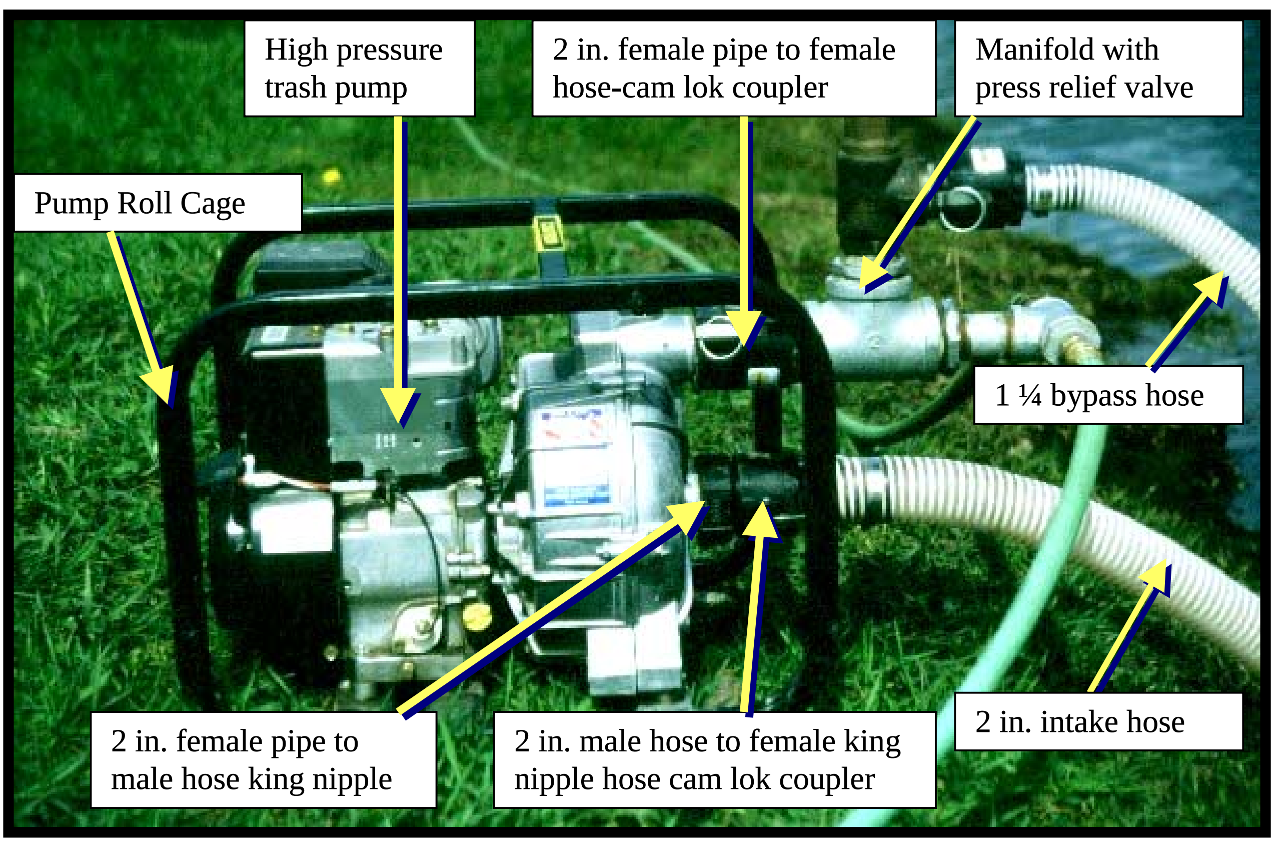
Name of item	Location	Number	Cost
Manifold parts			
1 ½ in. pressure relief valve	Manifold	1	$120.00
2 in. galvanized metal tee	Manifold	1	7.00
1 ¼ in. galvanized metal tee	Manifold	1	4.00
2 in. to 1 ½ in. galvanized metal reducer	Manifold	1	1.64
3-in.-long 1 ½ in. galvanized metal nipple	Manifold	1	1.59
3-in.-long 1 ¼ in. galvanized metal nipple	Manifold	1	1.19
2 in. to 1 ¼ in. galvanized metal reducer	Manifold	1	3.00
1 ¼ in. to 1 in. galvanized metal reducer	Manifold	2	5.00
2 in. male pipe to 2 in male coupler nipple	Manifold	1	4.75
1 ½ in male pipe to female cam lok coupler	Manifold	1	8.00
1 in. to ¾ in. brass pipe to hose adapter	Manifold	2	6.58
¾ in. to ¾ in. male hose to male hose adapter	Manifold	2	1.89
		Total:	164.64
Suction and Bypass parts			
1 ¼ in. plastic hose for discharge	Bypass	20 ft	30.00
1 ½ female cam lok to 1 ¼ male hose shank	Bypass	1	12.00
2 in. male pipe to male hose coupler	Screen	1	5.80
2 in. plastic hose for suction for intake	Intake	20 ft	40.00
2 in. male hose to female king nipple hose cam lok coupler	Intake	2	29.70
2 in. hose clamps for plastic hose	Intake	3	2.70
		Total:	120.20
Waterjet parts			
¾ in. ball valve	Probes	2	10.00
¾ in to ½ in elbow reducer	Probes	2	3.00
½ in to ¾ in metal reducer	Probes	2	2.00
1 in. to ¾ in. brass pipe to hose adapter	Probes	2	6.58
¾ in. male hose to ¾ in. male hose adapter	Probes	2	2.00
Female brass garden hose quick couplers	G. hoses	4	11.00
Heavy duty 5/8 in. garden hose (100 psi rated)		200 ft	120.00
Waterjets, manufactured by machinist		2	180.00
		Total:	334.58
Waterjet pump			
2 in. female pipe to male hose king nipple	Pump	1	5.30
2 in. female pipe to female hose-cam lok coupler	Pump	1	15.00
Pump and Motor (excludes freight)		1	495.00
Roll cage for pump		1	65.00
		Total:	595.30
Total cost of parts (as of March 2001)			$1199.72

APPENDIX B: LIST OF MATERIALS FOR THE ENTIRE WATERJET STINGER. (continued)






Waterjet
Stinger probe
¾ in. ball valve
Heavy duty 5/8
in. garden hose
(100 psi rated)
½ in to ¾ in
metal reducer
1 in to ¾ in
brass pipe to
hose adapter
Female brass
garden hose
quick coupler
¾ in to ½ in
elbow reducer
¾ in to ¾ in male
hose to male hose
adapter coupler


High pressure
trash pump
2 in. female pipe to female
hose-cam lok coupler
Manifold with
press relief valve
Pump Roll Cage
1 ¼ bypass hose
2 in. female pipe to
male hose king nipple
2 in. male hose to female king
nipple hose cam lok coupler
2 in. intake hose

APPENDIX C: HIGH PRESSURE GASOLINE POWERED PUMP SPECIFICATIONS

Note: Metal cage around the pump and motor was purchased separately.

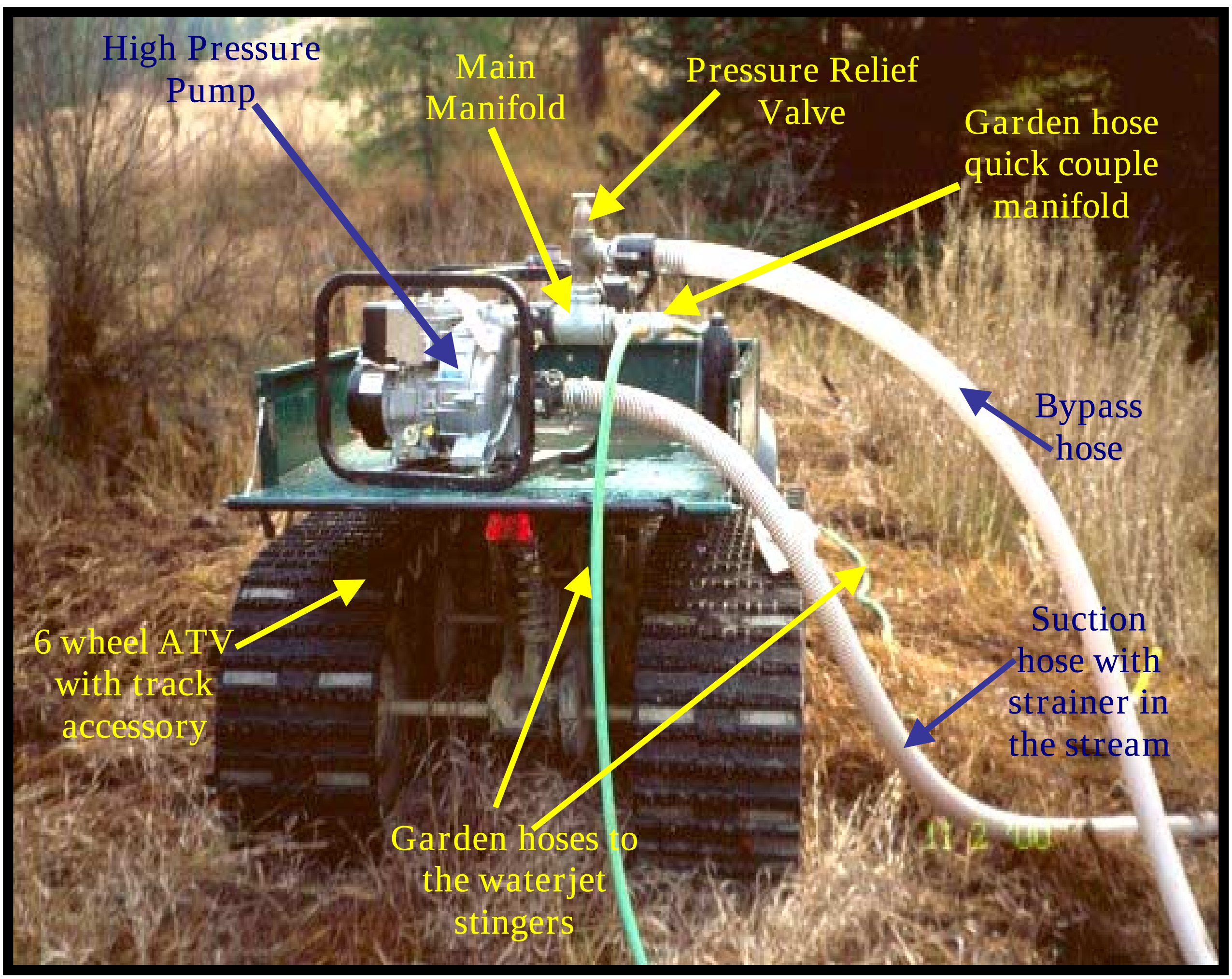
Specifications

- 5 HP Gas powered High pressure pump
- 7200 GPH, 200 foot head, 88 psi max
- Vertical lift 18 ft
- Self priming pump with 2 inch NPT suction and discharge ports
- Aluminum closed impeller
- Cast aluminum housing
- Cast Iron volute
- Built-in check valve
- Water and trash pump strainer 2 in included
- 64 pounds

Note: Trash Strainer shown was built for large stream systems so it could be perched above the stream bottom and was heavy enough not to move with the stream current. The pump was shipped with a small strainer that attaches to the end of the suction hose for use on smaller stream systems (Not shown).

APPENDIX D: AN ILLUSTRATED DIAGRAM OF AN OPERATING WATERJET STINGER

The waterjet stinger is sitting on a large 6-wheel ATV during a workshop in Lapwai, ID on Little Lapwai Creek. The 6-wheel ATV is larger than what is necessary to transport the waterjet stinger. The track option for the ATV is not necessary.



TECHNICAL NOTE

USDA NATURAL RESOURCES CONSERVATION SERVICE HAWAII

Biology Technical Note No. 9

HAWAII STREAM VISUAL ASSESSMENT PROTOCOL

Introduction

This coversheet transmits a copy of the NRCS Hawaii Stream Visual Assessment Protocol (HSVAP), Version 1.0. The HSVAP provides a first step, basic level of stream quality evaluation, based primarily on physical conditions. It can be used to determine the current stream condition as a snapshot, or used to observe changes over time. It can also be used to identify the need for more thorough assessment methods that focus on a particular aspect of the aquatic system (e.g. water quality or aquatic species habitat).

Conservationists with only limited knowledge of biology or hydrology can perform the assessment, after minimal training. NRCS staff should in most cases conduct the assessment with the client, as part of the field inventory of all resources -- Soil, Water, Air, Animals, Plants, and Humans (SWAPA+H). This first-step assessment will show the overall quality of the stream, and more importantly, the specific elements that are indicators of poor quality or deterioration of stream habitat. The elements can then be evaluated for potential restoration actions.

This protocol is based on the national version of the NRCS Stream Visual Assessment Protocol (NWCC Technical Note 99-1, December 1998). Initially, stream experts in Hawaii were asked to provide comments, and it became clear that numerous changes were needed to reflect Hawaii's unique stream conditions. NRCS Hawaii convened stream experts and other interested parties from around the state, beginning in January 1999. After a year of little activity on the protocol, the "Stream Bioassessment Working Group", which consisted of interagency, academic, and community group leaders interested in stream assessments, was formed. The NRCS State Biologist chaired the meetings. The group provided numerous review comments, both written and oral, from the meetings and the field site tests. The protocol became a work in progress (twelve drafts) for a year, and was modified substantially to better reflect stream conditions in Hawaii. The attached HSVAP is in its final form as Version 1.0.

Contents of the protocol include: (1) An *Equipment List* and (2) a *Guidance Document*, which explains each step in filling out the assessment forms, and defines and clarifies how the user should characterize and score the elements used to evaluate stream conditions. The *Guidance Document* can be utilized in the field as the *Overview Data Sheets* and the *Scoring Data Sheets* are being filled out.

Field Site Trials

The purpose of the field trials was to evaluate the accuracy, precision, and usability of the HSVAP. Stream Bioassessment Working Group members assessed a variety of streams that represent typical stream systems in the state. Many sites chosen were those that had previously been assessed, either by the National Water Quality Assessment team at USGS using strict national guidelines; or by the Department of Health/Stream Research Center, using the Hawaii Stream Bioassessment Protocol (Kido, Smith, Heacock, December 1999). Streams chosen reflected differing conditions, including a range from least-impacted reference sites → somewhat degraded → highly degraded; and sites with different flow regimes (such as Kawela stream and Hanalei River). Typically, 8 – 10 members of the Stream Bioassessment Working Group participated in the field. Eleven streams (one or two days each) were evaluated, including:

Most degraded

- July 15th, 1999 Waikakalaua Stream, Oahu
- July 21st, 2000 Unnamed Stream, Bellows AFB, Oahu
- August 10th, 2000 Waimanalo Stream, Oahu

Mid range, less degraded

- May 3rd, 2000 Waihee Stream, Oahu
- August 24th, 2000 Kawa Stream, Oahu
- November 9th 2000 Kawela Stream, Molokai
- December 5th, 2000 Iao Stream, Maui,
- January 12th, 2001 Maunawili Stream, Oahu,
- January 18th, 2001 Hanalei River, Kauai

Reference Conditions

- December 14th, 2000 Waiahole Stream, Oahu,
- February 25th, 2000 Limahuli Stream, Kauai
- January 17th, 2001 Limahuli Stream, Kauai

Acknowledgements

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Hawaii Stream Visual Assessment Protocol

USDA
Natural Resources Conservation Service
January 31, 2001

VERSION 1.0

GUIDANCE DOCUMENT

FOR COMPLETING THE FORMS:

EQUIPMENT LIST

Rubber boots, tabis or footwear that can get wet
Measuring tape (100m water resistant one is the best; 30 meter or 100 foot tape will do. Ensure you use same measurement units for all.
Meter or Yard Stick (for depth measurements)
Calculator
Watch with second count
Temperature probe (F or C)
Velocity meter or Guava /orange peels (for velocity test)
Flow meter (optional)
Sunscreen
Mosquito Repellant

OVERVIEW DATA SHEET:

Date/Evaluator(s)/Stream Name/ etc. – Fill out the top of the form. The Hydrologic/Watershed unit number and acres can be obtained from the NRCS Arcview database (Currently, Field Office staff should contact State Office GIS staff for this information if you do not have the information on hard copy maps).
Stream Order – This refers to the stream's connection to the ocean. First order streams would directly flow into the ocean; second order streams would feed into that stream that flows directly into the ocean; etc. Most streams in Hawaii are 1st, 2nd, or 3rd order streams. Note Yes/No if stream is tributary (connected to the ocean)
Fish Species/Endangered /Flow/Water Quality/Ownership/Major land use – Check the appropriate maps and databases, as applicable or available. There also may be Environmental Assessments or EIS' completed on the stream that would be helpful. Check OEQC or with County Planning. Evaluation of other land uses in the watershed is important for later determining restoration activities. Also, the client and other landusers in the area may have knowledge about the history, land uses, aquatic habitat, etc, so always query them.
Other Comments – If there have been other evaluations of the stream conducted, these should be mentioned and attached. Other comments might include landowner's participation in USDA programs, etc.

SCORING DATA SHEET:

CHARACTERIZATION

The following information will introduce the overall description of the stream reach being evaluated. These data can be used to follow changes over time (e.g. temperature fluctuations or substrate changes). Also, some of the information will be used in the second section, when you evaluate and "score" specific stream elements.

Date/Time/Weather/Stream Name/Surveyors – Fill out the top of the form. For weather, note approximate air temperature, cloud cover, precipitation, and wind.
Reach ID – The Reach ID is a number or letter identifying the reach on a quad map or other map of the stream. For this protocol, the length of the assessment reach is 20 times the active channel width, or a minimum of 100 meters/300 feet; maximum 300 meters/900 feet. The reach (es) to be sampled should be identified after the Overview is done and areas are looked at on aerial photos. Reaches should be representative—that is, there should not be a major change within the same reach (e.g. break into two reaches estuarine part of the stream vs. the upper part).
Stream Type – There are numerous kinds of classification systems. The recommended system for this protocol is one developed by Montgomery and Buffington. It recognizes six classes of alluvial channels – cascade, step-pool; plane-bed; riffle/pool, regime, and braided (based in large part on stream gradient). See the attached stream classification sketches, and pick the one that best fits the situation.
Segment Length – Measure or estimate the channel length (in meters or feet) of each Segment or habitat unit being evaluated (typically 20 meters, which is 100 meters divided by 5, or 60 feet, which is 300 feet divided by 5). Most categories evaluate the entire Segment. The number of Segments depends on the size of the reach (minimum three per reach; five is typical; more is better).

Temperature – Use a hand-held thermometer in at least 3 places in the Segment (include shady and open canopy areas if they occur within the segment), get an average, and enter the current stream temperature in Fahrenheit or Celsius. If the time of day for temperature measurement is different than time recorded at top of the form, note the time as well.
Substrate Composition – To estimate this important characteristic, split your segment equally into four plots (e.g. mark off every 5 meters on your 20 meter tape), visually assess substrate within the 5 meter rectangle by estimating cover/composition. Use the following definitions of terms for substrate:

- Silt/Clay – very fine sediment
- Sand – like beach sand
- Gravel – larger than sand; smaller than your thumbnail
- Cobble – larger than your thumbnail, smaller than your fist
- Rock – larger than your fist, smaller than your head
- Boulder – larger than your head or basketball
- Bedrock or concrete bottom – natural solid rock base or human-made concrete/rock bottom (circle which one)

Use the attached Munsell chart as a guide to assess cover. Make tally marks (or a dot count tally) of the top two dominant substrates per plot. If only one substrate dominates the plot, make two marks for that kind of substrate. Then add up tally marks for each kind of substrate and divide that number by 8 to get the overall percentages per substrate type. Also note the composition of the bank materials in “remarks” section.
Embeddedness – Embeddedness measures the degree to which cobble substrate is surrounded by fine sediment (sediment load in streams). It can relate to the suitability of the stream substrate as habitat for macroinvertebrates and fish, or show effects of sedimentation from the upper watershed. It can only be evaluated in riffle and run habitats. One to four representative sites in these types of habitats should be chosen along the Segment. If there are no riffles or runs, write “No RI or RU”. If there are, measure the depths to which objects are buried by sediment. This assessment can be accomplished by picking up gravel or cobble with your fingertips and estimating what percent of the stone was buried. At least 50 measurements should be taken, then averaged to produce the overall percentage of embeddedness. Use the back of the scoresheet to document and average your 50 measurements.
Bank Vegetation –Estimate the percentage cover of trees, shrubs/saplings, herbaceous, leaf litter or bare bank viewed upstream along the left and right bank. Look at the area directly adjacent to the stream and use the following definitions of terms:

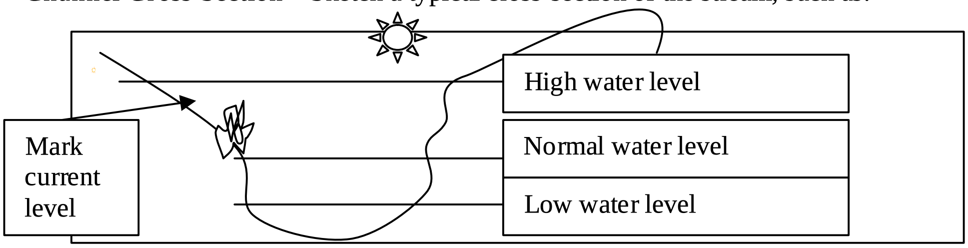
- Tree = a woody plant > 3.0 inches in diameter at breast height.
- Shrub/Sapling = a woody plant < 3.0 inches in diameter at breast height and > 3.2 feet in height.
- Herbaceous = all non-woody plants, regardless of height, and woody plants < 3.2 feet in height.

You should look downstream along the left and right bank of the Segment . In “notes” at the bottom of the page, list the dominant plant species for each segment and any notes about shallow or deep roots. Look at the area directly adjacent to the stream (along the banks). Ground coverage, not canopy, is what you should be estimating.
Average % Canopy/Shade – Record the average percentage of canopy cover over the active stream channel (where the water typically is, not the riparian area). You can either use a densiometer over the active channel, or visually assess the relative amount of shading or concealment of the stream by vegetation. For wide streams/rivers, do not consider the area where no shade is possible. The Munsel Chart guide can be used to visually assess this element.
Average Actual Width -- Cross section widths can be measured by a measuring taped stretched perpendicular to the stream flow across the stream at the normal water level. At least five measurements across the stream should be taken and averaged. Note average on form
Velocity and Depth – To determine velocity, two methods can be used. (1) a guava (or an orange) can be dropped at the top of the segment and timed to the end of the segment to get meters per second, then multiply by a roughness factor of either 0.6 (for rough boundaries) or 0.8 for smooth channels. This multiplier is important, since the guava will find the path of least resistance, and velocity in the channel varies. Do this at least ten times and take an average of the scores. OR (2) use a velocity meter at the same crossing where you measure depth. To determine depth, take at least ten measurements with your yard or meter stick at the same locations where you measured width, and average the scores.
Flow Status- Compare the current water level to the normal water level, and record as high, normal, or low. The normal water line is the line on the bank created by natural level fluctuation as evidenced by destruction of terrestrial vegetation, litter/debris lines, shelving, and changes in soil characteristics. Circle High/Normal/Low.

- High = if upland vegetation or area typically dry is submerged
- Normal = if water level appears to be within normal flow fluctuations
- Low = if water level is significantly lower than normal, as seen by bare areas exposed or wetland vegetation exposed and dead or dying.

Flow – If you have a flow meter, use it in at least your five transect plots used to assess substrate and get an average flow in cubic meters per second. If you do not have a flow meter, take the area of the cross section (your average depth multiplied by your average width) and multiply this number by your velocity number to get cubic meters per second.

Channel Cross-Section – Sketch a typical cross-section of the stream, such as:



THE TEN SCORED ELEMENTS

SCORING

This section involves evaluating different elements of the stream and documenting a score (from 0 to 2.0, low to high rating). Use the "Scoring Sheet for the Elements" for the rating. The total all of the scores recorded will be divided by the number of elements rated for the average score (typically 10, unless for instance embeddedness is not scored because there were no riffles or runs in the Segment). A general stream rating can be obtained from this score. This score can be compared over time, if more than one evaluation is done, or by segment, to determine most degraded or best segments for future restoration. Not only should this overall score be regarded. The evaluation of each scored element should be carefully assessed to determine the degraded elements in the system and to identify potential restoration actions.

1. TURBIDITY
Clarity of the water is an obvious and easy feature to assess. The deeper an object in the water can be seen, the lower the amount of turbidity. Use the depth that objects are visible only if the stream is deep enough to evaluate turbidity using this approach. For example, if the water is clear, but only 20 cms deep, do not rate it as if an object became obscured at a depth of 20 cms. This measure should be taken after a stream has had the opportunity to "settle" following a storm event. This element cannot be measured after recent heavy rains (come back to the site another day). Recognize that organic acids can create tea-colored water; this is not turbidity and should not be counted as turbid. Identify the condition and note the score on the datasheet.

2. PLANT GROWTH
Water that has slight nutrient enrichment may support communities of algae, which provide a greenish color to the water. Streams with heavy loads of nutrients have thick coatings of algae attached to the rocks and other submerged objects. Floating algal mats, surface scum, or microbial sheen (ferri hydrite) are indicators of a eutrophic stream. Note the level of plant/algal growth on the datasheet.

3. CHANNEL CONDITION
Changes in the channel may affect the way a stream naturally does its work, such as the transport of sediment and water, and the development and maintenance of habitat for fish, aquatic insects, and aquatic plants. Some modifications to the stream channels have more impact on stream health than others. And some stream types are more sensitive to management stress than others. For example, riprap along the sides and bottom of the Segment can affect a stream more than channelization. Active downcutting and excessive lateral cutting are serious impairments to stream function. Both conditions are indicative of an unstable stream channel. Usually, this instability must be addressed before committing time and money toward improving other stream problems. Extensive bank-armoring of channels to stop lateral cutting usually leads to more problems (especially downstream). To score this element, pick the condition that best characterizes the Segment and document the score on the data sheet.

4. CHANNEL FLOW ALTERATION
Water withdrawals from the stream affect habitat conditions and change the biological and geomorphological conditions of the stream. Temporary diversions are those that are not meant to last (e.g. small rock diversions for taro that would blow out during a normal storm event). Intermittent withdrawals are those that are occasional or periodic. Any flow alterations outside of the segment should not be counted in this element; instead, note distant diversions/inputs in the "Overview" sheet. If temporary or intermittent, the score should reflect also the amount of water being taken, scoring higher within the range if minimal water is being diverted. Also note if there are inputs, such as stormwater outfalls or culverts in the segment. Record score on the data sheet.

5. PERCENT EMBEDDEDNESS
Review your average number in the Characterization Section on "Percent Embeddedness", Pick the appropriate percentage and note the score on the data sheet. If there were no riffles or pools in the segment, do not score this (and divide total score by 9 instead of the 10 elements)

6. BANK STABILITY

This element is the potential for soil erosion from the upper and lower stream banks into the stream. Some bank erosion is normal in a healthy stream. Excessive bank erosion occurs where riparian zones are degraded or where the stream is unstable because of changes in hydrology, sediment load, or isolation from the flood plain. High and steep banks are more susceptible to erosion or collapse. A healthy riparian corridor with a vegetated flood plain contributes to bank stability. The type of vegetation along the banks is important. For example, most trees, shrubs, sedges, and rushes have the type of root masses capable of withstanding high streamflow events, while pioneer species (such as guinea grass) do not. Mulch can also act as a stabilizer (e.g. ironwood twigs). Hardened banks (e.g riprap) are also stable. Soil type at the surface and below the surface also influences bank stability. Look for signs of erosion, unvegetated stretches, exposed tree roots, or scalloped edges. Evidence of construction, vehicular, or animal paths near banks or grazing area leading directly to the water's edge suggest conditions that may lead to the collapse of banks. Take into account the six key factors that influence stability:

1. Bank Height
2. Bank Angle
3. Bank Composition
4. Root Depth
5. Root Density
6. Surface Protection

Estimate the size or area of the bank that is bare and unstable, relative to the total bank area. Total bank area includes the slope and area immediately adjacent that if unstable would erode into the stream. This element will be difficult to score during high water. Calculate the ratio of eroded-disturbed bank /total area, yielding a percent stable bank value.

7. CANOPY/SHADE

This element is the measurement of shade across the active channel. Shading of the stream is important because it keeps water cool and limits the growth of less preferred types of algae. Cool water has a greater oxygen holding capacity than does warm water. When streamside trees are removed, the stream is exposed to the warming effects of the sun, which can change plant and animal species composition and abundance. For instance, alien fish such as tilapia are more adaptable to high water temperatures than the native Hawaiian gobies. Review your numbers under the Characterization Section on Average % canopy/shade, and determine if the canopy is open, closed, or in-between.

8. RIPARIAN WIDTH/CONDITION

"Riparian area" is the width of the natural vegetation zone from the edge of the active channel (or normal water line) out onto the flood plain. For this element, the word natural vegetation means plants native to the site or introduced species that function like them.

In most cases, a riparian zone in good condition

- Reduces the amount of pollutants that reach the stream in surface runoff.
- Helps control surface and bank erosion.
- Provides a shaded microclimate that keeps the water cool for stream biota.
- Provides fish habitat in the form of undercut banks with the "ceiling" held together by roots of woody vegetation.
- Provides organic material for stream biota that, among other functions, is the base of the food chain in higher order streams.
- Provides habitat for terrestrial insects, and habitat and travel corridors for terrestrial animals.
- Dissipates energy during flood events.
- Often provides the only refuge areas for fish during out-of-bank flows (behind trees, stumps, and logs).

In Hawaii's streams, we often find highly incised stream channels with steep-sloped riparian areas in their "natural" condition. This means that the stream is in the evolutionary stage of headcutting. It will typically have a gradient greater than 3%, and should not be scored lower because it is not yet in the stage of having floodplains or terraces. For example, many of the pristine Hawaiian headwater streams are in this stage (e.g. upper reaches of Limahuli Stream on Kauai).

The type, timing, intensity, and extent of activity in riparian zones are critical in determining the impact on the riparian area and adjacent stream. Narrow riparian zones and/or riparian zones that have roads, agricultural activities, residential or commercial structures, or significant areas of bare soils have reduced stream functions. The filtering function of riparian zones can be compromised by concentrated overland flows. Look for evidence of concentrated flows through the riparian zone.

Compare the width of the riparian zone to the active channel width. In this case, observe how much of the flood plain is covered by riparian vegetation. The vegetation must be natural. Take particular note of pioneer, invasive species. These do not provide good cover or stability to the banks and can wash away after storm events. Vegetation should consist of all of the structural components (aquatic plants, sedges or rushes, grasses, forbs, shrubs, understory trees, and overstory trees) appropriate for the area.

Examine both sides of the stream (looking downstream) and note on the “Channel cross section” diagram which side of the stream has problems. Check for evidence of concentrated flows through the riparian zone that are not adequately buffered before entering the riparian zone. Pick the condition that best characterizes the Segment and document the score on the data sheet.

9. HABITAT AVAILIBLE FOR NATIVE SPECIES

This assessment element measures availability of physical habitat for native Hawaiian stream organisms. The potential for the maintenance of a healthy aquatic plant and animal community and its ability to recover from disturbance is dependent on the variety and abundance of suitable habitat and flow available.

Observe the number of different habitat and flow types within each Segment and document the score on the datasheet. If there is flow, there will be at least one type of habitat available. Each flow type must be present in appreciable amounts to score. Flow types are described below.

(1) Seeps and Springs (SS)– Areas in the riparian area where there is groundwater input (cooling the water and providing habitat to native aquatic invertebrates).
(2) Pools (PO)– Areas characterized by smooth undisturbed surface, generally slow current, , and typically deep (deep enough to provide protective cover for fish). Included in this habitat would be deep “plunge” pools at the base of a cascade or waterfall.
(3) Runs (RU) – Areas characterized by moving water, but no broken water surface or whitewater.
(4) Riffles (RI) – Areas characterized by broken water surface, rocky or firm substrate, moderate or swift current, and relatively shallow depth (usually less than 18 inches). Generally, flow is fast and shallow.
(5) Cascades (CA) – Waterfalls, or basically steep riffles (greater than 3% gradient).

Chose a high score within the range if there are multiple numbers of each flow type within the reach. Decide on a score in the higher range if there are numerous pools, runs or riffles versus one of each. The range of scores allows best professional judgement to suit each unique situation.

10. LITTER/TRASH

The presence of litter, trash and fish or animal carcasses are obvious signs of stream degradation. Assess the presence in both the wetted area and riparian zone. Note the condition and score on the datasheet.

EVALUATION

The following ideas are a few examples for improving the various stream elements. It is important to have interdisciplinary input from experts in geomorphology, engineering, plant ecology and fish and wildlife biology.

1. Turbidity – Improve water quality by reducing sediment loads into the stream, by revegetating banks, reducing inputs from fields, or other means.
2. Plant growth – Improve water quality by reducing nutrient loading in the stream (e.g. nitrates and phosphates). Improve canopy cover to encourage compatible species of algal growth.
3. Channel Condition – Evaluate ways to reconnect or enhance the connectivity of the stream channel to its floodplain, where applicable.
4. Channel Flow Alteration – Evaluate ways to restore altered sites, producing changes in hydrology (e.g. streambank bioengineering, removing diversions).
5. Percent Embeddedness – Reduce fine sediment input from the upper watershed and/or eroding streambanks (e.g., by adding filter strips or riparian buffers).
6. Bank Stability – Improve bank stability with a wide riparian buffer, better channel conditions and bioengineering methods. Note that if there is major, contiguous erosion occurring around a bend, it may be a system-wide problem that needs to be addressed, compared with small eroding spots that may be treated on site.
7. Canopy/Shade – Enhance canopy over the stream to keep water temperature cool with plantings and management.
8. Riparian Condition – Improve conditions with plantings and management for a wide riparian buffer.
9. Habitat Available for Native Species – Evaluate ways to improve habitat conditions for native flora and fauna (e.g. flow, water depth, roughness of the channel).
10. Litter/trash – Clean up litter/trash in the stream and stream riparian areas and set up regular trash pickup.

OVERVIEW DATA SHEET

Date_____________Evaluator(s)____
Stream Name__________________________Tributary to:______________________________
Tributary to:__________________________Tributary to:______________________________
County_____________________USGS Quad name____________________________________
Location (TMK)_________________Latitude____________Longitude___________________
Landowner / Access____
____
Hydrologic/Watershed Unit____
Aerial Photos (include scale/flight elev)____
Stream Order__________Connected to ocean at least 1x/year?______Total length______miles
Drainage Area__________sq.mi. Stream Length_________ Summer Base Flows____cfs or cms
Elevation range of reach__________feet/meters Headwaters____________feet/meters

Fish and other animal species (known to exist in stream, from HI stream assessment and/or personal contact with experts) ____
____
____
____

Endangered / Threatened / Proposed / Candidate / Sensitive Species (check The Nature Conservancy Heritage Database)____
____
____
____

Stream Flow Data (Check USGS database)(give sta + elevation)____________________________
____

Water Quality Data (Check w/ DOH)____
____

Ownership along Stream (miles) Federal______State______Private_____ (attach map if possible)
Additional information____
____
____

Major Land uses and other resource issues in the Watershed (e.g. groundwater withdrawals; buffalo grazing downstream; taro cultivation; urban impacts; roadways crossing stream) (attach map if poss)
____
____
____
____
____

Other Comments____
____
____
____
____
____
____
____

SCORING SHEET FOR THE ELEMENTS

1. TURBIDITY (indicator of present erosion)

Condition	Score
Very clear; objects visible at depth to the bottom.	2.0 - 1.5
Moderately turbid	1. 0 – 0.5
Very turbid	0

2. PLANT GROWTH (indicator of eutrophication)

Condition	Score
Water clear with no significant algal scum or microalgae; rocks may be slimy but algae not obvious	2.0 - 1.5
Large clumps of macroalgae present, or distinctive green/brown scums visible on bottom or sides of stream	1. 0 – 0.5
Water distinctly green or pea green; or channel choked with grasses	0

3. CHANNEL CONDITION

Condition	Score
Natural Channel	2.0 – 1.8
Channelized by humans but natural walls and bottom	1.7 – 1.2
Walls Hardened (e.g. concrete, riprap)	1.1 – 0.6
Walls and Bottom Hardened	0.5 – 0

4. CHANNEL FLOW ALTERATION

Condition	Score
No withdrawals, diversions, or stormwater/ag water discharge entering segment.	2.0 – 1.8
Temporary, Intermittent withdrawals occurring within segment.	1.7 – 1.2
Permanent, Intermittent withdrawals or stormflow inputs (e.g. culverts occurring within segment.	1.1 – 0.6
Temporary, Constant withdrawals occurring within segment.	0.5 – 0.2
Permanent, Constant withdrawals occurring within segment.	0 – 0.2

5. PERCENT EMBEDDEDNESS

Condition	Score
< 10%	2.0
11 – 25 %	1.5 – 1.0
26 – 50 %	0.9 – 0.5
50 – 75 %	0.4 – 0.2
Completely sedimented in (includes hardpan sedimentation)	0

6. BANK STABILITY (total, both sides)

Condition	Score
> 90% Stable (not bare or erodable)	2.0
75 to 89% Stable (not bare or erodable	1.5 – 1.9
50 to 74% Stable (not bare or erodable)	1.4 – 1.0
25 to 50% Stable (not bare or erodable)	0.9 – 0.1
<25% Stable (not bare or erodable)	0

7. CANOPY / SHADE

Condition	Score
Mixed canopy, 20 - 80% cover	2.0 - 1.6
Closed but mixed canopy, >80% cover	1. 5 – 1.0
Closed monotypic canopy >80% cover	0.9 – 0.5
Open canopy, 0- 19% cover	0

8. RIPARIAN CONDITION

Condition	Score
Riparian area same width as floodplain, diverse vegetation, or stream is naturally incised, stable banks. Undisturbed.	2.0 – 1.8
Riparian area width at least two channel widths wide, diverse vegetation, or stream is naturally incised. Minimal Degradation	1.7 – 1.0
Riparian area width at least one channel width wide, or stream is naturally incised, riparian area is somewhat degraded. Regularly grazed, cropped or other disturbance.	0.9 – 0.5
Severely degraded riparian area, less than one channel width wide.	0.4 – 0.2
Little to no riparian vegetation, dirt-lined or fully channelized and lined.	0

9. HABITAT AVAILABLE FOR NATIVE SPECIES

Condition	Score
5 habitat types available	2.0
4 habitat types available	1.9 – 1.8
3 habitat types available	1.7 – 1.0
2 habitat types available	0.5 – 0.2
1 habitat type available	0

Habitat types *(1) seeps/springs (2) pools (3) runs (4) riffles (5) cascades*

10. LITTER/TRASH (indicator of urban/human influence)

Condition	Score
No litter or trash is present.	2.0 - 1.8
Litter or trash is evident but not prominent.	1. 0 – 0.5
Abundant trash, unsanitary wastes, eg. animal carcass or excrement, diapers, or many dead fish.	0

SCORING DATA SHEET

Date		*Time*		*Weather*	
Stream Name		*Reach ID*			
	Segment #1	*Segment #2*	*Segment #3*	*Segment #4*	*Segment #5*
Stream Type					
Segment Length (ft or m)					
Temperature					
Elevation					
Substrate	*1 2 3 4 %*	*1 2 3 4 %*	*1 2 3 4 %*	*1 2 3 4 %*	*1 2 3 4 %*
Silt/clay					
Sand					
Gravel					
Cobble					
Rock					
Boulder					
Bedrock or Concrete					
Embeddedness %					
Bank Vegetation % - looking downstream, left bank / right bank					
Trees					
Shrubs					
Herbaceous					
Leaf Litter					
None (bare)					
Avg % canopy/shade					
Avg Width					
Velocity and Depth					
Flow Status:	*high/normal/low*	*high/normal/low*	*high/normal/low*	*high/normal/low*	*high/normal/low*
Flow (cfs) or (cms)					
Sketch Channel cross-section, include low, normal, and high flow lines and existing water level					
Score Each Element- Use "Scoring Sheet for the Elements" Guidar					
1. Turbidity					
2. Plant Growth					
3. Channel Condition					
4. Channel Flow Alteration					
5. Percent Embeddedness					
6. Bank Stability					
7. Canopy					
8. Riparian Condition					
9. Habitat Available					
10. Litter/Trash					
Total score					
Total score / # of elements					
Rating of Average					
1.8 - 2.0 Very High					
1.5 - 1.7 High					
1.1 - 1.4 Medium					
0 - 1.0 Low					

***Notes**: ie. wildlife sightings, vegetation species, etc.*

Exhibit C Hawaii Natural Heritage Data Query Procedure

TECHNICAL NOTE

USDA NATURAL RESOURCES CONSERVATION SERVICE HAWAII

Biology Technical Note No. 10

HAWAII NATURAL HERITAGE DATA QUERY PROCEDURE

I. PURPOSE OF WORKSHEET

This technical note explains how conservation planners can obtain data and maps showing the location and identification of rare, threatened or endangered plants, animals, and natural communities for clients and resource inventories. NRCS obtained a 2001 subscription to The Hawaii Natural Heritage Program database, which contains information about species sightings in both a GIS (ArcView) database and in an Access database. It is currently the most comprehensive native species location database in the state; however, many areas in Hawaii have not been surveyed, and new plants and animals are still being discovered. Therefore, it is important to recognize that it is not all-inclusive. On site observations and plant and animal identification may also be necessary to determine if there are rare, threatened or endangered species in the area.

Questions about this procedure should be directed to the NRCS GIS Coordinator; questions about the data should be directed to the NRCS State Biologist.

II. PROCEDURE

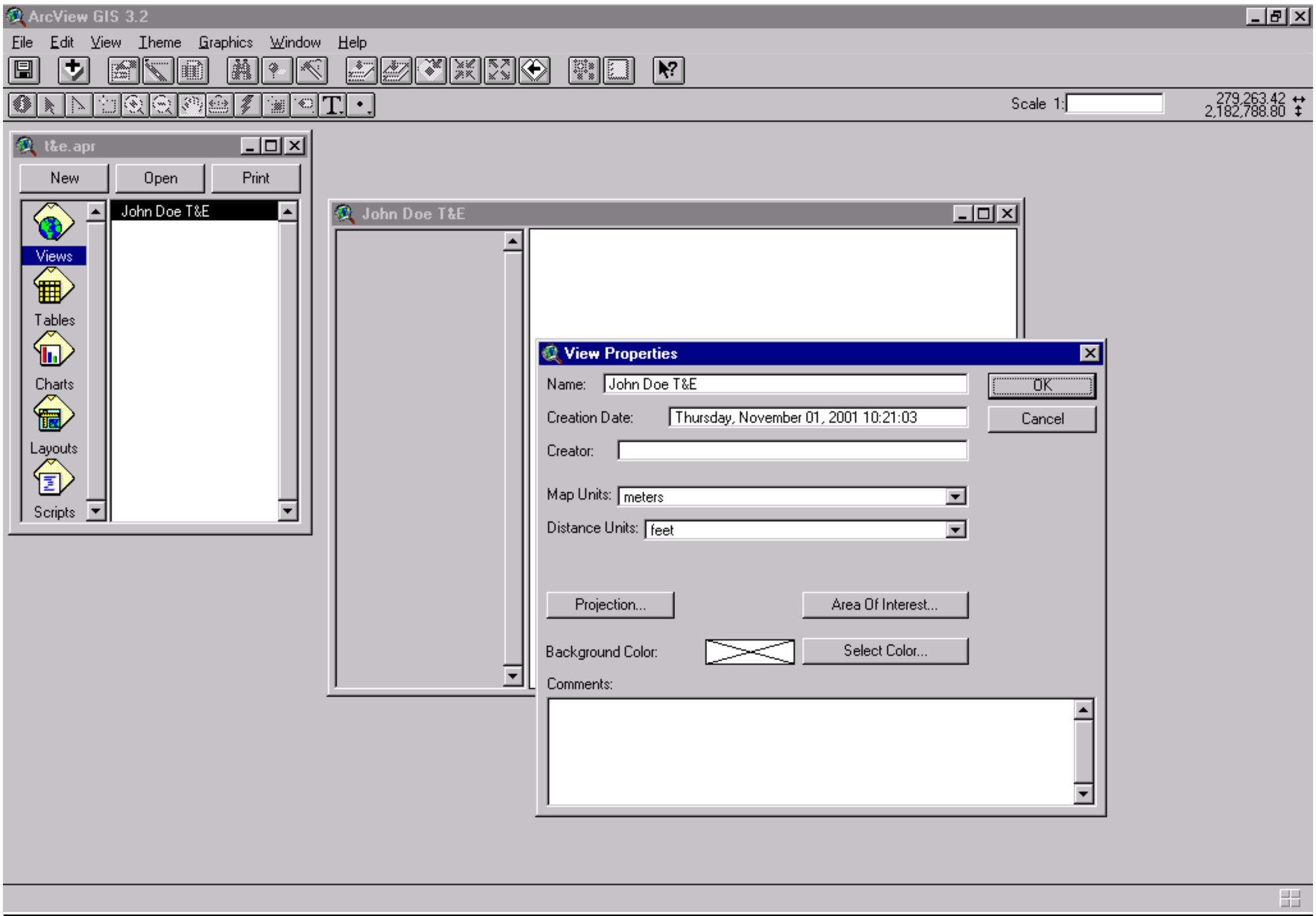
Attached are two documents. The first is a step-by-step instruction on (a) how to query the Heritage Database, using ArcView and Toolkit, (b) how to create maps with species locations, and (c) how to produce reports with the essential information about the data.

The second document includes all of the essential definitions of the GIS data and fields, verbatim from the Hawaii Natural Heritage Program.

This information should be used to develop conservation plans, to fill out ranking criteria for Farm Bill Programs, and/or to ensure compliance with the National Environmental Policy Act (NEPA) and the Endangered Species Act (ESA). The maps and information should be included in the Conservation Plan Folder.

Hawaii Natural Heritage Data Query Instructions

Open ArcView
Open a New project (on Menu Bar click File/New Project)
Open New view
Set view properties (on Menu Bar click View/Properties



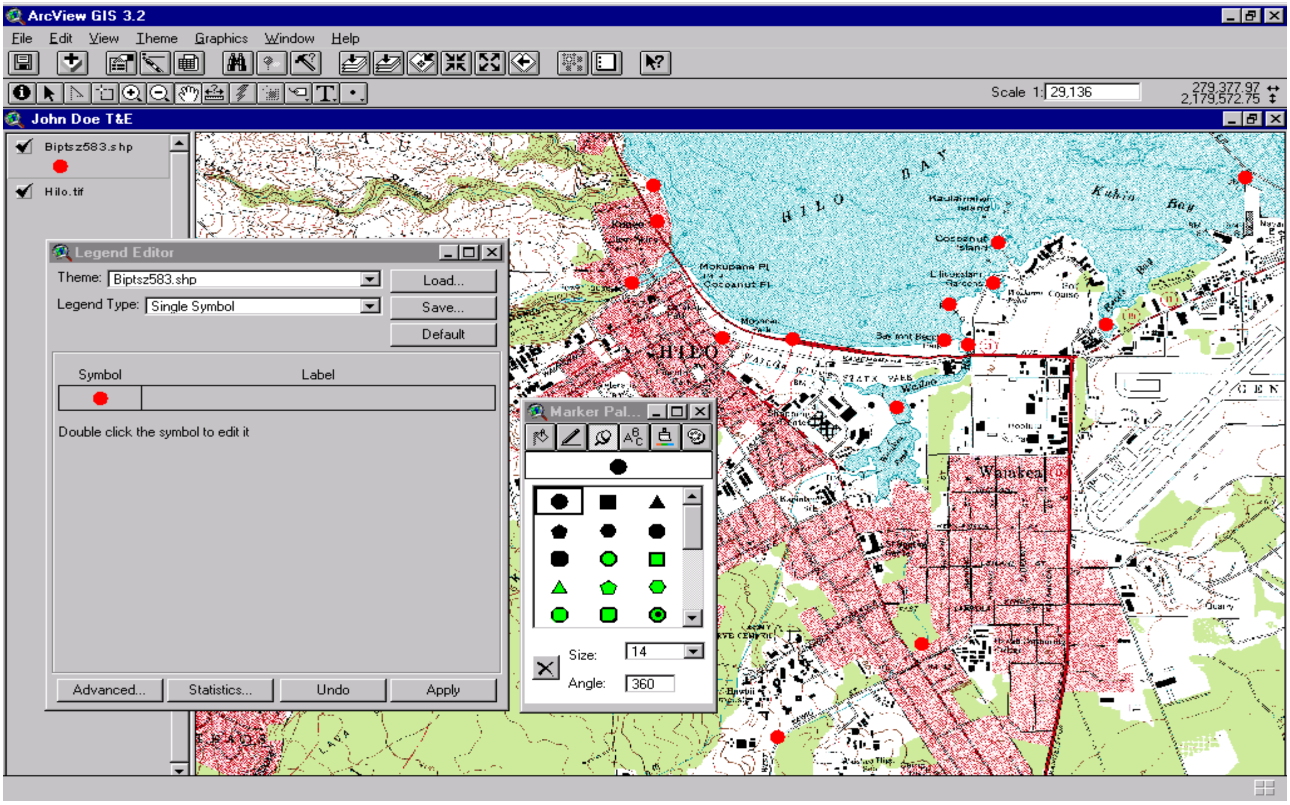
Name: select an appropriate name
Map Units: meters
Distance Units: Distance units are the units in which AV will display measurements while you work with this view. For example, if you use the Measure Tool to measure the distance between two places on the map.

File/Save Project. Choose drive and directory where you save your projects. When typing in project name, be sure to save the **.apr** extension.

Add themes: Add themes to a view by using the View menu/Add theme or use Add Theme button
First add drg(s). Example hilo.tif is the file name for Hilo Quad on Hawaii.
Next add Natural Diversity Data for appropriate island, located at:

C:\ServiceCenterThemes or C:\data\NaturalDiversityDatabase\ArcView\point_data\

Hawaii zone 5 = biptsz583.shp
Kaua'i = kaptsoh.shp
Lana'i = laptsoh.shp
Maui = maptsoh.shp
Moloka'i = molptsoh.shp
O'ahu = oapts.shp



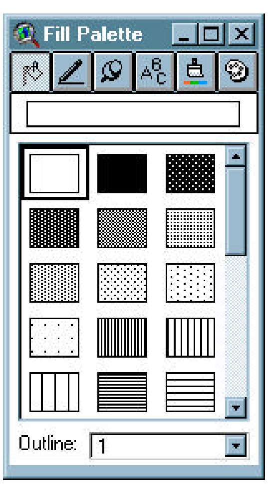
Make Natural Diversity theme active by clicking on it in the Table of Contents. It is active when it appears as a raised gray block around theme name. Click on the check box to draw the theme.

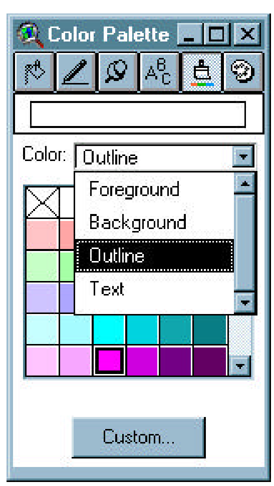
Double click on the Natural Diversity theme to bring up Legend Editor.

Set symbol to an appropriate shape, size & color. A dot, size 12 or 14, and the color red work well on most maps created for 8 ½ x 11, legal, or 11 x 17 size paper.

To set symbol properties double click on symbol box to bring up Symbol Window. Edit using Marker Palette and ColorPalette. Make selections. **Click Apply**. Close Legend Editor. Move or close Symbol Window.

Add TMK data if applicable. Open Legend Editor. In Fill Palette set properties to a polygon with no fill. Set Outline line width to 1.

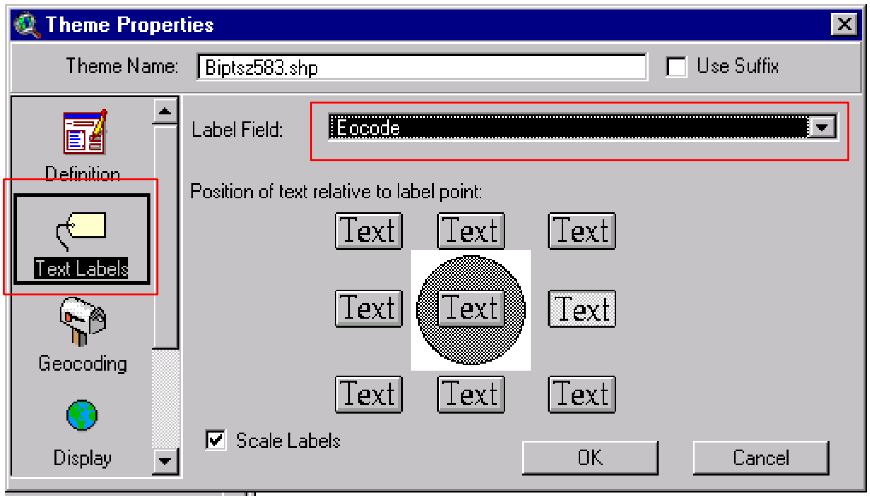




In Color Palette:

Open dropdown menu.
Select Outline.
Select a color.
Click Apply in Legend Editor.
Close Editor.

Save project.

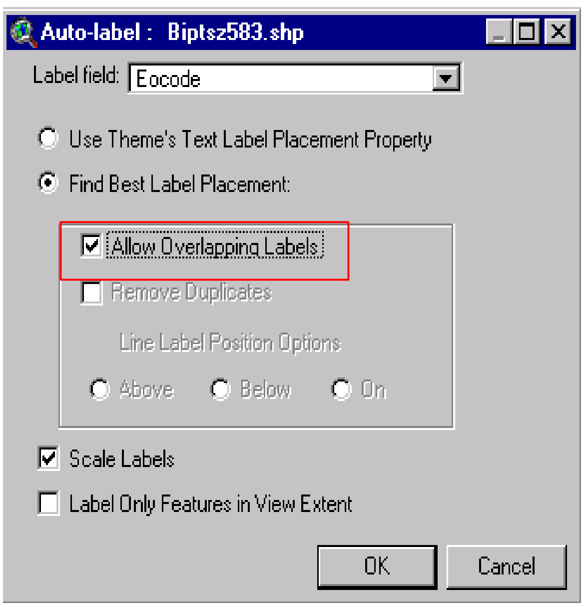


Label Natural Diversity points: Make Natural Diversity theme active. Zoom into area of interest in View Window. Click Theme Properties button or open using Theme menu/Properties.

Theme Properties dialog box opens.

Click on Text Labels (left side of dialog box).

In Label Field: open pulldown menu and select Eocode.



On Menu Bar select Themes/Auto-label. Leave defaults and click on check box Allow Overlapping Labels. Click OK.

On Menu Bar click Edit/Select all graphics. This will select all the labels and put handles (little blocks) around them.

To change font & size open Symbols Window by clicking on Window menu/Show Symbol Window from Menu bar or Ctrl p from the keyboard. Arial font, Bold, in size 10, 11, or 12 is good depending on scale of map and paper size.

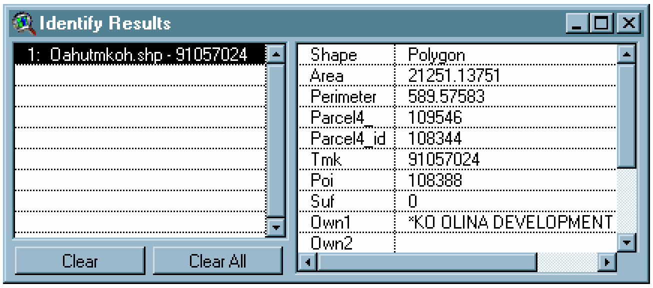
After completing changes, click anywhere in View window to deselect all labels. Move labels as necessary so they are visible and not overlapping by clicking on label with the pointer. This is the time consuming part. Be careful as one point may have many labels. Overlapping labels will appear in green text. Click on one of them and change to same font & size of the other labels if there is room. Otherwise, choose a slightly smaller font size.

Determine which point the label(s) is linked to. Click on the Identify Tool. Click on points to display a list of linked labels. Position labels so they align with point.

Save project.

Digitize parcel if applicable using digitizing tools. Symbolize in black with a line width of 2, shows up well.

If area of interest/parcel is a TMK boundary, there are a couple of ways to locate it.



A. Use **Identify Tool Butto** (1st on left)

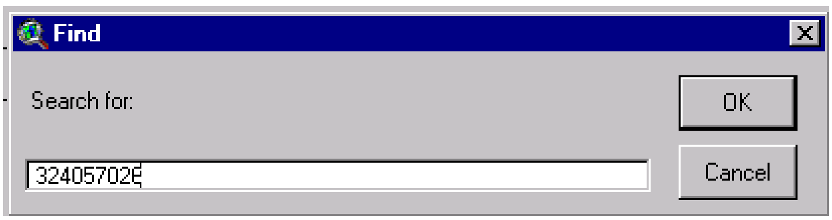
Make TMK theme active. Click on parcel to verify correct owner & TMK number.

Click on Select Feature button (4th on left). Click on the TMK parcel you identified.

Open the theme table. Click on TMK in the Title Bar (it will turn a darker color). See in illustration below.

B. Use **Find Tool**(binoculars).

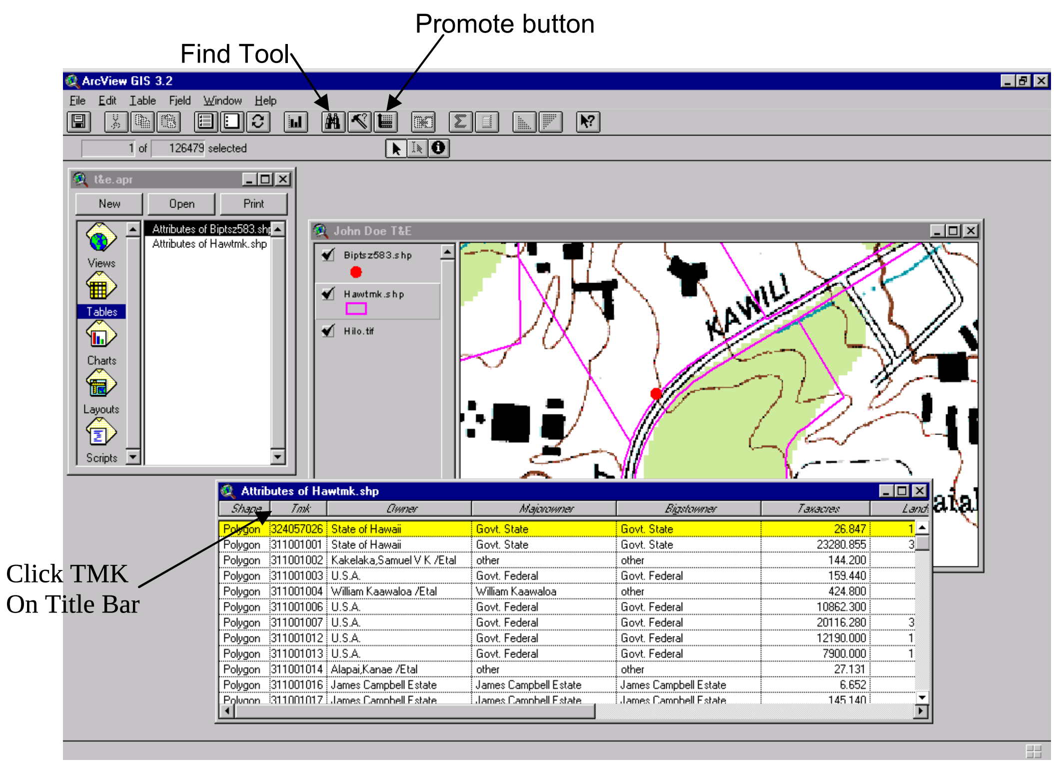
If you can't locate the TMK on the map use the Find Tool. Make TMK theme active. Open theme table. Click on Find Tool. Type in EXACT eight or nine digit TMK number (Oahu is 8, all other counties are 9).



Click OK.

Select Promote button. This brings the selected record to the top of the list in the theme table

See in illustration below.

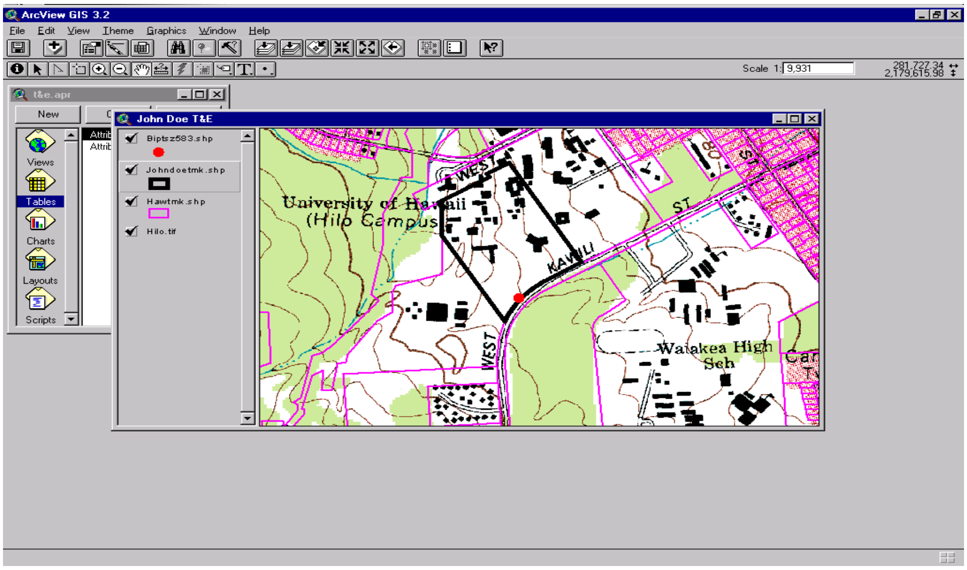


Leaving it selected, make View window active.

From Menu Bar select Theme/ Convert to shapefile.

You will be prompted to save as a file. Choose the appropriate drive & directory first, then name the file. Be careful to keep **.shp** extension.

You will be asked if you want to add theme to your view. Answer **Yes**.



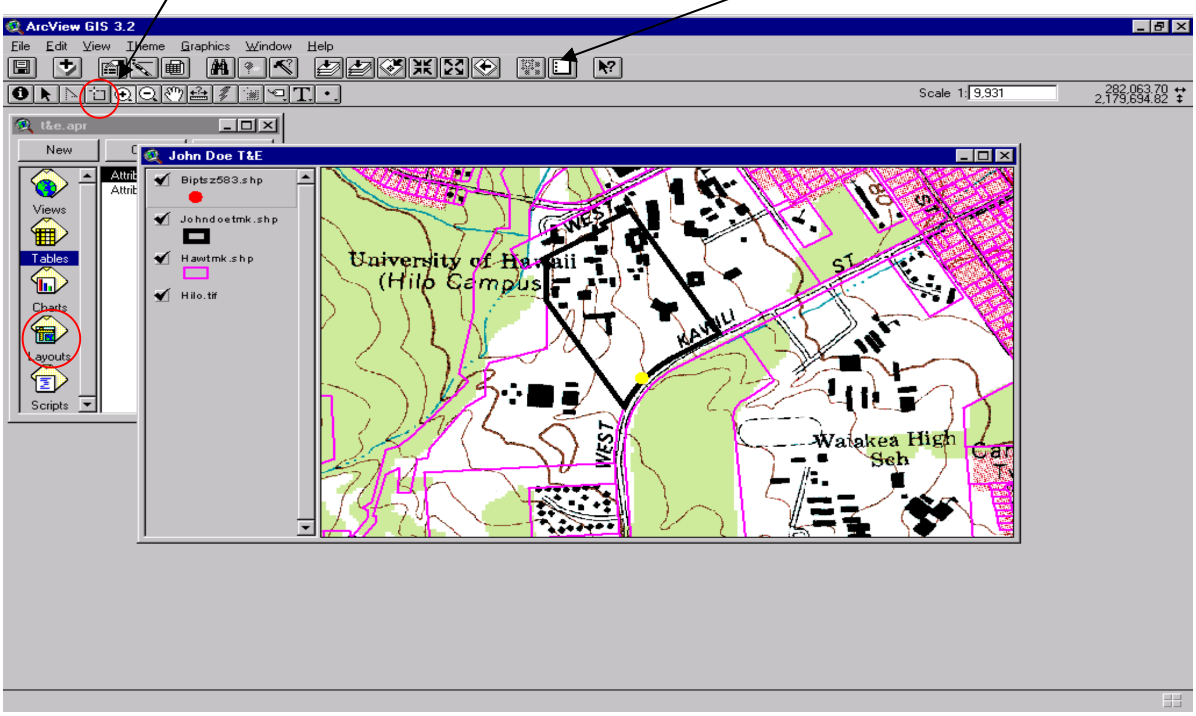
A new theme will appear in your view. Edit properties through Legend Editor to change to a polygon with no fill, outline width of 2, and black in color.

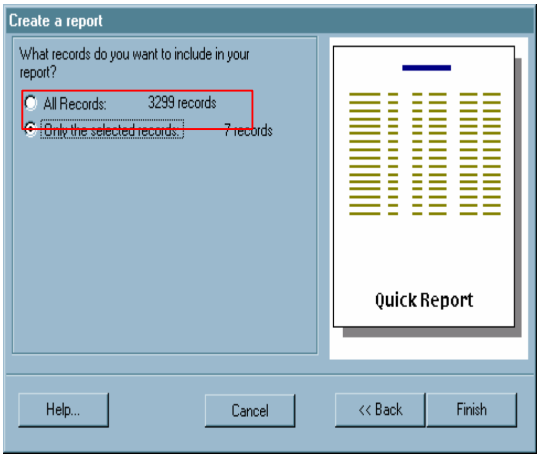
You may now remove the island TMK theme from the view by making it active, click on Edit menu/Delete Themes or simply don't draw the theme by clicking on the check box to remove the check mark.

Make the T&E theme active. Select the points that apply to your area of interest and that will appear on your map. You are doing this for two reasons. First, you will generate a report on the records linked to these points in a later step and second it will help you to determine and align the correct "view" area that will be displayed in the layout (the finished map). Use the Select Features Tool, as shown below. Hold down the shift key as you select multiple points. The points will be highlighted in yellow.

Save project.

Select Feature Tool Clear selected

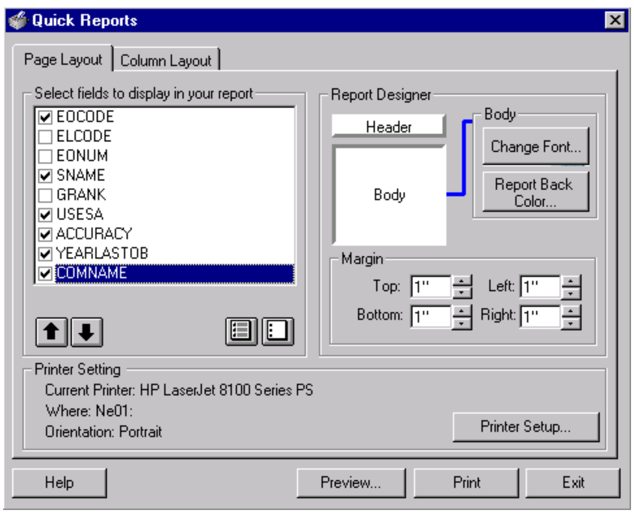




Create a Report.

Under File menu/Extensions, click the check box next to Report Writer. Make the view window active, and the Natural Diversity theme active. From the menu bar select Theme/Create a Report. Dialog box opens. Accept default of Quick Report. Click Next. Click on Only the selected records.

Click Finish.



Under the Page Layout tab, check mark the six elements that will be included in your report. They are: EOCODE, SNAME, USESA, ACCURACY, YEARLASTOB, COMNAME. Click Preview.

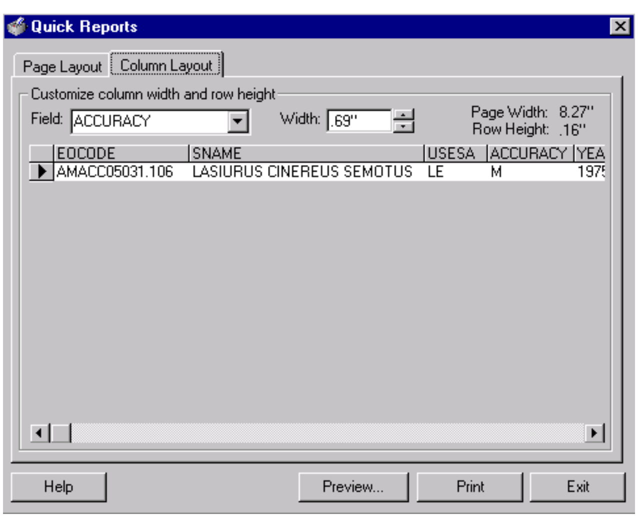
You can now finish your report using

A. **Quick Report** or

B. Export data into **Excel**

Quick Report has limited capabilities so you may want to use Excel if you are familiar with it.

A. To continue using **Quick Report:**

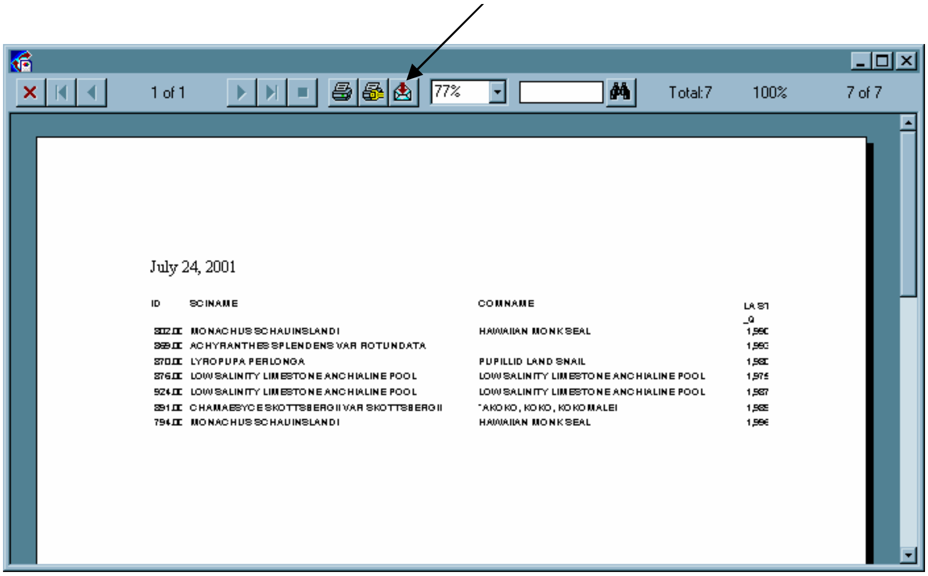


Click Column Layout tab.

Adjust widths of columns to display entire text in SNAME and COMNAME columns and decrease size in remaining four columns.

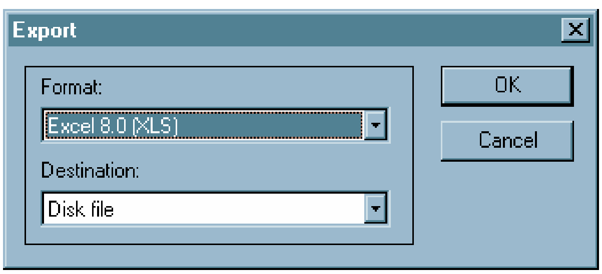
Click Preview, and if OK, then Print.

Export button



B. If you prefer using **Excel**

In Quick Report Preview window, click on Export button.

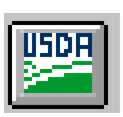


Export dialog box opens, select from the dropdown menu under Format, the Excel version you have.

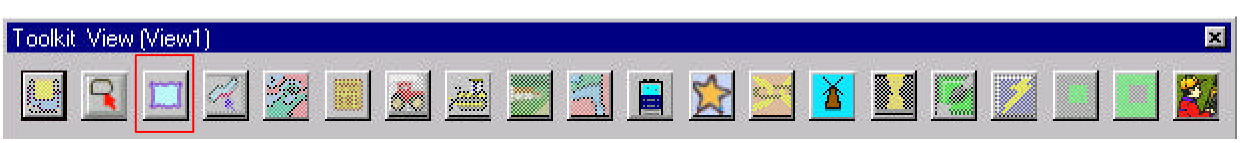
Click OK.

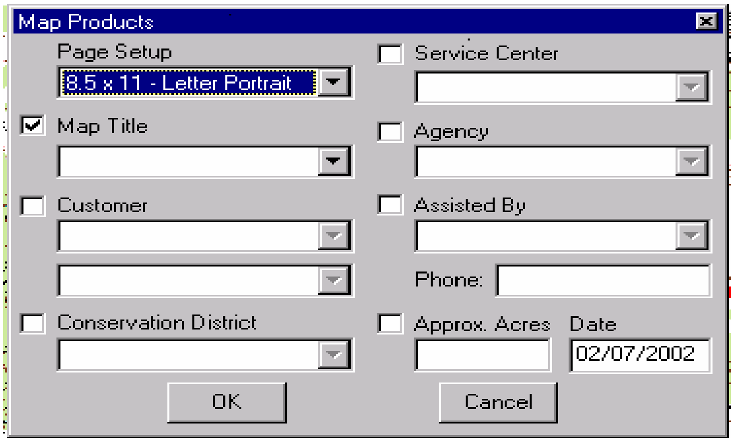
You will be prompted to save as an Excel file. Select drive and directory you want to save it in then type in file name. Be sure to include **.xls** extension. In Excel, make any edits and print.

After report is printed, close any report windows and return to the View window. Make the endangered species theme active, and clear the selected points (see button location on Page 6). They will now turn from yellow to red.



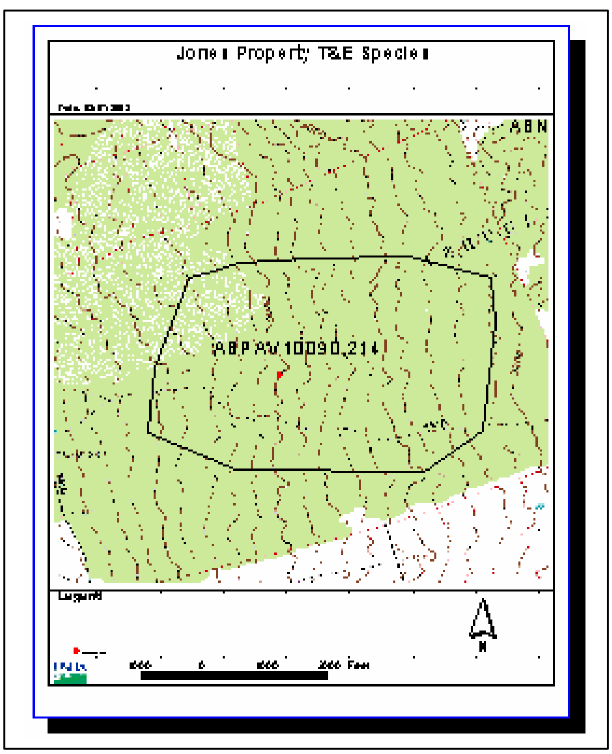
Click on the USDA button to open the Toolkit toolbar. (If you don't have the USDA button, click on File menu and click on Extensions. On the extension list, check the Toolkit Core Extension). On the Toolkit toolbar, click on the map products button.





Fill in the Map Title box and any other information you want included on the map and click OK.

A layout will be created, printed at the scale that was set in the view. If you want to change what is seen in the layout, click back in the view, use the pan and zoom tools, then click the map products button again to make a new layout. The standard Arcview layout tools can be used to edit this map.



For example, use the pointer to click on the legend information. Selection handles (small blocks) will appear around the legend symbols and text. Click on the Graphics menu, and pull down to Simplify. Then each individual object can be edited. Double click on the text next to the red dot, and edit the name of the shapefile. Or use the pointer to drag a box around both the red dot and text, and move them up under the word Legend.

Click on File menu and pull down to Print. Choose a color printer, and click OK.

Click on the File menu and pull down to Save Project. Choose the appropriate folder first, then name the file keeping the .apr extension.

Exit Arcview.

Definitions of GIS Data and Fields

Hawaii Natural Heritage Program, Natural Diversity Database and GIS shape files on this CD is restricted. It is only for the intended use of the individual or organized that requested it. Data on this CD may not be distributed with out the consent of the Hawaii Natural Heritage Program.

The Hawaii Natural Heritage Program (HINHP) collects information on the location and condition of Hawaii's rare animals, plants and natural communities (ecosystems). Information in this database spans from the 1800's to the present day. Data summarizes species current and historical ranges, decline or increase in the number of individuals, recorded habitat and observed threats.

The individual species, subspecies and natural communities in the database are referred to as "elements" in the Heritage database. There are four categories of elements: Natural Communities, Special Vertebrates, Special Invertebrates and Special Plants.

In the Heritage database, only data on rare element occurrences are incorporated. A natural community is considered rare and imperiled if it is known from 20 or fewer localities OR if it covers less than 2000 acres in the world. More widespread natural communities that are threatened with destruction throughout their range are also considered imperiled.

For plants and animals, the definition of a rare taxon varies depending on professional opinion. The Heritage Program defines a taxon as rare if available records indicate that its current distribution or abundance is limited, i.e. it is known from 20 or fewer locations OR fewer than 3000 individuals have been observed in the wild.

An "Element Occurrence" (EO) is a location or area which sustains or otherwise contributes to the survival of a population of a particular element. More simply, an EO is the place an element occurs, not each individual example or observation of the element itself. For example, a report of five `i`iwi at Palikea constitute a single EO, not five. Similarly, 20 reports of the rare fern, Marsilea villosa, at Ihiihilauakea on Koko Head are a single EO, not 20.

Although the specific definition of an element occurrence may differ for each element, the following descriptions typically apply:

Plants - any verified occurrence of one or more plants. Plants scattered along a cliff face, ridge top, or valley floor are considered a single occurrence if botanists believe the plants may cross-pollinate as a single population.

Animals With Limited Mobility (most invertebrates and most forest birds) - For birds, any reliable audio or visual sighting. For snails, any post-1945 observation of one or more snails, alive or recently dead.

Natural Communities - all contiguous habitat as defined by biological and physical features, where native elements comprise at least 60% of the vegetation cover in any layer.

The "Element Occurrence Record" (EOR) is a summary of the available information for a single element at a single location. Hence, some records reflect many observations spanning centuries, while others are based upon only very recent or very old observations. Each record is updated whenever new information becomes available.

Heritage maps and computer reports summarize data in short, terse narratives, and display information using a variety of codes, condensed phrases, and abbreviations. Given the finite amount of computer storage space, this enables us to maximize the amount of information in each record. Many of the codes and abbreviations are straightforward, and this guide should clarify most questions you might have.

The following lists the data provided. In each case, explanations for each entry or "data field" are provided. If you have any questions after consulting this material, please contact the Hawaii Natural Heritage Program Database Manager at 956-6894.

Natural Diversity Database ArcView Point and Polygon Shape Files

The Hawaii Natural Heritage Program ArcView point and polygon shape files depicts the locations of rare species and natural communities based upon the Element Occurrence Record Database. ArcView shape files are in UTM Zone 4 NAD 83. The accuracy of each location is dependant upon the source information that the Heritage staff was able to gather. See Accuracy (precision) for more information.

ELEMENT OCCURRENCE RECORD (EOR)

The Element Occurrence Reocord (EOR) is a summary of all the available information for a single element at a single location or occurrence. The record is produced by combining information from museum collections, published and unpublished reports, communications from knowledgeable individuals, and field surveys. Hence, some records reflect many observations spanning centuries while others are based upon only very recent or very old observations. All information sources pertinent to the record are listed in the CITATION field. Each record is updated whenever new information becomes available.

Definition of Data and Fields in the ArcView Point and Polygon files (EOR Database))

EOCODE (Element Occurrence Code)
Unique 14-character identifier code for each EOR location. Combines the ELCODE and EONUM together. See ELCODE and EONUM. Example: PDFAB3M090.001

ELCODE (Element Code)
The Element Code (ELCODE) is the first 10 characters preceding the decimal point of the EOCODE. The ELCODE identifies the species or natural community. It is an international unique species and natural community identifier code determined by the National Natural Heritage office of the Association for Biodiversity Information.

The element code such as the Sesbania (PDFAB3M090) represents several taxonomic descriptions. The 1st character represents the type of element as “Plant”. The second character represents more detailed descriptions about the element such as “Dicot”. The following table summarizes each of the types that the Hawaii Natural Heritage Program tracks:

1st & 2nd character of ELCODE	Element Type	# of elements tracked by Hawaii Heritage
P=Plants		
PD	Dicots	528
PM	Monocots	47
PP	Pteridophytes	32
A=Vertebrates		
AB	Birds	44
AF	Fish	2
AM	Mammals	2
AR	Reptiles	4
C=Natural Community		
CA	Aquatic	16
CS	Sub-terranean	26
CT	Terrestrial	101
I=Invertebrates		
IC	Crustaceans	8
II	Insects	220
IL	Chelicerates	1
IM	Mollusks	311

EONUM (Element Occurrence Number)
The three-digit number following the decimal point (EONUM) identifies the occurrence of this element. For example, PDFAB3M090.001 is the first occurrence of Sesbania tomentosa entered in the Heritage database.

SCINAME

Scientific name of the species or natural community.

GRANK (Global Element Rank)

The Global Rank (Grank) is an international ranking system developed by the Natural Heritage network. It determines the rarity of a species worldwide, and guides agencies to set priorities for protection. The ranking system is based on an element's number of occurrences and individuals, health, threats, etc. It is independent from the U.S. Fish and Wildlife Federal List of Endangered Species, but the USFWS often cites the Heritage Global Rank to help express how rare and imperiled a species is. See Definitions of Global Ranks.

Global Rank Definitions:

G1 (or T1 for subspecific taxa) = Critically imperiled globally. 1-5 occurrences and/or fewer than 1,000 individuals remaining; or more abundant but facing extremely serious threats range-wide.
G2 (or T2 for subspecific taxa) = Imperiled globally. 6-20 occurrences and/or 1,000-3,000 individuals remaining; or more abundant but facing serious threats range-wide.
G3 (or T3 for subspecific taxa) = Moderately imperiled globally. 21-100 occurrences and/or 3,000-10,000 individuals remaining; or more abundant but facing moderate threats range-wide; or restricted in range.
G4 (or T4 for subspecific taxa) = Widespread, abundant, and apparently secure, but with cause for long-term concern.
G5 (or T5 for subspecific taxa) = Demonstrably widespread, abundant, and secure.
GH (or TH for subspecific taxa) = Historical. No recent observations, but there remains a chance of rediscovery.
GX (or TX for subspecific taxa) = Extinct. No recent observations, and there does not appear to be a chance of rediscovery.
C = Persisting in cultivation.

USESA (United States Endangered Species Act)

Federal Status of the element. Official U.S. Fish & Wildlife Service, Endangered Species Act (ESA) categories for endangered and candidate endangered taxa (species, subspecies, & varieties) according to the Federal Register February 28, 1996.

Listed Endangered (LE)	=	Taxa formally listed as endangered.
Listed Threatened (LT)	=	Taxa formally listed as threatened.
Proposed Endangered (PE)	=	Taxa proposed to be formally listed as endangered.
Proposed Threatened (PT)	=	Taxa proposed to be formally listed as threatened.
Candidate (C)	=	Taxa for which substantial information on biological vulnerability and threat(s) support proposals to list them as endangered or threatened.
Species of Concern (SOC)	=	Taxa that available information does meet the criteria for concern and the possibility to recommend as candidate.

ACCURACY (PRECISION)

Precision (accuracy of information) of EO as mapped.

P	=	Precise with exact location reported with GPS reading. Up to 1 meter accuracy.
SC	=	Specific with exact location confirmed by source. Usually location determined with a detailed map provided by the source. Up to 6 meter accuracy.
S	=	Specific - EO reported within a 0.33 mile radius of mapped symbol (or 0.5 km)
M	=	Medium - EO reported within a 1.5 mile radius of mapped symbol (or 2.5 km)
G	=	General - EO reported within approximately 5 mile radius of mapped symbol (or 8km)
U	=	Unmappable - inadequate information to map EO
N	=	Not mapped - primarily cultivated plants & vague locations for which more specific occurrences are already mapped

YEARLASTOBS (Year Last Observed)

Date element was last observed extant at this site; not necessarily date site was last visited.

Notice

The Hawaii Natural Heritage Program database is dependent on the research and observations of many scientists and individuals. In most cases this information is not the result of comprehensive site-specific field surveys, and is not confirmed by the Heritage staff. Many areas in Hawaii have never been thoroughly surveyed, and new plants and animals are still being discovered. Database information should never be regarded as final statements or substituted for on-site surveys required for environmental assessments. Data provided by the Heritage Program do not represent a position taken by The Center for Conservation Research and Training or The Nature Conservancy of Hawaii. **Heritage information is only for the intended use of the individual or organization who requested it. It may not be distributed in any way without the consent of the Hawaii Natural Heritage Program**

Please cite the Heritage Program and primary sources in all documentation and reports.

Hawaii Natural Heritage Program, University of Hawaii, Center for Conservation Research and Training
3050 Maile Way, Gilmore 406, Honolulu, Hawaii 96822

Exhibit D Kentucky 2002 Threatened and Endangered Species List by County

This list identifies federal listed threatened and endangered species and species covered by a State Conservation Agreement (SCA) by county. NRCS personnel shall use this list for the NEPA planning process.					
COUNTY	**SPECIES TYPE**	**SPECIES**	**FEDERAL STATUS**	**Aquatic Species (Watershed/Stream Order)**	**USFWS Species Fact Sheet Available**
Adair	Mammal	Gray Bat	Endangered		
		Indiana Bat	Endangered		
Allen	Mammal	Gray Bat	Endangered		
		Indiana Bat	Endangered		
	Mussel	Fanshell	Endangered	Barren River Main Channel	
		*Clubshell	Endangered	Sulfur Creek Main Channel	
Anderson	Plant	Short’ s Bladderpod	Candidate		
Ballard	Bird	Bald Eagle	Threatened		
		Interior Least Tern	Endangered	Ohio River Main Channel	
	Fish	Pallid Sturgeon	Endangered	Ohio River Main Channel	
	Mammal	Indiana Bat	Endangered		
Barren	Crustacean	Cave Shrimp	Endangered	Mammoth Cave Watershed	
	Mammal	Gray Bat	Endangered		
		Indiana Bat	Endangered		
	Mussel	Fanshell	Endangered	Barren River Main Channel	
	Plant	Eggert’ s Sunflower	Threatened		
Bath	Mussel	*Northern Riffleshell	Endangered	Licking River Main Channel	
		*Clubshell	Endangered	Slate Creek Main Channel	
	Mammal	Indiana Bat	Endangered		
Bell	Fish	Blacksided Dace	Threatened	First, Second and Third Order Streams Within the Following Watersheds:	
				Laurel Creek	
				Bennetts Creek	
				Cannon Creek	
				Little Clear Creek	
				Brownies Creek	
				Mill Creek	
				Long Creek	
				Left Fork Straight Creek	
				Straight Creek	
				Four-Mile Creek	
				Sinking Creek	
				Yellow Creek	
				Stony Creek	
	Mammal	Indiana Bat	Endangered		
	Insect	Icebox Cave Beetle	Candidate		
Boone	Mussel	*Pink Mucket	Endangered	Ohio River Main Channel	
		*Ring Pink	Endangered	Ohio River Main Channel	
	Plant	Running Buffalo Clover	Endangered		Yes
Bourbon	Plant	Running Buffalo Clover	Endangered		Yes
		Short’ s Bladderpod	Candidate		
Boyd	Mussel	*Fanshell	Endangered	Big Sandy Main Channel	
Boyle	-	-	-	-	
Bracken	Mussel	*Clubshell Fanshell	Endangered Endangered	North Fork and Licking River Main Channel	
Breathitt	-	-	-	-	
Breckinridge	Mammal	Gray Bat	Endangered		
		Indiana Bat	Endangered		
Bullitt	Mammal	Gray Bat	Endangered		

Kentucky 2003 Threatened And Endangered Species List By County

COUNTY	SPECIES TYPE	SPECIES	FEDERAL STATUS	Aquatic Species (Watershed)	USFWS Species Fact Sheet Available
		Indiana Bat	Endangered		
	Mussel	Clubshell	Endangered	Salt River Main Channel	
		*Orange-Foot Pimpleback	Endangered	Salt River Main Channel	
Butler	Mussel	Purple Catspaw	Endangered	Green River Main Channel	
		*Clubshell	Endangered	Green River Main Channel	
				Russell Creek Main Channel	
		Fanshell	Endangered	Green River Main Channel	
		*Orange-Foot Pimpleback	Endangered	Green River Main Channel	
		Pink Mucket	Endangered	Green River Main Channel	
		*Ring Pink	Endangered	Green River Main Channel	
		Rough Pigtoe	Endangered	Green River Main Channel	
	Reptile	Copperbelly Water Snake	SCA		
Caldwell	Mammal	Gray Bat	Endangered		
	Reptile	Copperbelly Water Snake	SCA		
Calloway	Mammal	Gray Bat	Endangered		
	Plant	Price' s Potato-Bean	Endangered		
Campbell	Mussel	*Clubshell	Endangered	Ohio River Main Channel	
		Fanshell	Endangered	Licking River Main Channel	
		*Orange-Foot Pimpleback	Endangered	Ohio River Main Channel	
		*Pink Mucket	Endangered	Ohio River Main Channel	
		*Ring Pink	Endangered	Ohio River Main Channel	
		*Rough Pigtoe	Endangered	Ohio River Main Channel	
Carlisle	Bird	Bald Eagle	Threatened		
		Interior Least Tern	Endangered		
	Mammal	Indiana Bat	Endangered		
	Mussel	Fat Pocketbook	Endangered	Mississippi Main Channel	
Carroll	Mussel	*Orange-Foot Pimpleback	Endangered	Ohio River Main Channel	
		*Pink Mucket	Endangered	Ohio River Main Channel	
		*Ring Pink	Endangered	Ohio River Main Channel	
Carter	Mammal	Gray Bat	Endangered		
		Indiana Bat	Endangered		
	Mussel	*Fanshell	Endangered	Tygarts Creek Main Channel	
Casey	-	-	-	-	
Christian	Mammal	Gray Bat	Endangered		
		Indiana Bat	Endangered		
	Reptile	Copperbelly Water Snake	SCA		
Clark	Plant	Running Buffalo Clover	Endangered		Yes
		Short' s Bladderpod	Candidate		
Clay	-	-	-	-	
Clinton	Mammal	Gray Bat	Endangered		
	Mussel	*Cumberland Bean	Endangered	Cumberland River Main Channel & Fourth and Fifth Order Streams Joined to CRMC	
		*Orange-Foot Pimpleback	Endangered	Cumberland River Main Channel	

Kentucky 2003 Threatened And Endangered Species List By County

COUNTY	SPECIES TYPE	SPECIES	FEDERAL STATUS	Aquatic Species (Watershed)	USFWS Species Fact Sheet Available
Clinton (cont)		*Rough Pigtoe	Endangered	Cumberland River Main Channel	
Crittenden	Mussel	Fat Pocketbook	Endangered	Cumberland River Main Channel	
		*Orange-Foot Pimpleback	Endangered	Cumberland River Main Channel	
	Reptile	Copperbelly Water Snake	SCA		
Cumberland	Fish	Palezone Shiner	Endangered	Marrowbone Creek	
	Mussel	*Catspaw	Endangered	Cumberland River Main Channel	
		Cumberland Bean	Endangered	Cumberland River Main Channel & Fourth and Fifth Order Streams Joined to CRMC	
		*Cumberland Combshell	Endangered	Cumberland River Main Channel & Fourth and Fifth Order Streams Joined to CRMC	
		*Fanshell	Endangered	Cumberland River Main Channel	
		*Orange-Foot Pimpleback	Endangered	Cumberland River Main Channel	
		*Oyster Mussel	Endangered	Cumberland River Main Channel	
		*Pink Mucket	Endangered	Cumberland River Main Channel	
		*Ring Pink	Endangered	Cumberland River Main Channel	
		*Rough Pigtoe	Endangered	Cumberland River Main Channel	
Daviess	Mammal	Indiana Bat	Endangered		
	Reptile	Copperbelly Water Snake	SCA		
Edmonson	Crustacean	Mammoth Cave Shrimp	Endangered	Running Branch Spring Watershed	
	Mammal	Gray Bat	Endangered		
		Indiana Bat	Endangered		
	Mussel	Clubshell	Endangered	Green River Main Channel	
		Fanshell	Endangered	Green River Main Channel	
		Northern Riffleshell	Endangered	Green River Main Channel	
		Ring Pink	Endangered	Green River Main Channel	
		Rough Pigtoe	Endangered	Green River Main Channel	
	Plant	Eggert' s Sunflower	Endangered		
	Insect	Surprising Cave Beetle	Candidate		
Elliot	Mammal	Gray Bat	Endangered		
		Indiana Bat	Endangered		
Estill	Mammal	Indiana Bat	Endangered		
		Virginia Big-Eared Bat	Endangered		
Fayette	Insect	American Burying Beetle	Threatened		
	Mammal	Indiana Bat	Endangered		
	Plant	Running Buffalo Clover	Endangered		Yes

Kentucky 2003 Threatened And Endangered Species List By County

COUNTY	SPECIES TYPE	SPECIES	FEDERAL STATUS	Aquatic Species (Watershed)	USFWS Species Fact Sheet Available
Fleming	Mussel	Fanshell	Endangered	Licking River Main Channel	
				Fish Trap Creek Main Channel	
Floyd	-	-	-	-	
Franklin	Mammal	Gray Bat	Endangered		
	Plant	Short' s Bladderpod	Candidate		
	Mussel	*Northern Riffleshell	Endangered	Elkhorn Creek Watershed	
	Plant	Braun' s Rockcress	Threatened		
Fulton	Bird	Bald Eagle	Threatened		
		Interior Least Tern	Endangered		
Gallatin	Mussel	*Clubshell	Endangered	Eagle Creek Main Channel	
Garrard	Mammal	Gray Bat	Endangered		
Grant	-	-	-	-	
Graves	Fish	Relict Darter	Endangered	Bayou du Chien Watershed	Yes
Grayson	Mammal	Gray Bat	Endangered		
		Indiana Bat	Endangered		
	Mussel	*Clubshell	Endangered	Nolin River Main Channel	
		*Orange-Foot Pimpleback	Endangered	Rough River Main Channel	
		Northern Riffleshell	Endangered	Nolin River Main Channel	
	Plant	Eggert' s Sunflower	Endangered		
Green	Mammal	Gray Bat	Endangered		
	Mussel	Clubshell	Endangered	Green River Main Channel	
				Russell Creek Main Channel	
		*Fanshell	Endangered	Green River Main Channel	
		*Northern Riffleshell	Endangered	Green River Main Channel	
		Rough Pigtoe	Endangered	Green River Main Channel	
Greenup	Mussels	Fanshell	Endangered	Tygarts Creek Main Channel & Lower White Oak Creek Main Channel South of KYHWY 784	
		*Pink Mucket	Endangered	Ohio River Main Channel	
		*Ring Pink	Endangered	Ohio River Main Channel	
Hancock	Mussels	*Orange-Foot Pimpleback	Endangered	Ohio River Main Channel	
	Reptile	Cooperbelly Water Snake	SCA		
Hardin	Mammals	Indiana Bat	Endangered		
		Gray Bat	Endangered		
	Plant	Eggert' s Sunflower	Threatened		
Harlan	Fish	Blacksided Dace	Threatened	First, Second and Third Order Streams Within the Following Watersheds:	
				Breedens Creek Watershed	
				Clover Fork Watershed	
				Watts Creek Watershed	
				Brownies Creek Watershed	
				Clover Lick Creek Watershed	
				Straight Creek Watershed	
		Johnny Darter	Candidate	Martins Fork (Branch) Cumberland River Watershed	
	Mammal	Indiana Bat	Endangered		

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COUNTY	SPECIES TYPE	SPECIES	FEDERAL STATUS	Aquatic Species (Watershed)	USFWS Species Fact Sheet Available
Harrison	Mussel	*Clubshell	Endangered	Licking River Main Channel	
	Mussel	Fanshell	Endangered	Licking River Main Channel	
	Plant	Running Buffalo Clover	Endangered		Yes
	Insect	Beaver Cave Beetle	Candidate		
Hart	Crustacean	Mammoth Cave Shrimp	Endangered	McCoy Blue Springs Watershed	
				Suds Basin Watershed	
	Mammal	Gray Bat	Endangered		
		Indiana Bat	Endangered		
	Mussel	*Catspaw	Endangered	Green River Main Channel	
		Clubshell	Endangered	Green River Main Channel	
				Nolin River Main Channel	
		Fanshell	Endangered	Green River Main Channel	
		Northern Riffleshell	Endangered	Green River Main Channel	
				Nolin River Main Channel	
		Pink Mucket	Endangered	Green River Main Channel	
		Ring Pink	Endangered	Green River Main Channel	
		Rough Pigtoe	Endangered	Green River Main Channel	
	Plant	Eggert' s Sunflower	Threatened		
Henderson	Bird	Bald Eagle	Threatened		
	Mussel	*Catspaw	Endangered	Ohio River Main Channel	
		*Fanshell	Endangered	Ohio River Main Channel	
		*Fat Pocketbook	Endangered	Ohio River Main Channel	
		*Pink Mucket	Endangered	Ohio River Main Channel	
		*Ring Pink	Endangered	Ohio River Main Channel	
	Reptile	Copperbelly Water Snake	SCA		
Henry	Mussel	*Fanshell	Endangered	Kentucky River Main Channel	
	Plant	Braun' s Rockcress	Threatened		
Hickman	Bird	Bald Eagle	Threatened		
		Interior Least Tern	Endangered		
Hickman	Fish	Pallid Sturgeon	Endangered	Mississippi River	
		Relict Darter	Endangered	Bayou du Chien Watershed	Yes
	Mammal	Indiana Bat	Endangered		
Hopkins	Mammal	Gray Bat	Endangered		
	Reptile	Copperbelly Water Snake	SCA		
Jackson	Mammal	Indiana Bat	Endangered		
		Virginia Big-eared Bat	Endangered		
	Mussel	Cumberland Bean	Endangered	Rockcastle River Main Channel and Forth and Fifth Order Streams within the following watersheds:	
				Horselick Creek	
				Laurel Fork	
		*Cumberland Elktoe	Endangered	Third, Forth and Fifth Order Streams within the Horselick Creek Watershed	
		Little-Wing Pearly Mussel	Endangered	Forth Order Streams within the Horse Creek Watershed	

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COUNTY	SPECIES TYPE	SPECIES	FEDERAL STATUS	Aquatic Species (Watershed)	USFWS Species Fact Sheet Available
	Plant	Running Buffalo Clover	Endangered		Yes
Jefferson	Bird	Peregrine Falcon	De-listed		
	Mammal	Gray Bat	Endangered		
		Indiana Bat	Endangered		
	Mussel	*Clubshell	Endangered	Salt River Main Channel	
		Fanshell	Endangered	Ohio River Main Channel	
		Fat Pocketbook	Endangered	Ohio River Main Channel	
		Orange-Foot Pimpleback	Endangered	Ohio River Main Channel	
		Pink Mucket	Endangered	Ohio River Main Channel	
Jefferson	Mussel	Ring Pink	Endangered	Ohio River Main Channel	
	Plant	Running Buffalo Clover	Endangered		Yes
	Insect	Jefferson Cave Beetle	Candidate		
	Crustacean	Louisville Crayfish	**SMC	Goose Creek Watershed	
				Beargrass Creek Watershed	
Jessamine	Mammal	Gray Bat	Endangered		
		Indiana Bat	Endangered		
	Plant	Running Buffalo Clover	Endangered		Yes
Johnson	-	-	-	-	
Kenton	Mussel	*Catspaw	Endangered	Ohio River Main Channel	
		*Clubshell	Endangered	Ohio and Licking River Main Channel	
		Fanshell	Endangered	Ohio and Licking River Main Channel	
		Northern Riffleshell *	Endangered	Ohio River Main Channel	
		Orange-Foot Pimpleback*	Endangered	Ohio River Main Channel	
		Pink Mucket *	Endangered	Ohio River Main Channel	
		Ring Pink *	Endangered	Ohio River Main Channel	
		Rough Pigtoe *	Endangered	Ohio River Main Channel	
	Plant	Running Buffalo Clover	Endangered		Yes
Knox	Fish	Blackside Dace	Threatened	First, Second and Third Order Streams within the Following Watersheds:	
				Stinking Creek	
				Little Poplar Creek	
				Richard Creek	
LaRue	Mussel	Fanshell	Endangered	Rolling Fork River Main Channel	
	Plant	Eggert' s Sunflower	Threatened		
Laurel	Birds	Bald Eagle	Threatened		
Laurel	Fish	Blackside Dace	Threatened	First, Second and Third Order Streams within the Following Watersheds:	
				Craig Creek	
				Ned Branch	
		Johnny Darter	Candidate	Poor Folk (Branch) Cumberland River	
	Mussel	Cumberland Bean	Endangered	Forth and Fifth Order Streams within the Following Watersheds:	
				Rockcastle River	
				South Fork of Rockcastle River	

Kentucky 2003 Threatened And Endangered Species List By County

COUNTY	SPECIES TYPE	SPECIES	FEDERAL STATUS	Aquatic Species (Watershed)	USFWS Species Fact Sheet Available
				Sinking Creek	
		*Cumberlanian Combshell	Endangered	Cumberland River Main Channel & Fourth and Fifth Order Streams Joined to CRMC	
		Cumberland Elktoe	Endangered	Third and Higher Order Streams within the Sinking Creek Watershed	
		Little-Wing Pearly Mussel	Endangered	Forth Order Streams within the Horselick Creek Watershed	
		*Oyster Mussel		Cumberland River Main Channel	
	Plant	Virginia Speraea	Threatened	Rockcastle River Banks	
		White Fringeless Orchid	Candidate		
Lawrence	Mussel	Fanshell	Endangered	Big Sandy River Main Channel	
Lee	Mammal	Gray Bat	Endangered		
		Indiana Bat	Endangered		
		Virginia Big-Eared Bat	Endangered		
Leslie	Mammal	Indiana Bat	Endangered		
Letcher	Fish	Blackside Dace	Threatened	Poor Fork of the Cumberland River and First, Second and Third Order Streams within the Poor Fork of the Cumberland River Watershed	
	Mammal	Indiana Bat	Endangered		
Lewis	Mussel	*Catspaw	Endangered	Ohio River Main Channel	
		*Fanshell	Endangered	Ohio River Main Channel	
		*Orange-Foot Pimpleback	Endangered	Ohio River Main Channel	
		*Pink Mucket	Endangered	Ohio River Main Channel	
		*Ring Pink	Endangered	Ohio River Main Channel	
		*Rough Pigtoe	Endangered	Ohio River Main Channel	
	Plant	Virginia Spiraea	Threatened		
Lincoln	Mussel	Cumberland Bean	Endangered	Buck Creek and Forth and Fifth Order Streams within the Buck Creek Watershed	
Livingston	Bird	Interior Least Tern	Endangered	Ohio River	
	Mammals	Gray Bat	Endangered		
		Indiana Bat	Endangered		
	Mussel	*Clubshell	Endangered	Ohio River Main Channel	
		*Fanshell	Endangered	Ohio River Main Channel	
Livingston	Mussel	Fat Pocketbook	Endangered	Cumberland River Main Channel	
		Orange-Foot Pimpleback	Endangered	Ohio River Main Channel	
		Pink Mucket	Endangered	Tennessee River Main Channel	
		Ring Pink	Endangered	Tennessee River Main Channel	
	Plant	Price' s Potato-Bean	Endangered		

Kentucky 2003 Threatened And Endangered Species List By County

COUNTY	SPECIES TYPE	SPECIES	FEDERAL STATUS	Aquatic Species (Watershed)	USFWS Species Fact Sheet Available
	Reptile	Copperbelly Water Snake	SCA		
Logan	Mammal	Gray Bat	Endangered		
		Indiana Bat	Endangered		
	Mussel	Little-Wing Pearly Mussel	Endangered	Forth Order Streams within the Following Watersheds:	
				Red River	
				Wippoorwillow Creek	
	Reptile	Copperbelly Water Snake	SCA		
Lyon	Bird	Bald Eagle	Threatened		
	Mussel	*Clubshell	Endangered	Cumberland River Main Channel	
		*Fanshell	Endangered	Cumberland River Main Channel	
Lyon	Mussel	*Orange-Foot Pimpleback	Endangered	Cumberland River Main Channel	
		*Pink Mucket	Endangered	Cumberland River Main Channel	
		*Ring Pink	Endangered	Cumberland River Main Channel	
	Plant	Price' s Potato-Bean	Endangered		
Madison	Plant	Running Buffalo Clover	Endangered		Yes
	Insect	Greater Adams Cave Beetle	Candidate		
	Insect	Lesser Adams Cave Beetle	Candidate		
Magoffin	-	-	-	-	
Marion	Insect	Tatum Cave Beetle	Candidate		
Marshall	Mussel	Orange-Foot Pimpleback	Endangered	Tennessee & Ohio River (s) Main Channel	
		Pink Mucket	Endangered	Tennessee River Main Channel	
		Ring Pink	Endangered	Tennessee River Main Channel	
Martin	-	-	-	-	
Mason	-	-	-	-	
McCracken	Mammal	Indiana Bat	Endangered		
	Mussel	Fat Pocketbook	Endangered	Ohio River Main Channel	
		Orange-Foot Pimpleback	Endangered	Ohio River Main Channel	
		Pink Mucket	Endangered	Ohio River Main Channel	
		*Ring Pink	Endangered	Ohio River Main Channel	
McCreary	Fish	Blackside Dace	Threatened	First, Second and Third Order Streams within the Following Watersheds:	
				Rock Creek	
				Jellico Creek	
				Indian Creek	
				Eagle Creek	

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COUNTY	SPECIES TYPE	SPECIES	FEDERAL STATUS	Aquatic Species (Watershed)	USFWS Species Fact Sheet Available
McCreary (cont)				Mill Creek	
				Fishtrap Creek	
				Beaver Creek	
				Riggs Creek	
				Marsh Creek	
		Duskytail Darter	Endangered	Big South Fork Main Channel	
		Palezone Shiner	Endangered	Little S. F. Cumberland River	
		Johnny Darter	Candidate	Third, Forth and Larger Order Tributaries with the Following Watersheds:	
				Barren Fork	
				Laurel Creek	
				Cal Creek	
				Elisha Creek	
				Jenneys Branch	
				Kilburn Fork	
				Laural Fork	
				Indian Creek	
				Marsh Creek	
				Caddell Branch	
	Mammal	Indiana Bat	Endangered		
	Mussel	Cumberland Bean	Endangered	Forth and Fifth Order Streams within the Big South Fork of the Cumberland River Watershed	
		Cumberland Combshell	Endangered	Big South Fork River and Forth and Fifth Order Streams within the Big South Fork of the Cumberland River Watershed	
		Cumberland Elktoe	Endangered	Third Order and Larger Streams within the Following Watersheds:	
				Big South Fork of Cumberland River	
				Rock Creek	
				Marsh Creek	
		Little-Wing Pearly Mussel	Endangered	Forth Order Streams within the Big South Fork of the Cumberland River Watershed	
				Little S. F. Cumberland Water.	
		Oyster Mussel	Endangered	Big South Fork Main Channel	
	Plants	Cumberland Rosemary	Threatened	Big South Fork Watershed	
		Cumberland Sandwort	Endangered	Big South Fork Watershed	
		Virginia Spiraea	Threatened	Big South Fork Watershed	
		White Fringeless Orchid	Candidate		
McLean	Reptile	Copperbelly Water Snake	SCA		
Meade	Mammal	Indiana Bat	Endangered		

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COUNTY	SPECIES TYPE	SPECIES	FEDERAL STATUS	Aquatic Species (Watershed)	USFWS Species Fact Sheet Available
Menifee	Mammal	Indiana Bat	Endangered		
		Virginia Big-Eared Bat	Endangered		
	Plant	White Haired Goldenrod	Endangered		
Mercer	Mussel	*Clubshell	Endangered	Kentucky River Main Channel	
		*Fanshell	Endangered	Kentucky River Main Channel	
		*Northern Riffleshell	Endangered	Kentucky River Main Channel	
		*Ring Pink	Endangered	Kentucky River Main Channel	
		*Rough Pigtoe	Endangered	Kentucky River Main Channel	
Metcalf	Mammal	Gray Bat	Endangered		
	Plant	Eggert' s Sunflower	Threatened		
Monroe	Mammal	Gray Bat	Endangered		
Monroe	Mussel	*Fanshell	Endangered	Cumberland River Main Channel	
		*Orange-Foot Pimpleback	Endangered	Cumberland River Main Channel	
		*Ring Pink	Endangered	Cumberland River Main Channel	
Montgomery	Mammal	Indiana Bat	Endangered		
	Plant	Running Buffalo Clover	Endangered		Yes
Morgan	Mammal	Indiana Bat	Endangered		
		Virginia Big-Eared Bat	Endangered		
Muhlenberg	Mammal	Gray Bat	Endangered		
	Mussel	Catspaw	Endangered	Green River Main Channel	
		Fanshell	Endangered	Green River Main Channel	
	Reptile	Copperbelly Water Snake	SCA		
Nelson	Mammal	Gray Bat	Endangered		
	Mussel	*Clubshell	Endangered	Salt River Main Channel	
		*Northern Riffle Shell	Endangered	Salt River Main Channel	
		Fanshell	Endangered	Salt River Main Channel	
				Rolling Fork Main Channel	
	Plant	Running Buffalo Clover	Endangered		Yes
Nicholas	Mussel	Fanshell	Endangered	Licking River Main Channel	
Ohio	Mussel	*Catspaw	Endangered	Rough River Main Channel	
		Fanshell	Endangered	Rough River Main Channel	
		*Orange-Foot Pimpleback	Endangered	Rough River Main Channel	
Oldham	-	-	-	-	
Owen	Mussel	*Clubshell	Endangered	Kentucky River Main Channel	
		*Fanshell	Endangered	Kentucky River Main Channel	
Owsley	-	-	-	-	
Pendleton	Mussel	*Clubshell	Endangered	Licking River Main Channel	
		Fanshell	Endangered	Licking River Main Channel	
		*Northern Riffleshell	Endangered	Licking River Main Channel	
Pendleton	Mussel	Pink Mucket	Endangered	Licking River Main Channel	
		*Rough Pigtoe	Endangered	Licking River Main Channel	

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COUNTY	SPECIES TYPE	SPECIES	FEDERAL STATUS	Aquatic Species (Watershed)	USFWS Species Fact Sheet Available
Perry	-	-	-	-	
Pike	Mammal	Indiana Bat	Endangered		
Powell	Mammal	Indiana Bat	Endangered		
		Virginia Big-eared Bat	Endangered		
	Plant	White-haired Goldenrod	Endangered		
Pulaski	Fish	Blackside Dace	Threatened	First, Second and Third Order Streams in the Big Lick Branch Watershed	
	Mammal	Gray Bat	Endangered		
		Indiana Bat	Endangered		
Pulaski	Mussel	*Catspaw	Endangered	Buck Creek Watershed	
		Cumberland Bean	Endangered	Forth and Fifth Order Streams in the Buck Creek Watershed	
				Rockcastle River Main Channel	
		Cumberlandian Combshell	Endangered	Buck Creek and Rockcastle River Main Channel and Forth and Fifth Order Streams in the Buck Creek and R. River Watershed	
		Little-wing Pearly Mussel	Endangered	Buck Creek and Forth Order Streams within the Buck Creek Watershed	
				Pitman Creek	
		*Oyster Mussel	Endangered	Buck Creek Main Channel	
				Rockcastle River Main Channel	
		*Ring Pink	Endangered	Cumberland River Main Channel	
		*Rough Pigtoe	Endangered	Cumberland River Main Channel	
	Plant	Virginia Spiraea	Threatened		
		White Fringeless Orchid	Candidate		
Robertson	Mussel	*Clubshell	Endangered	Licking River Main Channel	
		Fanshell	Endangered	Licking River Main Channel	
	Plant	Short' s Goldenrod	Endangered		
Rockcastle	Mammal	Indiana Bat	Endangered		
		Virginia Big-eared Bat	Endangered		
	Mussel	Cumberlandian Combshell	Endangered	Forth Order Streams within the Following Watersheds:	
				Horselick Creek	
				Roundstone Creek	
				Rockcastle River (main channel)	
		Little-winged Pearly Mussel	Endangered	Forth Order Streams within the Following Watersheds:	
				Horselick Creek	
				Rockcastle River Main Channel	
	Plant	Virginia Spiraea	Threatened		
Rowan	Mammal	Virginia Big-eared Bat	Endangered		

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COUNTY	SPECIES TYPE	SPECIES	FEDERAL STATUS	Aquatic Species (Watershed)	USFWS Species Fact Sheet Available
	Mussel	*Northern Riffleshell	Endangered	Licking River Main Channel	
		Pink Mucket	Endangered	Licking River Main Channel	
Russell	Mussel	*Cumberlandian Combshell	Endangered	Cumberland River Main Channel	
		*Cumberland Bean	Endangered	Cumberland River Main Channel	
		*Fanshell	Endangered	Cumberland River Main Channel	
		*Orange-foot Pimpleback	Endangered	Cumberland River Main Channel	
		*Oyster Mussel	Endangered	Cumberland River Main Channel	
		*Pink Mucket	Endangered	Cumberland River Main Channel	
		*Ring Pink	Endangered	Cumberland River Main Channel	
		*Rough Pigtoe	Endangered	Cumberland River Main Channel	
Scott	Mammal	Gray Bat	Endangered		
	Plant	Short's Bladderpod	Candidate		
Shelby	Mammal	Gray Bat	Endangered		
Simpson	Mammal	Gray Bat	Endangered		
Spencer	Mussel	*Clubshell	Endangered	Salt River Main Channel	
		*Fanshell	Endangered	Salt River Main Channel	
		*Northern Riffleshell	Endangered	Salt River Main Channel	
		*Pink Mucket	Endangered	Salt River Main Channel	
Taylor	Mammal	Gray Bat	Endangered		
		Indiana Bat	Endangered		
	Mussel	Clubshell	Endangered	Green River Main Channel Below GR Lake Dam	
		*Northern Riffleshell	Endangered	Green River Main Channel Below GR Lake Dam	
Todd	Mussel	*Fanshell	Endangered	West Fork Red River Main Channel	
		*Little-wing Pearly Mussel	Endangered	West Fork Red River Main Channel	
		*Ring Pink	Endangered	West Fork Red River Main Channel	
Trigg	Mammal	Gray Bat	Endangered		
		Indiana Bat	Endangered		
	Mussel	*Orange-foot Pimpleback	Endangered	Cumberland River Main Channel	
		*Ring Pink	Endangered	Cumberland River Main Channel	
	Plant	Price's Potato-Bean	Endangered		
Trimble	Mammal	Indiana Bat	Endangered		
Union	Mammal	Indiana Bat	Endangered		
	Mussel	Fat Pocketbook	Endangered	Ohio River Main Channel	
	Reptile	Copperbelly Water Snake	SCA		
Warren	Mammal	Gray Bat	Endangered		
		Indiana Bat	Endangered		
	Mussel	Catspaw	Endangered	Green River Main Channel	

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COUNTY	SPECIES TYPE	SPECIES	FEDERAL STATUS	Aquatic Species (Watershed)	USFWS Species Fact Sheet Available
Warren (con't)		Fanshell	Endangered	Barren River Main Channel	
				Green River Main Channel	
		*Orange-foot Pimpleback	Endangered	Green River Main Channel	
		*Northern Riffleshell	Endangered	Barren River Main Channel	
				Drakes Creek Main Channel	
		Pink Mucket	Endangered	Barren River Main Channel	
				Green River Main Channel	
		*Ring Pink	Endangered	Green River Main Channel	
		Rough Pigtoe	Endangered	Barren River Main Channel	
		Clubshell	Endangered	Green River Main Channel	
Washington	-	-	-	-	
Wayne	Mammal	Gray Bat	Endangered		
		Indiana Bat	Endangered		
	Fish	Palezone Shiner	Endangered	Little S. F. Cumberland River Main Channel	
	Mussel	Cumberland Bean	Endangered	Forth and Fifth Order Streams within the following Watersheds:	
				Little S. F. Cumberland River	
				Kennedy Creek Watershed	
		*Cumberlandian Combshell	Endangered	Forth Order Streams within the Cumberland River Watershed	
		Fanshell	Endangered	Cumberland River Main Channel	
		Little-wing Pearly Mussel	Endangered	Forth Order Streams within the Following Watersheds:	
				Little S. F. Cumberland River	
				Kennedy Creek Watershed	
		*Orange-foot Pimbleback	Endangered	Little South Fork Cumberland River Main Channel	
		*Oyster Mussel	Endangered	Little South Fork Cumberland River Main Channel	
		*Pink Mucket	Endangered	Little South Fork Cumberland River Main Channel	
		*Ring Pink	Endangered	Little South Fork Cumberland River Main Channel	
		*Rough Pigtoe	Endangered	Little South Fork Cumberland River Main Channel	
Webster	Reptile	Copperbelly Water Snake	SCA		
Whitley	Bird	Red-cockaded Woodpecker	Endangered		
	Fish	Blackside Dace	Threatened	First, Second and Third Order Streams within the Following Watersheds:	
				Jellico Creek	
Whitley (con't)				Young Creek	

				Mud Creek	
				Patterson Creek	
	Fish	Johnny Darter	Candidate	Third, Forth and Larger Tributaries Within the Following Watersheds:	
				Cumberland River	
				Bunches Creek	
				Calf Pen Creek	
				Jellico Creek	
				Little Wolf Creek	
				Brier Creek	
				Youngs Creek	
	Mussel	*Cumberland Bean	Endangered	Cumberland River Watershed	
		Cumberland Elktoe	Endangered	Third Order and Larger Streams within the Following Watersheds:	
				Laurel Fork	
				Lynn Camp Creek	
		*Oyster Mussel	Endangered	Cumberland River Main Channel	
	Plant	Virginia Spiraea	Threatened		
		White Fringeless Orchid	Candidate		
Wolfe	Mammal	Indiana Bat	Endangered		
		Virginia Big-eared Bat	Endangered		
Woodford	Mussel	*Clubshell	Endangered	Kentucky River Main Channel	
		*Fanshell	Endangered	Kentucky River Main Channel	
		*Northern Riffleshell	Endangered	Kentucky River Main Channel	
		*Ring Pink	Endangered	Kentucky River Main Channel	
		*Rough Pigtoe	Endangered	Kentucky River Main Channel	
	Plant	Running Buffalo Clover	Endangered		Yes
	Insect	Clifton Cave Beetle	Candidate		

- * Denotes older records for species. Species may have been extirpated from watershed. However, survey data can be inconclusive and these species could still be present in very limited numbers.
- ** USFWS Species of Management Concern and unique to listed watersheds.

Exhibit E Kentucky Practice Effects on Threatened and Endangered Species

NRCS Practices Effects on Threatened and Endangered Species (T&E)

Zero (0) - Not likely to adversely affect T&E species
Minus (-) - Practice may adversely affect T&E species if present (May require further consultation.)
Plus (+) - Practice may beneficially affect T&E species if present

This table shall be used to assist in making planning decisions regarding threatened and endangered species. Contact the NRCS State Biologist for assistance. Numbers adjacent to Xs correspond to footnotes at the end of the table. Refer to the "NEPA Guidance Document For Threatened and Endangered Species" for further guidance on use of this table and other tools.

Practice Name and Unit	Practice Code	0	-	+
Access Road (Feet)	560		X1	
Agrichemcial Handling Facility	998	X		
Animal Trails and Walkways	575		X1	
Brush Management (Acre)	314		X1,X5	
Clearing and Snagging (Feet)	326		X1,X2, X3, X19	
Closure of Waste Impoundments (No)	360	X		
Commercial Fish Ponds (Catfish)	397A		X1, X4	
Commercial Fish Ponds (Shrimp)	397B		X1, X4	
Composting Facility (No)	317		X1	
Conservation Cover (Acre)	327		X5	
Conservation Cropping Sequence (Acre)	328	X		
Conservation Tillage (Acre)	329	X		
Contour Farming (Acre)	330	X		
Contour Orchard and Other Fruit Area (Acre)	331	X		
Cover and Green Manure (Acre)	340	X		
Critical Area Planting (Acre)	342		X5	
Crop Residue Use (Acre)	344	X		
Dike (Feet)	356		X1	
Diversion (Feet)	362		X1	
Dry Hydrant (Each)	432	X		
Farmstead and Feedlot Windbreak (Acre)	380	X		
Fence (Feet)	382	X		
Field Border (Feet)	386		X5	
Field Wind Break (Feet)	392		X5	
Filter Strip (Acre)	393		X5	X6
Firebreak (Feet)	394		X1, X5	
Fishpond Management (No)	399	X		
Forage Harvest Management	511	X		
Forest Land Erosion Control Systems (Acre)	408	X		
Forest Site Preparation (Acre)	490		X1, X5	
Grade Stabilization Structure (No)	410		X1,	X6
Grassed Waterway (Acre)	412		X1	
Heavy Use Area Protection (Acre)	561		X1	
Hedgerow Planting (Feet)	422		X5	
Irrigation Land Leveling (Acre)	464		X1	
Irrigation Storage Reservoir (No/Acre-Feet)	436		X1	

NRCS Practices Effects on Threatened and Endangered Species (T&E)

Practice Name and Unit	Practice Code	0	-	+
Irrigation System Sprinkler (No/Acre)	442	X		
Irrigation System, Surface and Subsurface	443	X		
Irrigation Water Conveyance, Pipeline (Feet)	430	X		
Irrigation Water Management (Acre)	449	X		
Land Clearing (Acre)	460		X1, X3, X19	
Land Reclamation, Fire Control (No)	451		X1, X19	
Land Reclamation			X1, X19	
Land Slides	453			
Subsidence Treatment (No/Acre)	454			
Toxic Discharge Control (No)	455			
Highwall Treatment (No/Feet)	456			
Land Reconstruction			X1, X19	
Abandoned Mine Land (Acre)	543			
New Mining	544A			
Land Smoothing (Acre)	466		X1	
Livestock Exclusion (Acre)	472			X6
Manure Transfer (No)	634	X		
Mulching (Acre)	484	X		
Nutrient Management (Acre)	590	X		
Obstruction Removal (Acre)	500		X1, X2, X3	
Open Channel (Feet)	582		X1, X18	
Pasture and Hayland Planting (Acre)	512		X5	
Pest Management (Acre)	595		X5	
Pipeline (Feet)	516		X1	
Pond (No)	378		X1	
Pond Sealing or Lining		X		
Flexible Membrane Lining (No)	521-A			
Soil Dispersant (No)	521-B			
Bentonite Sealant (No)	521-C			
Cationic Emulsion (No)	521-D			
Asphalt Sealed Fabric Liner (No)	521-E			
Precision Land Forming (Acre)	462		X1	
Prescribed Burning (Acre)	338		X1	
Prescribed Grazing (Acre)	528A	X		
Pumping Plant for Water Control (No)	533		X1	
Recreation Area Improvement (Acre)	562		X1	
Recreation land Grading and Shaping (Acre)	566		X1	
Recreation Trail and Walkway (Feet)	568		X1	
Riparian Forest Buffer (Acre)	391A		X1,X5	X6,X7,X8
Roof Runoff Management (No)	558	X		
Sediment Basin (No)	350		X1	
Shallow Water Management For Wildlife(Ac)	646			X7, X14

NRCS Practices Effects on Threatened and Endangered Species (T&E)

Practice Name and Unit	Practice Code	0	-	+
Sinkhole Protection (Acre)	725		X9	X15
Spoil Spreading (Feet)	572		X1	
Spring Development (No)	574		X1	
Streambank and Shoreline Protection (Feet)	580		X1, X2, X3,X10, X19	X6
Stream Crossing (Interim) (No)	576		X1, X2, X3, X10, X19	
Stripcropping, Contour (Acre)	585	X		
Stripcropping, Field (Acre)	586	X		
Structure For Water Control (No)	587		X1	
Subsurface Drain (Feet)	606		X1, X18	
Surface Drainage Field Ditch (Feet) Main or Lateral (Feet)	 607 608		X1, X18	
Terrace (Feet)	600		X1	
Tree/Shrub Establishment (Acre)	612		X5	X11
Trough or Tank (No)	614		X1	
Underground Outlet (Feet)	620		X18	
Vertical Drain (No)	630	X		
Waste Field Storage (Ea)	749	X		
Waste Storage Facility (No)	313		X1	
Waste Treatment Lagoon (No)	359		X1	
Waste Utilization (Acre)	633		X16	
Water and Sediment Control Basin (No)	638		X1	
Well (No)	642		X1	
Well Decommissioning (No)	351	X		
Wetland Restoration (Acre)	657		X1, X12	X7,X8
Wildlife Upland Habitat Management (Acre)	645		X1, X3, X13	X17
Wildlife Watering Facility (No)	648		X1	X14
Wildlife Wetland Habitat Management (Acre)	644	X		
Woodland Improvement (Acre)	666		X3	
Woodland Pruning (Acre)	660	X		

X1 – Earthmoving or placement of these practices may negatively affect threatened or endangered plant species. Further investigation is required if the practice will be placed in a habitat type where a threatened or endangered plant may reside. Review the habitat type, plant characteristics and appearance in the Kentucky Department of Fish and Wildlife Resources publication entitled Kentucky' s Threatened and Endangered Species, 2001. Make a visual observation of the area to determine if the species or habitat for the species exists. Contact the NRCS State Biologist for assistance, when a threatened or endangered plant is identified or thought to exist on the project area.

X2 – Appropriate permits, if required, must be acquired prior to conducting clearing and snagging activities. NRCS shall only provide assistance when the work will be in accordance with the appropriate permits.

X3 – Tree removal or land clearing may adversely affect the Indiana bat if conducted at the wrong time of the year. In counties noted to have the Indiana bat, NRCS must plan tree removal for periods between October 15th and March 31st unless the proposed site is within 5 miles of a cave, mine or other site used for hibernation. Tree removal and land clearing in these areas must be planned between November 15th and March 31st. In counties noted to have the Indiana bat, contact the NRCS State Biologist for assistance when planning tree removal to determine proximity to hibernation areas.

X4 – Currently, Kentucky NRCS is not providing technical or financial assistance for installation or management of commercial fish ponds. If in the future, NRCS provides technical or financial assistance for commercial fish ponds, the NRCS State Biologist must be contacted for assistance during the planning process if the commercial pond will be built in a watershed where threatened or endangered aquatic species are listed.

X5 – Herbicide application or conventional tillage planned as part of these practices may adversely affect listed plant species if present. Further investigation is required if the practice will be placed in a habitat type where a threatened or endangered plant may reside. Review the habitat type, plant characteristics and appearance in the Kentucky Department of Fish and Wildlife Resources publication entitled Kentucky' s Threatened and Endangered Species, 2001. Make a visual observation of the area to determine if the species or habitat for the species exists. Contact the NRCS State Biologist for assistance when a threatened or endangered plant is identified or thought to exist on the project area.

X6 – Practices will have a beneficial effect if the practice is installed on a stream that has aquatic threatened or endangered species. These practices will also provide beneficial effects when planned around sinkholes in counties where the Kentucky Cave Shrimp is listed.

X7 – Practice will have a beneficial effect if the practice is installed in a county noted to contain the Copperbelly Water Snake.

X8 – Practice will have a beneficial effect if the practice is installed in a county that contains the Indiana bat.

X9 – Prior to filling, closing or stabilizing an open throated sinkhole in a county noted to have Indiana, Gray, or Virginia Big Eared Bats, an investigation must be done to determine if any of these species utilize the sinkhole. Contact the NRCS State Biologist to arrange a site visit during planning.

X10 – An adverse effect may occur during practice installation on stream segments that are noted to have aquatic threatened or endangered species. Contact the NRCS State Biologist for assistance when planning these practices on stream segments noted to have threatened or endangered aquatic species.

X11- Tree and shrub establishment will have beneficial effects when it is planned in any county with the Indiana bat or on flood plain soils in counties noted to contain the Copperbelly Water Snake.

X12 - Wetland Restoration plans shall be reviewed by the USFWS.

X13 – Strip disking or forest openings done under Wildlife Upland Habitat Management (645) may adversely affect threatened or endangered plants. Further investigation is required if strip disking or forest openings will be planned in a habitat type where a threatened or endangered plant may reside. Review the habitat type, plant characteristics and appearance in the Kentucky Department of Fish and Wildlife Resources publication entitled Kentucky's Threatened and Endangered Species, 2001. Make a visual observation of the area to determine if the species or habitat for the species exists. Contact the NRCS State Biologist for assistance when a threatened or endangered plant is identified or thought to exist on the project area.

X14 – Practice will have a beneficial effect when installed in counties noted to contain the Indiana bat, Gray bat, or Virginia Big-eared bat.

X15 – Positive effect in counties where the Kentucky Cave Shrimp is listed if protection of the sinkhole does not include filling.

X16 – The following applies when Waste Utilization is being planned in watersheds where threatened or endangered aquatic species are listed:

1) When applicable, NRCS conservation plans shall include the required waste application set backs established in the Kentucky Division of Water's AFO/CAFO regulations and permit requirements.
2) When the Kentucky Division of Water's AFO/CAFO regulations do not apply, waste applications must be planned at least 40 feet from perennial, seasonal, and ephemeral streams, surface ditches, openings of open throated sinkholes, and other sensitive areas.

X17 – Positive effect when a cave gate is being placed over the entrance of a cave, mine, or other opening where Threatened or Endangered bats reside. The NRCS State Biologist must be contacted when planning to install cave gates.

X18 – All planned drainage must comply with NEPA, the Clean Water Act, and the Swamp Buster Provision of the Food Security Act.

X19 - Tree removal or land clearing around Bald Eagle nests may have an adverse effect on the species. Contact the NRCS State Biologist for assistance when Bald Eagle nests are identified during the planning process.

Exhibit F

Using Micro and Macrotopography in Wetland Restoration

Indiana Biology Technical Note No. 1

This document is intended to be used as a tool to assist in the planning of wetland restorations where the natural topography of the site has been eliminated. The planner is encouraged to be creative when developing the restoration plan. The concepts within can also be used whenever the development of macrotopographic features are desired.

WHAT IS MACROTOPOGRAPHY?

Background Undisturbed wetland systems in Indiana typically consist of complexes that contain a diversity of topographic relief from extremely shallow areas with minor ridges (microtopography) to deeper wetland habitats that include some upland characteristics (macrotopography). When wetlands are drained or altered, they normally lose most of their micro and macro topographic relief through land leveling or other agricultural activities.

Macrotopographic features are wetland "ridge and swale" complexes whose basins are depressional in landscape position and occur on terraces and in floodplains. The basin areas are normally from 0.1 acre to 5 acres in size with depths running from 0-30 inches, depending on the landscape position. These types of wetlands can be found in a multitude of shapes ranging from simple circular basins, to complex amoeba-like outlines, to meandering scours. Ridges (linear) and mounds (circular or elliptical) make up the "upland" component of macrotopographic features that normally do not exceed 30" in height. Together, the ridge and swale features form ephemeral wetlands that hold water from only a few weeks to several months during the year.

Microtopographic features are normally thought of as those shallow depressions with less than 6 inches of depth between the swales and ridges. Examples of microtopography can be seen in flat fields where shallow "sheet" water stands for short durations after a rain. Within the scope of this document, macrotopography will be assumed to include microtopographic features.

WHY IS THE DEVELOPMENT OF MACROTOPOGRAPHY IMPORTANT?

The development of macrotopographic complexity creates a diversity of water regimes (hydroperiods) which can increase water quality, provide flood storage, and enhance the development of a more diverse vegetative community. This results in greater overall wildlife benefits through the development of a variety of habitats. The dispersal, germination, and establishment of plant species, and the life cycles of many amphibians, reptiles, and other wildlife species are dependent on variations in the timing, depth, and duration of flooding.

Pickerel Frog

Food In the spring, shallow, ephemeral wetlands warm up before larger, deeper bodies of water, and provide important seasonal forage for shorebirds, waterfowl, nonmigratory bird species, and other wildlife. These types of wetlands produce significant amounts of protein-rich invertebrates including snails, worms, fairy shrimp, midge larvae, spiders, backswimmers, diving beetles, dragonflies, and damselflies. Organic (woody and herbaceous) debris, roots, leaves, and tubers from aquatic vegetation are additional food sources and provide substrates for macroinvertebrates.

Habitat Wetland restoration plans that include undulating landscape features create a diversity of habitat types. Swales, oxbows, potholes and other macrotopographic basins provide varying hydroperiods from short-term ponding to seasonal and semi-permanent water conditions. A wetland, or wetland complex, with multiple hydroperiods can support a variety of habitat zones. Scrub-shrub, submergent, emergent, and floating-leaf communities (e.g., duckweed) are examples of herbaceous aquatic habitats. A diverse wetland plant community benefits numerous species of wildlife including many fur-bearing mammals, waterfowl, shorebirds, wading birds, amphibians and reptiles. Because native plants provide the best overall habitat, are essentially self-sustaining, and tend to be non-invasive, only native vegetation should be planted. Note that Conservation Practice Standard 657, Wetland Restoration, has an extensive list of native wetland plant species.

Low-level mounds or ridges (maximum 30 inches) are considered to be a component of macrotopography, and can greatly increase the biological diversity of restoration sites when combined with basins. Amphibians, for example, tend to have small home ranges. Thus, having a diversity of wetland types in close proximity to terrestrial habitats within the project area will support the greatest populations.

PLANNING

When developing macrotopographic features, the planner should determine the target species (i.e. species of concern) and review historical aerial photography to determine the appropriate features to include in the restoration project.

Tiger Salamander

Amphibians and Reptiles A primary focus of macrotopography development is the creation of habitat for frogs, toads, salamanders, newts, turtles, and snakes. These amphibians and reptiles are known as herpetofauna or commonly called "herps". Amphibians are an especially diverse group and require wetlands with differing hydroperiods and habitat types. Because macrotopographic basins are often completely dry by summer or early fall, they are normally free of fish. Occasionally pools do retain water year round, but due to warm water conditions that create low oxygen levels, they still do not support fish populations. This is important because fish are primary predators of larval, tadpole, and adult amphibians. In general, sites flooded for longer periods will have more predators of amphibians.

The timing and duration of flooding are important factors that dictate which amphibians will use a particular wetland. Amphibian species are extremely variable in their habitat requirements. Most breeding occurs from May through August, with eggs hatching anywhere from 4 to 20 days later. Complete metamorphosis may take an additional 7 weeks to 3 months. Some species may need as much as a year to develop, with a few species even over-wintering as tadpoles, requiring permanent water. Table 1 (modified from Knutson et. al.) is an example of the diversity in preferred breeding periods and guild associations, for a study in an Iowa and Wisconsin.

Table 1[1]

			Breeding[2]		Nonbreeding[3]			Hibernation[4]		
Common name	Scientific name	Breeding period	Perm. water	Temp. water	Water	Forest/ litter	Open	Water	Forest/ litter	Ground
Wood frog	Rana sylvatica	Mar.-Apr.	N	Y	N	Y	N	N	Y	N
Chorus frog	Pseudacris triseriata	Mar.-May	N	Y	N	Y	Y	N	Y	N
Spring peeper	Pseudacris crucifer	Mar.-Summer	N	Y	N	Y	N	N	Y	N
N. leopard frog	Rana pipiens	Apr.-June	Y	Y	Y	N	Y	Y	N	N
Pickerel frog	Rana palustris	Apr.-mid June	Y	N	Y	Y	Y	Y	N	N
American toad	Bufo americanus	Apr.-June	Y	Y	N	Y	Y	N	Y	N
Eastern gray treefrog	Hyla versicolor	May-Aug.	Y	Y	N	Y	N	N	Y	N
Cope's gray treefrog	Hyla chrysoscelis	May-Aug.	Y	Y	N	Y	Y	N	Y	N
Cricket frog	Acris crepitans	May	Y	N	Y	N	N	N	Y	N
Green frog	Rana clamitans	Mid May-July	Y	N	Y	N	N	Y	N	N
Bullfrog	Rana catesbeiana	May-July	Y	N	Y	N	N	Y	N	N
Fowler's toad	Bufo woodhousii	Mar.-Aug.	N	Y	N	N	Y	N	N	Y

[1] Species that can successfully survive or reproduce in a habitat during the identified life-history phase are identified with a Y; those that do not with an N.
[2] Will breed in permanent water or temporary (ephemeral) ponds.
[3] Active, nonbreeding portion of the year is spent in the water or along the water edges, in trees or forest litter, or in open, nonforested habitats (grasslands).
[4] Hibernation or estivation period is spent in or near water, in forest litter, or underground.

In Indiana, the species that metamorphose their life cycle by early summer are the ones we need to target. Therefore, **macrotopographic basins should be designed to keep water available until at least mid-July.** Note that the process of a wetland drying out is beneficial. It eliminates insect and vertebrate predators, allows seeds to germinate, and exposes detritus to processes of oxidation thereby releasing nutrients.

When planning a site for amphibian and reptile habitat, macrotopographic features should make up approximately 30-50% of the area. The water (swale, meander, etc.) and the upland habitat (mound) acreage are combined to get the percent of macrotopographic features. It can be assumed that for every acre of water created, an additional acre of mound is created. **Table 2** can be used to record the planned macrotopographic features.

Table 2

Field Number	Field Size (acres)	Basin Number	Basin Amount (acres)	Macrotopography Description	Associated Habitat Mounds (height(#))

Where restoration sites have a designed water level, such as those with levees and control structures, approximatey 30% of the area should have macrotopographic features. Consider concentrating macrotopographic features in and near the more shallow water reaches.

Where restoration sites do NOT have a designed water level, such as in floodplains where high stream flows would destroy levees and control structures, approximatey 50% of the area should have macrotopographic features. Note that in these landscapes, the macrotopographic basins may provide the only standing water on the restoration site. Consider concentrating the deeper macrotopographic features in the lower elevations of the site, and shallower features in the higher elevations.

Shorebirds Shallow, ephemeral wetlands provide an abundance of aquatic invertebrates that are a critical food source for shorebirds during migration. Most shorebird species will utilize wetland habitats with water depths from 0-3 inches, and will rarely forage in water depths greater than 6 inches. Maximizing areas which provide conditions from mudflats through 3 inches deep during spring and late summer will provide the greatest benefits for migratory shorebirds.

Waterfowl These same shallow basins provide important invertebrate forage for waterfowl, particularly during spring migration when nutrient needs prior to nesting are high. In addition, several species of dabbling ducks (e.g. mallards and blue-winged teal) will utilize temporary wetlands for pair bonding and mating. Although these temporary ponds may not have water long enough to provide brood habitat in most years, they serve an important function in distributing pairs across the landscape and allowing for courtship rituals. Visually isolating basins, or portions of basins, through irregular shaping will particularly benefit species such as mallards which are more territorial. When combined with semi-permanent basins in close proximity, macrotopographic basins contribute to excellent wetland complexes for water fowl breeding.

Soils It is important for the planner to identify those portions of the restoration site which have hydric soils or soils that will most likely respond to macrotopographic development. Look for soils that have low permeability, a restrictive under-lying layer, or high water tables.

Sites which have soils that are hydric due only to flooding may not be appropriate if the soils are well drained and are not very frequently flooded. In these cases, it may not justify the expense of creating macrotopography and the planner should consider only vegetative restoration measures. If it is unclear whether or not there is sufficient hydrology to maintain the needed water levels within the basin areas, a water budget should be calculated.

Succession and Long-term Management Succession of wetlands is a natural process that can result in significant habitat changes over time. Primary changes include, for example, the development of aquatic macrophytes, invasion of wetlands by trees and shrubs, and canopy closure over wetlands embedded in forested landscapes. Such changes can alter the species composition of wetlands over time by selecting for species that favor or can tolerate later successional stages. Early successional species will consequently be lost, thereby lowering diversity, and can only be restored by periodically reversing succession. Plans to periodically (e.g. every 10-20 years) reverse the effects of succession in some portion of all wetlands (e.g. 5-10% of the total number per year) are important to consider. Natural processes that can reverse succession vary among regions and should mimic local regimes but may include flooding, drying, and burning. Human disturbance regimes such as mowing, timber harvest, draw-downs, or even herbicides may be considered, but only with extreme caution because of possible negative indirect effects.

MACROTOPOGRAHIC BASINS

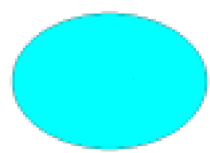
The macrotopograhic basins are described in abbreviated format as: shape/size/depth.
Where:
1) the shape is described below
2) the size is in acres
3) the depth is in feet

For example, a macrotopograhic basin described as Oxbow/1.5/0.5-1.0-2.0:
1) has shape #2 below,
2) is 1.5 acres in size, and
3) is composed of 3 depths (0.5', 1.0' and 2.0')

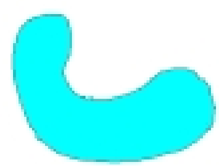
BASIN SHAPE DESCRIPTIONS

Basins should be irregular in shape. Irregular shapes increase edge and provide additional cover for waterfowl and other wildlife utilizing the site.

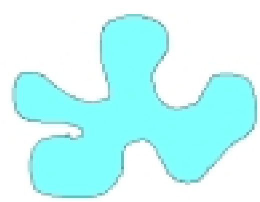
1) Shape: **Oval**
Description: Generally circular



2) Shape: **Oxbow**
Description: Kidney shaped with 2 lobes



3) Shape: **Amoeba**
Description: Multiple lobes with random shape, high perimeter to surface area ratio

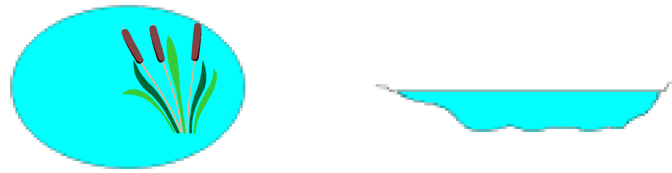


4) Shape: **Meander**
Description: Mimics an abandoned stream channel meander

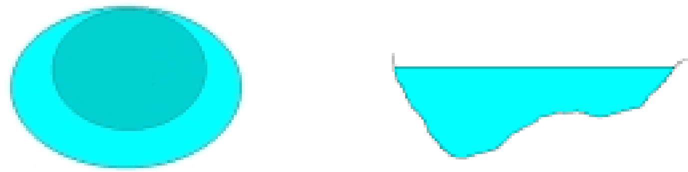
DEPTH DESCRIPTIONS

AERIAL VIEW | **CROSS SECTION**

When 1 depth is indicated:
- the basin is primarily 1 depth

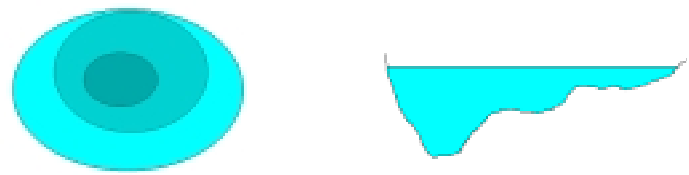


When 2 depths are indicated:
- each depth composes approximately 50% of the area



When 3 depths are indicated:

the depths compose approximately:
- deepest depth = 20% of the area
- middle depth = 30% of the area
- shallowest depth = 50% of the area



HABITAT MOUNDS

Fill excavated from the macro-topograhic basins can be used to create multiple upland habitat conditions based on the height, shape, and location of habitat mounds. Variations in habitat mound design can provide escape areas, denning sites, nesting opportunities, and plant diversity, as well as providing visual breaks within the wetland complex. All side slopes for mounds should have a minimum slope of 6:1, but should be as flat as is feasible. **Note:** In situations where geese are a nuisance, at least 30 feet should exist between the habitat mound and any water surface. This area should then be planted with a vegetative barrier such as warm season grasses, trees or shrubs.

Where restoration sites have a designed water level, habitat mounds should vary in elevation from above to below the expected normal waterline. Approxmately 1/3 of the mounds should be 6 inches to 1.0 foot **below** the normal water elevation, 1/3 should be 6 inches to 1.0 foot **above**, and 1/3 should be **at** the normal water elevation.

Where restoration sites *do not* have a designed water level, habitat mounds primarily provide upland habitat and tend to direct water flow during flood conditions. Approximately 50% of the mounds should be 6 inches to 1.0 foot above average ground level, and 50% should be 1.0 to 2.0 foot above the normal ground elevation. Mounds should mimic the natural landscape as much as possible. For example, if the site is located on the interior of a river oxbow, ridge and swale design may be appropriate (see figures 2 and 3). When possible, place mounds in such a way as to increase meander distance by directing water flow in a path that meanders across the unit.

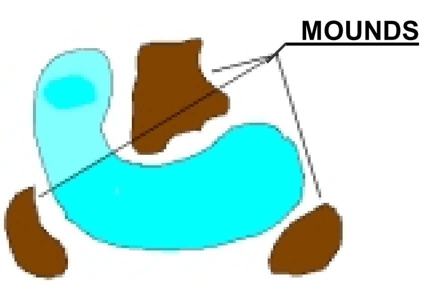


Figure 1

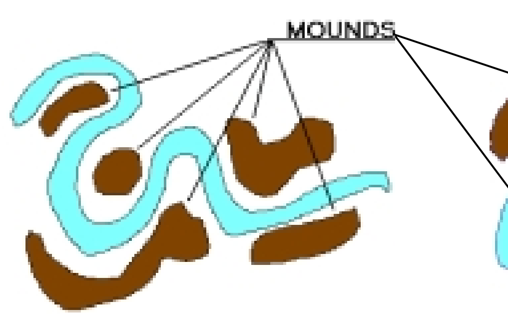


Figure 2

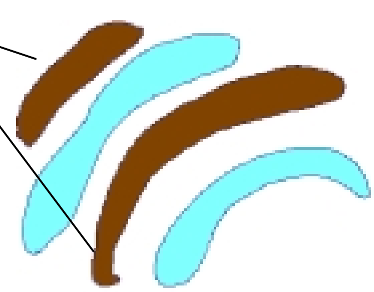


Figure 3

ADDITIONAL MODIFICATIONS

Ditches of varying depths and widths can connect basins to diversify a site. They provide additional cover for waterfowl as well as escape routes away from predators. Connection ditches may have 3:1 (or flatter) side slopes. In some cases, they can also be used for boat access to the site for hunting and recreational viewing, or to limit vehicular traffic of the site. See Figure 4.

Note: In situations where amphibians are the primary species of concern, connecting ditches should be limited because they provide access routes for predatory fish, particularly if connected to deeper, more permanent pools.

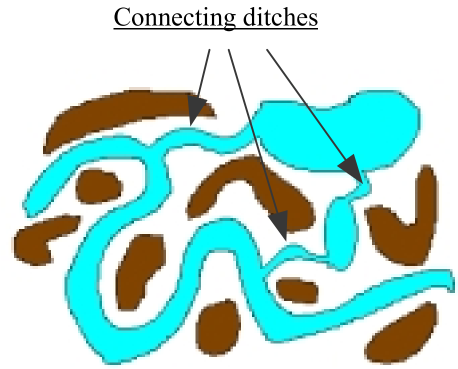


Figure 4

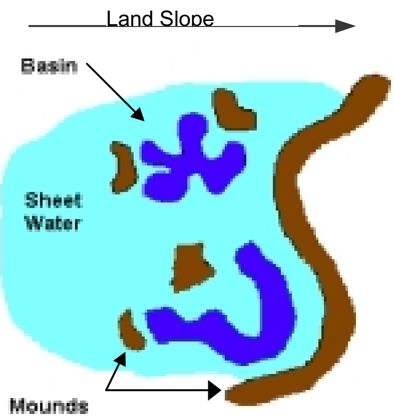


Figure 5

On gently sloping sites, an efficient means of providing shallow, "sheet" water habitat is through the creation of linear habitat mounds. The excavated material from a macrotopographic basin is used to form a low, meandering ridge on the down slope side of the basin(s). Typical heights for the mound range from 1 to 2 feet. By using the spoil in a creative manner, the total shallow water on a project site can be substancially increased. The impounded sheet water provides seasonal or ephemeral water for shallow feeders such as shorebirds, while the excavated basins provide longer hydroperiod wetland habitats. This method can also be utilized where wetland meadow conditions are desired.

CONSTRUCTION

Creative Borrowing Borrow areas for dikes or embankments can be incorporated into the development of macrotopographic features. Potholes, swales, meanders, and other shallow water habitats can serve as borrow areas for needed fill. All side slopes for basins should have a minimum slope of 6:1. Note that, when feasible, slopes should be as flat as possible. Slopes exceeding 20:1 are not considered excessive for habitat purposes. Examples of this include situations where equipment operators randomly fill their scrapers leaving shallow, single-trip borrow sites. Note that the borrow areas will result in the basins being the deepest portions of the wetland complex. In seasonal or ephemeral wetlands these areas provide a diversity of hydroperiods by holding water later into the year than the remainder of the wetland.

Rough-finish Grading The desired macrotopographic features will have rough surfaces on all side slopes and top, an undulating bottom, and a ragged shoreline.

Woody Debris

- Provides sunning and resting areas for herptiles
- Provides loafing sites for waterfowl
- Is a source for organic soil material
- Provides additional vertical and horizontal habitat
- Is an excellent substrate for invertebrates

Depending on water velocities the debris may or may not have to be partially buried. Use as needed.

ASSOCIATED TECHNICAL STANDARDS

This technical note can be used in association with the following technical standards:

- 657 Wetland Restoration
- 658 Wetland Creation
- 659 Wetland Enhancement
- 644 Wetland Wildlife Habitat Management

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Exhibit G

United States Department of Agriculture

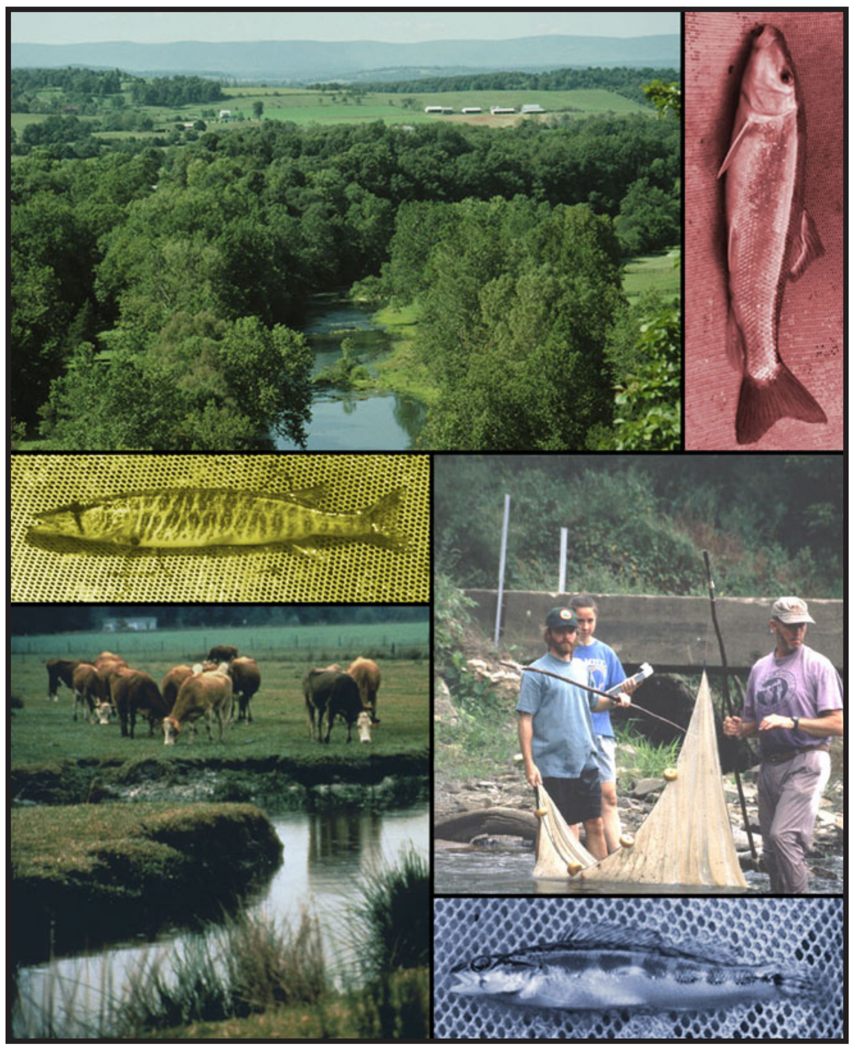
NRCS Natural Resources Conservation Service

Wetland Science Institute

July 2003

Technical Note 190–16

Fish Assemblages as Indicators of the Biological Condition of Streams and Watersheds



Issued July 2003

Acknowledgments

Fish Assemblages as Indicators of the Biological Condition of Streams and Watersheds is the product of a number of Natural Resources Conservation Service (NRCS) efforts to evaluate the use of the Index of Biotic Integrity (IBI) as a tool for watershed assessment. The document is based on an extensive literature review of multimetric approaches, such as the Index of Biotic Integrity, and field studies to determine the application of IBI for NRCS watershed activities. The document provides guidance on how to develop a regional IBI based on fish assemblages and provides many contacts and references that will aid in that process. Several institutes and scientists are responsible for this publication. I specifically thank the following individuals who made significant contributions through their support in conducting field studies or peer review of the document:

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Fish Assemblages as Indicators of the Biological Condition of Streams and Watersheds

Tables

Figures

Fish Assemblages as Indicators of the Biological Condition of Streams and Watersheds

Introduction

During a century of evolution, through changing human impacts on water and its associated resources, biological monitoring has taken a variety of approaches. One of the more recent and successful is the Index of Biotic Integrity (IBI) (Karr et al. 1986), a multimetric approach that uses fish assemblages to assess the biological condition of streams and watersheds. Now well-documented and widely used, the IBI combines multiple indicators or "metrics" with appropriate sampling design and data analysis to evaluate a stream's ability to support unimpaired living systems. A metric is a measurable component of a fish assemblage that is empirically shown to change in value along a gradient of human influence (e.g., total number of species or the percentage of individuals that are omnivores) (Karr and Chu 1997). Metrics are chosen based on how well they reflect specific and predictable biological responses to human activities. The procedures for developing and applying an IBI, first detailed by Karr et al. (1986), have been adapted in this section for assessments in small watersheds typical of those in which NRCS provides technical assistance.

Background

According to Karr et al. (1986), performing biological assessments in streams is in a sense analogous to measuring human health. When blood pressure readings, white blood cell counts, and the results of stress tests fall within acceptable ranges, good human health is indicated. Good health, however, is not a simple function of these attributes. Rather, a biological system, whether it is a human system or a stream ecosystem, can be considered healthy when it has all its natural parts and has no signs of debilitating stress, injury, or disease.

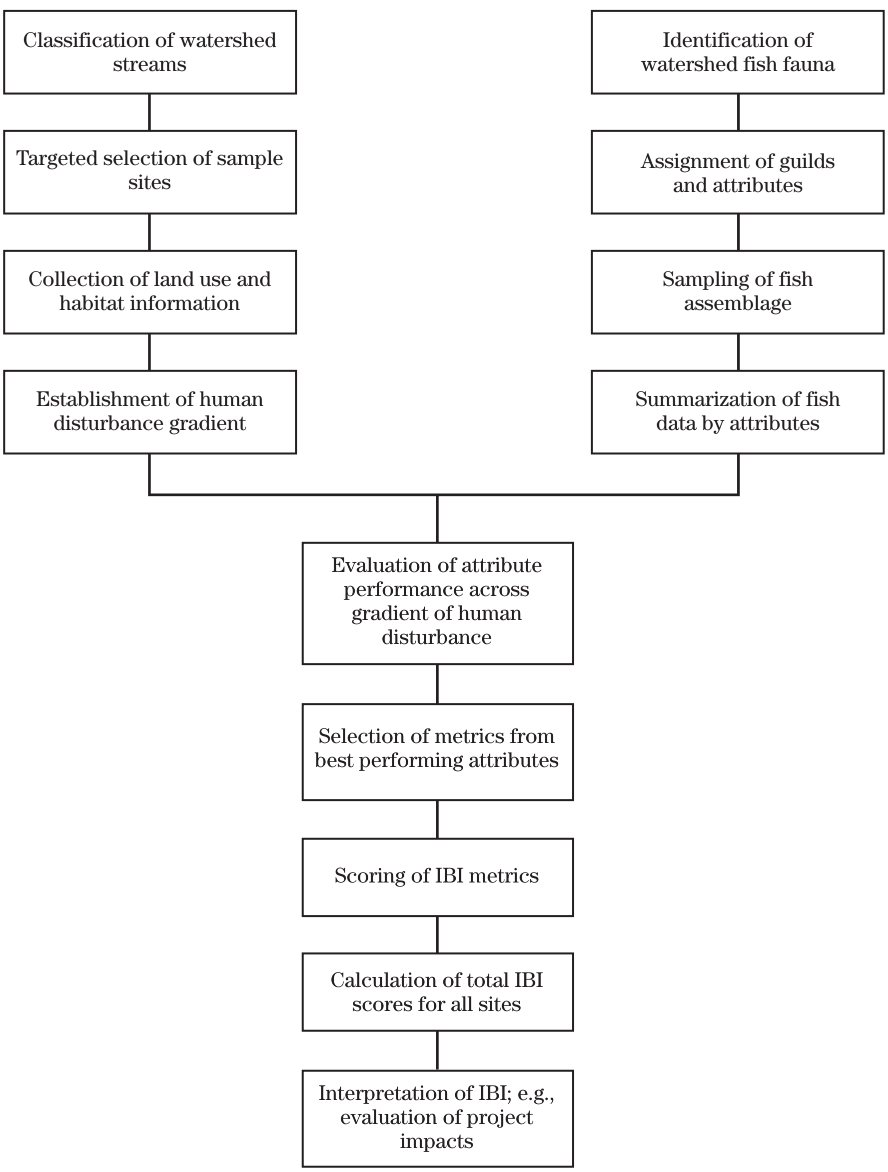
Fish are useful organisms for biological assessments for several reasons. First, fish are sensitive to a wide array of stresses. Fish integrate the adverse effects of complex and varied stresses to other components of the aquatic ecosystem, such as habitat and macroinvertebrates, by virtue of their dependence on those components for reproduction, survival, and growth. Secondly, because fish are relatively long-lived, their populations show effects of reproductive failure and mortality in many age classes and hence provide a long-term record of environmental stress. Finally, fish assemblages can be used to evaluate societal costs of degradation more directly than other taxa because their economic and aesthetic values are widely recognized (Fausch et al. 1990).

The accurate assessment of biological condition requires a method that integrates biotic responses through the examination of patterns and processes from individual to ecosystem levels. The IBI accomplishes this through a combination of key metrics that have demonstrated response to the effects of human influence. In this multimetric approach, each metric is scored depending on whether its value approximates, deviates somewhat from, or deviates strongly from values expected from the region's least impaired streams.

The IBI has been used not only to assess the conditions of streams, but the condition of their contributing watersheds as well (Fausch et al. 1990, Roth et al. 1996, Wang et al. 1997). In addition, several authors have used it to assess the impacts of various human-induced disturbances. For example, Berkman et al. (1986) used the IBI to describe the effects of agriculture on stream quality. Leonard and Orth (1986) used it in small coolwater streams to describe the effects of pollution from small towns and mining. Steedman (1988) used it to classify various landscape disturbances and to establish impairment thresholds for water quality in southern Ontario watersheds. Hughes and Gammon (1987) used it to describe longitudinal changes in fish assemblages and water quality in the Willamette River, Oregon. Various versions of the IBI are currently used in practically all U.S. states and Canadian provinces (Davis et al. 1996). The IBI has also been widely modified for use outside the USA and Canada (Hughes and Oberdorff 1999). The technique, because of its firm ecological foundation, also appears to be well suited to assessing the recovery of aquatic ecosystems (Hughes et al. 1990). However, like any tool, the IBI must be used appropriately. Protocols for fish sampling, establishment of reference conditions, and evaluation of metrics must be closely followed before it can accurately measure biological condition. Figure 1 details the major steps involved in constructing an IBI. Several of the steps include a number of subcomponents. Each of the steps and their subcomponents are described in more detail later under the section entitled "IBI development."

Many IBIs have been developed and are currently available for certain states, regions, or river basins. To avoid costly duplication and help achieve consistent results, state natural resource agencies may be contacted about the availability of an IBI for the area that you wish to study (table 1). In addition, many IBIs have been developed in universities and state water quality agencies. For additional information about other IBI applications, refer to Miller et al. (1988), Simon and Lyons (1995), Davis et al. (1996), and Simon (1999). Also see the text box entitled Sources for Metric Alternatives, page 24.

Figure 1 Sequence of activities in developing IBI (adapted from Karr et al. 1986)



Before collecting fish for IBI or other purposes, you should also contact the appropriate state agency to inquire about the need for a permit (table 1). In most states the collection of stream fishes requires a collection permit, even if fish are captured for only a short while and then returned to the stream. Not only does the permit allow collection to proceed under the prescribed authority, your survey results may be required for state databases that track species distribution in state waterbodies. In addition, upon request, location information from those databases may be made available to you for the streams you wish to study.

Another precursor to sampling is obtaining collection permits from the Fish and Wildlife Service and National Marine Fisheries Service (for anadromous species) under sections 4d, 7, and 10 of the Endangered Species Act (tables 2 and 3). These permits or consultations are required wherever a threatened or endangered species is likely to be encountered. The application or consultation process requires extensive information, and it takes several months to process the application. It is advisable to contact the district or regional biologist responsible for the species and waterbodies of interest before applying for State and Federal permits.

Table 1 State natural resources agencies responsible for issuing scientific collecting permits and reporting requirements (adapted from Walsh and Meador 1998)

State	State natural resources agency	Reporting requirements
Alabama	Alabama Department of Natural Resources Game and Fish Division 64 N. Union Street Montgomery, AL 36130 (334) 242-3469	Report due within 10 days of expiration
Alaska	Alaska Department of Fish and Game Division of Sport Fish P.O. Box 25526 Juneau, AK 99802-5526 (907) 465-4180	Report due within 30 days of expiration
Arizona	Arizona Game and Fish Department Nongame Branch 2221 West Greenway Road Phoenix, AZ 85023-4399 (602) 789-3504	Report due within 30 days of expiration
Arkansas	Arkansas Game and Fish Commission Fisheries Division 2 Natural Resources Drive Little Rock, AR 72205 (501) 223-6371	Report due within 30 days of expiration
California	California Department of Fish and Game License and Revenue Branch 3211 S Street Sacramento, CA 95816-7088 (916) 227-2225	Report due within 30 days of expiration unless waived

Table 1 State natural resources agencies responsible for issuing scientific collecting permits and reporting requirements (adapted from Walsh and Meador 1998)—Continued

State	State natural resources agency	Reporting requirements
Colorado	Colorado Department of Natural Resources Division of Wildlife 6060 Broadway Denver, CO 81601-1000 (970) 945-4717	Report due within 30 days of expiration
Connecticut	Connecticut Department of Environmental Protection Fisheries Division 79 Elm Street Hartford, CT 06106-5127 (860) 424-3474	Report due at expiration
Delaware	Delaware Department of Natural Resources Division of Fish and Wildlife P. O. Box 1401 Dover, DE 19903 (302) 739-3441	Report due within 30 days of expiration
Florida	Florida Game and Freshwater Fish Commission Division of Fisheries Farris Bryant Building 620 South Meridian Street Tallahassee, FL 32399-1600 (904) 488-1600	Report due at expiration or 30 days prior to renewal
Georgia	Georgia Department of Natural Resources Wildlife Resources Division Special Permit Office 2109 U. S. Highway 278 S.E. Social Circle, GA 30025 (770) 761-3044	Report due at expiration
Hawaii	Hawaii Department of Land and Natural Resources Division of Aquatic Resources 1151 Punchbowl Street, Room 330 Honolulu, HI 96813 (808) 587-0097	Report due within 30 days of expiration
Idaho	Idaho Department of Fish and Game P.O. Box 25 Boise, ID 83707 (208) 334-3791	Report due at end of calendar year
Illinois	Illinois Department of Natural Resources Division of Fisheries Office of Resource Conservation 524 S. 2nd Street Springfield, IL 62701-1787 (217) 524-8285	Report due at end of February

Table 1 State natural resources agencies responsible for issuing scientific collecting permits and reporting requirements (adapted from Walsh and Meador 1998)—Continued

State	State natural resources agency	Reporting requirements
Indiana	Indiana Department of Natural Resources Division of Fish and Wildlife Commercial License Clerk 402 West Washington Street, Room 273 Indianapolis, IN 46204 (317) 232-4080	Report due within 15 days of expiration
Iowa	Iowa Department of Natural Resources License Bureau Wallace State Office Building Des Moines, IA 50319-0035 (515) 281-8688	Report due by January 10
Kansas	Kansas Department of Wildlife and Parks Fish and Wildlife Division 512 S.E. 25th Avenue Pratt, KS 67124-8174 (316) 672-5911	Report due by January 31
Kentucky	Kentucky Department of Fish and Wildlife Resources Division of Fisheries 1 Game Farm Road Frankfort, KY 40601 (502) 564-3596	Report due by January 31
Louisiana	Louisiana Department of Wildlife and Fisheries Inland Fisheries Division P.O. Box 98000 Baton Rouge, LA 70898 (504) 765-2865	Report due within 60 days of permit expiration
Maine	Maine Department of Inland Fisheries and Wildlife Fisheries Research and Management Division 284 State Street 41 State House Station Augusta, ME 04333 (207) 287-5263	Report due at end of calendar year
Maryland	Maryland Department of Natural Resources Fisheries Service Tawes State Office Building 580 Taylor Avenue, B-2 Annapolis, MD 21401 (410) 260-8323	Report due by January 31

Table 1 State natural resources agencies responsible for issuing scientific collecting permits and reporting requirements (adapted from Walsh and Meador 1998)—Continued

State	State natural resources agency	Reporting requirements
Massachusetts	Massachusetts Division of Fisheries and Wildlife Executive Office of Environmental Affairs Permit Office 100 Cambridge Street Boston, MA 02202 (617) 727-9800 ext. 327	Report due at end of calendar year
Michigan	Michigan Department of Natural Resources Fisheries Division P.O. Box 30028 Lansing, MI 48909 (517) 373-1280	Report due at end of calendar year
Minnesota	Minnesota Department of Natural Resources Division of Fisheries 500 Lafayette Road St. Paul, MN 55155-4012 (612) 296-3325	Report due at end of calendar year
Mississippi	Mississippi Department of Wildlife, Fisheries, and Parks Division of Wildlife and Fisheries P.O. Box 451 Jackson, MS 39205 (601) 354-7303	Report due within 15 days of expiration
Missouri	Missouri Department of Conservation Wildlife Division P.O. Box 180 Jefferson City, MO 65102 (573) 751-4115 ext. 167	Report due within 1 year of expiration date
Montana	Montana Fish, Wildlife, and Parks 1420 East 6th Avenue P.O. Box 200701 Helena, MT 59620-0701 (406) 444-2449	Report due March 1
Nebraska	Nebraska Game and Parks Commission Wildlife Division 2200 N. 33rd Street P.O. Box 30370 Lincoln, NE 68503-0370 (402) 471-0641	Report due by February 1
Nevada	Nevada Dept. of Conservation and Natural Resources Division of Wildlife P.O. Box 10678 Reno, NV 89520 (702) 688-1549	Report due within 30 days of expiration

Table 1 State natural resources agencies responsible for issuing scientific collecting permits and reporting requirements (adapted from Walsh and Meador 1998)—Continued

State	State natural resources agency	Reporting requirements
New Hampshire	New Hampshire Fish and Game Department Fisheries Division 2 Hazen Drive Concord, NH 03301 (603) 271-1139	Report due by January 31
New Jersey	New Jersey Department of Environmental Protection Division of Fish, Game, and Wildlife CN 400 Trenton, NJ 08625-0400 (609) 292-8642	Report due within 30 days of expiration
New Mexico	New Mexico Department of Game and Fish Villagra Building P.O. Box 25112 Santa Fe, NM 87504 (505) 827-9904	Report due by January 31
New York	New York Department of Environmental Conservation Division of Fish and Wildlife Special Licenses Unit 50 Wolf Road Albany, NY 12233-4752 (518) 457-0689	Report due at expiration
North Carolina	North Carolina Wildlife Resources Commission Division of Boating and Inland Fisheries Archdale Building 512 N. Salisbury Street Raleigh, NC 27604-1188 (919) 733-3633	Report due quarterly
North Dakota	North Dakota Game and Fish Department Licensing Division 100 N. Bismarck Expressway Bismarck, ND 58501-5095 (701) 328-6300	Report due at expiration
Ohio	Ohio Department of Natural Resources Division of Wildlife Fountain Square 1840 Belcher Drive Columbus, OH 43224-1329 (614) 265-6666	Report due at expiration
Oklahoma	Oklahoma Department of Wildlife Conservation 1801 North Lincoln P. O. Box 53465 Oklahoma City, OK 73152 (405) 521-3721	Report due by January 31

Table 1 State natural resources agencies responsible for issuing scientific collecting permits and reporting requirements (adapted from Walsh and Meador 1998)—Continued

State	State natural resources agency	Reporting requirements
Oregon	Oregon Department of Fish and Wildlife Fish Division 2501 S.W. First Avenue P. O. Box 59 Portland, OR 97207 (503) 872-5252	Report due at expiration
Pennsylvania	Pennsylvania Fish and Boat Commission Nongame and Endangered Species Unit 450 Robinson Lane Bellefonte, PA 16823-9616 (814) 359-5113	Report due by January 31
Rhode Island	Department of Environmental Management Rhode Island Division of Fish and Wildlife 4808 Tower Hill Road Wakefield, RI 02879-3075 (401) 222-3075	Report due at expiration
South Carolina	South Carolina Department of Natural Resources Freshwater Fisheries P.O. Box 167 1000 Assembly Street Columbia, SC 29202 (803) 734-3943	Report due annually within 120 days of termination of sampling
South Dakota	South Dakota Department of Game, Fish, and Parks Scientific Collector's Permit 523 East Capitol Avenue Pierre, SD 57501-3182 (605) 773-4191	Report due by January 31
Tennessee	Tennessee Wildlife Resources Agency Ellington Agricultural Center P.O. Box 40747 Nashville, TN 37204 (615) 781-6575	Report due at expiration
Texas	Texas Parks and Wildlife Department Permits Section 4200 Smith School Road Austin, TX 78744 (512) 389-4491	Report due at expiration
Utah	Utah Department of Natural Resources Division of Wildlife Resources 1594 West North Temple, Suite 2110 P.O. Box 146301 (801) 538-4781	Report due within 30 days of expiration

Table 1 State natural resources agencies responsible for issuing scientific collecting permits and reporting requirements (adapted from Walsh and Meador 1998)—Continued

State	State natural resources agency	Reporting requirements
Vermont	Vermont Agency of Natural Resources Fish and Wildlife Department 103 S. Main Street, 10 South Waterbury, VT 05676 (802) 241-3708	Report due within 30 days of expiration
Virginia	Virginia Department of Game and Inland Fisheries Wildlife Information and Enhancement Division 4010 West Broad Street Richmond, VA 23230-1104 (804) 367-1185	Report due by January 31
Washington	Washington Department of Fish and Wildlife Enforcement Program 600 Capitol Way North Olympia, WA 98501-1091 (360) 902-2380	Report due by January 31
West Virginia	West Virginia Division of Natural Resources Wildlife Resources Section Scientific Collecting Permits P.O. Box 67 Elkins, WV 26241 (304) 637-0245	Report due within 30 days of expiration
Wisconsin	Wisconsin Department of Natural Resources Division of Fisheries South Central Regional Headquarters 3911 Fish Hatchery Road Fitchburg, WI 53711 (608) 275-3242	Report due by January 10
Wyoming	Wyoming Game and Fish Department Wildlife Division 5400 Bishop Boulevard Cheyenne, WY 82006 (307) 777-4559	Report due by December 31

Table 2 United States Fish and Wildlife Service Regional Offices responsible for consultations and issuing collection permits where threatened and endangered species may be encountered

Region	Office Address and Telephone Number	States
1	U.S. Fish and Wildlife Service Ecological Services Division 911 NE 11th Avenue Portland, OR 97232 (503) 231-6118	CA, HI, ID, NV, OR, WA, Pacific
2	U.S. Fish and Wildlife Service Ecological Services Division 500 Gold Avenue S.W. P.O. Box 1306 Albuquerque, NM 87103 (505) 766-2321	AZ, NM, OK, TX
3	U.S. Fish and Wildlife Service Ecological Services Division Federal Building 1 Federal Drive Fort Snelling, MN 55111-4056 (612) 713-5301	IA, IL, IN, MI, MN, MO, OH, WI
4	U.S. Fish and Wildlife Service Ecological Services Division 1875 Century Blvd. Atlanta, GA 30345 (404) 679-4000	AL, AR, FL, GA, KY, LA, MS, NC, PR, TN, SC
5	U.S. Fish and Wildlife Service Ecological Services Division 300 Westgate Center Drive Hadley, MA 01035-9589 (413) 253-8300	CN, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VA, VT, WV
6	U.S. Fish and Wildlife Service Ecological Services Division P.O. Box 25486 Denver Federal Center Denver, CO 80225 (303) 236-7920	CO, KS, MT, NE, ND, SD, UT, WY
7	U.S. Fish and Wildlife Service Ecological Services Division 1011 East Tudor Road Anchorage, AK 99503 (907) 786-3542	AK

Table 3 National Marine Fisheries Service Regional Offices responsible for consultations and issuing collection permits where anadromous threatened and endangered species may be encountered

Region	Office Address and Telephone Number	States
Northeast	National Marine Fisheries Service One Blackburn Drive Gloucester, MA 09130-2298 (508) 281-9250	CN, DE, DC, IL, IN, ME, MD, MA, MI, MN, NH, NJ, NY, OH, PA, RI, VT, WV, WI
Southeast	National Marine Fisheries Service 9721 Executive Center Drive, North St. Petersburg, FL 33702 (727) 570-5333	AL, AR, FL, GA, IA, KS, KY, LA, MS, MO, NE, NM, NC, OK, PR, SC, TN, TX, Virgin Islands
Southwest	National Marine Fisheries Service 501 W. Ocean Boulevard, Suite 4200 Long Beach, CA 90802-4213 (562) 980-4000	American Samoa, AZ, CA, Guam, HI, NV, Trust Territories of the Pacific Islands
Northwest	National Marine Fisheries Service 7600 Sand Point Way, N.E. BINC 15700 Building 1 Seattle, WA 98115-0070 (206) 526-6150	CO, ID, MT, ND, OR, SD, UT, WA, WY
Alaska	National Marine Fisheries Service Federal Building Annex, Suite 6 9109 Mendenhall Mall Road Juneau, AK 99802-7221 (907) 586-7221	AK

Fish assemblage sampling methods

General

The effectiveness of sampling stream fish varies according to many factors (e.g., size of stream, amount of cover, type of sampling gear, staff expertise). Nevertheless, a basic premise of the IBI is that the entire fish assemblage has been sampled in its true relative abundances without bias toward taxa or size of fish (Karr et al. 1986). Therefore, sampling methods must be standardized to ensure the quality of the data and to accurately reflect the fish assemblage present in a stream reach for a given time. According to Karr et al. (1986), several problems in sampling stream fishes particularly affect the accuracy of the data for IBI analyses. Each of the following sampling problems should be reviewed before data for IBI calculations are made and especially when the use of historical data is being considered (Karr et al. 1986).

First, the purpose for which the data were collected governs the nature of the data. Fish captured for taxonomic purposes, for example, are usually identified correctly, but may not be accurately counted; species common to a region may be ignored. Conversely, fish captured for purposes of fishery management will probably be counted, but small nongame species may be ignored or lumped into such categories as *forage fish* or *miscellaneous minnows.* For IBI purposes, an attempt should be made to collect fish species within a given reach or timeframe in a manner that represents their relative abundance.

Second, sampling gear, water conditions, and fish behavior affect the accuracy of the sample. Certain species are difficult to capture with standard electrofishing or seining gear. Finding darters, for example, requires the thorough disturbance of riffles, and catfishes are often best sampled at night. High flows or turbid water, on the other hand, affect collection of all species.

Third, the range of habitats sampled greatly affects data collection, and often the entire range of riffle, pool, and extra-channel habitats is not sampled, especially where large rivers are surveyed.

Fourth, atypical samples result when unrepresentative habitats are adjacent to the sampling site. Species richness near bridges or near the mouth of tributaries entering larger rivers, lakes, or reservoirs is, for example, more likely to be characteristic of larger-order habitats than the habitat under consideration (Fausch et al. 1984).

Lastly, the sample reach should be long enough to account for discontinuities in fish distribution. Recent studies have found that many traditional approaches to fish sampling provide reach distances that are too short to provide an adequate estimate of species richness (Lyons 1992b, Angermeier and Smogor 1994, Hughes et al. 1995, Paller 1995, and Patton et al. 2000). Hughes et al. and Paller (1995) found that increasing sampling distance is more effective in estimating species richness than increasing the sampling effort at the same site.

Sampling gear

Fish sampling requires a moderate amount of gear for field procedures as well as some supplies and equipment for the laboratory (Walsh and Meador 1998, Peck et al. 2000a). Most products, such as electrofishing equipment, seines, dip nets, waterproof paper, collection jars, and preservation chemicals, are commercially available from a variety of fishery suppliers. A supplier list can be accessed through the Web on the American Fisheries Society Homepage at www.main@fisheries.org. Look under **Resources/ Links** and then **Advertisers**.

Sampling large rivers and lakes

Fish sampling should account for the species present in a given stream reach in proportion to their relative abundance. The type of gear used is generally dependent on the size of stream. For larger streams and rivers, boats with mounted electrofishing equipment are generally used. For smaller streams, seines or portable electrofishing equipment are generally used. The drainage area of sites where boats are employed usually exceeds 75 square miles; however, local site conditions that may limit launching or maneuvering the boat may be a better gauge of where the technique can actually be applied (USEPA 1988, Peck et al. 2000b). In fact, a great deal of overlap occurs in the size of the drainage area where either boats or wading can be used. Generally, for the small watersheds that are so often the subject of NRCS investigations, wading is the more applicable technique.

Electrofishing wadeable streams

All types of fish sampling gear are generally considered selective to some degree; however, electrofishing has become the preferred method for collecting stream fishes. Pulsed DC (direct current) is generally considered the method of choice to obtain a representative sample of the fish assemblage (Barbour et al. 1999). Various electrical units have been used to sample wadeable streams. Practically all employ the use of generators and electrofishers that may be used in various combinations with light plastic tow-barges, or carried in a single backpack unit (Peck et al. 2000a, Yoder and Smith 1999). Net-poles or electrode devices (probes) are attached to the electrofisher unit and used to probe habitat where the fish are stunned and then collected. Procedures for sampling require a two- or three-person crew, all insulated from the water and electrodes by wearing chest waders (or hip boots for shallow streams) and rubber gloves. One person operates the probe while another guides the shocker and a third nets the fish. With some backpack units the person carrying the electrofisher may also probe, thus reducing the need for a third person to tend the electrofisher. Some probes, such as net-poles, are devised with net attachments so that the person operating the probe can also collect fish. In other instances, electric seines have been rigged to produce an electrical field and capture fish. All crew members should be trained in electrofishing safety precautions and the operation procedures identified by the unit manufacturer.

With backpack electrofishers, the person operating the probe works it around brush piles, log jams, boulders, and other submerged structures, generally in an upstream fashion. An effective technique for capturing fish under such objects is to thrust the probe into or under the structure with the current on and then quickly withdraw it in one swift motion. This has the effect of drawing fish out of the structure, making their capture possible. In riffle and run areas, the probe is raked over the substrate from upstream to downstream. At the same time, the netter may block off the area immediately downstream of the probe. This minimizes escape and avoidance of the electrical field by riffle species (USEPA 1988). Block nets placed at the upstream and downstream ends of the sample reach may be used to enhance sampling efficiency and help define the reach.

With electric seines, the upstream and downstream ends of a pool or riffle section are typically blocked with nets, and the electric seine is then dragged slowly upstream between the nets. The poles of the seine are rigged with electrical brails that are operated by the person on each end. Brails can be used to probe in and around instream cover in a manner similar to that described for backpack shockers. One or two people walk behind the seine to retrieve fish with dip nets. In addition, fish are removed from the downstream block net (Angermeier and Smogor 1994).

Since electrofishing is the most commonly used technique to collect fish for IBI purposes, most state agencies with developed IBIs have established protocols to detail how the technique is employed. For consistency, those state agencies should be consulted before designing a fish sampling technique of your own. Although electrofishing is effective and commonly used, like all fish sampling techniques, it can be selective. For example, electrofishing may stun and capture fish attempting to hide in vegetation, brush piles or on the shallow bottom, whereas some fish may detect the advancing electrical field and swim ahead, escaping the current unless they are cornered. Some benthic fishes (e.g., catfish, certain species of suckers) may be seldom taken because they are stunned in deeper water where they are difficult to see and collect (Bennet 1971). In addition, large fish may be captured at a higher rate than small fish with most electrofishing devices (Cooper 1952 and Johnson 1965).

Although most fish revive within 30 seconds to 2 minutes after being shocked (Bennet 1971), some mortality is inevitably experienced with electrofishing. For example, occasionally individuals are paralyzed or killed by direct contact with an electrode, and some may succumb to the electrical field itself (Wiley and Tsai 1983). Water quality conditions, such as salinity and hardness, greatly affect electrical conductivity, and thus the intensity and scope of the electrical field. As a result, care should be taken to set electrofisher unit adjustments to enable fish capture without unnecessarily harming individuals. Also, note that electrofishing in any form has been banned from certain salmonid spawning streams in the Northwest. Check with your appropriate state natural resources agency to determine where those restrictions have been placed (table 1).

Seining wadeable streams

Seines are reportedly the best tools for sampling fish in small, relatively simple streams (Karr et al. 1986). However, as streams increase in size and structural complexity, the efficiency of seines is diminished. Seining is performed by capturing fish from stream habitats in a small minnow seine. A 6-foot (length) by 4-foot (depth), 1/8 inch square mesh seine is the size most often employed for IBI analyses. In small streams it is important to use a seine that is not too large because they can be awkward to use and easily entangled.

Generally, a three-person crew is necessary to conduct the sampling, with one person handling each of the seine poles and another recording data. All habitat types, such as pools, runs, riffles, backwater areas, and isolated pools, are sampled in proportion to their occurrence within a sample reach or specified timeframe. Seining can proceed in either an upstream or downstream fashion. Microhabitats, such as spaces beneath logs and boulders, undercut banks, and aquatic vegetation, are sampled by kicking or otherwise disturbing the cover and then quickly seining through. Short, repeated hauls generally are more productive than long, continuous hauls. Short hauls also reduce fish mortality as does sorting fish in the bag of the seine while it is still in the water. As with electrofishing, the most productive efforts are realized when fish are cornered or disturbed from protective cover.

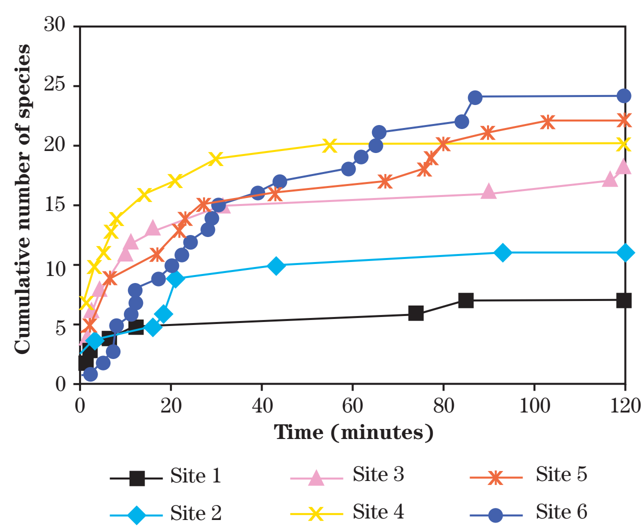
Seines are efficient in that they may collect smaller fishes from certain habitats (e.g., gravel riffles) that may be missed by electrofishing. Seines are also inexpensive, simple, easy to use, and seldom break down. However, as several studies have suggested, seining also has disadvantages that may, if not properly addressed, inappropriately influence the IBI. For example, in several studies seining was found to underestimate species richness in streams with slab boulders and cobbles, which interfered with efficient use of the seine (Hoover 1938, Wiley and Tsai 1983, Yoder and Smith 1999). In addition, in Ohio, seining was found to produce variable results caused by differing levels of skill between field crews (USEPA 1988). If the seining method is used, special care should be taken to maintain consistency across sample locations (e.g., primary investigator always present and rigid standardization of the sample effort).

Sample effort

Whereas several methods may be appropriately used to sample fish assemblages, sampling should always be conducted in a way that attempts to collect the species present, represents their relative abundance, and maintains sample consistency. Biologists have traditionally employed several techniques in this regard; for example, by using 100 meters of stream as a standard frame of reference. However, recent studies demonstrate that such techniques may not always provide a reach that is long enough to account for discontinuity in fish distributions (Lyons 1992b, Angermeier and Smogor 1994, Paller 1995, and Patton et al. 2000). Accordingly, care should be taken not to misrepresent species composition or relative abundance because sampling effort has been too little. In some instances 300 meters of stream or more is required to include all the habitat types that occur and account for discontinuity. Therefore, alternative techniques may be necessary to ensure that the sample length is adequate. For example, conducting pilot studies with oversampling may be needed to assess the effort needed to collect all species.

Angermeier and Smogor (1994) suggested that interactive approaches might be most effective for determining the appropriate sampling effort. For example, biologists could maintain a cumulative list of species found and stop sampling when a predetermined number of additional sampling efforts fail to yield additional species. Lyons (1992b) concludes that meaningful estimates of species richness for assessments of environmental quality or community-level ecological analyses can be achieved only if the length of each stream segment sampled approaches or exceeds the length at which the cumulative species number becomes asymptotic (fig. 2). Accordingly, for electrofishing, he recommends sampling 35 times the mean

Figure 2 Species/area curves for sites (1–6) that are progressively more speciose, demonstrating the asymptotic relationship (leveling of the curve) that should be considered for determining the level of sampling effort (Teels and Danielson 2001)



stream width to yield an acceptable estimate of species richness. However, he acknowledges that that distance might not be appropriate for all sampling gears. For example, that distance may be greater for seining, or it may be more useful to base the sample effort on the amount of time, rather than distance, that is required to produce an asymptotic curve. Regardless of the length of the reach sampled or the technique used, the location of the starting and ending points of the sample reach should be precisely recorded so that sampling can be repeated at that location in the future.

Seasonal considerations

Selecting the appropriate time of year for sampling is also critical. Although there is most likely no single best period to recommend, periods of low to moderate streamflow generally are preferred, and the variable flow conditions of early spring and autumn should be avoided. It is also best to maintain temporal consistency so data between sites can be accurately compared. For example, sampling can be limited to daylight hours at those times of the year when high streamflows are typically at a minimum.

Identification and enumeration

Because IBI derives its metrics from species assemblages, each individual specimen that is collected must be identified at least to the species level. The most controlled approach to ensure accurate taxonomic identification of fish specimens is to remove all fish specimens from the field and determine species' identification in a laboratory setting. However, it is not legal, ethical, or necessary to remove all fish specimens from the field (Walsh and Meador 1998). In most cases an experienced biologist can readily identify the adults and larger juveniles of most species in the field; thus, their numbers can be recorded and the fish then returned to the stream. If there is any uncertainty about the field identification of an individual fish, then it should be preserved in 10 percent formalin for later laboratory identification. Fish preserved in this manner should be labeled by date, time, and location.

Each individual specimen greater than 20 mm long should be counted. Most sampling procedures do not effectively sample individuals less than 20 mm in length. Such fish are also difficult to identify and may contain significant numbers of young-of-the-year that may inappropriately influence the IBI (Karr et al. 1986). Care should be taken not to collect or count the same individuals more than once. This can be done either by removing the fish temporarily to a bucket before additional sampling or by simply moving onto a different area of the stream. Each fish should also be examined for external anomalies. These are visible abnormalities that can observed with the naked eye during the field sorting process and include, for example, deformities, eroded fins, lesions, ulcers, tumors, or excessive external parasites. Numbers and types of anomalies should be recorded by species. In addition, the number of hybrid individuals should be recorded.

Proper handling maximizes the survival of live fish following their return to the stream. Care should be taken to count and record specimens quickly. If fish are held temporarily in buckets, then water temperature and dissolved oxygen in those buckets should be maintained as closely as possible to that in the stream. Examples of fish that may be difficult to hold live, even temporarily, are clupeids (shads and herrings) and atherinids (silversides) (Walsh and Meador 1998).

Although reference collections may at times be helpful in the identification of fish, personal reference collections are generally discouraged. Not only do they require space and considerable maintenance; they are generally unnecessary due to the availability of reference material housed elsewhere, such as ichthyological curation centers, local academic institutions, or museums (table 4). To help with species identification, many state or regional fish texts are available; most with keys, photos, line drawings, and species distribution maps (see appendix). If a fish cannot be identified through such means, then consult a fish identification expert in your area; typically an ichthyologist at a local academic institution or natural resources agency or at one of the centers listed in table 4.

Table 4 Ichthyological curation centers in the United States with significant freshwater holdings (Walsh and Meador 1998)

International

Academy of Natural Sciences of Philadelphia
Department of Ichthyology
19th and The Parkway
Philadelphia, PA 19103

American Museum of Natural History
Department of Ichthyology and Herpetology
79th Street and Central Park West
New York, NY 10024

California Academy of Sciences
Department of Ichthyology
Golden Gate Park
San Francisco, CA 94118

Field Museum of Natural History
Division of Fishes
Roosevelt Road at Lake Shore Drive
Chicago, IL 60605

Museum of Comparative Zoology
Harvard University
26 Oxford Street
Cambridge, MA 02138

National Museum of Natural History
Division of Fishes
Smithsonian Institution
Washington, DC 20560

Natural History Museum of Los Angeles County
Ichthyology Section
900 Exposition Boulevard
Los Angeles, CA 90007

University of Michigan Museum of Zoology
Division of Fishes
Ann Arbor, MI 48109-1079

National

Bernice P. Bishop Museum
Ichthyology Collection
P.O. Box 19000-A
1355 Kalihi Street
Honolulu, HI 96817-0916

Cornell University
Ichthyology Collection
Research Park, Building 3
Ithaca, NY 14850

National (continued)

Tulane University Museum of Natural History
Ichthyological Collection
Route 1, Box 46–B
Belle Chase, LA 70037

University of Florida
Florida Museum of Natural History
Gainesville, FL 32611

Regional

Gulf Coast Research Laboratory Museum
P.O. Box 7000
Ocean Spring, MS 39564-7000

Illinois Natural History Survey
607 E. Peabody Drive
Champaign, IL 61820

Northeast Louisiana University
Museum of Zoology
Monroe, LA 71209

Ohio State University
Museum of Zoology
1813 N. High Street
Columbus, OH 43210

Other important collections

University of Alabama
Ichthyological Collection
Museum of Natural History
Box 870344
University, AL 35487-0344

University of Washington
Fish Collection
FTR Building HF-15
Seattle, WA 98195

Auburn University
Museum Fish Collection
Department of Zoology and Wildlife Science
Auburn, AL 36849

James Ford Bell Museum of Natural History
University of Minnesota
Minneapolis, MN 55455

Table 4 Ichthyological curation centers in the United States with significant freshwater holdings (Walsh and Meador 1998)—Continued

Other important collections (continued)

Louisiana State University Museum of Zoology
Division of Fishes
Baton Rouge, LA 70803

Milwaukee Public Museum
Vertebrate Zoology
800 W. Wells Street
Milwaukee, WI 53233

New York State Museum
CEC 3140
Albany, NY 12230

North Carolina State Museum of Natural History
P.O. Box 27647
102 Salisbury Street
Raleigh, NC 27611

Oklahoma State University
Department of Zoology
Collection of Vertebrates
Stillwater, OK 74078

Pennsylvania State University
Fish Museum
School of Forestry
University Park, PA 16802

Other important collections (continued)

Southern Illinois University at Carbondale
Ichthyology Collection
Department of Zoology
Carbondale, IL 62901-6501

Texas Cooperative Wildlife Collection
Texas A&M University
College Station, TX 77843

University of Georgia Museum of Natural History
Ichthyological Collection
Athens, GA 30602

University of Tennessee
Fish Collection
Department of Zoology
Knoxville, TN 37996-0810

University of Washington
Fish Collection
FTR Building HF–15
Seattle, WA 98195

Yale University Peabody Museum
170 Whitney Avenue
New Haven, CT 06520

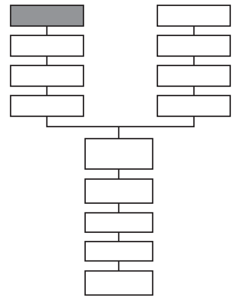
IBI development

General

Although the IBI is widely used, it is not a standard method. Essentially, an IBI must be built for each regional faunal assemblage based on an evaluation of metric responses to a human disturbance gradient. Collecting and interpreting IBI information is an hierarchical process (Karr et al. 1986) (fig. 1). It begins with defining the fish assemblage to be studied and building an appropriate study design and reference. In instances where an applicable IBI has been developed and undergone the necessary revisions, there is no need to build a separate IBI for your area. Alternatively, if one does not exist, it is possible to develop your own. However, appropriate use of an IBI requires experience and training in study design, fish assemblage sampling, species identification, ichthyogeography, reference condition determination, data analysis, and stream ecology. IBI development is discouraged without such skills and knowledge.

The process of developing an IBI begins by selecting an appropriate study design that is influenced by the scale at which the IBI is expected to function. Watersheds that are typically the focus of NRCS assistance are comparatively small (e.g., less than 250,000 acres). The boundaries of a focus watershed and the area for which an IBI is developed do not necessarily need to be the same. Ideally, the area for which an IBI is developed should be larger, such that most focus watersheds can be nested within. Although the size of the area for which an IBI is developed may vary, that area should be large enough to represent the various degrees of prevailing regional disturbances, yet small enough to account for differences in natural variables, such as landscape (or eco-region) and composition of the fish fauna. The area chosen to represent the IBI may be termed the reference area, which forms the boundary within which all sampling for that IBI will take place. It is important to note, that although most smaller watersheds can fit within a larger IBI framework, a number of metrics may be scale dependent or may not function at all at a smaller scale. Recognizing the influence of scale in the study design leads to the establishment of more accurate reference conditions, increased metric sensitivity, and a more meaningful and robust IBI. The following subsections provide guidance for the design and construction of an IBI following the general sequence of activities outlined in figure 1.

Classification of watershed streams



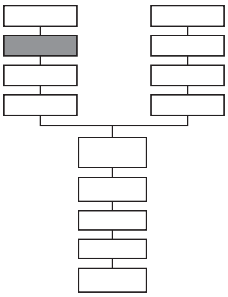
Because the IBI measures human impact, it is important to first sort out the natural from the human influences that affect the fish assemblage. Such sorting may require classification of sites. For example, because of natural differences in their biotic makeup, high-gradient streams should not be compared with low-gradient streams, even though they may be in close proximity. However, such classification need not be too rigorous; rather just enough, based on professional judgment, to ensure that "apples are being compared to apples and oranges to oranges." The challenge is to create a system with only as many classes as are needed to represent the range of relevant biological variation in a region and the level appropriate for detecting and defining the biological effects of human activity in that place (Karr and Chu 1997).

Because stream size affects biological assemblages in several ways, it may also be important to group sites by size. This process does not need to be too rigorous. Most studies do not separate streams into more than three size classes. As an alternative, size-related faunal differences can be accounted for in metric scoring using a trisection technique (Lyons 1992) (fig. 6). However, grouping streams according to size may also be useful for other purposes; e.g., to ensure that a relatively even distribution of different sized streams is included within the study. Sometimes it helps to review previously collected data or conduct some pre-project sampling to help determine the meaningful size classes to represent.

Another alternative is to categorize sites by stream order according to the system developed by Horton (1945) and modified by Strahler (1957). According to this system, the smallest streams in a watershed are first order. When two streams of the first order join, they form a stream of the second order; when two second-order streams join, they form a third-order stream, and so on. Although this classification is generally useful, the effects of stream order can vary among watersheds. Differences in climate, geology, and watershed geomorphology, for example, affect the nature of the stream-order pattern (Hughes and Omernik 1981, 1983), and thus the area of the watershed may be a more useful means of classification.

The use watershed area also facilitates smooth or continuous metric calibration instead of stepped calibrations that increase metric variability and noise.

Targeted selection of sample sites



Once classification has been accomplished, sample sites should be selected within the area for which the IBI is to be developed (reference area). These sites form the reference upon which the IBI is based. Since human influences arise from varied and complex sources, it may be virtually impossible to develop an IBI through a random process of site selection. Rather, a targeted approach is recommended to ensure that sites represent a full range of human disturbance and that relatively secure and accessible sites are selected. Within each stream class, at least three least-impaired and three most-impaired sites should be established to "pin down" the ends of the disturbance gradient. As much information as possible should be gathered to support the selection of those sites. Historical fish distribution, beaver abundance, vegetation, hydrology, and channel morphology data are valuable at this stage because it is extremely important to document the degree to which the watersheds have already been altered. Soil surveys, highway maps, local zoning maps, aerial photography, and other such information should be consulted to identify impairment sources. A field reconnaissance of the reference area should also be made. This is an extremely important part of the IBI development process. Without early attention to establishing the ends of the gradient, sampling may overlook the very sites that contain the most valuable information.

Least-impaired sites should be incorporated into the reference to represent the high end of the disturbance gradient. As the name implies, least-impaired sites are the stream sample reaches selected within the reference area because they are least impacted by human influences. In reality, there are no absolutely pristine habitats, and in certain instances, least-impaired sites may be hard to find. For example, in a small urban watershed or political area (e.g., a county) there simply may not be streams that are not at least moderately influenced by man. In such cases it would be advisable to look over a broader area so that least-impaired reference sites can be found, thus expanding the area of reference. Again, it is important that the size of the reference area not be too small to represent the full range of human disturbance. Although no standard protocol for selecting least-impaired reference sites is available, the following factors may be considered:

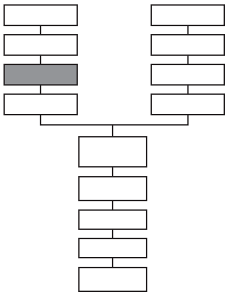
- no upstream or downstream impoundments,
- no known discharges,
- no known spills or other pollution incidents,
- low human population density,
- low agricultural activity,
- low road and highway density,
- minimal nonpoint source pollution, and
- no known intensive fish stocking (Gibson 1996).

Some pilot sampling of the fish assemblage may also be used to support the identification of least-impaired sites.

Equally important to the process of establishing the reference is the targeted selection of most-impaired sites. These sites represent the low end of the gradient and can be selected based on the same factors used to identify least impaired-sites, only with reverse logic. Strong candidates are sites with large amounts of urban drainage or intensive agriculture. Often not enough attention is given to including these highly impacted areas within the reference. However, they are extremely important because they provide tangible demonstration of what a stream should not look like and offer a tool to test negative metrics (those that respond positively to degradation).

After sites have been located to represent either end of the gradient, other sites should be selected to represent intermediate degrees of impairment. Sites with intermediate impairments are useful for evaluating metric sensitivity to subtle increases in stressors. This process can be performed either by random selection, or more comprehensively, by selecting sites within each of the reference area's primary stream systems. To draw relevant statistical comparisons, at least 12 sites should be included within each stream size class.

Collection of land use and habitat information



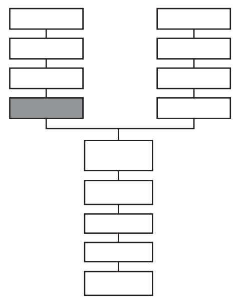
Before starting the field sampling, gather information about the study sites through published sources and field reconnaissance. The overall goal of this stage is to learn as much as possible about the sites so that you have as complete an understanding of them as possible. The information gathered during this stage can (1) help verify that streams are classified correctly, (2) provide information for constructing human disturbance gradients, and (3) provide insights into why biological communities are damaged during the IBI interpretation phase. A wealth of information can be collected about sites without even leaving your office. Some sources of information are

- USGS quadrangle topographic maps can provide baseline information on slope, elevation, land use and the hydrological network of watersheds and proximity of dams or other barriers to fish movement.
- NRCS soil surveys are an invaluable source of information on watershed soils, geologic and landscape features.
- USDA aerial photos, if available, are useful to gather information on watershed land use. They can also be used to reconstruct historical changes in land use by analyzing a series of photos taken over past years.
- Historical fish distribution data from state fish books and museum records are also valuable.

The collection of habitat and land use information may also be greatly aided by a Geographic Information System (GIS). GIS can be used to delineate boundaries of drainages above fish sample points. Those data can then be overlaid with other spatial data, such as land use information, to help assess the broad impacts of human influence. For example, several recent GIS studies have found significant negative correlations between watershed-wide agricultural or urban land uses and stream health, as represented by the IBI (Lenat and Crawford 1994, Richards et al. 1996, Roth et al. 1996, and Wang et al. 1997). Although GIS can be a powerful tool for helping define a disturbance gradient, it is not a replacement, or even a good surrogate, for the IBI itself or for biological monitoring (Karr and Chu 1997). In addition to the broad spatial relationships examined by GIS, onsite visits are generally required to define more local impacts.

Several onsite techniques have been developed to assess the habitat of streams. Examples include U.S. EPA, Rapid Bioassessment Procedures (RBP) and EMAP; Ohio EPA, Qualitative Habitat Evaluation Index (QHEI); and NRCS, Stream Visual Assessment Protocol (SVAP). Although any of those techniques can be used to help define a disturbance gradient, users should sort out those components of the assessment that are not related to human influence (e.g., stream gradient) from the ones that are (e.g., riparian quality).

Establishment of human disturbance gradient



Once sites have been targeted for selection into the reference, they should be ranked according to degrees of human disturbance. This is important to ensure that metrics are sensitive. Human disturbance serves as the gradient along the X-axis to which biological attribute data along the Y-axis are compared. Determining the disturbance gradient must be done before sampling begins, rather than as an afterthought, because post-hoc categorization may reveal that the full range of human disturbance was not captured, thus requiring additional sampling or limiting the usefulness of the IBI.

In most circumstances, diverse human activities interact to affect conditions in watersheds, waterbodies, or stream reaches (Karr and Chu 1997). In fact, in most instances it is virtually impossible to find regions influenced by only a single human activity, thus making the disturbance gradient difficult to construct. Where there is adequate information, the development and use of a Human Disturbance Index may greatly help to define the disturbance gradient. Such an index should incorporate values representing various degrees and combinations of prevailing human disturbances for all sites, not just the least- and most-disturbed. Although there is no standard protocol for constructing such an index, it should be derived from a variety of disturbances, rather than from a single source. Furthermore, the disturbances should be represented from both watershed and local scales. For example, scores from the landscape (e.g., percent cropland, pastureland, and urban land) should be combined with scores from onsite assessments. In addition, the adverse effects of isolating mechanisms, such as dams, drop structures, culverts, or other fish barriers have been widely documented (Avery 1978, Etnier and Starnes 1993, Minckley and Deacon 1991, Winston et al. 1991) and may be considered as features of the index (fig. 3).

Figure 3 Criteria and scoring for ranking sites according to a human disturbance index (HDI) (Teels and Danielson 2001)

Urban/Cropland (condition applies that would result in lowest score)

<5% of drainage urban; or <11% cropland	5-10% of drainage urban; or 11-20% cropland	11-15% of drainage urban; or 21-29% cropland	16-20% of drainage urban; or 31-38% cropland	>20% of drainage urban; or >38% cropland
10	8	6	4	2

Urban/Pastureland (condition applies that would result in lowest score)

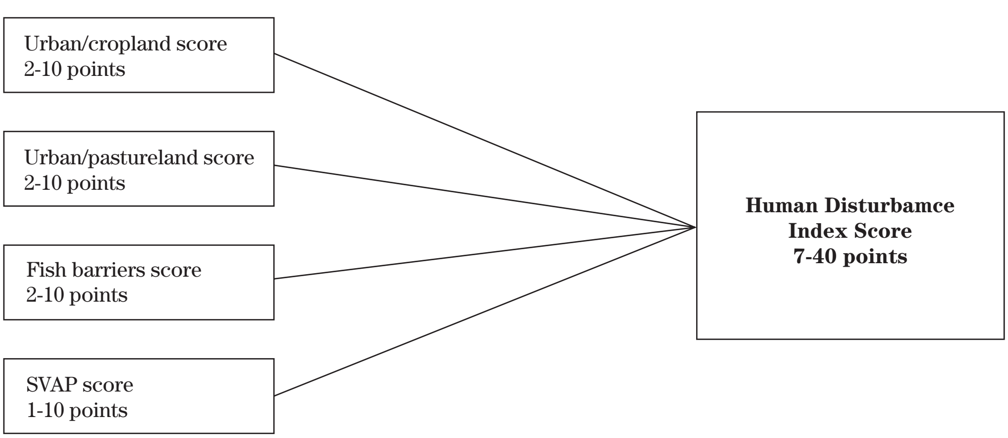
<5% of drainage urban; or <13% pasture	5-10% of drainage urban; or 13-22% pasture	11-15% of drainage urban; or 23-32% pasture	16-20% of drainage urban; or 33-42% pasture	>20% of drainage urban; or >42% pasture
10	8	6	4	2

Fish Barriers

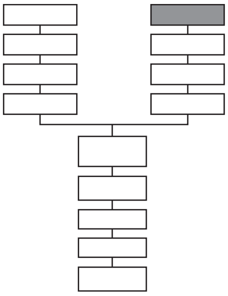
No barriers	Season water withdrawals inhibit fish movement	Drop structures, culverts, dams, or diversions(<0.3m drop) within the reach	Drop structures, culverts, dams, or diversions (>0.3m drop) within 5 km of the reach	Drop structured, culverts, or diversions (>0.3m drop) within or bordering the reach
10	8	6	4	2

Reach Impairment (SVAP) Score

>9.6	9.0-9.6	8.3-8.9	7.6-8.2	6.9-7.5	6.2-6.8	5.5-6.1	4.8-5.4	4.1-4.7	<4.0
10	9	8	7	6	5	4	3	2	1

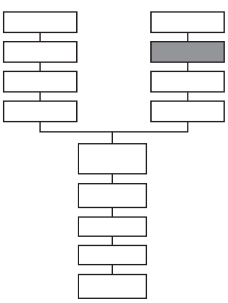


Identification of watershed fish fauna



The area for which the IBI is developed must be composed of a similar fauna, or at least one that was similar historically. In certain instances, significant differences occur in species assemblages across major drainage boundaries, for example between the Gulf and Atlantic drainages of a single state. If such conditions occur, then a separate IBI may need to be developed for each drainage. However, there are advantages and disadvantages of having a separate IBI for each drainage or region. Depending upon study objectives, a single IBI can generally be used across a relatively large area with some modifications in metric scoring and calibration. In any case, before fish are sampled and their numbers recorded, the species that will likely be encountered in your focus watershed should be listed and assigned guild designations for purposes of the IBI.

Assignment of guilds and attributes



The IBI requires the classification of species from the regional fish fauna into "guilds" or biological groupings from which potential metrics (attributes) are proposed and tested (table 5). To aid this process, recent works (e.g., Smogor 1996, Whittier and Hughes 1998, Zaroban et al. 1999, Barbour et al. 1999, Simon 1999) have developed such groupings that may apply to your area. However, species classifications may differ among regions. For example, an intolerant Midwestern species may not be intolerant in Western mountains. Therefore, caution should be exercised in extending those classifications beyond their intended scope.

After defining the watershed fish fauna and classifying species into the appropriate biological groupings, attributes should then be developed. Attributes, in the context of biological assessments, are defined as measurable components of a biological system (Karr and Chu 1997). They include characteristics of an individual or assemblage of species that may or may not provide useful information regarding response to a disturbance. After defining the list of taxa, make a list of attributes that you think will change in value along a gradient of human influence from least to most disturbed streams. Also, predict whether each attribute will increase in value or decrease in value as impairment increases or decreases.

Again, scale is important to consider in this part of the process because some attributes may need to be altered. Each attribute should be composed of species that you would expect to be sensitive to human disturbances in your focus watershed. For example, the use of an intolerant group of species as an attribute may function well at a state level; however, that same group of species may be extremely rare or totally absent from your focus watershed. However, this does not mean that the *number of intolerant species* should be excluded as a potential metric. It merely means that the species composition of the attribute should be modified to include those species that fit the concept of intolerant within your area of concern.

Each attribute considered for an IBI should be based on sound ecological theory. Although theory can be a good guide for selecting metrics, the theory must be tested with real-world data before a metric is used. Ecology's path as a scientific discipline is littered with the carcasses of "good" theoretical constructs that evidence later showed were flawed (Karr and Chu 1997). Even if the underlying theory is sound, many variables control an attribute's response to human disturbance, which in turn affects its utility. For example, an attribute that works in one stream may not in another because of differences in the prevailing human influence. For example, the anomalies metric (percent of individuals with lesions, tumors, eroded fins) may function only in extremely degraded conditions; providing valuable information to a region if at least some of the streams are severely degraded, but little information if all streams are only moderately degraded to unimpaired. Sometimes there may even be inherent differences in how an attribute relates biologically to human disturbances. For example, the number of native species typically declines with added human disturbance except, however, in some coldwater streams where the effect may actually be reversed because increased nutrients and temperatures may result in increased species numbers (Lyons et al. 1996, Mundahl and Simon 1999). Thus, attributes and their underlying assumptions need to be tested not only to validate that there is an empirical dose-response relationship, but also to be able to understand and predict the nature of that relationship. The

Table 5 Biological groupings for the Occoquan River (VA) Watershed fish species (Teels and Danielson 2001)

Scientific name	Tol[1]	No. food groups	Trophic[2]	Ben[3]	Lith[4]	Pio[5]	Late maturing
Esocidae							
Esox americanus Gmelin	I	1	PIS				
Umbridae							
Umbra pygmaea (DeKay)		1	INV				
Cyprinidae							
Notemigonus chrysoleucas (Mitchill)		2	AHI			x	
Clinostomus funduloides Girard		1	INV		x		
Semotilus corporalis (Mitchill)		4	IP				
Semotilus atromaculatus (Mitchill)	T	4	IP				
Nocomis micropogon (Cope)		3	INV	x			x
Exoglossum maxillingua (Lesueur)		1	INV				
Rhinichthys atratulus (Hermann)		3	INV		x		
Rhinichthys cataractae (Valenciennes)	I	2	INV	x	x		
Hybognathus regius Girard		2	DAH				
Luxilus cornutus (Mitchill)		4	INV		x		
Cyprinella analostana Girard		2	INV				
Pimephales notatus (Rafinesque)		3	AHI			x	
Pimephales promelas Rafinesque		3	AHI			x	
Notropis amoenus (Abbott)		1	INV		x		
Notropis hudsonius (Clinton)		2	INV				
Notropis procne (Cope)		2	INV		x		
Notropis rubellus (Agassiz)		1	INV		x		
Catostomidae							
Catostomus commersoni (Lacepede)	T	3	AHI	x	x		x
Erimyzon oblongus (Mitchill)		3	INV	x		x	
Hypentelium nigricans (Lesueur)		2	INV	x	x		x
Moxostoma erythrurum (Rafinesque)		3	INV	x	x		x
Fundulidae							
Fundulus diaphanus (Lesueur)		1	INV				
Poeciliidae							
Gambusia holbrooki Girard		1	INV			x	
Ictaluridae							
Ameiurus natalis (Lesueur)		3	IP			x	
Ameiurus nebulosus (Lesueur)		3	IP				x
Noturus insignis (Richardson)	I	2	INV				x
Centrarchidae							
Lepomis auritus (Linnaeus)		2	IP				
Lepomis cyanellus Rafinesque	T	2	IP				
Lepomis gibbosus (Linnaeus)		1	INV			x	
Lepomis macrochirus Rafinesque	T	1	INV				
Lepomis microlophus (Gunther)		1	INV			x	
Pomoxis annularis Rafinesque		2	IP			x	
Micropterus dolomieu (Lacepede)		2	PIS				
Micropterus salmoides (Lacepede)		1	PIS				
Percidae							
Percina peltata (Stauffer)	I	1	INV	x	x		
Etheostoma olmstedi Storer		1	INV	x			
Etheostoma flabellare Rafinesque		1	INV	x			

1 Tolerance: T = tolerant, I = intolerant
2 Trophic groups: PIS = piscivore, INV = invertivore, AHI = algivore/herbivore/invertivore, IP = invertivore/ piscivore, DAH = detritivore/algivore/herbivore
3 Ben = benthic
4 Lith = simple lithophil
5 Pio = pioneer

primary underlying assumptions that have been used in most IBIs follow. These assumed effects of environmental degradation on biological assemblages are modified from Hughes and Oberdorff (1999).

- Number of native species, and those in specialized taxa or guilds, declines. (In some instances, particularly in oligotrophic environments, reverse relationships may be observed.)
- Number of sensitive species declines.
- Percent of trophic and habitat specialists declines.
- Total number of individuals declines. (In some instances, particularly in oligotrophic environments, reverse relationships may be observed.)
- Percent of large individuals and the number of size classes decrease.
- Percent of alien or non-native species or individuals increases.
- Percent of tolerant individuals increases.
- Percent of trophic and habitat generalists increases.
- Percent individuals with anomalies increases.

For most watersheds, 20 or 30 attributes can be proposed that you believe would be most sensitive to human disturbance in your region. This should be influenced by the metric composition of IBIs in neighboring regions or the IBI area in which your watershed is nested. Some studies suggest that attributes can be conveniently grouped into the following categories:

- Species richness and composition
- Tolerance and intolerance
- Trophic structure
- Reproduction, abundance, and condition

A balance of attributes from each category should be proposed and tested for your area. The biological basis for attribute/metric development is aptly described in Karr et al. (1986) and summarized in the following subsection. Examples of attributes that have been successfully used in various regions of North America are provided in table 6.

Species richness and composition

Attributes from this category are generally the most common feature of most IBIs. In most cases they display a declining response to added human disturbance (Karr 1981). Usually, a population must be viable at a site for some time before a species' presence can be consistently detected (Karr and Chu 1997). The absence of a species at a site (especially species with low dispersal abilities) may suggest that viable populations are not being maintained. Over time, species assemblages have evolved that are capable of withstanding or rapidly recovering from most natural perturbations. However, changes in the chemical, physical, and biological environment caused by humans often cannot be tolerated and thus one or more species declines in abundance or becomes extirpated (Karr et al. 1986). Attributes within this category generally include total species richness and species richness for taxa that are particularly sensitive to specific kinds of degradation (e.g., sensitivity of darters to benthic impairments). Attributes have often been refined by restricting the groupings to native species.

Tolerance and intolerance

Tolerance, as it relates to IBI development, implies a general tolerance of a species to a number of human influences, rather than tolerance to a specific variable. A number of species are very intolerant (i.e., are very sensitive) to a variety of perturbations, whereas others are adept at exploiting particular types of disturbances. Intolerant species are among the first to be decimated after perturbation and the last to recolonize after normal conditions have returned (Karr et al. 1986). Trends (increases or decreases) in distribution or abundances from historical data can be examined to help assign taxa to these attributes. Endangered or threatened species should not automatically be considered intolerants because their low numbers may be due to factors other than human disturbance. They might be, for example, glacial relics (Karr et al. 1986).

The mere presence of intolerant species is a strong indicator of good biological condition. The relative abundance of these species, in contrast, is difficult to estimate accurately without extensive and costly

Sources for Metric Alternatives (Barbour et al. 1999)

Karr et al. (1986)	Simon (1991)
Leonard and Orth (1986)	Lyons (1992a)
Moyle et al. (1986)	Barbour et al. (1995)
Fausch and Schrader (1987)	Simon and Lyons (1995)
Hughes and Gammon (1987)	Hall et al. (1996)
USEPA, Ohio (1988)	Lyons et al. (1996)
Miller et al. (1988)	Roth et al. (1997)
Steedman (1988)	Simon (1999)

Table 6 Original Karr (1981) IBI metrics (bold) and alternative metrics from various regions of North America (adapted from Barbour et al. 1999)

Alternative IBI metrics	Midwest	New England	Ontario	Ohio	Colorado	Oregon	California	\Wisconsin	Maryland
1. Total number of species	x	x			x		x		x
# native fish species	x			x		x		x	
# salmonid age classes			x			x	x		
2. Number of darter species	x			x	x				
# sculpin species						x			
# benthic inveretivore species		x							x
# darter and sculpin species	x	x							
# salmonid yearlings							x		
3. Number of sunfish species	x			x	x			x	
# cyprinid species	x				x				
# water column species		x							
# sunfish and trout species			x						
# salmonid species							x		
# headwater species	x						x		
4. Number of sucker species	x	x		x		x		x	
# adult trout species	x					x	x		
% round-bodied suckers	x					x	x		
# sucker and catfish species			x						
5. Number of intolerant species	x	x		x	x		x	x	
# sensitve species	x								
presence of brook trout			x				x		
6. Percent green sunfish	x					x			
% tolerant species	x			x		x		x	x
% common carp									
% white sucker		x			x				
% creek chub									
% pioneering species	x								
% dominant species									
7. Percent omnivores	x	x	x	x	x			x	
% yearling salmonids					x				
% generalists/herbivore/invertivores									x
8. Percent insectivorous cyprinids	x								x
% benthic invertivores									
% speicialist insectivores					x				
% insectivores	x	x		x		x	x	x	
# juvenile trout									
9. Percent top carnivores	x	x	x	x				x	
% specialist carnivores									
% catchable salmonids						x			
% catchable trout							x		
10. Number of individuals	x		x	x	x	x	x	x	x
density of individuals		x							
11. Percent hybrids	x	x		x					
% introduced species					x	x			
% simple lithophils	x							x	x
% native species							x		
12. Percent anomalies	x	x	x	x	x	x		x	x

sampling efforts (Karr and Chu 1997). Therefore, intolerant species generally should be represented simply as the number of intolerant species per unit sample effort. In contrast to intolerant species, the presence alone of tolerant taxa says little about biological condition since tolerant groups inhabit a wide range of places and conditions. Therefore, tolerance attributes are generally expressed as percent of tolerant individuals from either a single species or a grouping of highly tolerant species. If a high number of tolerant or intolerant species are included in the composition of attributes, then the usefullness of those attributes may be diminished. In general, it is recommended that only about 10 percent (no fewer than 5% or no more than 15%) of species in a region should be classed as intolerant or tolerant. The point of these metrics is to highlight the strong signal coming from the lowest and highest ends of the biotic integrity continuum without being swamped by the weak or intermediate signals from in-between (Karr and Chu 1997).

Trophic composition

Because the food base is central to the maintenance of a community, information about trophic composition is important to an IBI (Karr et al. 1986). All organisms require a reliable source of energy. Stream fishes are affected dramatically by changes or reductions in those energy sources. The dominance of trophic generalists occurs as specific components of the food base become less reliable and the opportunistic foraging habits of the generalists make them more successful than trophic specialists (Karr et al. 1986). In some instances little sensitivity may be displayed by certain trophic metrics because most species are composed of only one feeding group (e.g., in high gradient coldwater streams most species are invertivores). However, sometimes entire groups of organisms, such as top carnivores, have been extirpated from aquatic ecosystems using persistent pesticides and the process of biological magnification. Thus, the trophic structure of a community can provide information on patterns of consuming and producing organisms that are affected by impairment. To improve attribute performance, tolerant species may be subtracted from attributes of this and the next category.

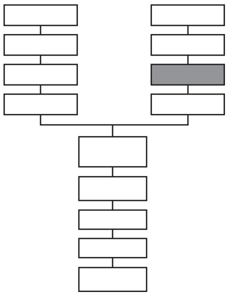
Reproduction, abundance, and condition

The attributes in this category assess characteristics of populations, such as reproduction, growth, and condition of individual organisms belonging to populations. Ecosystems can maintain themselves only if populations of organisms are able to compensate for loss of members through reproduction. Human influences that negatively affect reproduction are ordinarily indicated by an accompanying reduction in the proportion of reproductive specialists (percent nest spawners, percent simple lithophils). In addition, conditions must also be favorable for the young of a population to survive, disperse, and to grow to sexual maturity. Therefore, attributes that characterize population structure (number of late-maturing species, abundance or size of key species) can also be effective indicators of human disturbance.

Individual abundance is a common surrogate for system productivity, and some types of highly disturbed sites are expected to support fewer individuals than high-quality sites (Karr 1981). However, Karr and Chu (1997) suggest that abundance may be a poor candidate for a multimetric index because it varies too much even when human influence is minimal, and is also difficult to measure and score. Recognizing the tendency for moderate levels of nutrient and thermal enrichment to elevate fish abundance, Oberdorff and Hughes (1992) scored this metric so that very high abundances received lower metric scores than moderate numbers; only very low abundances received the lowest score. This scoring adaptation is an example of the need to evaluate metric performance across disturbance gradients before applying the IBI in resource assessments (Hughes and Oberdorff 1999).

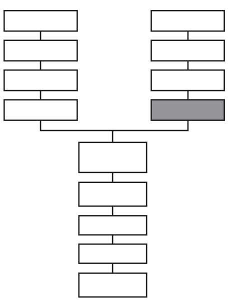
Sites with especially severe degradation often yield a high number of individuals in poor health (Mills et al. 1966; Brown et al. 1973; Sanders et al. 1999). Parasitism has been shown to reflect poor environmental condition and reduction in reproductive capacity (sterility) in fish (Mahon 1976). Indications of poor health include individuals with tumors, limb damage or other deformities, heavy infestations of parasites, discoloration, excessive mucus, and hemorrhaging. Leonard and Orth (1986) found increases in the incidence of disease and anomalies only after substantial degradation was evident, indicating that this metric may be sensitive only at the most severely impacted sites. In certain instances the metric has been dropped (e.g., in the absence of severely impaired sites); however, it should be considered wherever the possibility exists for changes in the incidence of disease or deformed organisms (Hughes and Oberdorff 1999).

Sampling of fish assemblage



A basic premise of IBI is that the entire fish fauna has been sampled in its true relative abundance without bias toward taxa or size of fish (Karr et al. 1986). As this assumption is relaxed, the reliability of inferences based on the IBI is reduced. However, with any single sampling technique there are certain inherent biases that affect the quality of the sample. Therefore, it is important to understand method limitations and adhere as strictly as possible to sampling protocols to maintain consistency of data and reduce sampling variability. Protocols for sampling are described in the Fish assemblage sampling methods section of this technical note.

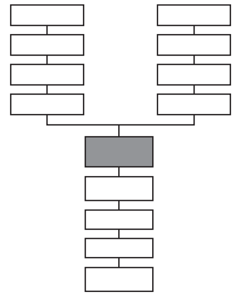
Summarization of fish data by attributes



Sampling will generate numbers for fish species collected at a given site that are typically recorded on field data sheets. The species counts from field data sheets should be entered into a computer spreadsheet for summary and simple analysis (e.g., Lotus 1-2-3, Microsoft Excel). Regardless of the type of computer software being used, the data must be summarized based on the list of attributes. For example, if 10 species compose the benthic invertivore attribute, then the total number of individuals of those species should be summed and then divided by the total number of species collected at that site. In this example, the attribute is expressed as percent benthic invertivores.

The process for evaluating metric performance involves the testing of a larger set of biological attributes (candidate metrics) and boiling them down to the 12 or so metrics that work best and will ultimately compose the IBI. This process generally can be performed with spreadsheet functions or more sophisticated database or statistical software (e.g., SAS).

Evaluation of attribute performance across gradient of human disturbance

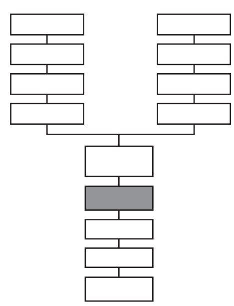


The need to test and validate biological responses of attributes across degrees of human influence is a core assumption of IBI (Karr and Chu 1999). From such testing sensitive metrics are developed and refined. Metrics are attributes empirically shown to change in value along a gradient of human influence. The biological metrics incorporated into a multimetric index are selected because they

- reflect specific and predictable responses of organisms to changes in landscape condition,
- are minimally affected by natural variability,
- are sensitive to a range of factors that stress biological systems, and
- are relatively easy to measure and interpret (Karr and Chu 1997).

Ideally, metrics should be sensitive to a range of biological stresses and not narrowly focused on one particular aspect of the community or another (e.g., species richness). Most importantly, metrics must be able to discriminate human influences from the background "noise" of natural variability (Karr and Chu 1997).

Selection of metrics from best performing attributes



At least 5 (but preferably 8 to 12) metrics should be defined and selected to construct the IBI. Each chosen metric should reflect the quality of a different aspect of biota that responds in a different manner to disturbances in streams (Fausch et al. 1990; Hughes and Noss 1992) (table 7). Therefore, whenever possible some care should be taken to select metrics from the different categories (species composition and richness, tolerance and intolerance, trophic structure, reproduction, and individual condition). Generally, the wider the range of ecological conditions represented by the chosen metrics the better.

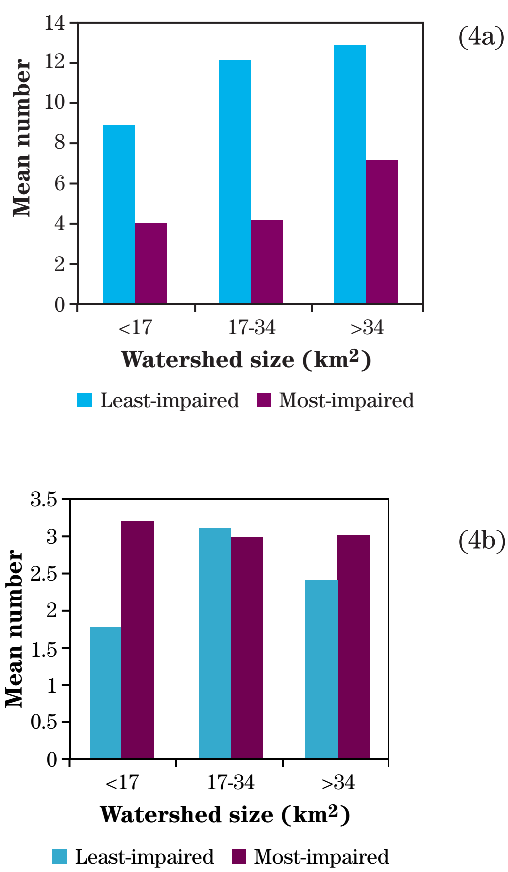
The performance of each attribute should be evaluated by assessing how well it

- increases or decreases along a gradient of human influence,
- separates the least from the most impaired sites,
- provides similar values for similarly impaired sites, and
- provides a unique (nonredundant) discriminatory response (Karr and Chu 1997).

Several graphical and statistical approaches may be used to evaluate attribute performance. Each may be used individually or in concert with another to screen out attributes that do not perform acceptably while retaining those that do. One frequently used approach is to construct bar graphs to compare the mean or median attribute values between least- and most-disturbed sites (fig. 4a and b). The degree of separation can then form the basis for retaining or discarding the attribute for subsequent analyses. The statistical significance of the separation can be determined using standard statistical tests (e.g., t-test).

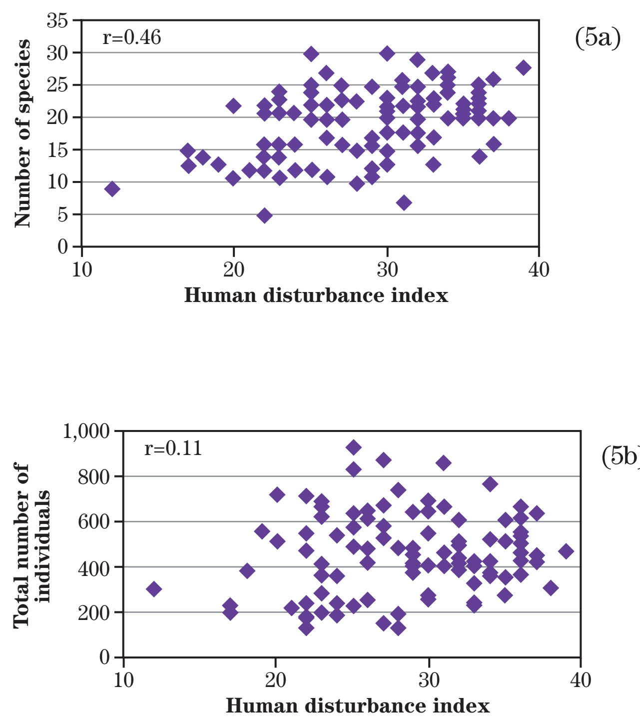
Another frequently used test is to compare attribute data not just from the extreme sites, but from all sites across the spectrum of human disturbance. That relationship can be expressed either graphically (scatter plot) or by a comparison of correlation coefficients (fig. 5a and b). Attributes that contain many of the same species can be expected to be redundant. Redundancy can be tested statistically (e.g., factor analyses (Hatcher 1994)) or by simply examining similarities in the taxa groupings that form each attribute. Although some redundancy is acceptable in a multimetric mix, selected metrics should tend to avoid using the same set of species repeatedly. Simple tables can be con-

Figure 4 Separation of least- from most-impaired sites*



* The metric number of minnow species (4a) predictably separates least- from most-impaired sites and therefore may be retained for further analysis, whereas the attribute number of sunfish species (4b) does not and may be eliminated (Teels and Danielson 2001).

Figure 5 Correlation to disturbance gradient (gradient decreases in disturbance from left to right along the x-axis)*



* Based on degree of correlation, only one metric, total number of species (5a), should be retained for further evaluation (Teels and Danielson 2001).

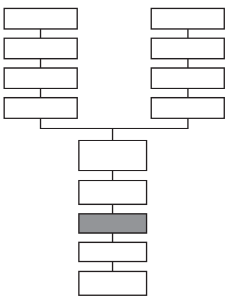
Table 7 Example metric evaluation process used to screen attributes to select the metrics that would best compose the IBI (Teels and Danielson 2001)

Species richness and composition	Separates least from most impaired sites ($p<0.05$)	Correlates with Human Disturbance Index ($r>0.35$)	Performs notably better than one of Karr's (1981) original metrics	Surviving metrics that can be further evaluated by redundancy analysis
1. Total # of species	yes	yes	*	✓
2. # of native species	yes	yes	no	
3. # of non-native species	no	no	no	
4. # of darter species	yes	yes	*	✓
5. # of darter and sculpin sp.	yes	no	no	
6. # of sunfish species	no	no	*	
7. # of sucker species	no	no	*	
8. # of minnow species	yes	yes	yes	✓
Tolerance/intolerance				
9. % dominant species	yes	yes	yes	✓
10. % pioneers	yes	yes	yes	✓
11. # of intolerant species	yes	yes	*	✓
12. % tolerant individuals	yes	yes	*	✓
Trophic				
13. % AHI (omnivorous)	yes	yes	*	✓
14. % AHI + DAH	yes	yes	no	
15. % generalist feeders	no	no	no	
16. % insectivorous minnows	yes	yes	*	✓
17. % benthic invertivores	yes	yes	yes	✓
18. % specialist carnivores	no	no	no	
19. % specialist carn. - tol	no	no	yes	✓
20. % piscivores	no	no	*	
Abundance, condition, and reproduction				
21. % simple lithophils	yes	no	no	
22. % simple lith. – tol	yes	yes	yes	✓
23. # late maturing species	yes	yes	yes	✓
24. % manipulative spawners	yes	yes	yes	✓
25. Total individuals	yes	no	*	
26. % anomalies	yes	yes	*	✓
27. % hybrids	yes	no	*	
28. % anomalies + hybrids	yes	yes	no	

AHI algivore/herbivore/invertivore trophic group
DAH detritivore/algivore/herbivore trophic group
* one of Karrs original metrics

structured to compare metric performance over the various tests and summarize the screening results (table 6). The purpose of this stage of the process is to cull attributes, even those that may show some relationship to the human disturbance gradient, to select those few metrics that are highly sensitive to human disturbance yet not redundant, to form the IBI.

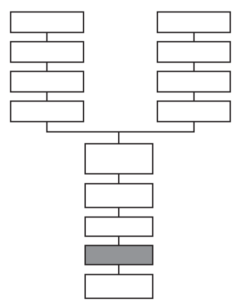
Scoring of IBI metrics



The selected metrics can then be scored by assigning values depending on whether the data they represent are comparable to, deviate somewhat from, or deviate greatly from values exhibited by the reference area's least- impaired streams (Karr et al. 1986). Such scoring allows for the fine-tuning of metrics that is tied to the reference. Such calibration increases regional metric sensitivity and may preclude the need to develop a new IBI for every region. For example, Ohio EPA has effectively used a single IBI for streams statewide through setting different IBI scoring criteria by region and designated use (USEPA 1988).

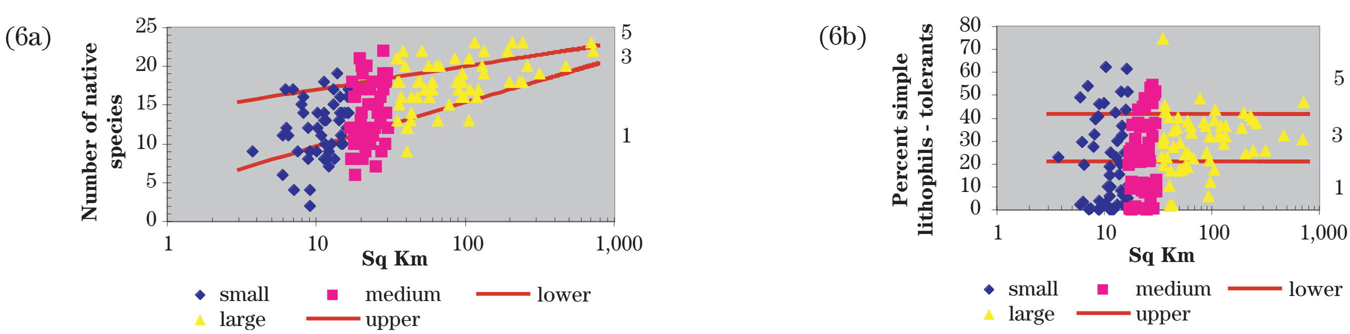
Since species richness tends to increase with increasing stream size, the scoring for species richness metrics must be adjusted accordingly (Lyons 1992a). Recent studies have demonstrated that a number of other metrics may be influenced by stream size as well (Smogor and Angermeier 1999a). Therefore, it is a good idea to examine each metric in light of the size gradient to detect corresponding relationships and then score metrics accordingly. Scoring may be accomplished either by determining the range in values (minimum and maximum) for each metric within each stream size class (table 8), and then dividing that data into equal thirds; or, by trisecting metric versus watershed area data with best-fit lines (fig. 6a and b). Best-fit lines can be established through either professional judgment or regression analysis; however, outliers in data should be avoided when constructing such lines. Metric values falling in the higher third of the range have traditionally been assigned a score of 5, those in the middle third scored a 3, and those in the lower third scored a 1. If the data are negatively correlated, the scoring is reversed. However, increasing numbers of practitioners are scoring metrics on a continuous (0–1 or 0–10) scale to reduce the noise and arbitrariness of the scoring classes (Minns et al. 1994; Howlin et al. in review; McCormick et al. in review).

Calculation of total IBI scores for all sites



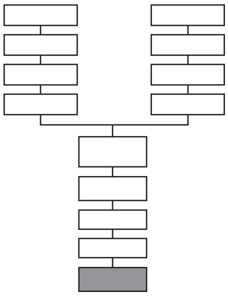
An IBI is composed of the sum of the individual metrics that collectively provide a relative measure of biological condition and individually point to likely causes of degradation at different sites (Karr et al. 1986, Yoder and Rankin 1995). An IBI score can be calculated for each site by applying the scoring criteria to the data from each site. This can be easily done in most modern worksheet programs (e.g., Excel, Lotus) or alternatively, in statistical software packages (e.g., SAS).

Figure 6 Example of metric scoring using the trisection technique (Lyons 1992)*



* The metric number of native species (a) demonstrates a clear size influence; whereas percent simple lithophils minus tolerants (b) does not. Best-fit lines have been drawn accordingly (Teels and Danielson 2001).

Interpretation of IBI; e.g., evaluation of project impacts



Once IBI scores have been calculated for each sample location, various interpretations can then be made. For example, sites and their contributing watersheds can be categorized by degrees of impairment by establishing IBI integrity classes (table 9). As a result, watersheds or individual drainages that are highly impaired can be identified. Geographic information systems can help define the distribution and spatial relationships of those drainages and aid in the development of targeted solutions (fig. 7).

By examining the specific metrics affected, the IBI can also help users diagnose sources of impairment. For example, streams with high nutrient inputs often have high proportions of tolerant and omnivorous individuals and low proportions of trophic specialists (Karr and Chu 1997). To help locate impairment sources, scores from the IBI and Human Disturbance Index (HDI) can be compared (fig. 8a). Where the two procedures agree, sites with low scores can be further examined to determine which HDI components are most responsible for impairment (e.g., broad land use patterns, fish barriers, local reach impairments). In that regard, the individual components of the HDI can be compared against the IBI to detect significant correlation (fig. 8b). For example, in a Michigan watershed, Roth et al. (1996) found that stream biotic integrity was more strongly influenced by broad land use patterns than by local land use. In that study, sites where upstream drainages were dominated by agriculture ranked lowest by both the IBI and HDI, whereas sites with land areas that had higher percentage of naturally vegetated land, particularly wetlands, tended to rank higher.

Although Roth et al. found watershed-wide land use patterns tended to be a better predictor of biological integrity, in other instances local impairments may be a greater influence. For example, in a Wisconsin study, Wang et al. (1997) found in a number of sites that grazing in the riparian area had removed bank grasses and woody vegetation, resulting in higher stream temperature and loss of overhanging cover for fish.

Table 8 Example of metric scoring by size of watershed area

Metric	Size class <17 km^2			Size class 17–34 km^2			Size class >34 km^2		
	------ Score ------			------ Score ------			------ Score ------		
	1	3	5	1	3	5	1	3	5
Species richness and composition									
1. Total number of species	<11	11–15	>15	<16	16–20	>20	<17	17–23	>23
2. Number of darter species	<2	2	>2	<2	2	>2	<2	2	>2
3. Number of minnow species	<5	–8	>8	<6	6–9	>9	<7	7–11	>11
Tolerance/intolerance									
4. Percent dominant species	<40	40–20	<20	<40	40–20	<20	<40	40–20	<20
5. Number of intolerant species	<2	2	>2	<2	2–3	>3	<2	2–3	>3
6. Percent tolerant individuals	>61	31–61	<31	>61	31–61	<31	>61	31–61	<31
Trophic composition									
7. Percent omnivores	>35	17–35	<17	>35	17–35	<17	>35	17–35	<17
8. Percent insectivorous minnows	<22	22–44	>44	<22	22–44	>44	<22	22–44	>44
9. Percent specialist carnivores	<20	20–40	>40	<20	20–40	>40	<20	20–40	>40
10. Percent benthic invertivores	<25	25–50	>50	<25	25–50	>50	<25	25–50	>50
Abundance/reproduction/condition									
11. Percent simple lithophils	<25	25–50	>50	<25	25–50	>50	<25	25–50	>50
12. Number of late maturing species	<2	2–3	>3	<2	2–3	>3	<2	2–3	>3

Figure 7 Example of identification of problem drainages using IBI integrity classes (Teels and Danielson 2001)

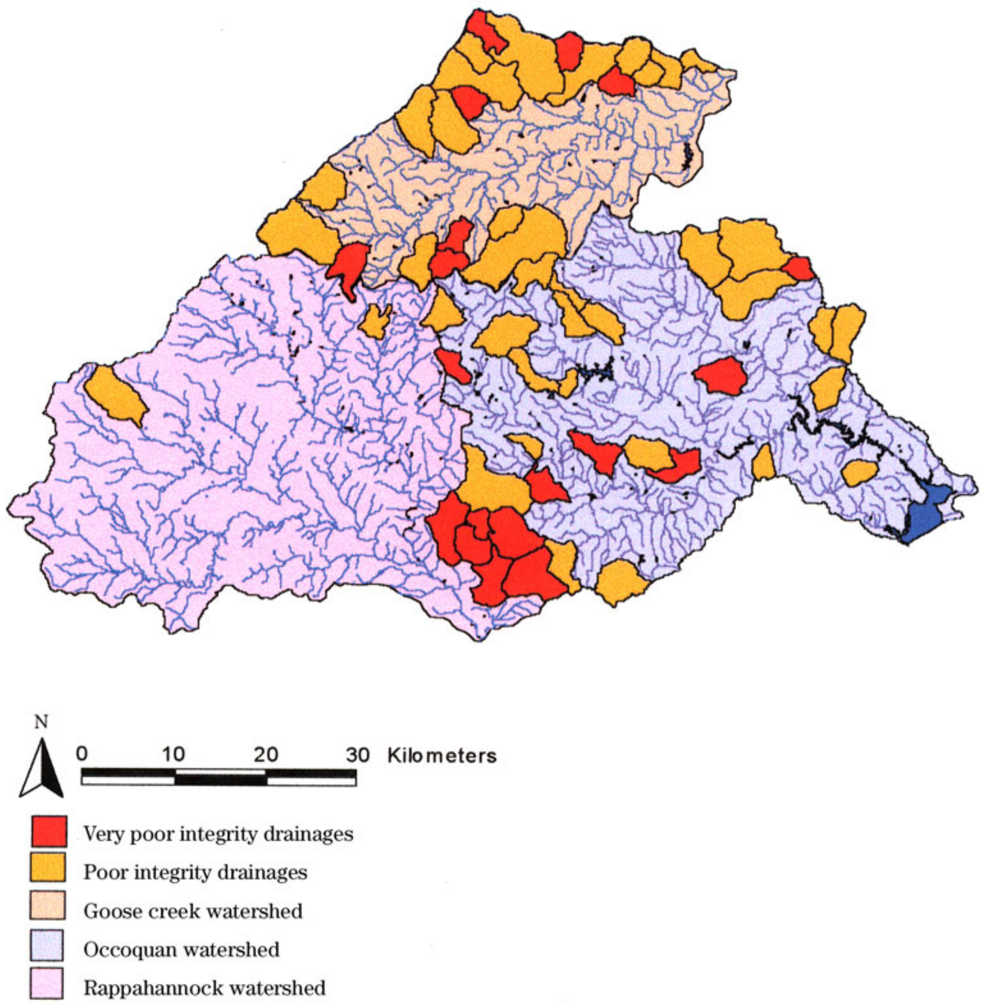
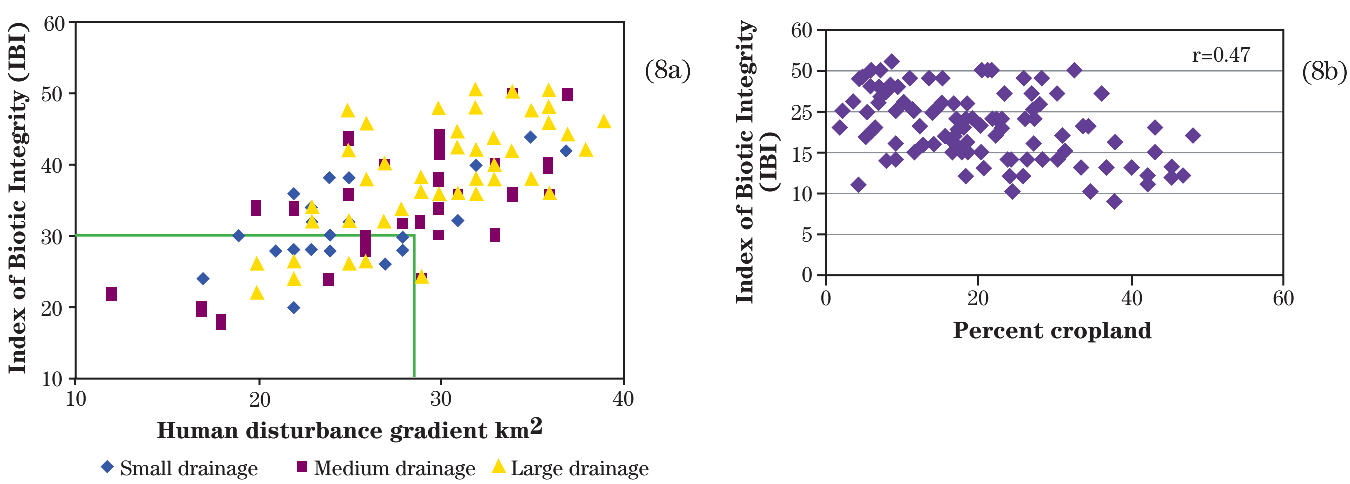


Figure 8 Examples of IBI application*



* In (8a) the IBI and HDI in conjunction can identify sites that are highly impaired (e.g., sites scoring less than 30). Further analysis of the HDI may help identify impairment sources by examining the individual HDI components (e.g., percent cropland, percent urban land) that are responsible for the low scores (8b) (Teels and Danielson 2001).

Along with high watershed slope, livestock grazing and trampling had destabilized the banks, leading to extensive erosion and sedimentation. For those sites the local impairments influenced the IBI more than broader, watershed-wide impacts. To help detect localized impairments, reach assessment scores from techniques, such as SVAP (USDA NRCS 1998), should be compared against the IBI (fig. 9a). Where there is mutual agreement for the highly impaired sites, the SVAP can be further analyzed to determine which of its individual components are most responsible for low scores (fig. 9b). Through such stepwise analysis, not only may the causes of impairment be pinpointed, but information may be gained that will lead to the selective design of conservation practices needed to correct watershed problems.

Although the IBI and HDI are expected to agree in most instances, in some instances they will not. For example, the HDI cannot possibly account for all causes of impairment (e.g., toxic chemical spills, historical pesticide use) and does not effectively deal with temporary disturbances. However, such impacts are integrated by the IBI. If low IBI scores should occur without HDI agreement, then you should still suspect that some disturbing factor is responsible. In such instances the metrics that are most affected should be identified and reasons for their impairment should be explored. In some cases a full explanation may not be revealed without examining historical land use practices (e.g., the application of persistent pesticides) or designing more comprehensive monitoring of current physical and chemical stream parameters.

In addition to helping diagnose sources of impairment, the IBI can also effectively assess the impacts of water resource projects by comparing IBI scores from before and after project installation (e.g., dams, wetland mitigation, stream restoration) (fig. 10). By knowing the response of individual metrics to project activities, projects may be designed to accommodate the metrics either individually or collectively. Thus, using the IBI as a gauge, projects may be built with the least amount of environmental harm. Because the IBI is able to integrate both positive and negative effects of human influence, it may also afford a measure of the combined effects of conservation practices (e.g., buffer strips, conservation tillage, terraces, windbreaks) that are typical of those planned by NRCS in cooperation with private landowners. It may also serve as a useful tool to assess the success or failure of conservation programs that are designed at the landscape level to solve specific watershed problems through targeted conservation (e.g., the Conservation Reserve Enhancement Program).

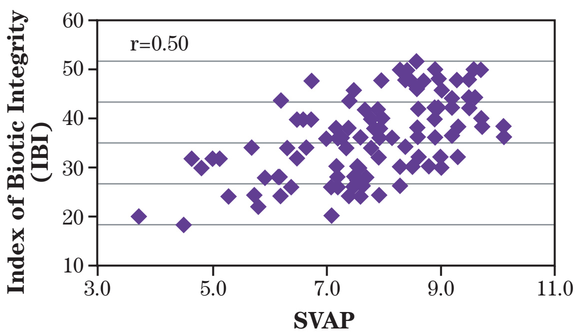
Table 9 Total IBI scores, integrity classes, and their attributes for stream reaches in a watershed (adapted from Karr et al. 1986)

Total IBI score*	Integrity class	Attributes
51–60	Excellent	Comparable to the best situations in the watershed without human disturbance; contains all species expected for the watershed for the habitat and stream size, including the most intolerant forms; exhibits balanced trophic structure and reproductive success.
41–50	Good	Species richness somewhat below expectation, especially due to the loss of the most intolerant forms; some species are present with less than optimal abundance; trophic structure and reproduction shows some sign of stress.
31–40	Fair	Signs of additional deterioration include loss of intolerant forms, fewer species, highly skewed trophic structure (e.g., increasing frequency of omnivores or tolerant species); older age classes of top predators may be rare.
21–30	Poor	Dominated by omnivores, tolerant forms, and habitat generalists; few top carnivores; reproductive and condition factors commonly depressed; hybrids or diseased fish often present.
11–20	Very poor	Dominated by highly tolerant forms (e.g., green sunfish or creek chubs), hybrids may be common; disease, lesions, parasites, fin damage, and other anomalies may be regular.

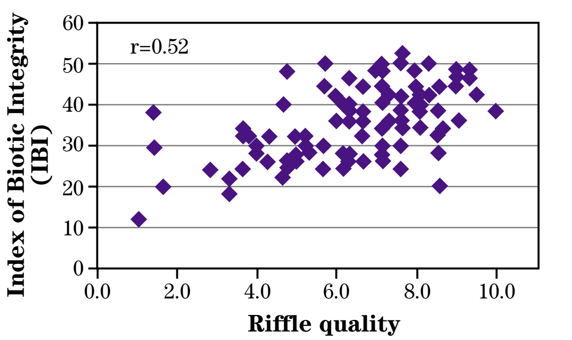
* Sum of the 12 metric scorings.

In summary, the IBI is a robust management tool that can rapidly assess the biological condition of aquatic resources. Perhaps the greatest benefit of an IBI is that it summarizes and presents complex biological information in a format that is easily communicated to managers and the public. Not only can it accurately reflect stream and watershed conditions, most people can relate more easily to fish as an indicator of condition than with complex statistical calculations or more abstract chemical and physical measures.

Figure 9 Examples of IBI application*



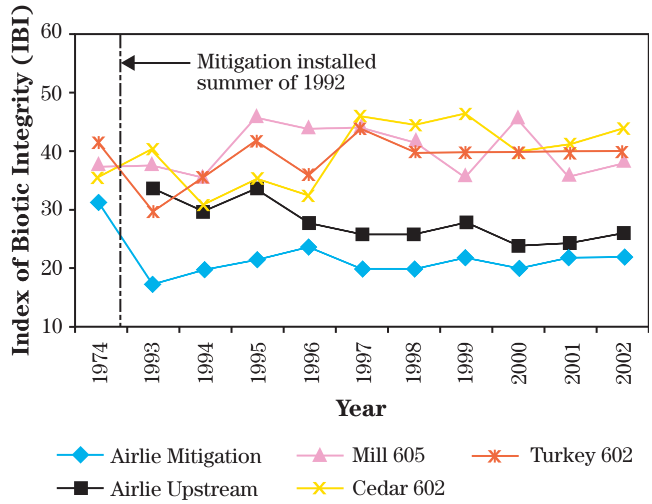
(9a)



(9b)

* Local impacts (e.g., livestock overgrazing) can be assessed by comparing the IBI to reach assessment scores (e.g., SVAP)(9a). Individual SVAP component scores can then be examined to help identify specific causes of impairment (9b)(Teels and Danielson 2001).

Figure 10 Example of IBI application*



* Water resource project impacts may be assessed using the IBI by studying before and after conditions. In this instance the IBI detected the immediate effects of stream inundation and isolation for two stream reaches (mitigation site and mitigation upstream) resulting from construction of a dam and upstream mitigation cells. The effect has persisted at both sites over a 10-year period; whereas the IBI scores of other nearby sites (Mill 605, Cedar 602, and Turkey 602) used as reference have varied, but remained higher over that same period.

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Appendix
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Exhibit H

United States Department of Agriculture

Natural Resources Conservation Service

National Water and Climate Center

Technical Note

Stream Visual Assessment Protocol

Issued November 2003

Cover photo: Stream in Clayton County, Iowa, exhibiting an impaired riparian zone.

Preface

This document presents an easy-to-use assessment protocol to evaluate the condition of aquatic ecosystems associated with streams. The protocol does not require expertise in aquatic biology or extensive training. Least-impacted reference sites are used to provide a standard of comparison. The use of reference sites is variable depending on how the state chooses to implement the protocol. The state may modify the protocol based on a system of stream classification and a series of reference sites. Instructions for modifying the protocol are provided in the technical information section. Aternatively, a user may use reference sites in a less structured manner as a point of reference when applying the protocol.

The Stream Visual Assessment Protocol is the first level in a hierarchy of ecological assessment protocols. Information on chemical monitoring of surface water and groundwater is available in the National Water Quality Handbook, Part 614, Design of Water Quality Monitoring Systems, and Part 615, Analysis of Water Quality Monitoring Data.

The protocol is designed to be conducted with the landowner. Educational material is incorporated into the protocol. The document is structured so that the protocol (pp. 7–20) can be duplicated to provide a copy to the landowner after completion of an assessment. The assessment is recorded on a single sheet of paper (copied front and back).

Acknowledgments

This protocol was developed by the Natural Resources Conservation Service (NRCS) Aquatic Assessment Workgroup. The principal authors were **Bruce Newton,** limnologist, National Water and Climate Center, NRCS, Portland, OR; **Dr. Catherine Pringle,** associate professor of Aquatic Ecology, University of Georgia, Athens, GA; and **Ronald Bjorkland,** University of Georgia, Athens, GA. The NRCS Aquatic Assessment Workgroup members provided substantial assistance in development, field evaluation, and critical review of the document. These members were:

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Stream Visual Assessment Protocol

Introduction

This assessment protocol provides a basic level of stream health evaluation. It can be successfully applied by conservationists with little biological or hydrological training. It is intended to be conducted with the landowner and incorporates talking points for the conservationist to use during the assessment. This protocol is the first level in a four-part hierarchy of assessment protocols. Tier 2 is the NRCS Water Quality Indicators Guide, Tier 3 methods are available elsewhere in the National Biology Handbook, and Tier 4 is the intensive bioassessment protocol used by your State water quality agency.

This protocol provides an assessment based primarily on physical conditions within the assessment area. It may not detect some resource problems caused by factors located beyond the area being assessed. The use of higher tier methods is required to more fully assess the ecological condition and to detect problems originating elsewhere in the watershed. However, most landowners are mainly interested in evaluating conditions on their land, and this protocol is well suited to supporting that objective.

What makes for a healthy stream?

A stream is a complex ecosystem in which several biological, physical, and chemical processes interact. Changes in any one characteristic or process have cascading effects throughout the system and result in changes to many aspects of the system.

Some of the factors that influence and determine the integrity of streams are shown in figure 1. Often several factors can combine to cause profound changes. For example, increased nutrient loads alone might not cause a change to a forested stream. But when combined with tree removal and channel widening, the result is to shift the energy dynamics from an aquatic biological community based on leaf litter inputs to one based on algae and macrophytes. The resulting chemical changes caused by algal photosynthesis and respiration and elevated temperatures may further contribute to a completely different biological community.

Many stream processes are in a delicate balance. For example, stream power, sediment load, and channel roughness must be in balance. Hydrologic changes that increase stream power, if not balanced by greater channel complexity and roughness, result in "hungry" water that erodes banks or the stream bottom. Increases in sediment load beyond the transport capacity of the stream leads to deposition, lateral channel movement into streambanks, and channel widening.

Most systems would benefit from increased complexity and diversity in physical structure. Structural complexity is provided by trees fallen into the channel, overhanging banks, roots extending into the flow, pools and riffles, overhanging vegetation, and a variety of bottom materials. This complexity enhances habitat for organisms and also restores hydrologic properties that often have been lost.

Chemical pollution is a factor in most streams. The major categories of chemical pollutants are oxygen depleting substances, such as manure, ammonia, and organic wastes; the nutrients nitrogen and phosphorus; acids, such as from mining or industrial activities; and toxic materials, such as pesticides and salts or metals contained in some drain water. It is important to note that the effects of many chemicals depend on several factors. For example, an increase in the pH caused by excessive algal and aquatic plant growth may cause an otherwise safe concentration of ammonia to become toxic. This is because the equilibrium concentrations of nontoxic ammonium ion and toxic un-ionized ammonia are pH-dependent.

Finally, it is important to recognize that streams and flood plains need to operate as a connected system. Flooding is necessary to maintain the flood plain biological community and to relieve the erosive force of flood discharges by reducing the velocity of the water. Flooding and bankfull flows are also essential for maintaining the instream physical structure. These events scour out pools, clean coarser substrates (gravel, cobbles, and boulders) of fine sediment, and redistribute or introduce woody debris.

What's the stream type?

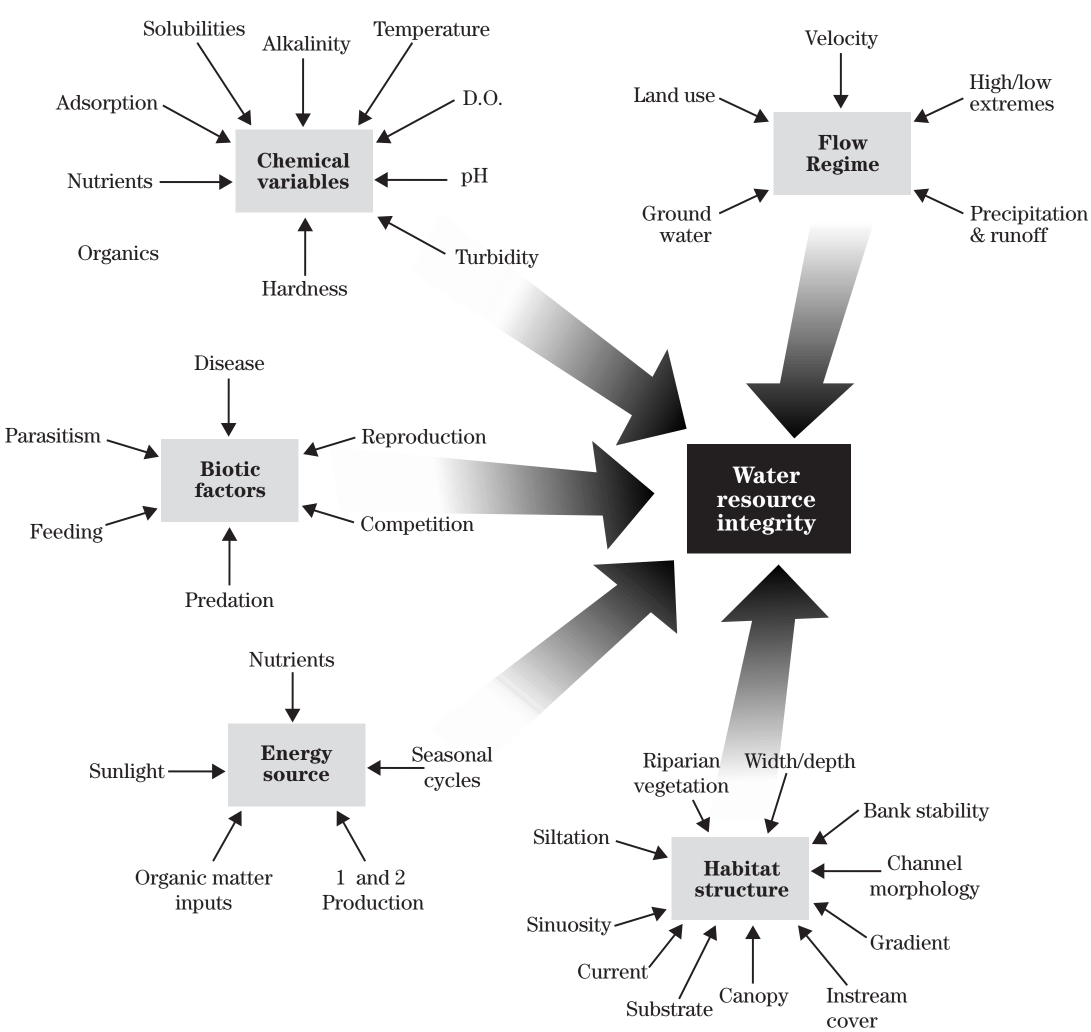
A healthy stream will look and function differently in different parts of the country and in different parts of the landscape. A mountain stream in a shale bedrock is different from a valley stream in alluvial deposits. Coastal streams are different from piedmont streams. Figuring out the different types of streams is called stream classification. Determining what types of streams are in your area is important to assessing the health of a particular stream.

There are many stream classification systems. For the purpose of a general assessment based on biology and habitat, you should think in terms of a three-level classification system based on ecoregion, drainage area, and gradient. Ecoregions are geographic areas in which ecosystems are expected to be similar. A national-level ecoregion map is available, and many states are working to develop maps at a higher level of resolution. Drainage area is the next most important factor to defining stream type. Finally, the slope or gradient of the reach you are assessing will help you determine the stream type. If you are familiar with another classification system, such as Rosgen or Montgomery/Buffington, you should use that system. This protocol may have been adjusted by your state office to reflect stream types common in your area.

Reference sites

One of the most difficult issues associated with stream ecosystems is the question of historic and potential conditions. To assess stream health, we need a benchmark of what the healthy condition is. We can usually assume that historic conditions were healthy. But in areas where streams have been degraded for 150 years or more, knowledge of historic conditions may have been lost. Moreover, in many areas returning to historic conditions is impossible or the historic conditions would not be stable under the current hydrology. Therefore, the question becomes what is the best we can expect for a particular stream. Scientists have grappled with this question for a long time, and the

Figure 1 Factors that influence the integrity of streams (modified from Karr 1986)



consensus that has emerged is to use reference sites within a classification system.

Reference sites represent the best conditions attainable within a particular stream class. The identification and characterization of reference sites is an ongoing effort led in most states by the water quality agency. You should determine whether your state has identified reference sites for the streams in your area. Such reference sites could be in another county or in another state. Unless your state office has provided photographs and other descriptive information, you should visit some reference sites to learn what healthy streams look like as part of your skills development. Visiting reference sites should also be part of your orientation after a move to a new field office.

Using this protocol

This protocol is intended for use in the field with the landowner. Conducting the assessment with the landowner gives you the opportunity to discuss natural resource concerns and conservation opportunities.

Before conducting the assessment, you should determine the following information in the field office:

- ecoregion (if in use in your State)
- drainage area
- stream gradients on the property
- overall position on the landscape

Your opening discussion with landowners should start by acknowledging that they own the land and that you understand that they know their operation best. Point out that streams, from small creeks to large rivers, are a resource that runs throughout the landscape—how they manage their part of the stream affects the entire system. Talk about the benefits of healthy streams and watersheds (improved baseflow, forage, fish, waterfowl, wildlife, aesthetics, reduced flooding downstream, and reduced water pollution). Talk about how restoring streams to a healthy condition is now a national priority.

Explain what will happen during the assessment and what you expect from them. An example follows:

This assessment will tell us how your stream is doing. We'll need to look at sections of the stream that are representative of different conditions. As we do the assessment we'll discuss how the functioning of different aspects of the stream work to keep the system healthy. After we're done, we can talk about the results of the assessment. I may recommend further assessment work to better understand what's going on. Once we understand what is happening, we can explore what you would like to accomplish with your stream and ideas for improving its condition, if necessary.

You need to assess one or more representative reaches. A reach is a length of stream. For this protocol, the length of the assessment reach is 12 times the active channel width. The reach should be representative of the stream through that area. If conditions change dramatically along the stream, you should identify additional assessment reaches and conduct separate assessments for each.

As you evaluate each element, try to work the talking points contained in the scoring descriptions into the conversation. If possible, involve the owner by asking him or her to help record the scores.

The assessment is recorded on a two-page worksheet. A completed worksheet is shown in figure 2. (A worksheet suitable for copying is at the end of this note.) The stream visual assessment protocol worksheet consists of two principal sections: reach identification and assessment. The identification section records basic information about the reach, such as name, location, and land uses. Space is provided for a diagram of the reach, which may be useful to locate the reach or illustrate problem areas. On this diagram draw all tributaries, drainage ditches, and irrigation ditches; note springs and ponds that drain to the stream; include road crossings and note whether they are fords, culverts, or bridges; note the direction of flow; and draw in any large woody debris, pools, and riffles.

The assessment section is used to record the scores for up to 15 assessment elements. Not all assessment elements will be applicable or useful for your site. Do not score elements that are not applicable. Score an element by comparing your observations to the descriptions provided. If you have difficulty matching descriptions, try to compare what you are observing to the conditions at reference sites for your area.

The overall assessment score is determined by adding the values for each element and dividing by the number of elements assessed. For example, if your scores add up to 76 and you used 12 assessment elements, you would have an overall assessment value of 6.3, which is classified as *fair*. This value provides a numerical assessment of the environmental condition of the stream reach. This value can be used as a general statement about the "state of the environment" of the stream or (over time) as an indicator of trends in condition.

USDA

Stream Visual Assessment Protocol

Owners name *Elmer Smith* Evaluator's name *Mary Soylkahn* Date *6-20-99*

Stream name *Camp Creek* Waterbody ID number ______

Reach location *About 2,000 feet upstream of equipment shed*

Ecoregion ______ Drainage area *2,200 acres* Gradient *1.2 % (map)*

Applicable reference site *Cherry Creek north of the Rt 310 bridge*

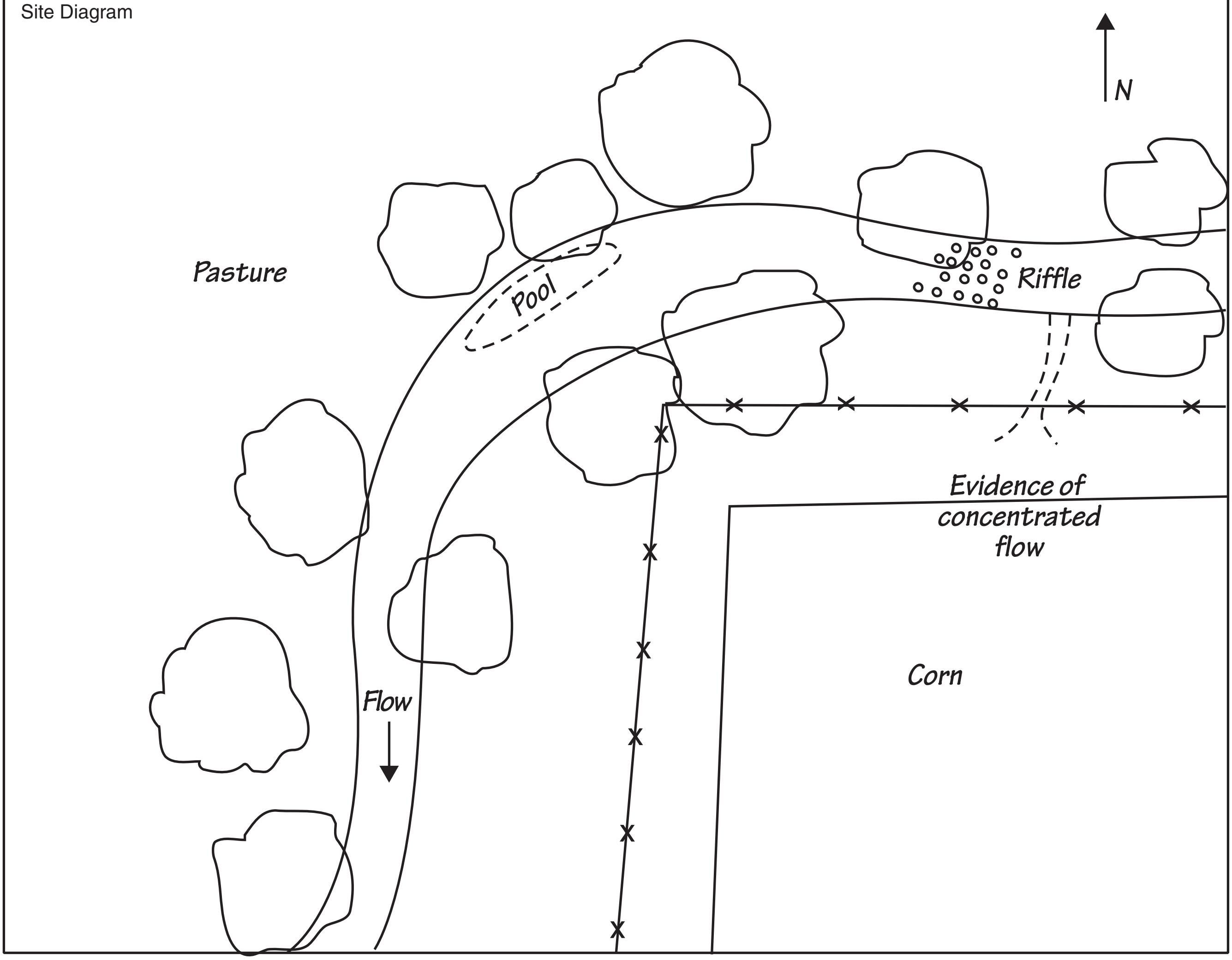
Land use within drainage (%): row crop *40* hayland *30* grazing/pasture *20* forest *10* residential ______

confined animal feeding operations ______ Cons. Reserve ______ industrial ______ Other: ______

Weather conditions-today *clear* Past 2-5 days *clear*

Active channel width *15 feet* Dominant substrate: boulder ______ gravel *x* sand *X* silt ______ mud ______

Site Diagram



Assessment Scores

Channel condition	8
Hydrologic alteration	10
Riparian zone	1
Bank stability	5
Water appearance	3
Nutrient enrichment	7
Barriers to fish movement	10
Instream fish cover	3
Pools	3
Invertebrate habitat	7

Score only if applicable

Canopy cover	3
Manure presence	1
Salinity	
Riffle embeddedness	5
Marcroinvertebrates Observed (optional)	10

Overall score		<6.0	**Poor** (circled)
(Total divided by number scored)		6.1-7.4	**Fair**
76/14	5.4	7.5-8.9	**Good**
		>9.0	**Excellent**

Suspected causes of observed problems *This reach is typical of the reaches on the property. Severely degraded riparian zones lack brush, small trees. Some bank problems from livestock access. Channel may be widening due to high sediment load. Does not appear to be downcutting.*

Recommendations *Install 391-Riparian Forest Buffer. Need to encourage livestock away from stream using water sources and shade or exclude livestock. Concentrated flows off fields need to be spread out in zone 3 of buffer. Relocate fallen trees if they deflect current into bank–use as stream barbs to deflect current to maintain channel.*

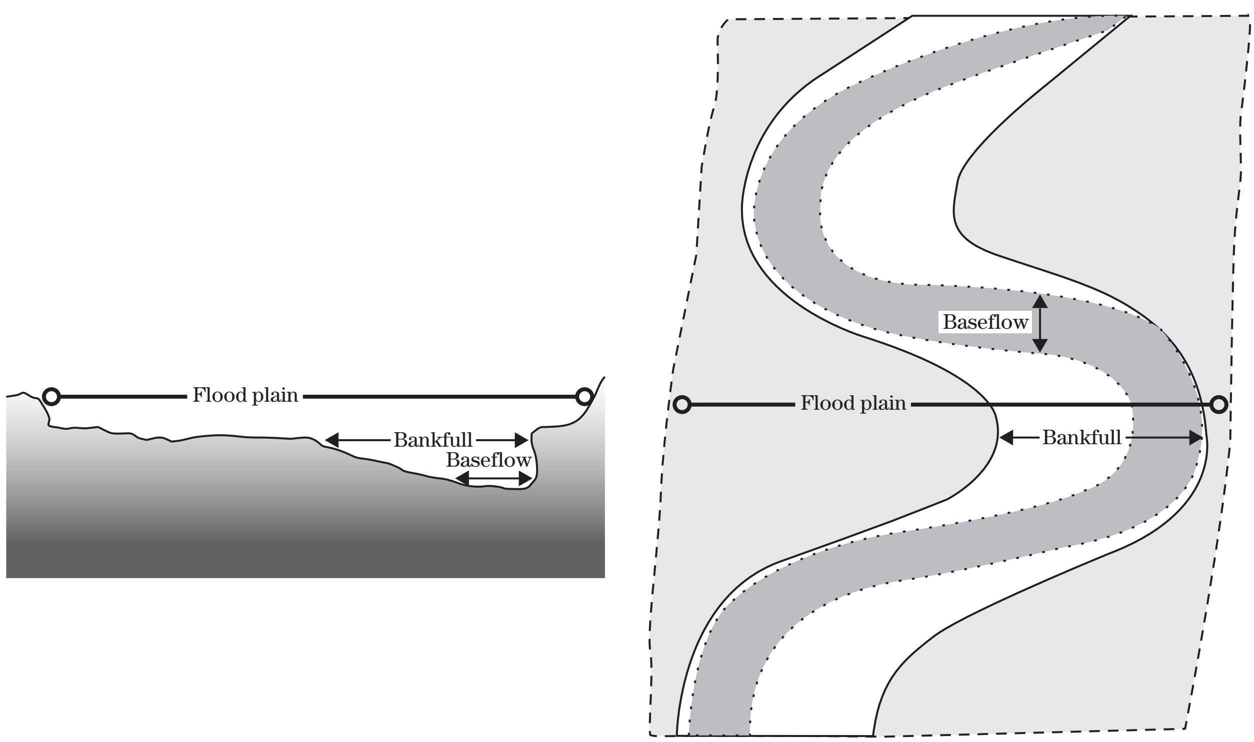
Reach description

The first page of the assessment worksheet records the identity and location of the stream reach. Most entries are self-explanatory. Waterbody ID and ecoregion should be filled out only if these identification and classification aids are used in your state.

Active channel width can be difficult to determine. However, active channel width helps to characterize the stream. It is also an important aspect of more advanced assessment protocols; therefore, it is worth becoming familiar with the concept and field determination. For this protocol you do not need to measure active channel width accurately — a visual estimate of the average width is adequate.

Active channel width is the stream width at the bankfull discharge. Bankfull discharge is the flow rate that forms and controls the shape and size of the active channel. It is approximately the flow rate at which the stream begins to move onto its flood plain if the stream has an active flood plain. The bankfull discharge is expected to occur every 1.5 years on average. Figure 3 illustrates the relationship between baseflow, bankfull flow, and the flood plain. Active channel width is best determined by locating the first flat depositional surface occurring above the bed of the stream (i.e., an active flood plain). The lowest elevation at which the bankfull surface could occur is at the top of the point bars or other sediment deposits in the channel bed. Other indicators of the bankfull surface include a break in slope on the bank, vegetation change, substrate, and debris. If you are not trained in locating the bankfull stage, ask the landowner how high the water gets every year and observe the location of permanent vegetation.

Figure 3 Baseflow, bankfull, and flood plain locations (Rosgen 1996)



Scoring descriptions

Each assessment element is rated with a value of 1 to 10. Rate only those elements appropriate to the stream. Using the Stream Visual Assessment Protocol worksheet, record the score that best fits the observations you make based on the narrative descriptions provided. Unless otherwise directed, assign the lowest score that applies. For example, if a reach has aspects of several narrative descriptions, assign a score based on the lowest scoring description that contains indicators present within the reach. You may record values intermediate to those listed. Some background information is provided for each assessment element, as well as a description of what to look for. The length of the assessment reach should be 12 times the active channel width.

Channel condition

Natural channel; no structures, dikes. No evidence of down-cutting or excessive lateral cutting.	Evidence of past channel alteration, but with significant recovery of channel and banks. Any dikes or levies are set back to provide access to an adequate flood plain.	Altered channel; <50% of the reach with riprap and/or channelization. Excess aggradation; braided channel. Dikes or levees restrict flood plain width.	Channel is actively downcutting or widening. >50% of the reach with riprap or channelization. Dikes or levees prevent access to the flood plain.
10	7	3	1

Stream meandering generally increases as the gradient of the surrounding valley decreases. Often, development in the area results in changes to this meandering pattern and the flow of a stream. These changes in turn may affect the way a stream naturally does its work, such as the transport of sediment and the development and maintenance of habitat for fish, aquatic insects, and aquatic plants. Some modifications to stream channels have more impact on stream health than others. For example, channelization and dams affect a stream more than the presence of pilings or other supports for road crossings.

Active downcutting and excessive lateral cutting are serious impairments to stream function. Both conditions are indicative of an unstable stream channel. Usually, this instability must be addressed before committing time and money toward improving other stream problems. For example, restoring the woody vegetation within the riparian zone becomes increasingly difficult when a channel is downcutting because banks continue to be undermined and the water table drops below the root zone of the plants during their growing season. In this situation or when a channel is fairly stable, but already incised from previous downcutting or mechanical dredging, it is usually necessary to plant upland species, rather than hydrophytic, or to apply irrigation for several growing seasons, or both. Extensive bank-armoring of channels to stop lateral cutting usually leads to more problems (especially downstream). Often stability can be obtained by using a series of structures (barbs, groins, jetties, deflectors, weirs, vortex weirs) that reduce water velocity, deflect currents, or act as gradient controls. These structures are used in conjunction with large woody debris and woody vegetation plantings. Hydrologic alterations are described next.

What to look for: Signs of channelization or straightening of the stream may include an unnaturally straight section of the stream, high banks, dikes or berms, lack of flow diversity (e.g., few point bars and deep pools), and uniform-sized bed materials (e.g., all cobbles where there should be mixes of gravel and cobble). In newly channelized reaches, vegetation may be missing or appear very different (different species, not as well developed) from the bank vegetation of areas that were not channelized. Older channelized reaches may also have little or no vegetation or have grasses instead of woody vegetation. Drop structures (such as check dams), irrigation diversions, culverts, bridge abutments, and riprap also indicate changes to the stream channel.

Indicators of downcutting in the stream channel include nickpoints associated with headcuts in the stream bottom and exposure of cultural features, such as pipelines that were initially buried under the stream. Exposed footings in bridges and culvert outlets that are higher than the water surface during low flows are other examples. A lack of sediment depositional features, such as regularly-spaced point bars, is normally an indicator of incision. A low vertical scarp at the toe of the streambank may indicate downcutting, especially if the scarp occurs on the inside of a meander. Another visual indicator of current or past downcutting is high streambanks with woody vegetation growing well below the top of the bank (as a channel incises the bankfull flow line moves downward within the former bankfull channel). Excessive bank erosion is indicated by raw banks in areas of the stream where they are not normally found, such as straight sections between meanders or on the inside of curves.

Hydrologic alteration

Flooding every 1.5 to 2 years. No dams, no water withdrawals, no dikes or other structures limiting the stream's access to the flood plain. Channel is not incised.	Flooding occurs only once every 3 to 5 years; limited channel incision. or Withdrawals, although present, do not affect available habitat for biota.	Flooding occurs only once every 6 to 10 years; channel deeply incised. or Withdrawals significantly affect available low flow habitat for biota.	No flooding; channel deeply incised or structures prevent access to flood plain or dam operations prevent flood flows. or Withdrawals have caused severe loss of low flow habitat. or Flooding occurs on a 1-year rain event or less.
10	7	3	1

Bankfull flows, as well as flooding, are important to maintaining channel shape and function (e.g., sediment transport) and maintaining the physical habitat for animals and plants. High flows scour fine sediment to keep gravel areas clean for fish and other aquatic organisms. These flows also redistribute larger sediment, such as gravel, cobbles, and boulders, as well as large woody debris, to form pool and riffle habitat important to stream biota. The river channel and flood plain exist in dynamic equilibrium, having evolved in the present climatic regime and geomorphic setting. The relationship of water and sediment is the basis for the dynamic equilibrium that maintains the form and function of the river channel. The energy of the river (water velocity and depth) should be in balance with the bedload (volume and particle size of the sediment). Any change in the flow regime alters this balance.

If a river is not incised and has access to its flood plain, decreases in the frequency of bankfull and out-of-bank flows decrease the river's ability to transport sediment. This can result in excess sediment deposition, channel widening and shallowing, and, ultimately, in *braiding* of the channel. Rosgen (1996) defines braiding as a stream with three or more smaller channels. These smaller channels are extremely unstable, rarely have woody vegetation along their banks, and provide poor habitat for stream biota. A *split channel*, however, has two or more smaller channels (called side channels) that are usually very stable, have woody vegetation along their banks, and provide excellent habitat.

Conversely, an increase in flood flows or the confinement of the river away from its flood plain (from either incision or levees) increases the energy available to transport sediment and can result in bank and channel erosion.

The low flow or baseflow during the dry periods of summer or fall usually comes from groundwater entering the stream through the stream banks and bottom. A decrease in the low-flow rate will result in a smaller portion of the channel suitable for aquatic organisms. The withdrawal of water from streams for irrigation or industry and the placement of dams often change the normal low-flow pattern. Baseflow can also be affected by management and land use within the watershed — less infiltration of precipitation reduces baseflow and increases the frequency and severity of high flow events. For example, urbanization increases runoff and can increase the frequency of flooding to every year or more often and also reduce low flows. Overgrazing and clearcutting can have similar, although typically less severe, effects. The last description in the last box refers to the increased flood frequency that occurs with the above watershed changes.

What to look for: Ask the landowner about the frequency of flooding and about summer low-flow conditions. A flood plain should be inundated during flows that equal or exceed the 1.5- to 2.0-year flow event (2 out of 3 years or every other year). Be cautious because water in an adjacent field does not necessarily indicate natural flooding. The water may have flowed overland from a low spot in the bank outside the assessment reach.

Evidence of flooding includes high water marks (such as water lines), sediment deposits, or stream debris. Look for these on the banks, on the bankside trees or rocks, or on other structures (such as road pilings or culverts).

Excess sediment deposits and wide, shallow channels could indicate a loss of sediment transport capacity. The loss of transport capacity can result in a stream with three or more channels (braiding).

Riparian zone

Natural vegetation extends at least two active channel widths on each side.	Natural vegetation extends one active channel width on each side. or If less than one width, covers entire flood plain.	Natural vegetation extends half of the active channel width on each side.	Natural vegetation extends a third of the active channel width on each side. or Filtering function moderately compromised.	Natural vegetation less than a third of the active channel width on each side. or Lack of regeneration. or Filtering function severely compromised.
10	8	5	3	1

This element is the width of the natural vegetation zone from the edge of the active channel out onto the flood plain. For this element, the word *natural* means plant communities with (1) all appropriate structural components and (2) species native to the site or introduced species that function similar to native species at reference sites.

A healthy riparian vegetation zone is one of the most important elements for a healthy stream ecosystem. The quality of the riparian zone increases with the width and the complexity of the woody vegetation within it. This zone:

- Reduces the amount of pollutants that reach the stream in surface runoff.
- Helps control erosion.
- Provides a microclimate that is cooler during the summer providing cooler water for aquatic organisms.
- Provides large woody debris from fallen trees and limbs that form instream cover, create pools, stabilize the streambed, and provide habitat for stream biota.
- Provides fish habitat in the form of undercut banks with the "ceiling" held together by roots of woody vegetation.
- Provides organic material for stream biota that, among other functions, is the base of the food chain in lower order streams.
- Provides habitat for terrestrial insects that drop in the stream and become food for fish, and habitat and travel corridors for terrestrial animals.
- Dissipates energy during flood events.
- Often provides the only refuge areas for fish during out-of-bank flows (behind trees, stumps, and logs).

The type, timing, intensity, and extent of activity in riparian zones are critical in determining the impact on these areas. Narrow riparian zones and/or riparian zones that have roads, agricultural activities, residential or commercial structures, or significant areas of bare soils have reduced functional value for the stream. The filtering function of riparian zones can be compromised by concentrated flows. No evidence of concentrated flows through the zone should occur or, if concentrated flows are evident, they should be from land areas appropriately buffered with vegetated strips.

What to look for: Compare the width of the riparian zone to the active channel width. In steep, V-shaped valleys there may not be enough room for a flood plain riparian zone to extend as far as one or two active channel widths. In this case, observe how much of the flood plain is covered by riparian zone. The vegetation must be natural and consist of all of the structural components (aquatic plants, sedges or rushes, grasses, forbs, shrubs, understory trees, and overstory trees) appropriate for the area. A common problem is lack of shrubs and understory trees. Another common problem is lack of regeneration. The presence of only mature vegetation and few seedlings indicates lack of regeneration. Do not consider incomplete plant communities as natural. Healthy riparian zones on both sides of the stream are important for the health of the entire system. If one side is lacking the protective vegetative cover, the entire reach of the stream will be affected. In doing the assessment, examine both sides of the stream and note on the diagram which side of the stream has problems. There should be no evidence of concentrated flows through the riparian zone that are not adequately buffered before entering the riparian zone.

Bank stability

Banks are stable; banks are low (at elevation of active flood plain); 33% or more of eroding surface area of banks in outside bends is protected by roots that extend to the base-flow elevation.	Moderately stable; banks are low (at elevation of active flood plain); less than 33% of eroding surface area of banks in outside bends is protected by roots that extend to the baseflow elevation.	Moderately unstable; banks may be low, but typically are high (flooding occurs 1 year out of 5 or less frequently); outside bends are actively eroding (overhanging vegetation at top of bank, some mature trees falling into steam annually, some slope failures apparent).	Unstable; banks may be low, but typically are high; some straight reaches and inside edges of bends are actively eroding as well as outside bends (overhanging vegetation at top of bare bank, numerous mature trees falling into stream annually, numerous slope failures apparent).
10	7	3	1

This element is the existence of or the potential for detachment of soil from the upper and lower stream banks and its movement into the stream. Some bank erosion is normal in a healthy stream. Excessive bank erosion occurs where riparian zones are degraded or where the stream is unstable because of changes in hydrology, sediment load, or isolation from the flood plain. High and steep banks are more susceptible to erosion or collapse. All outside bends of streams erode, so even a stable stream may have 50 percent of its banks bare and eroding. A healthy riparian corridor with a vegetated flood plain contributes to bank stability. The roots of perennial grasses or woody vegetation typically extend to the baseflow elevation of water in streams that have bank heights of 6 feet or less. The root masses help hold the bank soils together and physically protect the bank from scour during bankfull and flooding events. Vegetation seldom becomes established below the elevation of the bankfull surface because of the frequency of inundation and the unstable bottom conditions as the stream moves its bedload.

The type of vegetation is important. For example, trees, shrubs, sedges, and rushes have the type of root masses capable of withstanding high streamflow events, while Kentucky bluegrass does not. Soil type at the surface and below the surface also influences bank stability. For example, banks with a thin soil cover over gravel or sand are more prone to collapse than are banks with a deep soil layer.

What to look for: Signs of erosion include unvegetated stretches, exposed tree roots, or scalloped edges. Evidence of construction, vehicular, or animal paths near banks or grazing areas leading directly to the water's edge suggest conditions that may lead to the collapse of banks. Estimate the size or area of the bank affected relative to the total bank area. This element may be difficult to score during high water.

Water appearance

Very clear, or clear but tea-colored; objects visible at depth 3 to 6 ft (less if slightly colored); no oil sheen on surface; no noticeable film on submerged objects or rocks.	Occasionally cloudy, especially after storm event, but clears rapidly; objects visible at depth 1.5 to 3 ft; may have slightly green color; no oil sheen on water surface.	Considerable cloudiness most of the time; objects visible to depth 0.5 to 1.5 ft; slow sections may appear pea-green; bottom rocks or submerged objects covered with heavy green or olive-green film. or Moderate odor of ammonia or rotten eggs.	Very turbid or muddy appearance most of the time; objects visible to depth < 0.5 ft; slow moving water may be bright-green; other obvious water pollutants; floating algal mats, surface scum, sheen or heavy coat of foam on surface. or Strong odor of chemicals, oil, sewage, other pollutants.
10	7	3	1

This element compares turbidity, color, and other visual characteristics with a healthy or reference stream. The depth to which an object can be clearly seen is a measure of turbidity. Turbidity is caused mostly by particles of soil and organic matter suspended in the water column. Water often shows some turbidity after a storm event because of soil and organic particles carried by runoff into the stream or suspended by turbulence. The water in some streams may be naturally tea-colored. This is particularly true in watersheds with extensive bog and wetland areas. Water that has slight nutrient enrichment may support communities of algae, which provide a greenish color to the water. Streams with heavy loads of nutrients have thick coatings of algae attached to the rocks and other submerged objects. In degraded streams, floating algal mats, surface scum, or pollutants, such as dyes and oil, may be visible.

What to look for: Clarity of the water is an obvious and easy feature to assess. The deeper an object in the water can be seen, the lower the amount of turbidity. Use the depth that objects are visible only if the stream is deep enough to evaluate turbidity using this approach. For example, if the water is clear, but only 1 foot deep, do not rate it as if an object became obscured at a depth of 1 foot. This measure should be taken after a stream has had the opportunity to "settle" following a storm event. A pea-green color indicates nutrient enrichment beyond what the stream can naturally absorb.

Nutrient enrichment

Clear water along entire reach; diverse aquatic plant community includes low quantities of many species of macrophytes; little algal growth present.	Fairly clear or slightly greenish water along entire reach; moderate algal growth on stream substrates.	Greenish water along entire reach; overabundance of lush green macrophytes; abundant algal growth, especially during warmer months.	Pea green, gray, or brown water along entire reach; dense stands of macrophytes clog stream; severe algal blooms create thick algal mats in stream.
10	7	3	1

Nutrient enrichment is often reflected by the types and amounts of aquatic vegetation in the water. High levels of nutrients (especially phosphorus and nitrogen) promote an overabundance of algae and floating and rooted macrophytes. The presence of some aquatic vegetation is normal in streams. Algae and macrophytes provide habitat and food for all stream animals. However, an excessive amount of aquatic vegetation is not beneficial to most stream life. Plant respiration and decomposition of dead vegetation consume dissolved oxygen in the water. Lack of dissolved oxygen creates stress for all aquatic organisms and can cause fish kills. A landowner may have seen fish gulping for air at the water surface during warm weather, indicating a lack of dissolved oxygen.

What to look for: Some aquatic vegetation (rooted macrophytes, floating plants, and algae attached to substrates) is normal and indicates a healthy stream. Excess nutrients cause excess growth of algae and macrophytes, which can create greenish color to the water. As nutrient loads increase the green becomes more intense and macrophytes become more lush and deep green. Intense algal blooms, thick mats of algae, or dense stands of macrophytes degrade water quality and habitat. Clear water and a diverse aquatic plant community without dense plant populations are optimal for this characteristic.

Barriers to fish movement

No barriers	Seasonal water withdrawals inhibit movement within the reach	Drop structures, culverts, dams, or diversions (< 1 foot drop) within the reach	Drop structures, culverts, dams, or diversions (> 1 foot drop) within 3 miles of the reach	Drop structures, culverts, dams, or diversions (> 1 foot drop) within the reach
10	8	5	3	1

Barriers that block the movement of fish or other aquatic organisms, such as fresh water mussels, must be considered as part of the overall stream assessment. If sufficiently high, these barriers may prevent the movement or migration of fish, deny access to important breeding and foraging habitats, and isolate populations of fish and other aquatic animals.

What to look for: Some barriers are natural, such as waterfalls and boulder dams, and some are developed by humans. Note the presence of such barriers along the reach of the stream you are assessing, their size, and whether provisions have been made for the passage of fish. Ask the landowner about any dams or other barriers that may be present 3 to 5 miles upstream or downstream. Larger dams are often noted on maps, so you may find some information even before going out into the field. Beaver dams generally do not prevent fish migration. Look for structures that may not involve a drop, but still present a hydraulic barrier. Single, large culverts with no slope and sufficient water depth usually do not constitute a barrier. Small culverts or culverts with slopes may cause high water velocities that prevent passage.

Instream fish cover

>7 cover types available	6 to 7 cover types available	4 to 5 cover types available	2 to 3 cover types available	None to 1 cover type available
10	8	5	3	1

Cover types: Logs/large woody debris, deep pools, overhanging vegetation, boulders/cobble, riffles, undercut banks, thick root mats, dense macrophyte beds, isolated/backwater pools, other: ________________________________.

This assessment element measures availability of physical habitat for fish. The potential for the maintenance of a healthy fish community and its ability to recover from disturbance is dependent on the variety and abundance of suitable habitat and cover available.

What to look for: Observe the number of different habitat and cover types *within a representative subsection of the assessment* reach that is equivalent in length to *five times* the active channel width. Each cover type must be present in appreciable amounts to score. Cover types are described below.

Logs/large woody debris—Fallen trees or parts of trees that provide structure and attachment for aquatic macroinvertebrates and hiding places for fish.

Deep pools—Areas characterized by a smooth undisturbed surface, generally slow current, and deep enough to provide protective cover for fish (75 to 100% deeper than the prevailing stream depth).

Overhanging vegetation—Trees, shrubs, vines, or perennial herbaceous vegetation that hangs immediately over the stream surface, providing shade and cover.

Boulders/cobble—Boulders are rounded stones more than 10 inches in diameter or large slabs more than 10 inches in length; cobbles are stones between 2.5 and 10 inches in diameter.

Undercut banks—Eroded areas extending horizontally beneath the surface of the bank forming underwater pockets used by fish for hiding and protection.

Thick root mats—Dense mats of roots and rootlets (generally from trees) at or beneath the water surface forming structure for invertebrate attachment and fish cover.

Dense macrophyte beds—Beds of emergent (e.g., water willow), floating leaf (e.g., water lily), or submerged (e.g., riverweed) aquatic vegetation thick enough to provide invertebrate attachment and fish cover.

Riffles—Area characterized by broken water surface, rocky or firm substrate, moderate or swift current, and relatively shallow depth (usually less than 18 inches).

Isolated/backwater pools—Areas disconnected from the main channel or connected as a "blind" side channel, characterized by a lack of flow except in periods of high water.

Pools

Deep and shallow pools abundant; greater than 30% of the pool bottom is obscure due to depth, or the pools are at least 5 feet deep.	Pools present, but not abundant; from 10 to 30% of the pool bottom is obscure due to depth, or the pools are at least 3 feet deep.	Pools present, but shallow; from 5 to 10% of the pool bottom is obscure due to depth, or the pools are less than 3 feet deep.	Pools absent, or the entire bottom is discernible.
10	7	3	1

Pools are important resting and feeding sites for fish. A healthy stream has a mix of shallow and deep pools. A *deep* pool is 1.6 to 2 times deeper than the prevailing depth, while a *shallow* pool is less than 1.5 times deeper than the prevailing depth. Pools are abundant if a deep pool is in each of the meander bends in the reach being assessed. To determine if pools are abundant, look at a longer sample length than one that is 12 active channel widths in length. Generally, only 1 or 2 pools would typically form within a reach as long as 12 active channel widths. In low order, high gradient streams, pools are abundant if there is more than one pool every 4 channel widths.

What to look for: Pool diversity and abundance are estimated based on walking the stream or probing from the streambank with a stick or length of rebar. You should find deep pools on the outside of meander bends. In shallow, clear streams a visual inspection may provide an accurate estimate. In deep streams or streams with low visibility, this assessment characteristic may be difficult to determine and should not be scored.

Insect/invertebrate habitat

At least 5 types of habitat available. Habitat is at a stage to allow full insect colonization (woody debris and logs not freshly fallen).	3 to 4 types of habitat. Some potential habitat exists, such as overhanging trees, which will provide habitat, but have not yet entered the stream.	1 to 2 types of habitat. The substrate is often disturbed, covered, or removed by high stream velocities and scour or by sediment deposition.	None to 1 type of habitat.
10	7	3	1

Cover types: Fine woody debris, submerged logs, leaf packs, undercut banks, cobble, boulders, coarse gravel, other: ____.

Stable substrate is important for insect/invertebrate colonization. *Substrate* refers to the stream bottom, woody debris, or other surfaces on which invertebrates can live. Optimal conditions include a variety of substrate types within a relatively small area of the stream (5 times the active channel width). Stream and substrate stability are also important. High stream velocities, high sediment loads, and frequent flooding may cause substrate instability even if substrate is present.

What to look for: Observe the number of different types of habitat and cover within a representative subsection of the assessment reach that is equivalent in length to five times the active channel width. Each cover type must be present in appreciable amounts to score.

Score the following assessment elements
only if applicable

Canopy cover (if applicable)

Coldwater fishery

> 75% of water surface shaded and upstream 2 to 3 miles generally well shaded.	>50% shaded in reach. or >75% in reach, but upstream 2 to 3 miles poorly shaded.	20 to 50% shaded.	< 20% of water surface in reach shaded.
10	7	3	1

Warmwater fishery

25 to 90% of water surface shaded; mixture of conditions.	> 90% shaded; full canopy; same shading condition throughout the reach.	(intentionally blank)	< 25% water surface shaded in reach.
10	7		1

Do not assess this element if active channel width is greater than 50 feet. Do not assess this element if woody vegetation is naturally absent (e.g., wet meadows).

Shading of the stream is important because it keeps water cool and limits algal growth. Cool water has a greater oxygen holding capacity than does warm water. When streamside trees are removed, the stream is exposed to the warming effects of the sun causing the water temperature to increase for longer periods during the daylight hours and for more days during the year. This shift in light intensity and temperature causes a decline in the numbers of certain species of fish, insects, and other invertebrates and some aquatic plants. They may be replaced altogether by other species that are more tolerant of increased light intensity, low dissolved oxygen, and warmer water temperature. For example, trout and salmon require cool, oxygen-rich water. Loss of streamside vegetation (and also channel widening) that cause increased water temperature and decreased oxygen levels are major contributing factors to the decrease in abundance of trout and salmon from many streams that historically supported these species. Increased light and the warmer water also promote excessive growth of submerged macrophytes and algae that compromises the biotic community of the stream. The temperature at the reach you are assessing will be affected by the amount of shading 2 to 3 miles upstream.

What to look for: Try to estimate the portion of the water surface area for the whole reach that is shaded by estimating areas with no shade, poor shade, and shade. Time of the year, time of the day, and weather can affect your observation of shading. Therefore, the relative amount of shade is estimated by assuming that the sun is directly overhead and the vegetation is in full leaf-out. First evaluate the shading conditions for the reach; then determine (by talking with the landowner) shading conditions 2 to 3 miles upstream. Alternatively, use aerial photographs taken during full leaf out. The following rough guidelines for percent shade may be used:

stream surface not visible .... > 90
surface slightly visible or visible only in patches .. 70 – 90
surface visible, but banks not visible .... 40 – 70
surface visible and banks visible at times .... 20 – 40
surface and banks visible .... < 20

Manure presence (if applicable)

(Intentionally blank)	Evidence of livestock access to riparian zone.	Occasional manure in stream or waste storage structure located on the flood plain.	Extensive amount of manure on banks or in stream. or Untreated human waste discharge pipes present.
	5	3	1

Do not score this element unless livestock operations or human waste discharges are present.

Manure from livestock may enter the water if livestock have access to the stream or from runoff of grazing land adjacent to the stream. In some communities untreated human waste may also empty directly into streams. Manure and human waste increase biochemical oxygen demand, increase the loading of nutrients, and alter the trophic state of the aquatic biological community. Untreated human waste is a health risk.

What to look for: Do not score this element unless livestock operations or human waste discharges are present. Look for evidence of animal droppings in or around streams, on the streambank, or in the adjacent riparian zone. Well-worn livestock paths leading to or near streams also suggest the probability of manure in the stream. Areas with stagnant or slow-moving water may have moderate to dense amounts of vegetation or algal blooms, indicating localized enrichment from manure.

Salinity (if applicable)

(Intentionally blank)	Minimal wilting, bleaching, leaf burn, or stunting of aquatic vegetation; some salt-tolerant streamside vegetation.	Aquatic vegetation may show significant wilting, bleaching, leaf burn, or stunting; dominance of salt-tolerant streamside vegetation.	Severe wilting, bleaching, leaf burn, or stunting; presence of only salt-tolerant aquatic vegetation; most streamside vegetation salt tolerant.
	5	3	1

Do not assess this element unless elevated salinity from anthropogenic sources is known to occur in the stream.

High salinity levels most often occur in arid areas and in areas that have high irrigation requirements. High salinity can also result from oil and gas well operations. Salt accumulation in soil causes a breakdown of soil structure, decreased infiltration of water, and potential toxicity. High salinity in streams affects aquatic vegetation, macroinvertebrates, and fish. Salts are a product of natural weathering processes of soil and geologic material.

What to look for: High salinity levels cause a "burning" or "bleaching" of aquatic vegetation. Wilting, loss of plant color, decreased productivity, and stunted growth are readily visible signs. Other indicators include whitish salt encrustments on the streambanks and the displacement of native vegetation by salt-tolerant aquatic plants and riparian vegetation (such as tamarix or salt cedar).

Riffle embeddedness (if applicable)

Gravel or cobble particles are < 20% embedded.	Gravel or cobble particles are 20 to 30% embedded.	Gravel or cobble particles are 30 to 40% embedded.	Gravel or cobble particles are >40% embedded.	Riffle is completely embedded.
10	8	5	3	1

Do not assess this element unless riffles are present or they are a natural feature that should be present.

Riffles are areas, often downstream of a pool, where the water is breaking over rocks or other debris causing surface agitation. In coastal areas riffles can be created by shoals and submerged objects. (This element is sensitive to regional differences and should be related to reference conditions.) Riffles are critical for maintaining high species diversity and abundance of insects for most streams and for serving as spawning and feeding grounds for some fish species. Embeddedness measures the degree to which gravel and cobble substrate are surrounded by fine sediment. It relates directly to the suitability of the stream substrate as habitat for macroinvertebrates, fish spawning, and egg incubation.

What to look for: This assessment characteristic should be used only in riffle areas and in streams where this is a natural feature. The measure is the depth to which objects are buried by sediment. This assessment is made by picking up particles of gravel or cobble with your fingertips at the fine sediment layer. Pull the particle out of the bed and estimate what percent of the particle was buried. Some streams have been so smothered by fine sediment that the original stream bottom is not visible. Test for complete burial of a streambed by probing with a length of rebar.

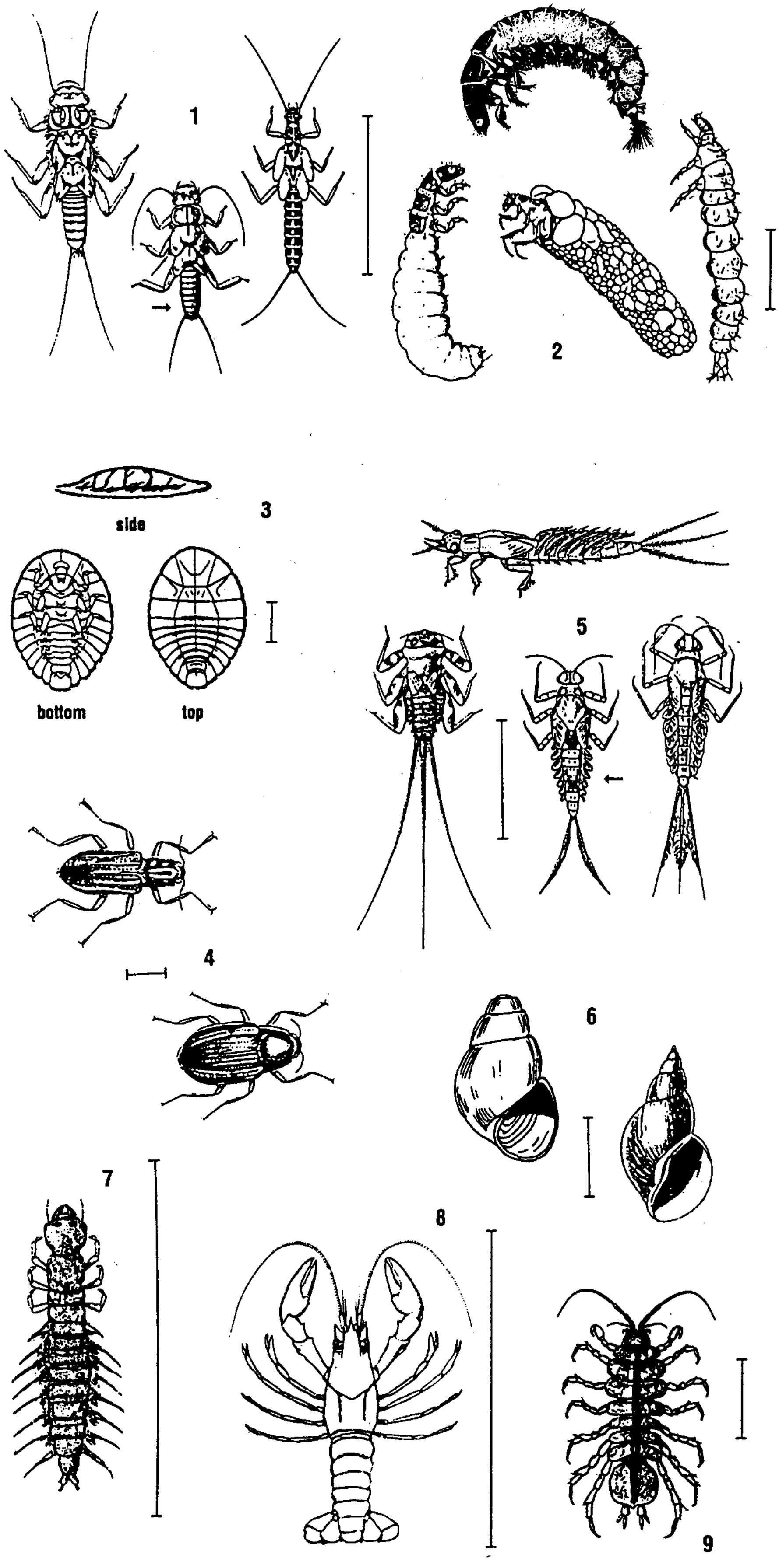
Macroinvertebrates observed

Community dominated by Group I or intolerant species with good species diversity. Examples include caddisflies, mayflies, stoneflies, hellgrammites.	Community dominated by Group II or facultative species, such as damselflies, dragonflies, aquatic sowbugs, blackflies, crayfish.	Community dominated by Group III or tolerant species, such as midges, craneflies, horseflies, leeches, aquatic earthworms, tubificid worms.	Very reduced number of species or near absence of all macroinvertebrates.
15	6	2	– 3

This important characteristic reflects the ability of the stream to support aquatic invertebrate animals. However, successful assessment requires knowledge of the life cycles of some aquatic insects and other macroinvertebrates and the ability to identify them. For this reason, this is an optional element. The presence of intolerant insect species (cannot survive in polluted water) indicates healthy stream conditions. Some kinds of macroinvertebrates, such as stoneflies, mayflies, and caddisflies, are sensitive to pollution and do not live in polluted water; they are considered Group I. Another group of macroinvertebrates, known as Group II or facultative macroinvertebrates, can tolerate limited pollution. This group includes damselflies, aquatic sowbugs, and crayfish. The presence of Group III macroinvertebrates, including midges, craneflies and leeches, suggests the water is significantly polluted. The presence of a single Group I species in a community does not constitute good diversity and should generally not be given a score of 15.

What to look for: You can collect macroinvertebrates by picking up cobbles and other submerged objects in the water. Look carefully for the insects; they are often well camouflaged and may appear as part of the stone or object. Note the kinds of insects, number of species, and relative abundance of each group of insects/macroinvertebrates. Each of the three classes of macroinvertebrates are illustrated on pages 19 and 20. ***Note that the scoring values for this element range from –3 to 15.***

Stream Invertebrates



Bar lines indicate relative size

Group One Taxa

Pollution sensitive organisms found in good quality water.

1 **Stonefly Order Plecoptera.** 1/2" to 1 1/2", 6 legs with hooked antenna, 2 hair-line tails. Smooth (no gills) on lower half of body (see arrow).

2 **Caddisfly: Order Trichoptera.** Up to 1", 6 hooked legs on upper third of body, 2 hooks at back end. May be in a stick, rock, or leaf case with its head sticking out. May have fluffy gill tufts on underside.

3 **Water Penny: Order Coleoptera.** 1/4", flat saucer-shaped body with a raised bump on one side and 6 tiny legs and fluffy gills on the other side. Immature beetle.

4 **Riffle Beetle: Order Coleoptera.** 1/4", oval body covered with tiny hairs, 6 legs, antennae. Walks slowly underwater. Does not swim on surface.

5 **Mayfly: Order Ephemeroptera.** 1/4" to 1", brown, moving, plate-like or feathery gills on the sides of lower body (see arrow), 6 large hooked legs, antennae, 2 or 3 long hair-like tails. Tails may be webbed together.

6 **Gilled Snail: Class Gastropoda.** Shell opening covered by thin plate called operculum. When opening is facing you, shell usually opens on right.

7 **Dobsonfly (hellgrammite): Family Corydalidae.** 3/4" to 4", dark-colored, 6 legs, large pinching jaws, eight pairs feelers on lower half of body with paired cotton-like gill tufts along underside, short antennae, 2 tails, and 2 pairs of hooks at back end.

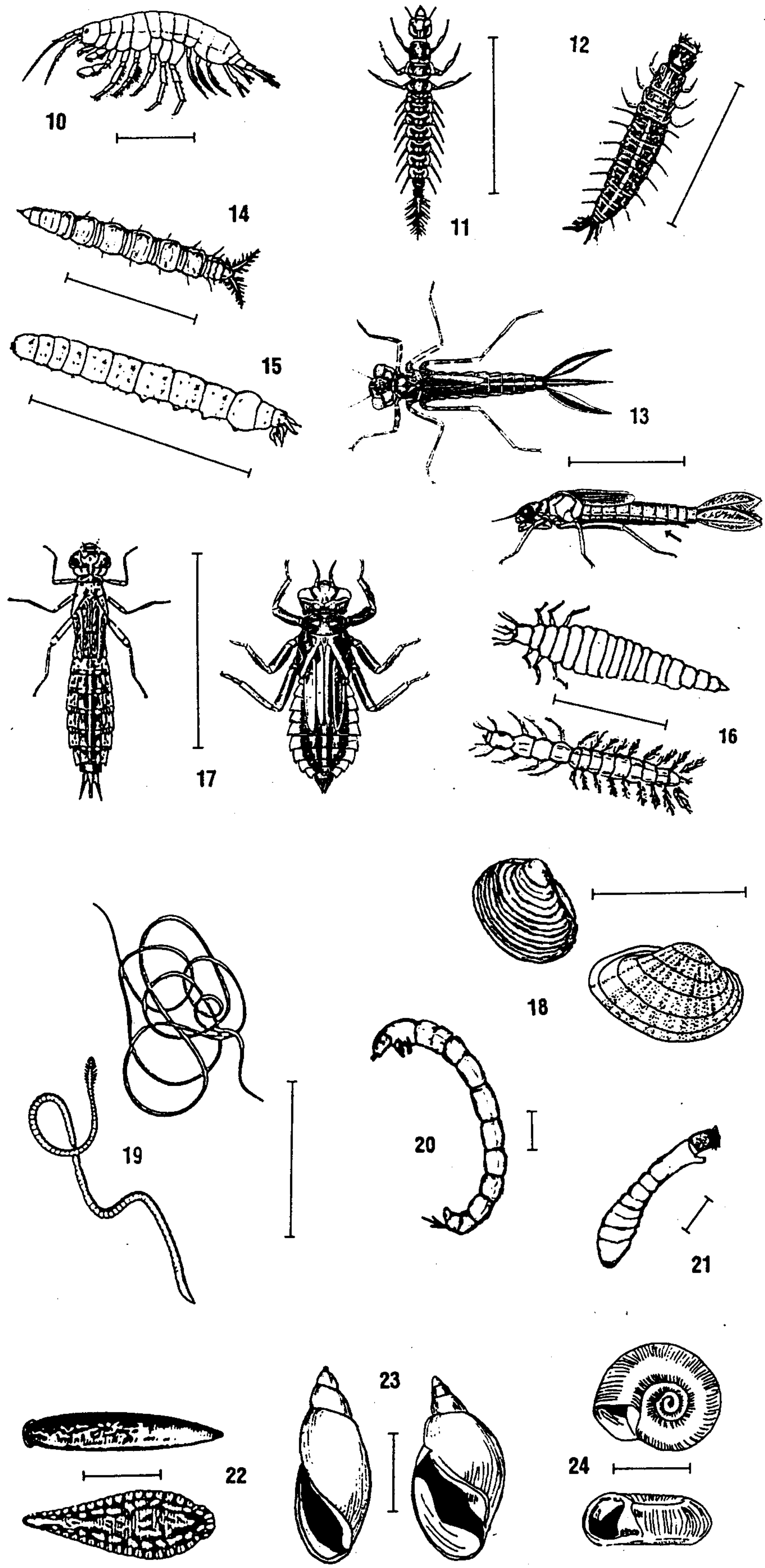
Group Two Taxa

Somewhat pollution tolerant organisms can be in good or fair quality water.

8 **Crayfish: Order Decapoda.** Up to 6", 1 large claws, 8 legs, resembles small lobster.

9 **Sowbug: Order Isopoda.** 1/4" to 3/4", gray oblong body wider than it is high, more than 6 legs, long antennae.

Source: Izaak Walton League of America, 707 Conservation Lane, Gaithersburg, MD 20878-2983. (800) BUG-IWLA



Bar lines indicate relative size

Group Two Taxa

Somewhat pollution tolerant organisms can be in good or fair quality water.

10 Scud: Order Amphipoda. 1/4", white to gray, body higher than it is wide, swims sideways, more than 6 legs, resembles small shrimp.

11 Alderfly Larva: Family Sialedae. 1" long. Looks like small Hellgramite but has long, thin, branched tail at back end (no hooks). No gill tufts underneath.

12 Fishfly Larva: Family Cordalidae. Up to 1 1/2" long. Looks like small hellgramite, but often a lighter reddish-tan color, or with yellowish streaks. No gill tufts underneath.

13 Damselfly: Suborder Zygoptera. 1/2" to 1", large eyes, 6 thin hooked legs, 3 broad oar-shaped tails, positioned like a tripod. Smooth (no gills) on sides of lower half of body. (See arrow.)

14 Watersnipe Fly Larva: Family Athericidae (Atherix). 1/4" to 1", pale to green, tapered body, many caterpillar-like legs, conical head, feathery "horns" at back end.

15 Crane Fly: Suborder Nematocera. 1/3" to 2", milky, green, or light brown, plump caterpillar-like segmented body, 4 finger-like lobes at back end.

16 Beetle Larva: Order Coleoptera. 1/4" to 1", light-colored, 6 legs on upper half of body, feelers, antennae.

17 Dragon Fly: Suborder Anisoptera. 1/2" to 2", large eyes, 6 hooked legs. Wide oval to round abdomen.

18 Clam: Class Bivalvia.

Group Three Taxa

Pollution tolerant organisms can be in any quality of water.

19 Aquatic Worm: Class Oligochaeta. 1/4" to 2", can be very tiny, thin worm-like body.

20 Midge Fly Larva: Suborder Nematocera. Up to 1/4", dark head, worm-like segmented body, 2 tiny legs on each side.

21 Blackfly Larva: Family Simulidae. Up to 1/4", one end of body wider. Black head, suction pad on other end.

22 Leech: Order Hirudinea. 1/4" to 2", brown, slimy body, ends with suction pads.

23 Pouch Snail and Pond Snails: Class Gastropoda. No operculum. Breath air. When opening is facing you, shell usually open to left.

24 Other Snails: Class Gastropoda. No operculum. Breath air. Snail shell coils in one plane.

Technical information to support implementation

Introduction

This section provides a guide for implementation of the Stream Visual Assessment Protocol (SVAP). The topics covered in this section include the origin of the protocol, development history, context for use in relation to other methods of stream assessment, instructions for modifying the protocol, and references.

Origin of the protocol

In 1996 the NRCS National Water and Climate Center surveyed the NRCS state biologists to determine the extent of activity in stream ecological assessment and the need for technical support. The survey indicated that less than a third of the NRCS states were active in supporting stream assessment within their state. Most respondents said they believed they should be more active and requested additional support from the National Centers and Institutes. In response to these findings, the NRCS Aquatic Assessment Workgroup was formed. In their first meeting the workgroup determined that a simple assessment protocol was needed. The Water Quality Indicators Guide (WQIG) had been available for 8 years, but was not being used extensively. The workgroup felt a simpler and more streamlined method was needed as an initial protocol for field office use.

The workgroup developed a plan for a tiered progression of methods that could be used in the field as conservationists became more skilled in stream assessment. These methods would also serve different assessment objectives. The first tier is a simple 2-page assessment — the Stream Visual Assessment Protocol (SVAP). The second tier is the existing WQIG. The third tier is a series of simple assessment methods that could be conducted by conservationists in the field. An example of a third tier method would be macroinvertibrate sampling and identification to the taxonomic level of Order. The fourth tier is fairly sophisticated methods used in special projects. Examples of fourth tier methods would be fish community sampling and quantitative sampling of macroinvertebrates with shipment of samples to a lab for identification.

The workgroup also found that introductory training and a field handbook that would serve as a comprehensive reference and guidance manual are needed. These projects are under development as of this writing.

Context for use

The Stream Visual Assessment Protocol is intended to be a simple, comprehensive assessment of stream condition that maximizes ease of use. It is suitable as a basic first approximation of stream condition. It can also be used to identify the need for more accurate assessment methods that focus on a particular aspect of the aquatic system.

The relationship of the SVAP to other assessment methods is shown in figure 4. In this figure a specific reference to a guidance document is provided for some methods. The horizontal bars indicate which aspects of stream condition (chemical, physical, or biological) are addressed by the method. The SVAP is the simplest method and covers all three aspects of stream condition. As you move upwards in figure 4 the methods provide more accuracy, but also become more focused on one or two aspects of stream condition and require more expertise or resources to conduct.

The SVAP is intended to be applicable nationwide. It has been designed to utilize factors that are least sensitive to regional differences. However, regional differences are a significant aspect of stream assessment, and the protocol can be enhanced by tailoring the assessment elements to regional conditions. The national SVAP can be viewed as a framework that can evolve over time to better reflect State or within-State regional differences. Instructions for modification are provided later in this document.

Development

The SVAP was developed by combining parts of several existing assessment procedures. Many of these sources are listed in the references section. Three drafts were developed and reviewed by the workgroup and others between the fall of 1996 and the spring of 1997. During the summer of 1997, the workgroup conducted a field trial evaluation of the third draft. Further field trials were conducted with the fourth draft in 1998. A report on the field trial results is appendix A of this document.

The field trials involved approximately 60 individuals and 182 assessment sites. The field trial consisted of a combination of replication studies (in which several individuals independently assessed the same sites) and accuracy studies (in which SVAP scores were compared to the results from other assessment methods). The average coefficient of variation in the replication studies was 10.5 percent. The accuracy results indicated that SVAP version 3 scores correlated well with other methods for moderately impacted and high quality sites, but that low quality sites were not scoring correspondingly low in the SVAP. Conservationists in the field who participated in the trial were surveyed on the usability and value of the protocol. The participants indicated that they found it easy to use and thought it would be valuable for their clients.

Revisions were made to the draft to address the deficiencies identified in the field trial, and some reassessments were made during the winter of 1998 to see how the revisions affected performance. Performance was improved. Additional revisions were made, and the fifth draft was sent to all NRCS state offices, selected Federal agencies, and other partners for review and comment during the spring of 1998.

Comments were received from eight NRCS state offices, the Bureau of Land Management, and several NRCS national specialists. Comments were uniformly supportive of the need for the guidance and for the document as drafted. Many commenters provided improved explanatory text for the supporting descriptions accompanying the assessment elements. Most of the suggested revisions were incorporated.

Implementation

The SVAP is issued as a national product. States are encouraged to incorporate it within the Field Office Technical Guide. The document may be modified by States. The electronic file for the document may be downloaded from the National Water and Climate Center web site at http://www.wcc.nrcs.usda.gov.

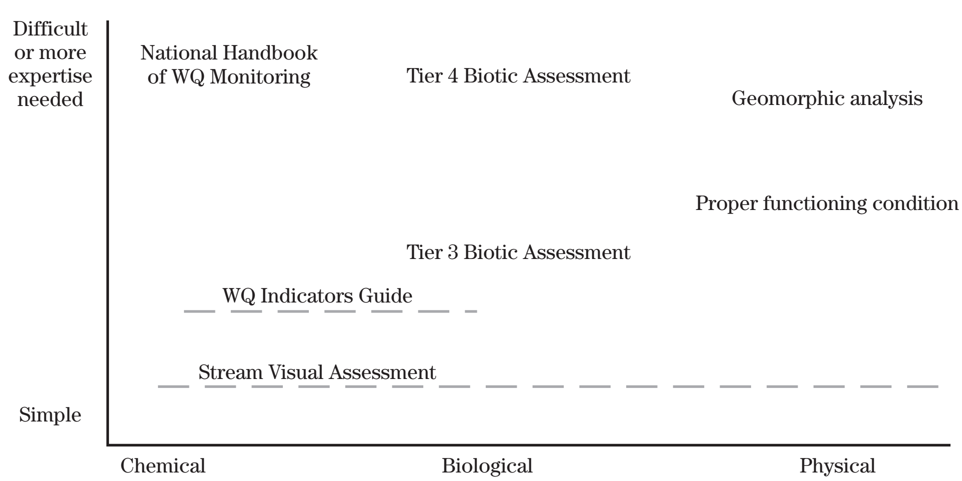
A training course for conservationists in the field suitable for use at the state or area level has been developed to facilitate implementation of the SVAP. It is designed as either a 1-day or 2-day session. The first day covers basic stream ecology and use of the SVAP. The second day includes an overview of several stream assessment methods, instruction on a macroinvertebrate survey method, and field exercises to apply the SVAP and macroinvertibrate protocols. The training materials consist of an instructor's guide, slides, video, a macroinvertebrate assessment training kit, and a student workbook. Training materials have been provided to each NRCS state office.

Instructions for modification

The national version of the Stream Visual Assessment Protocol may be used without modification. It has been designed to use assessment elements that are least sensitive to regional differences. Nonetheless, it can be modified to better reflect conditions within a geographic area. Modifying the protocol would have the following benefits:

- The protocol can be made easier to use with narrative descriptions that are closer to the conditions users will encounter.
- The protocol can be made more responsive to differences in stream condition.
- Precision can be improved by modifying elements that users have trouble evaluating.
- The rating scale can be calibrated to regionally-based criteria for excellent, good, fair, and poor condition.

Figure 4 Relationship of various stream condition assessment methods in terms of complexity or expertise required and the aspects of stream condition addressed



Two parts of the SVAP may be modified—the individual elements and their narrative descriptions, and the rating scale for assigning an overall condition rating of excellent, good, fair, or poor.

The simplest approach to modifying the SVAP is based on professional experience and judgment. Under this approach an interdisciplinary team should be assembled to develop proposed revisions. Revisions should then be evaluated by conducting comparison assessments at sites representing a range of conditions and evaluating accuracy (correlation between different assessment methods), precision (reproducibility among different users), and ease of use.

A second, more scientifically rigorous method for modifying the protocol is described below. This approach is based on a classification system for stream type and the use of reference sites.

Step 1 Decide on tentative number of versions.
Do you want to develop a revised version for your state, for each ecoregion within your state, or for several stream classes within each ecoregion?

Step 2 Develop tentative stream classification.
If you are developing protocols by stream class, you need to develop a tentative classification system. (If you are interested in a statewide or ecoregion protocol, go to step 3.) You might develop a classification system based on stream order, elevation, or landscape character. Do not create too many categories. The greater the number of categories, the more assessment work will be needed to modify the protocol and the more you will be accommodating degradation within the evaluation system. As an extreme example of the latter problem, you would not want to create a stream class consisting of those streams that have bank-to-bank cropping and at least one sewage outfall.

Step 3 Assess sites.
Assess a series of sites representing a range of conditions from highly impacted sites to least impacted sites. Try to have at least 10 sites in each of your tentative classes. Those sites should include several potential "least impacted reference sites." Try to use sites that have been assessed by other assessment methods (such as sites assessed by state agencies or universities). As part of the assessments, be sure to record information on potential classification factors and if any particular elements are difficult to score. Take notes so that future revisions of the elements can be re-scored without another site visit.

Step 4 Rank the sites.
Begin your data analysis by ranking all the sites from most impacted to least impacted. Rank sites according to the independent assessment results (preferred) or by the SVAP scores. Initially, rank all of the sites in the state data set. You will test classifications in subsequent iterations.

Step 5 Display scoring data.
Prepare a chart of the data from all sites in your state. The columns are the sites arranged by the ranking. The rows are the assessment elements, the overall numerical score, and the narrative rating. If you have independent assessment data, create a second chart by plotting the overall SVAP scores against the independent scores.

Step 6 Evaluate responsiveness.
Does the SVAP score change in response to the condition gradient represented by the different sites? Are the individual element scores responding to key resource problems? Were users comfortable with all elements? If the answers are yes, do not change the elements and proceed to step 7. If the answers are no, isolate which elements are not responsive. Revise the narrative descriptions for those elements to better respond to the observable conditions. Conduct a "desktop" reassessment of the sites with the new descriptions, and return to step 4.

Step 7 Evaluate the narrative rating breakpoints.
Do the breakpoints for the narrative rating correspond to other assessment results? The excellent range should encompass only reference sites. If not, you should reset the narrative rating breakpoints. Set the excellent breakpoint based on the least impacted reference sites. You must use judgment to set the other breakpoints.

Step 8 Evaluate tentative classification system.
Go back to step 4 and display your data this time by the tentative classes (ecoregions or stream classes). In other words, analyze sites from each ecoregion or each stream class separately. Repeat steps 5 through 7. If the responsiveness is significantly different from the responsiveness of the statewide data set or the breakpoints appear to be significantly different, adopt the classification system and revise the protocol for each ecoregion or stream class. If not, a single statewide protocol is adequate.

After the initial modification of the SVAP, the state may want to set up a process to consider future revisions. Field offices should be encouraged to locate and assess least impacted reference sites to build the data base for interpretation and future revisions. Ancillary data should be collected to help evaluate whether a potential reference site should be considered a reference site.

Caution should be exercised when considering future revisions. Revisions complicate comparing SVAP scores determined before and after the implementation of conservation practices if the protocol is substantially revised in the intervening period. Developing information to support refining the SVAP can be carried out by graduate students working cooperatively with NRCS. The Aquatic Assessment Workgroup has been conducting a pilot Graduate Student Fellowship program to evaluate whether students would be willing to work cooperatively for a small stipend. Early results indicate that students can provide valuable assistance. However, student response to advertisements has varied among states. If the pilot is successful, the program will be expanded.

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Glossary

Active channel width The width of the stream at the bankfull discharge. Permanent vegetation generally does not become established in the active channel.

Aggradation Geologic process by which a stream bottom or flood plain is raised in elevation by the deposition of material.

Bankfull discharge The stream discharge (flow rate, such as cubic feet per second) that forms and controls the shape and size of the active channel and creates the flood plain. This discharge generally occurs once every 1.5 years on average.

Bankfull stage The stage at which water starts to flow over the flood plain; the elevation of the water surface at bankfull discharge.

Baseflow The portion of streamflow that is derived from natural storage; average stream discharge during low flow conditions.

Benthos Bottom-dwelling or substrate-oriented organisms.

Boulders Large rocks measuring more than 10 inches across.

Channel A natural or artificial waterway of perceptible extent that periodically or continuously contains moving water. It has a definite bed and banks that serve to confine the water.

Channel roughness Physical elements of a stream channel upon which flow energy is expended including coarseness and texture of bed material, the curvature of the channel, and variation in the longitudinal profile.

Channelization Straightening of a stream channel to make water move faster.

Cobbles Medium-sized rocks which measure 2.5 to 10 inches across.

Confined channel A channel that does not have access to a flood plain.

Degradation Geologic process by which a stream bottom is lowered in elevation due to the net loss of substrate material. Often called downcutting.

Downcutting See Degradation.

Ecoregion A geographic area defined by similarity of climate, landform, soil, potential natural vegetation, hydrology, or other ecologically relevant variables.

Embeddedness The degree to which an object is buried in steam sediment.

Emergent plants Aquatic plants that extend out of the water.

Flood plain The flat area of land adjacent to a stream that is formed by current flood processes.

Forb Any broad-leaved herbaceous plant other than those in the Gramineae (Poceae), Cyperacea, and Juncaceae families (Society for Range Management, 1989).

Gabions A wire basket filled with rocks; used to stabilize streambanks and to control erosion.

Geomorphology The study of the evolution and configuration of landforms.

Glide A fast water habitat type that has low to moderate velocities, no surface agitation, no defined thalweg, and a U-shaped, smooth, wide bottom.

Gradient Slope calculated as the amount of vertical rise over horizontal run expressed as ft/ft or as percent (ft/ft * 100).

Grass An annual to perennial herb, generally with round erect stems and swollen nodes; leaves are alternate and two-ranked; flowers are in spikelets each subtended by two bracts.

Gravel Small rocks measuring 0.25 to 2.5 inches across.

Habitat The area or environment in which an organism lives.

Herbaceous Plants with nonwoody stems.

Hydrology The study of the properties, distribution, and effects of water on the Earth's surface, soil, and atmosphere.

Incised channel A channel with a streambed lower in elevation than its historic elevation in relation to the flood plain.

Intermittent stream A stream in contact with the ground water table that flows only certain times of the year, such as when the ground water table is high or when it receives water from surface sources.

Macrophyte bed A section of stream covered by a dense mat of aquatic plants.

Meander A winding section of stream with many bends that is at least 1.2 times longer, following the channel, than its straight-line distance. A single meander generally comprises two complete opposing bends, starting from the relatively straight section of the channel just before the first bend to the relatively straight section just after the second bend.

Macroinvertebrate A spineless animal visible to the naked eye or larger than 0.5 millimeters.

Nickpoint The point where a stream is actively eroding (downcutting) to a new base elevation. Nickpoints migrate upstream (through a process called headcutting).

Perennial stream A steam that flows continuously throughout the year.

Point bar A gravel or sand deposit on the inside of a meander; an actively mobile river feature.

Pool Deeper area of a stream with slow-moving water.

Reach A section of stream (defined in a variety of ways, such as the section between tributaries or a section with consistent characteristics).

Riffle A shallow section in a stream where water is breaking over rocks, wood, or other partly submerged debris and producing surface agitation.

Riparian The zone adjacent to a stream or any other waterbody (from the Latin word ripa, pertaining to the bank of a river, pond, or lake).

Riprap Rock material of varying size used to stabilize streambanks and other slopes.

Run A fast-moving section of a stream with a defined thalweg and little surface agitation.

Scouring The erosive removal of material from the stream bottom and banks.

Sedge A grasslike, fibrous-rooted herb with a triangular to round stem and leaves that are mostly three-ranked and with close sheaths; flowers are in spikes or spikelets, axillary to single bracts.

Substrate The mineral or organic material that forms the bed of the stream; the surface on which aquatic organisms live.

Surface fines That portion of streambed surface consisting of sand/silt (less than 6 mm).

Thalweg The line followed by the majority of the streamflow. The line connecting the lowest or deepest points along the streambed.

Turbidity Murkiness or cloudiness of water caused by particles, such as fine sediment (silts, clays) and algae.

Watershed A ridge of high land dividing two areas that are drained by different river systems. The land area draining to a waterbody or point in a river system; catchment area, drainage basin, drainage area.

Appendix A—1997 and 1998 Field Trial Results

Purpose and methods

The purpose of the field trials was to evaluate the accuracy, precision, and usability of the draft Steam Visual Assessment Protocol. The draft protocols evaluated were the third draft dated May 1997 and the fourth draft dated October 1997. A field trial workplan was developed with study guidelines and a survey form to solicit feedback from users. Accuracy was evaluated by comparison to other stream assessment methods. Precision was evaluated by replicate assessments conduced by different individuals at the same sites. In all studies an attempt was made to utilize sites ranging from high quality to degraded. Results consisted of the scoring data and the user feedback form for each site.

Results

Overall, 182 sites were assessed, and approximately 60 individuals participated in the field trials. The individual studies are summarized in table A–1.

Precision could be evaluated using data from the Colorado, New Jersey, Oregon, Virginia, and Georgia studies. Results are summarized in table A–2. The New Jersey sites had coefficients of variation of 9.0 (n=8), 14.4 (n=5), and 5.7 (n=4) percent. The Oregon site with three replicates was part of a course and had a coefficient of variation of 11.1 percent. One Georgia site was assessed using the fourth draft during a pilot of the training course. There were 11 replicates, and the coefficient of variation was 8.8 percent. In May 1998 the workgroup conducted replicate assessments of two sites in Virginia using the fifth draft of the protocol. Coefficients of variation were 14.7 and 3.6 percent. The average coefficient of variation of all studies in table A–2 is 10.5 percent.

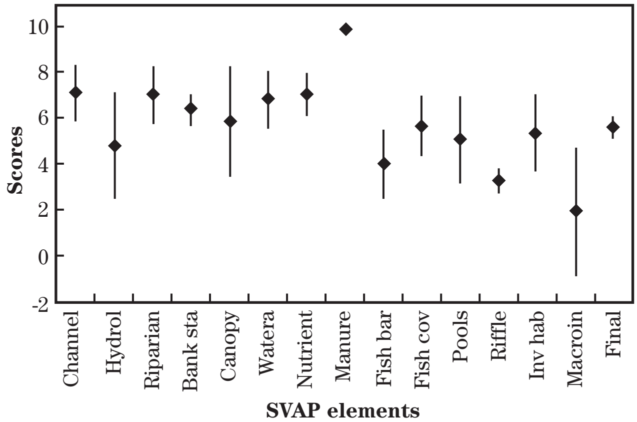
Variability within the individual elements of the SVAP was evaluated using the Georgia site with 11 replicates. The results of the individual element scores are presented in figure A–1. It should be noted that two individuals erroneously rated the "presence of manure" element.

Accuracy was evaluated by comparing the SVAP rating to other methods as noted in table A–1. Some of the comparisons involved professional judgment. In others the SVAP score could be compared with a quantitative evaluation. Figures A–2 through A–5 present data from the two studies that had larger numbers of sites. The Pearson's Correlation Coefficient is presented for these data. The results from other sites are presented in table A–3.

Table A–1 Summary of studies in the field trial

Location	Number of sites	Number of replicates	SVAP compared to	SVAP conducted by
VA	56	3, 5	IBI (fish) and Ohio QHEI	FO personnel
NC/SC	90	none	IBI, EPT	Soil scientists
MI	5	none	professional judgment	State biologist
NJ	3	4, 5, 8	NJDEP ratings	FO personnel
OR	3	none	IBI	NWCC scientist
CO	1	3	professional judgment	FO personnel
WA	3	none	professional judgment	State biologist
OR	2	3	no comparisons	FO personnel
GA	8	4-5	macroinvertebrates	FO personnel
GA	2	12, none	IBI, macroinvertebrate	FO personnel

Figure A–1 Means and standard deviations from the Parker's Mill Creek site in Americus, GA (n=11) (mean plus and minus one standard deviation is shown; SVAP version 4 used)



The SVAP version 3 scores correlated extremely well with the Ohio Qualitative Habitat Index and reasonably well with the fish community IBI in the Virginia study (fig. A–2 and A–3). However, the SVAP version 3 scores in the Carolinas study did not correlate well with either IBI or EPT Taxa (fig. A–4 and A–5). These results may reflect the fact that the SVAP primarily assesses physical habitat within the assessment reach whereas IBI and EPT Taxa are influenced by both physical habitat within the assessment reach and conditions within the watershed. Onsite physical habitat may have been a relatively more important factor at the Virginia sites than at the Carolina sites.

Overall, the field trial results for the third draft seemed to indicate that SVAP scores reflected conditions for sites in good to moderate condition. However, SVAP scores tended to be too high for poor quality sites.

Both the user questionnaires and verbal feedback indicated that users found the SVAP easy to use. Users reported that they thought it would be an effective tool to use with landowners. The majority indicated that they would recommend it to landowners.

Table A–2 Summary of replication results (version refers to the SVAP draft used; mean for overall score reported)

Site	SVAP version	No. replicates	Mean [1/]	Standard deviation	Coefficient of variation
Alloway Cr. NJ	3	5	3.6 F	0.52	14.4
Manasquan R. NJ	3	4	5.1 G	0.29	5.7
S. Br. Raritan R. NJ	3	8	5.9 G	0.53	9.0
Gales Cr. OR	3	3	5.5 G	0.61	11.1
Clear Cr. CO	3	3	5.4 G	0.74	13.7
Piscola Cr. GA #1	4	5	9.2 E	0.77	8.4
Piscola Cr. GA #2	4	5	9.0 E	0.85	9.4
Piscola Cr. GA #3	4	4	4.7 F	1.10	23.4
Piscola Cr. GA #4	4	4	7.4 G	0.96	13.0
Little R. GA # 1	4	4	8.3 E	0.73	8.8
Little R. GA # 2	4	4	7.4 E	0.83	11.2
Little R. GA # 3	4	4	8.1 E	0.41	5.1
Little R. GA # 4	4	4	7.3 G	0.60	8.2
Parker's Mill Cr. GA	4	11	5.7 F	0.50	8.8
Cedar Run (up), VA	5	5	7.7 G	1.1	14.7
Cedar R. (down), VA	5	5	6.6 F	.2	3.6

1/ Includes SVAP narrative ratings (P = poor, F = fair, G = good, E = excellent)

Table A–3 Accuracy comparison data from studies with too few sites to determine a correlation coefficient

Site	SVAP version	SVAP score and rating	Comparative rating	Comparative method
Alloway Cr. NJ	3	3.6* — fair	12 — mod. impaired	NJIS (macro.)
Manasquan R. NJ	3	5.1* — good	12 — mod. impaired	NJIS (macro.)
S. Br. Raritan R. NJ	3	5.9* — good	30 — not impaired	NJIS (macro.)
Site 1 OR	3	2.7 — fair	12 — very poor	IBI (fish)
Site 2 OR	3	4.6 — good	22 — poor	IBI (fish)
Site 3 OR	3	7.0 — excellent	44 — good	IBI (fish)
Muckalee Cr. GA	4	8.6 — good	good to excellent	mussel taxa

* Mean value of replicates

Figure A–2 Correlation between SVAP and IBI values in the Virginia study (n=56)

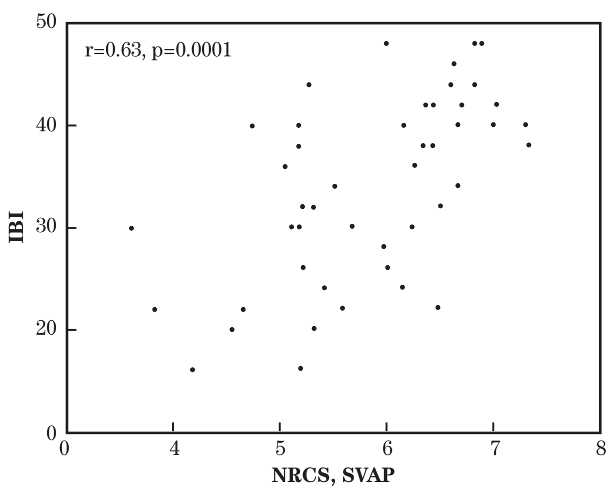


Figure A–3 Correlation between SVAP and Ohio Qualitative Habitat Evaluation Index values in the Virginia study (n=56)

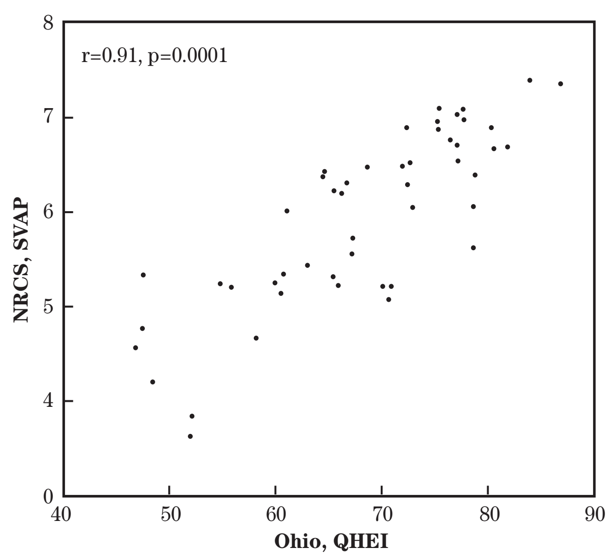


Figure A–4 Correlation between SVAP and IBI values in the Carolinas study (n=90)

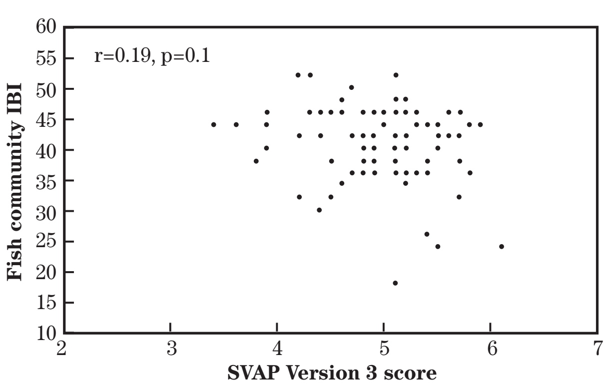
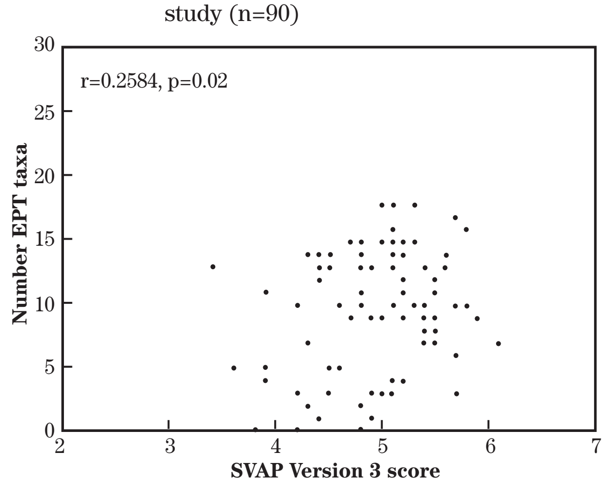


Figure A–5 Correlation between SVAP and macroinverte-brate index values in Carolinas study (n=90)



Discussion

Overall, the workgroup concluded from the first field trial that the SVAP could be used by conservationists in the field with reasonable reproducibility and a level of accuracy commensurate with its objective of providing a basic assessment of ecological condition provided the poor response to degraded streams could be corrected.

Several potential causes for the lack of accuracy with degraded sites were identified by the workgroup as follows:

- Because the overall score is an average of all assessed elements, the effect of low scoring elements can be damped out by averaging if the degradation is not picked up by many of the other assessed elements.
- Some of the elements needed to be adjusted to give lower scores for problems.
- The numerical breakpoints for the narrative ratings of poor/fair and fair/good were set too low.

To correct these problems the number of assessment elements was reduced and the instructions were modified so that certain elements are not scored if they do not apply. For example, the "presence of manure" element is not scored unless there are animal operations present. These changes reduced the potential for low scores to be damped out by the averaging process.

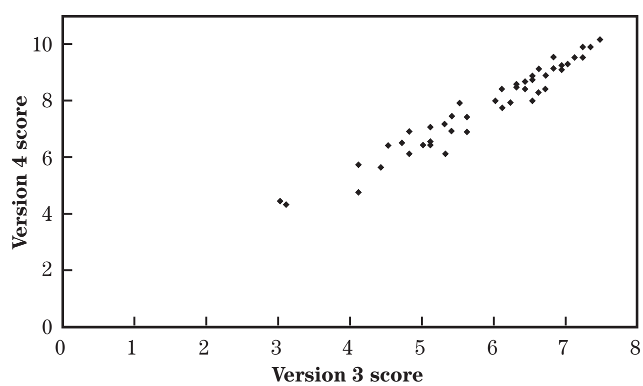
Several elements were also rewritten to reduce ambiguity at the low end of the rating scale. Additionally, several elements were rewritten to have five narrative descriptions instead of four to address a concern that users might err on the high side. The scoring scale was changed from a scale of 1 to 7 to a scale of 1 to 10 because it was felt that most people have a tendency to think in terms of a decimal scale.

The revisions were incorporated into a fourth draft and evaluated by the workgroup. Sites from the first field trial were rescored using the new draft. Response seemed to have improved as indicated by the greater separation of sites at lower scores in figure A–6.

During pilot testing of the training materials in March 1998, the fourth draft was used by 12 students independently at one site and collectively at another site. The coefficient of variation at the replication site was 8.8 percent. One of the sites had been previously assessed using other methods, and the SVAP rating corresponded well to the previous assessments.

After the evaluation of the fourth draft, minor revisions were made for the fifth draft. The breakpoints for the narrative rating of excellent, good, fair, and poor for the fifth draft were set using the Virginia data set. These breakpoints may be adjusted by the NRCS state office as explained in this document.

Figure A–6 Version 4 scores for VA plotted against version 3 scores (n=56)



Stream Visual Assessment Protocol

Owners name ___________________________________ Evaluator's name_______________________________ Date ________________

Stream name ____ Waterbody ID number ____________________________________

Reach location ____

____

Ecoregion ___________________________________ Drainage area _______________________ Gradient__________________________

Applicable reference site ____

Land use within drainage (%): row crop ______ hayland ______ grazing/pasture _______ forest ______ residential _______

confined animal feeding operations ______ Cons. Reserve ________ industrial _______ Other: _________________

Weather conditions-today _______________________________________ Past 2-5 days ____

Active channel width ______________________ Dominant substrate: boulder ______ gravel ______ sand ______ silt ______ mud ______

Site Diagram

Assessment Scores

Channel condition	☐	Pools	☐
Hydrologic alteration	☐	Invertebrate habitat	☐
Riparian zone	☐		
Bank stability	☐		
Water appearance	☐		
Nutrient enrichment	☐		
Barriers to fish movement	☐		
Instream fish cover	☐		

Score only if applicable

Canopy cover	☐
Manure presence	☐
Salinity	☐
Riffle embeddedness	☐
Marcroinvertebrates Observed (optional)	☐

Overall score
(Total divided by number scored) ___________

<6.0	**Poor**
6.1-7.4	**Fair**
7.5-8.9	**Good**
>9.0	**Excellent**

Suspected causes of observed problems____

____

____

____

Recommendations____

____

____

____

____

____

____

____

____

Exhibit I

Field Borders

Wildlife Job Sheet Insert — *386W*

Natural Resources Conservation Service (NRCS)—Illinois — ***July 2001***

Field border
Photo courtesy of USDA NRCS

Part I. Planning and Design Considerations

Applicability of Practice

Field borders can be created along field boundaries, ditch or waterway banks, terraces, contour strips, or pipeline areas. Frequent disturbance, such as vehicle traffic, turning farm equipment, mowing, or other farm activities, may limit the value of field borders for wildlife. Nonetheless, in Midwestern agricultural landscapes, field borders can provide a protective buffer between cultivated farmland and sensitive upland or aquatic habitats adjacent to farm fields. Undisturbed or infrequently disturbed field borders potentially provide habitat for feeding, nesting, and resting wildlife. Field borders also may serve as travel corridors that allow animals to move safely between habitats.

Site Considerations

- Landowner objectives (types of wildlife, intended use of the field border)
- Proximity to available water
- Adjacent cropland (irrigated or non-irrigated; type of crop)
- Soil qualities (texture, depth, moisture content)
- Connectivity to other wildlife habitats
- Plant hardiness zones
- Width and length of field border and ability to accommodate desired wildlife species
- Special wildlife needs (e.g., threatened or endangered species)

Design Considerations

Fish and wildlife design considerations in Midwestern agricultural landscapes include (1) frequency, timing, and nature of disturbance; (2) buffer width and length; (3) food value of plants; (4) plant selection to create diverse vertical and horizontal structure; (5) adjacent land uses; and (6) opportunities to link other wildlife habitats. If disturbance is frequent and pervasive, then opportunities to manage field borders for wildlife are greatly limited. Attention, therefore, should focus on those situations where disturbance is infrequent. As is true for all linear or strip habitats (e.g., fencerows, roadsides, or other buffer practices such as filter strips, windbreaks-shelterbelts, riparian forest buffers), wider buffers with mixtures of different plant types (e.g., grass and forb) will attract more species of wildlife than narrow buffers comprised of a single species. If the goal is to provide wildlife with secure travel corridors and year-round cover, then mixes of

Eastern cottontail

native grasses and forbs should be emphasized over introduced or cultivated species such as brome grass and alfalfa. Introduced plants generally do not stand up to adverse weather as well as natives, so their value as winter cover is reduced relative to native plantings. Nonetheless, mixes of wildlife-friendly introduced grasses and forbs may provide excellent nesting and brood-rearing cover for ground-nesting birds if stands are properly maintained. Note that aggressive introduced plants such as reed canarygrass and tall fescue adversely affect wildlife and should always be avoided when planning for wildlife. Refer to the table in Part II for determining plant species suitable to meet the wildlife objectives. Recommended widths of field borders used as travel corridors is 50 ft (20-ft minimum) and nesting or escape cover is 100 ft (40-ft minimum).

Maintenance Considerations

The amount of maintenance required and the method used to maintain field border vegetation depends on how the area is used by the landowner, wildlife or habitat goals, and types of vegetation established in the buffer. For example, maintenance requirements for borders planted in alfalfa hay will be different from plantings of native grasses and forbs. Within the above constraints, management should seek to maintain a non-uniform vegetative structure and minimize disturbance to wildlife especially during the reproductive period. Timing of maintenance is particularly critical if ground-nesting birds are using the field border. Disturbances necessary for maintaining vegetation or buffer function such as light disking, mowing, selective herbicide treatment, or grazing should be delayed until after August 1. Native plantings should be burned approximately every three years; treating one-third of the area each year is preferable to treating the entire area in the same year. Regarding timing of burns, fall burns eliminate winter cover, so burning in spring before the onset of nesting (May 1) is commonly recommended for resident wildlife such as ring-necked pheasant. Fall or winter burning is recommended to maintain the forb component of buffers and enhance their value for pollinators (e.g., butterflies) and young birds. **(Note: Before conducting a prescribed burn, have a qualified professional develop a prescribed burning plan for your area.)** Mowing at night causes high mortality of wildlife (adults and young) and should be avoided at all times. Maintenance schedule of field borders may need to be adjusted to take into consideration activities occurring on adjacent areas. For example, if nests of ground-nesting birds are disturbed in nearby fields (e.g., pastureland or hayland), then displaced birds may attempt to renest in field borders. Delaying treatments beyond conventional dates may be necessary to accommodate these late nesting birds.

Part II. List of Recommended Plants

Native Grasses

Common Name	Scientific Name	Rooting Habit	Site Suitability[1]
Big bluestem	*Andropogon gerardi*	Bunch	D–WM
Blue joint grass	*Calamagrostis canadensis*	Sod	WM–W
Canada wildrye	*Elymus canadensis*	Bunch	DM–WM
Eastern gamagrass	*Tripsacum dactyloides*	Bunch	DM–WM
Indiangrass	*Sorghastrum nutans*	Bunch	D–WM
Little bluestem	*Schizachyrium scoparium*	Bunch	D–M
Prairie cordgrass	*Spartinia pectinata*	Sod	M–W
Prairie dropseed	*Sporobolus heterolepis*	Bunch	D–W
Sideoats grama	*Bouteloua curtipendula*	Sod	D–DM
Switchgrass	*Panicum virgatum*	Sod	D–WM
Virginia wildrye	*Elymus virginicus*	Bunch	WM–W
Western wheatgrass	*Agropyron smithii*	Sod	DM–WM

—Continued

Part II. List of Recommended Plants (continued)

Native Forbs

Common Name	Scientific Name	Site Suitability[1]
Black-eyed Susan	*Rudbeckia hirta*	D–WM
Butterfly milkweed	*Asclepias tuberosa*	DM–M
Cardinal flower	*Lobelia cardinalis*	WM–W
Common spiderwort	*Tradescantia ohiensis*	D–M
Compass plant	*Silphium laciniatum*	DM–M
Cream wild indigo	*Baptisia bracteata leucophaea*	D–M
Culver's root	*Veronicastrum virginicum*	M–W
False indigo	*Baptisia leucophaea*	DM–M
False sunflower	*Heliopsis helianthoides*	M
Gray-headed coneflower	*Ratibida pinnata*	D–WM
Great blue lobelia	*Lobelia siphilitica*	W
Hoary vervain	*Verbena stricta*	D–DM
Illinois bundleflower	*Desmanthus illinoensis*	DM–M
Illinois tick trefoil	*Desmodium illionoense*	D–M
Lead plant	*Amorpha canescens*	D–M
New England aster	*Aster novae-angliae*	M–WM
Pale beard tongue	*Penstemon pallidus*	D–DM
Pale purple coneflower	*Echinacea pallida*	M
Partridge Pea	*Chamaecrista fasciculata*	DM–M
Prairie blazing star	*Liatris pycnostachya*	DM–WM
Prairie dock	*Silphium terebinthinaceum*	M
Purple prairie clover	*Dalea purpureum*	D–M
Rattlesnake master	*Eryngium yuccifolium*	DM–M
Round-headed bush clover	*Lespedeza capitata*	D–M
Showy tick trefoil	*Desmodium canadense*	M-WM
Spotted Joe-Pye weed	*Eupatorium maculatum*	W
Stiff goldenrod	*Solidago rigida*	D–M
Swamp milkweed	*Asclepias incarnata*	W
Tall tickseed	*Coreopsis tripteris*	M–WM
White wild indigo	*Baptisia alba macrophylla*	DM–WM
White prairie clover	*Dalea candida*	DM–M
Wild bergamont bee balm	*Monarda fistulosa*	D–M
Wild quinine	*Parthenium integrifolium*	DM–WM

—Continued

Part II. List of Recommended Plants (continued)

Non-native Grasses Species Common Name	Rooting Habit	Site Suitability[2]
Smooth bromegrass	Sod	D,WD
Kentucky bluegrass	Sod	WD,PD
Orchardgrass	Bunch	D,WD
Timothy	Bunch	WD,PD
Red top	Sod	WD,PD
Perennial ryegrass	Bunch	WD,PD

Non-native Legume Species Common Name		
Alfalfa		D,WD
Red clover		D,WD
Birdsfoot trefoil		WD,PD
Ladino clover		WD,PD
Alsike clover		WD,PD
Annual lespedeza[3]		D,WD

[1]Site Suitability: D = Dry, DM = Dry Mesic, M = Mesic, WM = Wet Mesic, W = Wet.

[2]Site Suitability: D = Droughty, WD = Well Drained, PD = Poorly Drained.

[3]Annual lespedezas are limited to Illinois NRCS Plant Suitability Zones 2 and 3 only. Common Korean and Summit are recommended varieties of Korean lespedeza. Kobe and Marion are recommended varieties of common (striate) lespedeza.

Part III. Specifications Sheet

Use Specification Sheet provided with general Field Borders Job Sheet. Include wildlife species desired and maintenance specifications relevant to this species or assemblage of species.

Exhibit J

Wildlife Habitat in Field Borders (Supplement to Job Sheet 386)

USDA – NATURAL RESOURCES CONSERVATION SERVICE – NORTH CAROLINA

Photo courtesy of Melissa McGaw, North Carolina Wildlife Resources Commission.

Photo courtesy of USDA Natural Resources Conservation Service.

Field borders can be developed to create valuable cover and food resources for wildlife that inhabit grassy and brushy habitats, such as bobwhite quail, gray fox, indigo buntings, and box turtles. Well-managed field borders may also provide foraging opportunities for typical forest wildlife, such as raccoons, whitetail deer and wild turkey. This job sheet will help you design a field border that provides optimum wildlife habitat.

The importance of properly managed field borders to wildlife include:

- ♦ The diversity of plants in a well-managed field border will increase the availability of food resources such as seeds and insect prey (important for many wildlife species, e.g., during the first few weeks of life, the diet of species like quail and turkey chicks is composed almost entirely of insects).
- ♦ Field borders provide links between forests and fields around the farm, expanding the amount of useable wildlife habitat.
- ♦ Field borders provide critical winter and nesting cover for a variety of grassland wildlife.

Field Border Establishment

- ♦ Recommended field border width is at least 20 feet. Where a field border for wildlife will be used as an equipment turn-row, the field border width should be sufficient to allow a minimum of 20 feet of undisturbed habitat.
- ♦ For wildlife habitat purposes, the ideal field border will appear unkempt and be composed of a variety of plant species.
- ♦ A field border managed for wildlife will attain a height of 3-6 feet. It should be comprised of planted species, for example, switchgrass and shrub lespedeza, as well as volunteer vegetation such as beggarlice, goldenrod, and ragweed (See attached table of Suggested Wildlife Field Border Mixtures).
- ♦ Existing cropland can be converted to a field border for wildlife by establishing desired vegetation (See attached table of Suggested Wildlife Field Border Mixtures).
- ♦ Field borders can be widened and enhanced for wildlife by cutting woodland edges back to encourage low growing food and cover plant species.

October, 1999

- The Southeast Quail Study Group recommends the following for replacing tall fescue with wildlife plantings:
  Step 1: Mow, graze, or preferably burn the fescue in late winter for a spring treatment or late summer for a fall treatment.
  Step 2: Allow the fescue to green-up to a height of at least six inches.
  Step 3: Spray the field with one or two quarts per acre of glyphosate (Roundup^Tm) or 3 WSP (water soluble packets) of Plateau^Tm, 6-7 ounces of surfactant, and ten gallons of water per acre. Always check the product label to insure that the mixture used is adequate for the situation in which this herbicide will be used. In spring treatments wait two weeks after the initial spraying. If there is still green fescue, spot spray the problem areas. For fall treatments, spray during fall green-up then wait until the next spring and spot spray if needed.
  Step 4: After a good kill is achieved, establish wildlife-friendly vegetation.

To get the most wildlife benefits out of a field border, consider the following management practices:

- Periodic disturbance of field borders is necessary to stimulate growth of desirable vegetation and to eliminate encroachment of woody vegetation.
- As a rule of thumb, disturbance should occur within a field border every 3-5 years. However, if visual observation suggests more or less frequent disturbance activity is required, then adapt the schedule accordingly.
- Although disturbance is necessary, not more than 50% of all field border habitat should be disturbed in any one year. In addition, never disturb all of the field border habitat around a single field in the same year.
- Prescribed fire and light disking are preferred management tools.

Field Border Management for Wildlife

METHOD	TIMING	NOTES
Prescribed Burning	1 February through 15 April	burn prior to spring green-up; insure firebreaks are properly installed to contain fire
Light disking	1 February through 1 April	use disking to chop woody vegetation and lightly scarify the soil surface; leave a minimum of 30% residue
Weed Sweep^Tm herbicide appl.	15 April through 15 June	select herbicide to control target species and follow label directions for environmental concerns
Spot spray herbicide	15 April through 15 June	select herbicide to control target species and follow label directions for environmental concerns
Mowing	15 September through 1 April	mowing should be done after August to avoid quail nests, rabbits, turkeys and other ground nesting wildlife; mow to maintain $\geq$12 inches of cover, 18 inches preferred

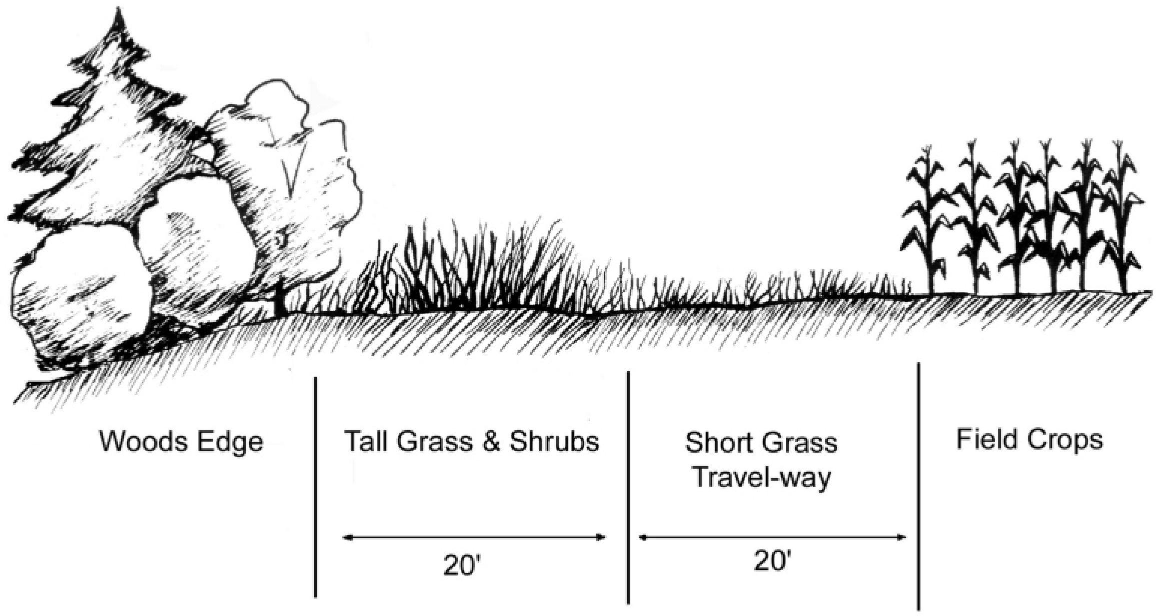
October, 1999

SUGGESTED FIELD BORDER MIXTURES BENEFICIAL TO WILDLIFE

PLANTING DATE	MIXTURE/RATE
1) 15 September thru 1 November..............	Small grain planting allowed to develop into native vegetation
2) 15 September thru 1 November..............	Small grain/switchgrass mix (40 lbs. wheat or rye, 5 lbs. switchgrass)
3) Fall/Spring..	Small grain planting overseeded with Kobe or Korean lespedeza
4) January thru-April....................................	10 lbs. Kobe, 5 lbs. partridge pea, 40 lbs. wheat or rye, 4 lbs. little bluestem
5) May thru August..	5 lbs. browntop millet, 5 lbs. Kobe, 3 lbs. 'Atlantic' Coastal panic grass, 3 lbs. switchgrass, 3 lbs. little bluestem
6) September thru December........................	40 lbs. wheat or rye, 5 lbs. switchgrass, 2 lbs. Ladino clover
7) Early Summer..	Switchgrass - 7 lbs. drilled, 9 lbs. broadcast
8) Early Summer..	'Atlantic' Coastal panic grass - 10 lbs. drilled or broadcast
9) Early Summer..	Eastern gamma grass - 8 lbs. drilled only
10) May...	5 lbs. switchgrass, 4 lbs. Atlantic' Coastal panic grass, 3 lbs. Kobe/Korean Lespedeza
11) Late February thru mid-April.................	3 lbs. reseeding soybeans, 5 lbs. Kobe/Korean lespedeza, 5 lbs. red clover, 5 lbs. partridge pea
12) September-thru October.........................	18 lbs. Shilo orchardgrass, 40 lbs. wheat or rye, 3 lbs. Ladino clover, 5 lbs. crimson clover
13) Sept.-Nov...	10 lbs. Kobe lesp., 40 lbs. wheat/rye/oats, 4 lbs. little bluestem, 3 lbs. innnoc. white clover, 3 lbs. unhulled shrub lespedeza, 2 lbs. orchard grass, 5 lbs. switchgrass
14) April-June..	15 lbs. browntop millet, 15 lbs. sudex, 5 lbs. Kobe lesp., 3 lbs. hulled shrub lesp., 3 lbs. 'Atlantic' coastal panic grass, 3 lbs. switchgrass, 3 lbs. Eastern gamma grass, indian grass, or big bluestem

October, 1999

Two Zone Field Border for Wildlife



Additional information is available from your local NRCS office, North Carolina Cooperative Extension Service, North Carolina Wildlife Resources Commission, and various conservation organizations.

This project was a cooperative effort of personnel from the USDA North Carolina Natural Resources Conservation Service, NRCS Watershed Science Institute, the North Carolina Wildlife Resources Commission, and the North Carolina State University Cooperative Extension Service. We gratefully acknowledge Dr. Virgil Kopf, Virginia Department of Game and Inland Fisheries, for facilitating the discussions that took place and eventually resulted in the production of this document.

October, 1999

Exhibit K

Texas Buffers for Wildlife

BUFFERS
COMMON-SENSE
CONSERVATION

United States
Department of
Agriculture

Natural Resources
Conservation Service

Temple, Texas

March 2000

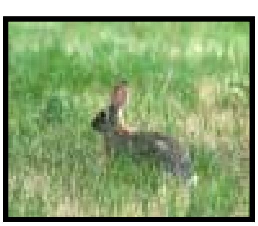
Field Borders

Conservation Buffer Job Sheet 386

DEFINITION
A field border is a band or strip of perennial vegetation established on the edge of a cropland field.

PURPOSE
This supplement to the national job sheet is designed to assist with integrating wildlife habitat prescriptions into planning field borders. A field border provides wildlife habitat; reduces sheet, rill, and gully erosion at the edge of fields; protects water quality by trapping sediment, chemicals and other pollutants; and provides a turning area for farm equipment. Field borders can provide a strip of habitat between two crop fields, or a transition zone between croplands and rangelands, between croplands and forestlands or between croplands and farmsteads or urban development.

The wildlife habitat components that can be provided by a field border include nesting cover, feeding cover, escape cover, travel corridors between habitats, and protection of aquatic habitat. Although species such as bobwhite quail, ring-necked pheasant and blue birds are typically considered users of grassy shrubby field borders, they also provide food and cover for many other species of wildlife native to Texas and migratory wildlife passing through. White-tailed deer, wild turkeys, and great horned owls occasionally use this habitat provided by a common agricultural conservation practice.



SITE CONSIDERATIONS
- Landowner objectives (specific types of wildlife or wildlife habitat integrated into non-wildlife purpose)
- Proximity to available water
- Adjacent landuse (type of crop, irrigated or non-irrigated, range, forest, grazed, etc)
- Soil characteristics (texture, depth, moisture, etc)
- Annual rainfall
- Plant hardiness zones
- Connection to other wildlife habitats

DESIGN CONSIDERATIONS

Alternatives can vary from simple, when creating habitat where wildlife is not the landowner's primary objective, to complex when managing field borders for specific wildlife such as bobwhite quail or migratory songbirds. The habitat contribution of a field border is determined by the vegetation selected, the width of the border, and the maintenance/management (light disking, prescribed burning, prescribed grazing, etc.) techniques selected. Typically a field border designed and managed with wildlife in mind will have an unkempt appearance with a variety of different plants.

Border Width

Additional width is important to minimize the destruction of nests by predators and to provide habitat that is not disturbed by turning equipment during the primary nesting and brood rearing season.

	Minimum	Optimum
Movement corridor	20 feet	50 feet
Nesting or escape cover	40 feet	100 feet

Vegetation

See the Texas supplement to conservation practice standard 645, Upland Wildlife Management and Plant Materials Fact Sheet for conservation practice standard 386, Field Border to select grasses, forbs, legumes, and shrubs that are beneficial to wildlife.

Simple Option

Plant a native clump grass and legume combination that is suited to the site conditions. On areas subject to erosion, a dead litter cover crop should be sown to protect the soil until the vegetation becomes established.

or

Allow border to grow up in native plants, if suitable species for targeted wildlife are available in the seed bank. When using this option, specific vegetation management will have to be planned in order to comply with the standard. On areas subject to erosion, a dead litter cover crop should be sown to protect the soil until the vegetation becomes established.

Complex Option

Plant a mixture of native clump grasses, forbs, and legumes that are suited to the site conditions. On areas subject to erosion, a dead litter cover crop should be sown to protect the soil until the vegetation becomes established. Depending on the wildlife objective, small group plantings of native shrubs, suited to the site, can add woody cover and/or food to field borders between crop fields or those providing a transition zone between crop fields and rangeland or crop fields and forest land. Leaving several rows of standing crops adjacent to the field border will enhance fall and winter food.

or

Allow border to grow up in native plants, if suitable species for targeted wildlife are available in the seed bank. When using this option, specific vegetation management will have to be planned in order to comply with the standard. On areas subject to erosion, a dead litter cover crop should be sown to protect the soil until the vegetation becomes established. As a supplement to natural establishment, develop plots, within the border, planted to a mixture of native clump grasses, forbs, and legumes. Native shrubs can be established by planting or protecting small groups that become established naturally.

Establishment specifications are as follows:

1. Seedbed preparation and seeding operations for grasses, legumes, and forbs may be accomplished by conventional (plowing, disking, chiseling) and/or no-till methods. Seedbed preparation for shrubs may be accomplished by disking, mowing or herbicide treatment. Planting of shrubs may be accomplished by machine or hand planting. Erosion control during the establishment period must be considered with any seeding operation.
2. Fertilizer and lime will be applied at recommended rates according to soil test results. All materials shall conform to established state specifications for agricultural applications. Nitrogen is usually not recommended during the first year of establishment of native grasses.
3. Field borders established with natural regeneration may be sown to a dead litter cover crop to protect soil as native vegetation becomes established on the fallowed area.
4. Certain (pesticides) herbicides and insecticides may be specified for application as needed to facilitate grass and legume establishment. When these pesticides are applied, the participant is responsible for assuring that all application rates and methods are consistent with label directions and that all required record keeping is maintained.

Maintenance/Management

In order to maximize wildlife benefits over the life of the practice, periodic management practices may need to be implemented. This can include cultural practices such as light disking, prescribed burning, mowing, re-seeding, prescribed grazing, and spot herbicide treatment. Management practices and implementation timing are generally dictated by local conditions, vegetation structure, and habitat conditions desired.

Maintenance/Management specifications are as follows:

1. To avoid interfering with nesting activities, light disking and/or mowing should not be performed between March 15 and July 15. Delaying mowing and/or light disking until after August 15 is recommended to further enhance wildlife habitat.
2. Mowing and/or light disking alone or in combination should be performed on no more than 1/3 of the field border in any year. When the disked areas are rotated, the previously disked strips should have sufficient vegetation to control erosion.
3. Mowing height should be no lower than 8 inches.
4. Disked areas shall have a minimum of 30 percent residue remaining on the soil after disking operations are complete.

5. Prescribed burning is a management option and should be limited to 1/3 of the field border in any year. The participant will be responsible for obtaining a Prescribed Burn Plan and adhering to all local and state laws applicable to open burning.
6. Prescribed grazing is a management option and should be accompanied by grazing management plan that provides the timing, duration and intensity necessary to promote the vegetation composition and structure most beneficial to wildlife and insures the primary purpose of the field border.

SPECIFICATIONS

Field Borders- Specification Sheet

Landowner ____ Field Number ______

Purpose (check all that apply)	
[] Wildlife	[] Trap sediment, nutrients, pesticides, & other contaminants
[] Stabilize field boundaries, turn rows, and headlands	[] Erosion Control
[] Provide protective turn row or equipment travel lane	[] Other (specify)

Field border layout (for exact location see job sketch)	**Field border 1**	**Field border 2**	**Field border 3**
Border width (ft)			
Border length along edge of field (ft)			
Area (ac)			
Slope (%)			
Species #1			
Species #2			
Species #3			
Seeding rate (PLS) (lb/acre)			
Seedling spacing (Shrub Planting)			
Lime (tons/acre)			
N (lb/acre)			
P2 O5 (lb/acre)			
K2O (lb/acre)			

Site preparation
Prepare firm seedbed. Apply lime and fertilizer according to recommendations.
Planting Methods
Drill grass and legume seed _______ inches deep uniformly over area. Establish stand of

vegetation according to recommended seeding rate. If necessary, mulch newly seeded area with _______ tons per acre of mulch material. May seed small grain as a companion crop at the rate of ______ pounds per acre, but clip or harvest before it heads out.
Maintenance
Maintain original width and depth of the grass area. Harvest, mow, reseed, and fertilize to maintain plant density, vigorous plant growth, and to remove plant nutrients. Inspect after major storms, remove trapped sediment, and repair any eroding areas. Shut off pesticide sprayers when turning on a field border.

Field Borders- Job Sketch

If needed, an aerial view of the field border layout can be shown below. Other relevant information, such as complementary practices, and adjacent field or tract conditions, the positioning of multiple or single row sets across a field or tract, and additional specifications may be included.

Scale 1"= _______ ft. (NA indicates sketch not to scale: grid size= 1/2" by 1/2")

Additional Specifications and Notes:

Exhibit L

Job Sheet for

Field Borders as Wildlife Habitat

(386, 645)

Purpose: **A field border** is a strip of *native herbaceous vegetation* established along the edges of crop fields to reduce invasion of woody plant succession, to provide natural wildlife food and cover. Additional benefits may be provided for farm machinery access, erosion control, and water quality.

Requirements:

- Minimum width 25 feet
  - Note: Width may be increased to compensate for field border irregularities and to facilitate row patterns
- Where erosion is a consideration, a temporary cover crop or native perennial species may be planted
  - Suggested temporary cover crops: Spring – browntop and proso millet; Fall – rye, oats, or wheat
    - Reseeding annuals — partridge pea, Kobe or Korean
    - lespedeza
  - Suggested native perennials: native warm-season grasses such as switchgrass, Indiangrass, little bluestem grass, Eastern gammagrass, or Atlantic Coast panicgrass

Maintenance:

- One third of the field borders should be disked each year in late February or early March
  - For example: a field border that is three disks wide would be maintained by disking an area one disk wide each year on a three year rotation
  - Note: supplementary wildlife plantings are not necessary, but would be allowed at the time of disking
- **DO NOT** disk, mow, or burn field borders between **April 1-September 1**

Primary Habitat Consideration:

- Nesting and brood-habitat for quail and various songbirds
- Natural food and cover for quail, rabbits, doves, and turkeys

Site Specific Comments and Recommendations:

USDA-NRCS Georgia
July 1999

Exhibit M

Field Borders for Utah Wildlife Job Sheet
(Supplement to Job Sheet 386)

Part I. Planning and Design Considerations

Applicability of practice*:* Field borders that consider habitat for terrestrial wildlife or protect aquatic habitat can be used to effectively link other habitats or provide a protective buffer in agricultural landscapes. They can be created along field boundaries, ditch or waterway banks, pipeline areas, any area suitable for attracting specific wildlife species.

Site considerations:
- Landowner objectives (types of wildlife, non-wildlife use of the field border that must be accommodated)
- Proximity to available water
- Adjacent landuse (irrigated or non-irrigated, type of crop, grazed, etc.)
- Soil qualities (texture, depth, moisture content)
- Connectivity to other wildlife habitats
- Plant hardiness zones
- Size of field border and ability to accommodate species needs

Design considerations*:* The type of vegetation, maintenance regime and width of the field border will vary depending on the wildlife species desired, the habitat components it will provide (such as food, cover, travel corridor, or access to water source), and the area required for farm equipment turn-around. Refer to the vegetation matrix for determining plant species suitable to meet wildlife objectives. In general, Utah agricultural landscapes suitable for this practice should strive for the following minimum widths for field borders:

Size of Border:

	Minimum	**Optimal**
Movement corridor	**20 feet**	**50 feet**
Nesting or escape cover	**40 feet**	**100 feet**

1

Additional design considerations can be obtained form publications such as “Establishing Food and Cover Plots”(Pheasants Forever 1993); NRCS Technical Notes or contacting the local Division of Wildlife Resources office or the NRCS Wildlife Biologist.

Maintenance considerations: The amount of maintenance required, and the method used to maintain the vegetation/habitat of the field border depends on the needs of the landowner (for example, turn-around area for equipment), and the type of wildlife use it is expected to provide. Timing of maintenance is particularly critical if ground-nesting birds are using the field border.

Maintenance: Delay mowing until after _____________
Burn after __________ or during ____________
Graze after ___________ (develop a grazing management plan)

Part II Vegetation Matrix

(Matrix under development by Utah State Office)

Part III. Evaluation Guidelines

Following can be utilized as a planning/evaluation tool. It calculates an index rating for the potential effect on wildlife habitat to compare proposed alternatives. It can be used for evaluating the success of the practice(s) when used several years after establishment.

EVALUATION MATRIX

	Present	W/Plan	+ years	+ years
Index of Plant Rating (Sum plant ratings/# of plants)				
Diversity index				
Interspersion Index				
Target species (method used:)				
Other				

Instructions:

A. Index of plant rating is calculated by taking the sum of the plant rating numbers and dividing by the number of plants. This represents the overall rating of the plant community to benefit wildlife.

B. The diversity index (DI) is a numerical representation of the value of an area to wildlife based on the change of plant communities within the area. The numerical value is derived by measuring the linear distance of the edge and dividing it by the number of square feet in the area evaluated. Count only edge changes where the strip of vegetation is >10 ft. wide. The following is the formula used to generate the DI:

$$DI = \frac{E}{2\sqrt{A \times \Pi}}$$ (2 X (sq. root of area X Pi)

Where-

E = Edge (total length in feet) estimated from aerial photos or field observation for the area being evaluated.

A = Area (approx.) expressed in square ft.

Π = 3.14

C. Interspersion index: To measure the amount of interspersion of an area count the number of times the habitat or vegetation types change using the following procedure:

1. Obtain an aerial photograph.
2. Count the number of changes along an imaginary north-south line that it drawn across the widest part of the area.
3. Count the number of changes along an imaginary east-west line that it drawn across the widest part of the area.
4. By counting the number of times the lines intersect different habitat or vegetation types and then summing the numbers, you will get an interspersion index value for the area. This value then can be compared over the life of the project or to other sites to determine which sites might be better for the desired wildlife species. The comparisons must be made using the same size areas and map scales. The higher the value, the better for many resident wildlife species and migratory species that establish seasonal territories.

D. Target species: These are species the habitat is designed to benefit. There are several methods (use only one method) to choose from to measure this parameter:

1. Presence or absence of the target species
2. A relative change in abundance (example: A 50 % increase in occurrence)
3. Species-specific model(s) (if available) could be used for evaluation.
   NRCS currently has models for the yellow-headed blackbird, muskrat, ferruginous hawk, mule deer and pheasant. USFWS has many models available.

Part IV. Specifications Sheet

Use specification sheet provided with Field Borders Conservation Practice Job Sheet. Include wildlife species desired, and maintenance specifications relevant to the species or assemblage of species. Specification sheet can be obtained from the local NRCS office or can be accessed on the Internet at: ftp://ftp.ftw.nrcs.usda.gov/pub/nhcp/jobsheet/386js.pdf. Other specification sheets can be used at the planner's discretion.

Appendix: Utah Buffer Job Sheets

1. PLANTS THAT PROVIDE HABITAT FOR UTAH BIRDS

SPECIES	VALUE	NESTING	FOOD	HEIGHT
GRASS - GRASSLIKE plants provide ground cover, food, cover near ground for nesting.				
Bluegrass, Big	Good	Yes	Yes	1-3’
Canarygrass	Fair	----	Yes	1-6’
Fescue, Hard	Fair	Yes	Yes	.5-2’
Fescue, Idaho	Fair	Yes	Yes	1-3’
Fescue, Sheep	Fair	Yes	Yes	.5-2’
Millet, Foxtail	Good	----	Yes	1-2’
Millet, Japanese	Good	----	Yes	1-3’
Orchardgrass	Fair	Yes	Yes	1-4’
Ricegrass, Indian	Good	Yes	Yes	.5-2’
Wheatgrass, Bluebunch	Fair	Yes	----	1-2’
Wheatgrass, Intermediate	Fair	Yes	----	2-4’
Wheatgrass, Tall	Fair	Yes	----	2-8’
Wildrye, Altai	Good	Yes	----	2-5’
Wildrye, Basin	Good	Yes	----	3-6’
Wildrye, Blue	Good	Yes	----	2-5’
Wildrye, Russian	Fair	Yes	----	1-2’
FORBS - FLOWERS provide ground cover and a food supply.				
Aster	Fair	----	Yes	1-3’
Buckwheat	Fair	----	Yes	1-2’
Burnet, Small	Good	Yes	Yes	1-3’
Clover species	Good	----	Yes	.5-3’
Columbine	Fair	----	Yes	1-4’
Coral Bells	Fair	----	Yes	1-2’
Coreopsis	Fair	----	Yes	1-3’
Cornflower	Fair	----	Yes	1-2’
Cosmos	Fair	----	Yes	1-3’
Dahlia	Fair	----	Yes	1-5’
Doveweed	Fair	----	Yes	1-6’
Flax, Blue	Fair	----	Yes	1-2’
Filaree	Fair	----	Yes	.5-2’
Hollyhock	Fair	----	Yes	3-8’
Lupine	Fair	----	Yes	1-3’
Marigold	Fair	----	Yes	1-4’
Petunia	Fair	----	Yes	.5-2’
Phlox	Fair	----	Yes	.5-1’
Pinks	Fair	----	Yes	1-2’
Poker Plant	Fair	----	Yes	2-5’
Primrose	Fair	----	Yes	1-6’
Salvia	Fair	----	Yes	1-2’
Sunflower	Fair	----	Yes	1-8’
Zinnia	Fair	----	Yes	1-2’

SPECIES	VALUE	NESTING	FOOD	HEIGHT
WET AREAS plants				
Bulrush, Alkali	Good	Yes	Yes	2-5’
Bulrush, Hardstem	Good	Yes	Yes	6-10’
Bulrush Threesquare	Good	Yes	Yes	1-3’
Cattail	Fair	Yes	----	6-10’
Pondlily	Fair	----	Yes	Floating
Pondweed	Fair	----	Yes	1-3’
Rush, Baltic	Fair	----	Yes	1-3’
Sedge, Beaked	Fair	----	Yes	1-4’
Sedge, Nebraska	Fair	----	Yes	1-3’
Sedge, Water	Fair	----	Yes	1-3’
Smartweed	Good	----	Yes	1-5’
Spikerush, Creeping	Good	----	Yes	1-3’
Watercress	Fair	----	Yes	.5-1’
Wildrice	Good	Yes	Yes	3-10’
LOW SHRUBS, and VINES provide nesting sites, food, and cover near ground.				
Bearberry	Good	Yes	Yes	1-3’
Huckleberry	Exc.	Yes	Yes	1-6’
Juniper, Horizontal	Fair	----	Yes	1-6’
Orgegon Grape	Fair	----	Yes	1-4’
Sagebrush, Black	Fair	----	Yes	1-3’
Thicket Creeper	Good	Yes	Yes	Vine
Thrumpet Vine	Good	----	Yes	Vine
Virginia Creeper	Good	Yes	Yes	Vine
Winterfat	Fair	----	Yes	1-3’
SHRUBS provide nesting sites, food, and cover near ground.				
Blackberry	Good	Yes	Yes	3-10’
Bitterbrush	Good	----	Yes	3-8’
Buffaloberry	Good	Yes	Yes	5-15’
Caragana	Good	Yes	Yes	10-25’
Cherry Mongolian	Good	Yes	Yes	3-6’
Cherry Nanking	Good	Yes	Yes	6-10’
Chockcherry	Exc.	Yes	Yes	10-25’
Cotoneaster	Fair	----	Yes	8-12’
Currant, Golden	Exc.	Yes	Yes	5-10’
Dogwood	Exc.	Yes	Yes	7-15’
Elderberry	Good	----	Yes	8-15’
Honeysuckle	Good	Yes	Yes	6-15’
Lilac	Fair	Yes	----	10-20’
Mockorange	Fair	Yes	----	6-8’
Plum	Good	Yes	----	5-10’
Pyracantha	Good	Yes	Yes	5-15’
Quince	Fair	----	Yes	5-10’
Rose, Woods	Good	Yes	Yes	2-6’

Field Border

SPECIES	VALUE	NESTING	FOOD	HEIGHT
Sagebrush, Basin	Good	Yes	Yes	3-8’
Sagebrush, Wyoming	Good	Yes	Yes	2-5’
Saltbush, Fourwing	Fair	----	Yes	3-8’
Sandcherry	Good	Yes	Yes	3-6’
Serviceberry	Good	Yes	Yes	5-15’
Silverberry	Good	Yes	Yes	4-9’
Shrubby Cinquefoil	Fair	Yes	----	3-4’
Snowberry	Exc.	Yes	Yes	2-6’
Spirea	Good	Yes	Yes	4-8’
Sumac, Fragrant	Good	Yes	----	3-9’
Sumac, Skunkbush	Exc.	Yes	Yes	3-9’
Sumac, Smooth	Good	Yes	----	5-15’
Sumac, Staghorn	Good	Yes	----	10-15’
Vibrurnum	Good	----	Yes	6-14’

SMALL TREES provide nesting and foraging sites, food, canopy and habitat structure.

Apple	Good	Yes	Yes	15-30’
Apricot	Fair	Yes	Yes	10-15’
Black Cherry	Exc.	Yes	Yes	15-30’
Chockcherry, Amur	Good	Yes	Yes	15-25’
Crabapple	Exc.	Yes	Yes	10-30’
Hawthorn	Good	Yes	Yes	10-25’
Maple, Amur	Fair	Yes	----	15-25’
Maple, Tatarian	Fair	Yes	----	15-25’
Mountain Ash	Fair	----	Yes	20-30’
Mulberry	Fair	Yes	Yes	15-30’
Pear, Harbin	Fair	----	Yes	15-30’
Russian Olive	Exc.	Yes	Yes	15-30’

MEDIUM TO TALL TREES provide nesting and foraging sites, food, canopy and habitat.

Alder	Good	Yes	Yes	30-60’
Ash, Green	Fair	Yes	Yes	30-60’
Aspen, Quaking	Fair	----	Yes	25-60’
Birch	Fair	----	Yes	30-60’
Boxelder	Fair	----	Yes	30-60’
Cottonwood	Fair	----	Yes	40-120’
Elm	Good	----	Yes	25-65’
Hackberry	Exc.	Yes	Yes	30-60’
Locust, Black	Fair	----	Yes	30-60’
Locust, Honey	Fair	----	Yes	30-50’
Maple	Good	Yes	Yes	30-65’
Oak, Bur	Exc.	Yes	Yes	40-70’
Oak, Mongolian	Exc.	Yes	Yes	30-50’
Poplar species	Fair	----	Yes	40-60’
Walnut, Black	Good	Yes	Yes	30-60’
Willow, Golden	Good	Yes	Yes	30-60’
Willow, Laurel	Good	Yes	Yes	25-40’
Willow, Pacific	Good	Yes	Yes	25-40’

SPECIES	VALUE	NESTING	FOOD	HEIGHT
CONIFERS provide excellent winter cover, food and nesting sites				
Arborvitae	Good	Yes	Yes	10-40’
Douglas Fir	Fair	Yes	Yes	25-70’
Eastern Redcedar	Exc.	Yes	Yes	25-50’
Juniper, Rocky Mtn.	Exc.	Yes	Yes	20-40’
Pine, Mugo	Fair	Yes	----	5-20’
Pine, Ponderosa	Exc.	Yes	Yes	30-70’
Pine, Austrian	Good	Yes	Yes	25-50’
Pine, Scotch	Fair	Yes	----	25-50’
Spruce	Good	Yes	----	30-80’

2. REFERENCES AVAILABLE THROUGH UTAH STATE OFFICE

1951. Martin, A. C., Zim, H.S., and Nelson, A.L. American Wildlife and Plants: A Guide to Wildlife Food Habits. A wildlife classic that ranks plants according to their value for groups of wildlife (e.g., water birds, song birds). Plants are listed by common name.

1982. Plant Use Guide for Wildlife. Soil Conservation Service. Somewhat dated information about suppliers, wildlife species utilization of common plants, and site characteristics. May be especially useful for windbreaks and field borders.

1993. Mule Deer Habitat Suitability Model. Soil Conservation Service. Unpublished draft HSM, but has extensive plant list (both scientific and common names) for mule deer.

1996. Krausman, P.R. (editor). Rangeland Wildlife. Relatively up-to-date reference, mostly for upland wildlife.

3. USEFUL WEBSITES

http://www.nr.state.ut.us/dwr/notebook.htm

http://www.utahcdc.usu.edu/ucdc

http://www.ms.nrcs.usda.gov/whmi/technotes.htm

USEFUL WEBSITES (continued)

http://www.wcc.nrcs.usda.gov/watershed/products.html

http://plants.usda.gov/plants/index.html

http://waterhome.brc.tamus.edu/NRCSdata/models/rangecal/

http://Plant-Materials.nrcs.usda.gov/

This project was a cooperative effort of personnel from the USDA Utah Natural Resources Conservation Service (NRCS), NRCS Wildlife Habitat Management Institute, the Utah Division of Wildlife Resources, the US Fish and Wildlife Service, and Utah State University Cooperative Extension Service. We gratefully acknowledge the help of Dr. Alan Clark, Utah DWR, in facilitating the discussions that resulted in the production of this document.

Additional information is available from your local NRCS office, Utah State Cooperative Extension Service, Utah Division of Wildlife Resources, and various conservation organizations.

Conservation Buffers for Wildlife
Maryland Planning and Design Guidelines

Field Border

Supplement to NRCS Job Sheet 386

C. Rewa

DEFINITION

A strip of permanent vegetation established at the edge or around the perimeter of a field.

PURPOSE

While field borders are frequently used to serve as turn-rows and travel-ways for farm equipment, they also provide a number of conservation functions. Field borders are effective for providing wildlife cover and food, reducing erosion from wind and water, protecting soil and water quality, and managing harmful insect populations. Field borders are particularly useful for maximizing the quality of wildlife habitat in agricultural settings.

The purpose of these planning and design guidelines is to assist conservation planners to integrate wildlife considerations into the establishment and maintenance of field borders. Therefore, these guidelines focus on using field borders to provide wildlife habitat. Many of the concepts presented here can also be applied to other conservation buffer practices as well.

Unlike filter strips and riparian buffers that are typically used on the down-slope side of fields, field borders are generally herbaceous, non-crop buffers that can be used anywhere along the entire field margin to remove low-producing areas from production and provide wildlife habitat. Field borders are a buffer practice that can substantially increase wildlife habitat while minimally affecting farm profitability.

WHERE USED

Edges of agricultural fields and other open areas.

REQUIREMENTS

The minimum field border width to meet the Maryland practice standard is 10 feet. Field borders that are at least 20 feet wide provide room for turn-rows needed for most field equipment. However, wildlife habitat potential can be greatly improved by increasing field border width to meet specific wildlife habitat objectives (see Table 1).

- Select plant species that are native, or are naturalized and non-invasive. Choose species that will maximize wildlife habitat values while providing for erosion control, aesthetics, and other objectives for the site.
- Establish vegetative cover by using appropriate site preparation and planting techniques to ensure survival and growth of the selected species.
- Manage vegetative cover by using appropriate methods and timing to maximize wildlife habitat values.

Table 1. Optimum border widths for wildlife habitat.

Type of Wildlife Desired	Optimum Field Border Width
Butterflies and other beneficial insects	35 feet or more
Small mammals, reptiles and amphibians	50 feet or more
Upland game birds and mammals	100 feet or more
Grassland songbirds	150 feet or more

Specific cost-sharing programs or other funding sources may impose additional establishment and maintenance requirements for field borders. Refer to the applicable program manuals, handbooks, and job sheets for details.

RESOURCE MANAGEMENT SYSTEMS

Field borders are most effective when they are used in combination with other agronomic or structural practices. Whenever possible, field borders should be integrated components of resource management systems that address the soil, water, air, plant, and animal needs and the client's objectives on the planning unit. For example, if gully erosion or other soil erosion problems are identified during the planning process, these problems should be treated by implementing appropriate conservation practices before or in conjunction with establishing field borders. To maintain proper functioning of field borders, excessive erosion must be controlled up-slope of the border, and field border vegetation should be protected from disturbance during the primary nesting season (April 15 to August 15) to the extent possible.

WILDLIFE CONSIDERATIONS

Alternatives can vary from those that are simple, in order to provide habitat when wildlife is not the client's primary objective, to complex, when managing field borders for specific wildlife such as bobwhite quail or migratory songbirds. The habitat contribution of a field border is determined by the vegetation selected, the width of the border, and the maintenance/management techniques that will be used (such as light disking, prescribed burning, prescribed grazing, etc.). Typically, a field border that is designed and managed with wildlife in mind will have an unkempt appearance with a variety of different plant species and growth forms.

Mississippi Cooperative Extension Service

Figure 1. Bobwhite quail.

Consider the following factors when planning field borders for maximum wildlife utility:

1. Composition of vegetation.

Like other conservation buffer practices, field borders support wildlife populations on agricultural landscapes by providing physical habitat structure. This habitat supports the food and cover needs of many species within the field border itself, and also serves as a travel corridor through which individuals disperse and migrate. Maximizing the diversity of native grasses, forbs and legumes increases the availability of wildlife foods in the form of green forage, seeds, fruits, and insects.

The composition of plant species in field borders is a critical element in determining the quality of wildlife habitat provided. In many instances, natural regeneration of field borders provides a diversity of grasses and forbs. Table 2 (see page 6) provides a selected list of common plants that are known to provide wildlife food and cover.

Diversity in both vertical and horizontal structure increases wildlife species diversity. Field borders should be established and maintained to maximize vertical and horizontal structure to the extent possible, as illustrated below in Figure 2.

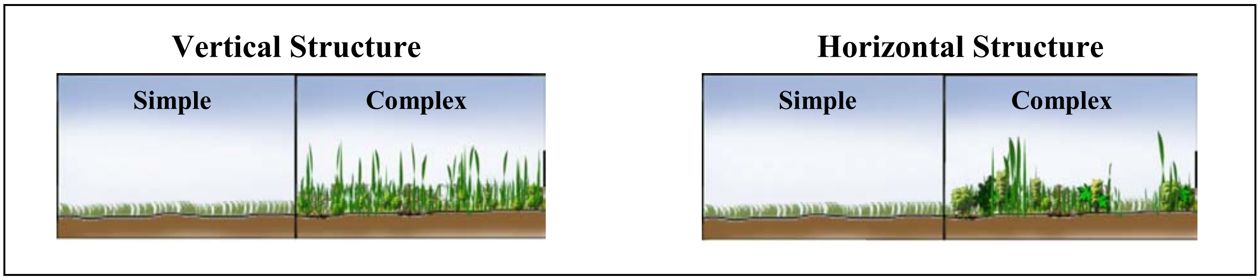


Figure 2. Structural diversity of vegetation.

Vertical structure refers to the "layers" of different plant forms and sizes in the plant community. Vertical structure has a significant influence on the diversity of wildlife species present in the community. Different layers offer food, water, cover, shelter, or breeding sites to different species, resulting in a rich diversity of wildlife utilizing one habitat type. Each species fills a niche or specialized position in the habitat.

Horizontal structure refers to the arrangement of habitat types or plants as seen from above. Field borders can be established and maintained to maximize horizontal structure by encouraging a variety of native vegetation types to become established within certain sections of the field border through planting and disturbance activities. Where feasible, small group plantings of native shrubs (especially fleshy fruit-producing species) can be used to add woody cover and food sources between crop fields. Shrubby field borders can also serve as transition zones between open fields (such as cropland and pasture) and woodlands.

One way to maintain horizontal structure is to provide two zones within the field border (see Figure 3). The zone closest to the field is generally subject to greater disturbance from farm equipment working the crop field, while the outside zone is more protected from frequent disturbance. The outside zone also provides a smooth transition to adjacent wooded habitats.

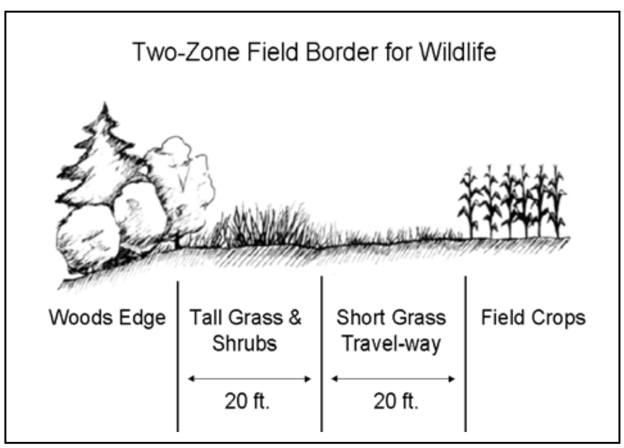


Figure 3. Field border design utilizing principles of vertical and horizontal structure.

2. Field border width.

As with many conservation buffer practices, wider field borders provide more and better quality habitat for most wildlife species than narrower buffers. In many situations, field borders should be at least 35 feet wide to provide enough habitat to be used by beneficial insects, small mammals, and other wildlife. Where field borders are used as equipment turn rows, they should be wide enough to leave a strip of undisturbed habitat at least 20 feet wide along the outside edge of the field border.

Figure 4. Field borders that typically have limited wildlife habitat potential are those that are narrow, consist of a monoculture of sod-forming non-native grasses with little vertical or horizontal structure, are mowed every year, and are associated with abrupt edges.

Figure 5. Field borders that provide habitat for a variety of wildlife are those that are substantially wider than 35 feet, consist of a diversity of native grasses and forbs with significant vertical and horizontal structural diversity, are maintained on a 3 to 5-year rotational cycle, and are associated with gradual edges.

Where field borders occur along woodlands, they may be widened by cutting woodland edges back to encourage growth of shrubs and other wildlife food-bearing plants. Leaving cut slash and woody material on the ground along woodland borders can provide additional wildlife cover adjacent to field borders. Leaving several rows of crops standing along field edges can also increase the functional width of field borders, providing increased food and cover for wildlife.

Caution: Take note of applicable regulatory constraints in Maryland concerning removal of existing woody vegetation. Laws pertaining to forest conservation, wetland protection, critical area protection, stream buffers, and erosion and sediment control may be applicable. Permits or approvals from federal, state, or local government agencies may be needed before woody vegetation is cut or removed.

Figure 6. Leaving several standing rows of crops along field borders improves wildlife food and cover availability.

3. Field border height.

Field borders managed for wildlife should attain a height of 3 to 6 feet. They should be comprised of planted species as well as volunteer vegetation that produces wildlife food and cover. Grasses with sturdy stalks (such as the 'Shelter' variety of switchgrass) are especially desirable in regions with heavy snow because they provide residual cover for early nesting species.

4. Disturbance and maintenance.

Periodic disturbance of field borders is usually necessary to stimulate growth of desirable vegetation and to control the growth of woody plants, especially trees. Field borders that are disturbed on a 3 to 5-year rotation typically provide the best habitat over the life of the practice. Periodic disturbance can be accomplished by light disking or burning portions of the field border as needed during late winter to early spring to reduce the amount of rank and woody vegetation and litter build-up. Mowing can also be used as a management technique to control undesirable vegetation, but unlike light disking and prescribed burning, it has the disadvantage of not removing accumulated litter. Where feasible, livestock grazing (especially "flash grazing") may also be an option for managing herbaceous field borders.

Disturbance actions should be tied to local climate conditions. For example, prescribed burning should not be conducted during times of drought. Maintenance activities should be scheduled before or after the nesting and birthing season. Any disturbance action taken to maintain or improve wildlife habitat conditions must also consider how it affects water quality, erosion, and other buffer practice objectives. This is especially important if the field border is enrolled in a cost-sharing or easement program that restricts some management activities.

Disturbance and its effects on succession are the principal agents of change in buffer vegetation. Light disking reduces the density of a grass planting and allows wildlife better movement on the ground. By disturbing the soil surface, disking also encourages germination of seed-producing annuals such as partridge pea, black-eyed susan, ragweed, beggarticks, foxtail and other weedy species that provide food and cover. Maintenance must take into consideration the local climate, soil quality, and moisture conditions. For example, on sites where soils are usually too wet in the spring, maintenance such as light disking or mowing may need to be done in early fall when soils are more likely to be dry.

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Figure 7. Seed-producing annuals such as partridge pea provide wildlife food and cover after light disking or other disturbance measures.

Although disturbance is necessary, no more than half of the field border around a single field should be disturbed in any one year. In this manner, disturbance can be used as a tool to replenish field border habitat conditions while maximizing horizontal structural diversity.

Frequently, initial nesting attempts by birds in hayfields are destroyed by hay harvesting operations. These birds attempt to re-nest in available habitat elsewhere--typically in nearby buffer areas and other strip cover habitats. Field borders and other buffer areas can provide crucial habitats for these second nesting attempts. Where buffers need to be mowed for maintenance, mowing should be delayed until at least mid-August to allow second nesting attempts to succeed.

Pesticide drift in field borders should be minimized to support a broad spectrum of butterflies and other native pollinators and beneficial insects.

In conclusion, when well-designed and managed, field borders can provide substantial wildlife food and cover on agricultural lands in Maryland.

Table 2. Commonly used native plants that provide food and cover for various wildlife groups in Maryland.

Plant Species	Plants Provide Food and Cover for:: 1/		
	Upland Game Birds and Mammals	Grassland Songbirds	Butterflies and Pollinators
Native Grasses			
Big Bluestem (*Andropogon gerardii)*	●	●	
Broomsedge (*Andropogon virginicus)*	●	●	
Deertongue (*Dichanthelium clandestinum)*	●	●	
Eastern Gamagrass (*Tripsacum dactyloides)*	●	●	
Indiangrass (*Sorghastrum nutans)*	●	●	
Little Bluestem (*Schizachyrium scoparium)*	●	●	
Switchgrass *(Panicum virgatum)*	●		
Virginia Wild Rye (*Elymus virginicus)*	●	●	
Native Forbs			
American Vetch (*Vicia americana)*	●	●	●
Black-eyed Susan (*Rudbeckia hirta)*	●	●	●
Blazing Star (*Liatris spicata)*			●
Bush Clover (*Lespedeza capitata)*	●		●
Butterflyweed (*Asclepias tuberosa)*			●
Heath Aster (*Aster pilosus)*			●
Lance-leaved Coreopsis *(Coreopsis lanceolata)*	●		●
Partridge Pea (*Chamaecrista fasciculata)*	●	●	
Purple Coneflower (*Echinacea purpurea)*			●
Tickseed (*Coreopsis tinctoria)*	●		●
Wild Blue Indigo (*Baptisia australis)*			●

1/ *Note: Depending on the animal's food preferences, wildlife may consume flowers, seeds, nectar, stems, roots, or foliage from these plants.*

C. Rewa