Chapter Five - Maintenance and Monitoring

MAINTENANCE

A newly installed bioengineering project will require some initial maintenance. Once vegetation is established, it generally becomes self-sustaining through regrowth and requires little to no maintenance. The establishment period varies from location to location. Common maintenance tasks are shown below.

Maintenance Tasks

1. Clear debris around plantings.
2. Secure stakes, wire, twine, etc.
3. Control weeds.
4. Repair fences.
5. Replant.

Some replanting is usually necessary to ensure the streambank is fully vegetated in a short time frame. The need to replant should not be looked at as a failure. In the Great Basin and Intermountain West, fluctuating stream levels from year to year influence the success of new riparian plantings. Planting success varies greatly from project to project. The following table illustrates some potential success rates for bioengineering. Your project's success should be weighed against the project's goals. Even one willow cutting that survives is an improvement in an area where riparian vegetation was absent.

Potential Success Rates

Method	Growing
Pole Plantings	70-100%
Live Fascines	20-50%
Brush layers	40-70%
Post Plantings	50-70%

Source: NRCS Engineering Field Handbook, Chap. 18

MONITORING

Periodic monitoring of the project site will provide valuable insight into the streambank stabilization process and important information for future projects. All too often, monitoring of stream restoration and bioengineering projects is neglected.

There are several reasons why projects are not monitored. There is a misconception that monitoring is expensive and time consuming. Many project managers and designers may not want to evaluate the project in case the project does not meet all of the objectives and may be perceived as a "failure" (Kondolf 1995a). In reality, there is no such thing as a failure if something is learned from each project.

Kondolf (1995b) outlines five key elements for effective evaluation of stream restoration projects: clear objectives, baseline data, good study design, commitment to the long term, and willingness to acknowledge and accept "failures".

<u>Clear Objectives</u>
A set of clear objectives is the most critical component of an evaluation program because it provides the benchmarks against which the project will be assessed. Project objectives should be clearly stated, not only in qualitative terms, but also quantitatively where possible. Stating an objective such as "to improve fish

habitat" is an acceptable goal in the early planning phase. However, more specific objectives are needed to design a realistic evaluation program.

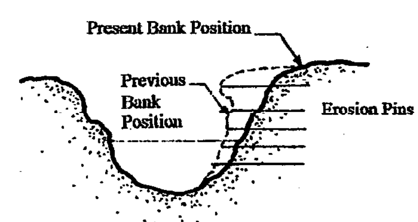
Baseline Data
Project success can only be determined with reference to prior conditions. Baseline data is necessary for the planning and design phase of a project and provides a solid basis for future monitoring efforts. Establishing permanent photo points before restoration is very valuable for visually documenting changes over time. Stream cross-sections taken before construction can also be used to assess future changes in bank stability.

Good Study Design
A good study design does not need to result in a complex and elaborate evaluation program. Often a simple set of photo points and cross-sections, both upstream and downstream of the treatment area, can serve as baseline reference sites to be compared against the treatment area. Being able to document erosion rates in treated areas versus untreated areas can often be used to promote future projects. A simple and cost-effective method to measure erosion rates is the use of metal pins (Fig. 5.1) (Gordon et al. 1992).

Long-Term Commitment
Evaluation programs require long-term commitment to fully assess the effects of a restoration project. Riparian vegetation requires a few years of growth before success can be fully evaluated. Consequently, monitoring methods must be kept simple and cost-effective if they are to be repeated over several years. For example, measurements do not need to be collected each year but could be collected in alternate years. Monitoring can also be carried out by volunteer groups once they are trained. Many high school science and university classes would probably relish the opportunity to apply some of their lessons in a real setting.

Willingness to Acknowledge "Failures"
There should be a willingness to acknowledge when projects do not meet all objectives so that important lessons can be transferred to future projects. It should also be noted that due to the dynamic nature of streams and rivers, a very large flood in the first year may wash out a project before the roots have had a chance to stabilize the bank. This does not necessarily mean the project was a failure or poorly designed. It also does not necessarily imply the streambank should have been armored with rip-rap or concrete. Where possible, we must always strive for multiple objectives such as wildlife and fisheries habitat and water quality improvement in addition to bank stability.

Evaluation Criteria and Methods
Briggs (1996) offers some examples of evaluation criteria for different project objectives. These include:



Metal pins or large nails at least 10" in length can be inserted into the bank so only a small portion is exposed. Mark pin locations with painted stakes to facilitate future relocation. Bank retreat can be estimated from the increase in pin exposure over time.

Fig. 5.1 *Use of Metal Pins to Monitor Bank Erosion*

Channel Capacity and Stability. Criteria may include channel cross-sections, flood stage surveys, rates of bank or bed erosion, longitudinal profile, and aerial photography interpretation.

Improve Aquatic Habitat. Criteria may include water depth, water velocities, percentage of overhanging cover, increases in large woody debris, shading, stream temperatures, bed material composition, and population assessments for fish and invertebrates.

Improve Riparian Habitat. Criteria may include percentage of vegetative cover, species diversity, species densities, survival of plantings, size distribution, age-class distribution, and wildlife use.

Improve Water Quality. Criteria may include temperature, pH level, conductivity, dissolved oxygen concentration, nitrogen and phosphorus concentrations, and turbidity.

Recreation and Community Involvement. Criteria may include visual resource improvement and recreational use surveys.

Since most projects have several objectives, the project manager may need to select a few key criteria to measure each objective. Since the emphasis of this guide is on bank stabilization, bank morphology and vegetation are key factors to monitor. The following section offers some guidelines for evaluating these parameters.

Bank Morphology

Beginning at the design phase of the project, a base map of the project area should be available. This map can be used during monitoring to record specific notes and locations of stream cross-sections or transects.

Cross-sections can be taken at the project area to document changes in channel width, bank shapes, deposition, and erosion. Cross-sections should be taken perpendicular to the flow of water. Usually, three cross-sections are taken in each treatment area: at the upstream end, middle, and downstream end, in addition to untreated reference areas.

To take a cross-section, two people, a line level, steel measuring tape, tension scale, stakes, twine, and a level rod are desirable (Refer to Fig. 5.2). First, determine a cross-section location and place a stake on both sides of the stream. Mark the location on the base map. Use permanent stakes that can be located during the following monitoring seasons. Secure the end of the steel measuring tape to the left side stake and stretch the tape across the channel. Use a line level to level the measuring tape. Using a tension scale,

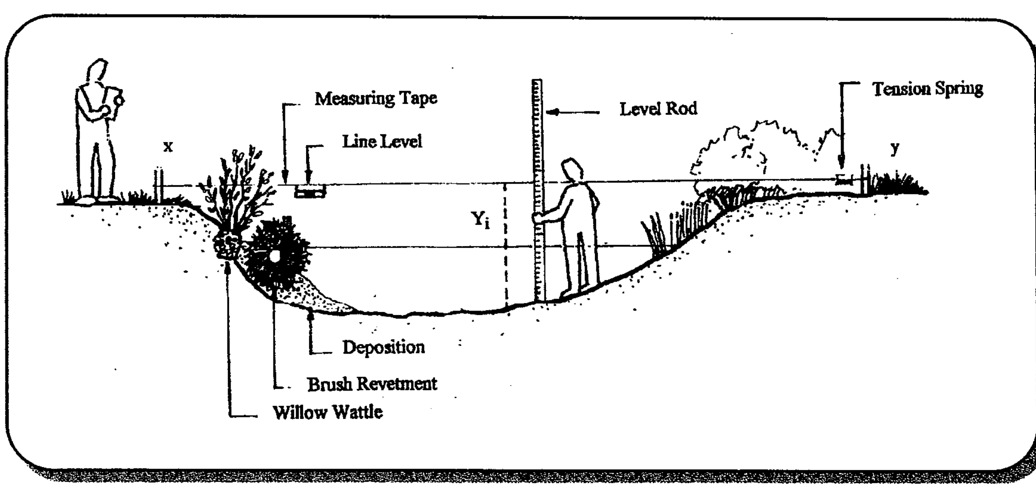


Fig. 5.2 *Acquiring Cross-sectional Data*

pull the tape until 10 to 20 pounds of tension is obtained and secure to the right stake. Record the height of the tape by both stakes (x, y) so the tape can be set to that height during following evaluations. This line will become the permanent datum for future measurements.

The other person should take level rod readings (Y_i) starting at the left bank. Usually readings are taken every foot to allow for a detailed cross-section. This data can then be plotted to scale on graph paper or on the sample monitoring sheet. Generally, the drawing of the cross-section should use the same horizontal and vertical scales to avoid exaggeration of features.

Drawings of the channel cross-sections can be visually compared from season to season to assess changes in bank morphology. For example, when some streams degrade, they tend to become wide and shallow. If the transects of the treatment area begin to show that the stream is becoming narrower and deeper, this may indicate a positive change depending on the specific context and objectives.

One way to compare pre-treatment and post-treatment cross-sections is simply by using a light table. If the cross-sections are taken at the same location using the same datum and scale, the cross-sections can be overlaid on a light table. A planimeter can be used to measure changes in area due to erosion or deposition.

Mathematical methods for quantifying channel morphology are also available. Several are described by Olson-Runtz and Marlow (1992).

In addition to monitoring channel geometry, it may be worthwhile to document peak flows that have occurred at the bioengineering project. If a gauging station is nearby, data can be acquired from it and used to determine the discharge and approximate velocity based on the known channel geometry. If a gauging station is not available, an inexpensive crest stage gauge can be constructed from a PVC tube. Briggs (1996) outlines the construction of a crest stage gauge which is a simple device constructed of a hollow tube mounted on a strong post that is anchored in the streambed (Fig. 5.4). Inside the tube, a strip of Velcro and a staff gauge are mounted while the bottom has a perforated cap. Small Styrofoam beads (chopped Styrofoam in a blender) are placed inside the tube. When a flow event occurs, water fills the tube and the beads float. As the flood recedes, the beads adhere to the Velcro strip recording the crest stage of the flood. By using at least three crest stage gauges,

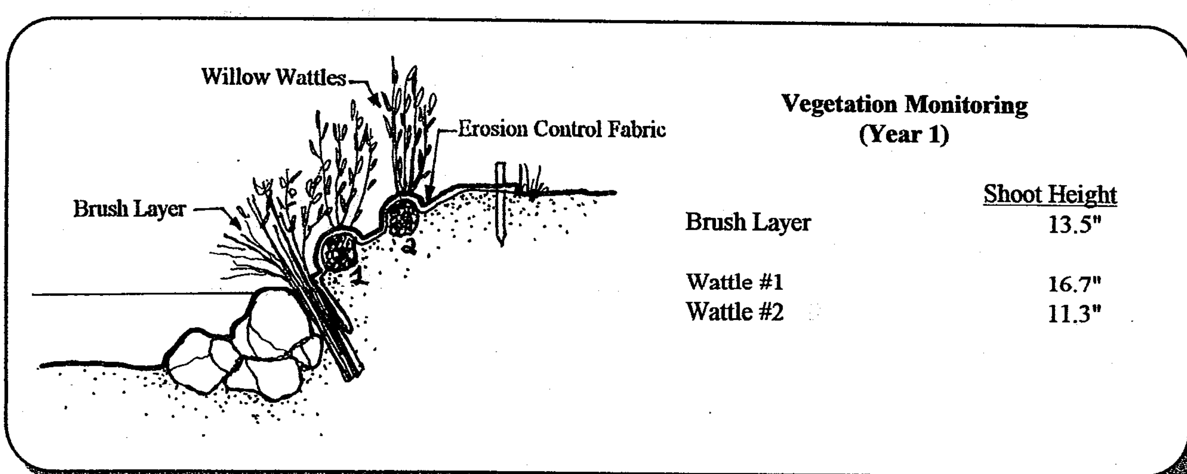


Fig. 5.3 *Example of Vegetation Monitoring*

a slope of the flood peak can be obtained (Briggs 1996). Using Manning's equation and the tractive force equation, discharge and shear stress can be estimated.

Vegetation
Another key component to evaluate is the vegetation. Different methods can be used to assess the success of the revegetation techniques including simple measurements of stem height, stem density, and vegetative cover (Refer to Fig. 5.3). Specific methods for vegetation sampling that may be particularly useful for bioengineering projects include visual estimation of percentage cover, line intercept, and quadrats. Many of these techniques are described in various publications (Gordon et al. 1992, Chambers and Brown 1983).

Many of the vegetative components of bioengineering are planted in a linear row (i.e. wattles, brush layer, etc.) and lend themselves to techniques such as measuring the number of live stems per linear foot of treatment. Table 5.1 offers some suggestions for monitoring different types of treatments. Permanent photo points should also be used.

Monitoring Resources
A good resource for additional information on evaluating riparian areas is the publication entitled *Methods for Evaluating Riparian Habitats With Applications to Management* (Platts et al. 1987). See the Resource section for information on additional monitoring guides.

Sample Monitoring Sheet
A sample monitoring sheet is shown on the following page. A blank copy of the sheet can be found in Appendix C. The monitoring sheet is only an example and can be tailored for specific projects.

Monitoring is a critical component of restoration and with a little imagination, it can be done in a cost-effective manner using simple tools and volunteers.

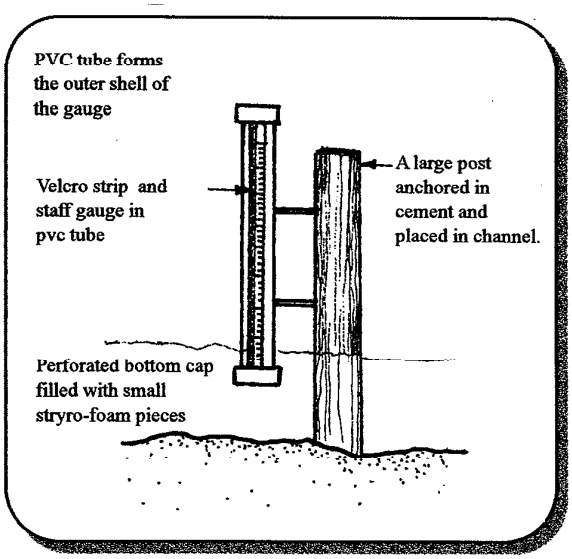


Fig. 5.4 *Crest Stage Gauge*
Adapted from Briggs (1996)

Table 5.1 *Potential Evaluation Methods*

Bioengineering Technique	**Evaluation Method**
Brush Layer	B,C,D
Brush Trench	B,C,D
Vertical Bundles	C
Willow Wattles	B,C,D
Pole Plantings	A,C
Post Plantings	A,C
Brush Mattress	B,C,D

A. Percent survival of individual plants.
B. Average number of shoots per linear foot.
C. Average height of shoots per linear foot.
D. Stem density per unit area.

Fig. 5-5 Bioengineering Monitoring Sheet

Bioengineering Monitoring Sheet

Project Name: Clear Creek - Phase 1
Project Location: Clear ck. S. of Hwy 95 Bridge
Monitoring Team: Clear Creek H.S. Biology Class
Date: 6/25/96

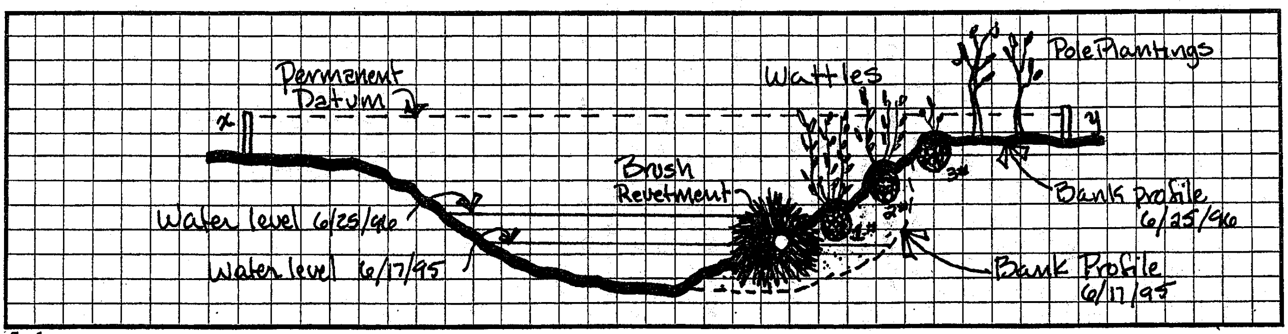
Bioengineering Technique: Brush revetment w/ willow wattles & pole plantings
Riparian Species Present: Salix exigua (Sandbar willow wattles) Populus fremontii (Fremont Cottonwood pole plantings) Misc Species - Carex nebrascensis (Nebraska Sedge)

Total # of poles or post plantings: 24
# of dead: 3 # of live: 21
% survival: 87.5%
Average height: 3.4'

Average # of live stems per linear foot: Wattle #1 (12/per l.f.) Wattle #2 (8/per l.f.) Wattle #3 (2/per l.f.)
Average height of stems per linear foot: Wattle #1 (27.4") Wattle #2 (23.5") Wattle #3 (4")
Stem density per unit area: -NA-

Notes: Brush revetment & erosion control fabric is holding up & is catching sediment. Wattles #1 & 2 are doing great - Wattle #3 is struggling. Probably should have planted pole plantings instead of wattle #3 (probably not enough moisture). Water temp. seems cooler now that channel narrower & deeper - need to do some temp. monitoring to assess this!

STREAM CROSS-SECTION ID#: 1-4 Measuring Tape Height: x 18" y 14"



Scale: Horz. 1" = 5'-0"
Vert. 1" = 5'-0"

Glossary

Aggradation: To fill and raise the level of the bed of a stream by deposition of sediment.

Alluvial: Deposited by running water.

Bankfull Discharge: The discharge corresponding to the stage at which the natural channel is full. This flow typically has a recurrence interval of 1.5 to 2 years.

Best Management Practices: A practice used to reduce the impacts from a particular land use.

Bioengineering: The integration of living woody and herbaceous materials along with organic and inorganic materials to increase the strength and structure of soil.

Buffer: A vegetated area of grass, shrubs, or trees designed to capture and filter runoff from surrounding land uses.

Canopy: The overhead branches and leaves of vegetation.

Capillary Fringe: The distance water is wicked upwards above the water table by capillary action in the soil.

Coir: A woven mat of coconut fibers. Used for various soil erosion control applications. Biodegrades after a period of time.

Degradation: The process of by which stream beds lower in elevation. Opposite of aggradation.

Deposition: The settlement of material out of water.

Fiberschine: A sausage-like bundle of coconut fibers woven together. Used to stabilize the toe of a streambank.

Geomorphology: The geologic study of the evolution and configuration of land forms.

Habitat: The area or environment in which an organism lives.

Headcutting: The cutting of the streambed to a lower elevation.

Incised Channel: A stream that has cut its channel into the bed of a valley.

Nonpoint Source Pollution: Pollution that originates from many diffuse sources.

Piping: Flow of water through subsurface conduits in the soil.

Reach: A short length of stream that has similar physical and biological characteristics.

Riparian Area: A riparian area is an ecosystem situated between aquatic and upland environments that is at least periodically influenced by flooding.

Scour: Erosive action of flowing water in a stream.

Seepage: Groundwater emerging from the face of a streambank.

Substrate: The mineral and organic material that from the bed of a stream.

Thalweg: A longitudinal line that follows the deepest part of the channel of a stream.

Tractive Force: The drag or force on a streambank or bed particles caused by flowing water.

Velocity: The distance that water travels in a given direction in a stream during a given interval of time.

Watershed: An area of land that drains into a particular river or stream, usually divided by topography.

Wattle: A sausage-like bundle of plant cuttings used to streambanks and other slopes.

BIOENGINEERING AND WATERSHED RESTORATION TECHNIQUES

Note: Phone numbers, addresses and prices are given for many of the publications. In the case with some of the non-governmental publications, these resources can usually be ordered from your local bookstore.

Stream Corridor Restoration Handbook. Available in 1998. An excellent, comprehensive technical resource developed by several federal agencies. Contains restoration technology applicable for streams in both urban and rural settings. For more information, visit web site (www.usda.gov/stream_restoration).

A Guide to Field Identification of Bankfull Stage in the Western U.S. A useful video for field identification of bankfull discharge. Source USFS Streams Systems Technology Center, Rocky Mountain Station, 240 West Prospect, Ft. Collins, CO 80525.

Better Trout Habitat: A Guide to Stream Restoration and Management. 1990. A 320 page book by C. Hunter that examines in-stream trout habitat restoration practices. Includes case studies. Source: Island Press, Box 7, Covelo, CA 95428 or call (800) 828-1302 (soft cover - $24.94).

Biotechnical Slope Protection and Erosion Control. 1989. A good technical book by D. Gray and A. Leiser on the scientific principles behind bioengineering. Source: Krieger Publishing Co., Krieger Drive, Malabar, FL 32950.

A Citizen's Streambank Restoration Handbook. 1995. A 111 page grassroots guide for streambank stabilization projects using bioengineering techniques by K. Firehock and J. Doherty. Source: Izaak Walton League of America, Save Our Streams Program, 707 Conservation Lane, Gaithersburg, MD 20878-2983 or call (301) 548-0150 (notebook-$15).

Guidelines for Bank Stabilization Projects in the Riverine Environments of King County. 1993. A 195 page manual developed by A.W. Johnson and J.M. Stypula to help professionals with the design of bank stabilization projects for streambank protection. Although geared to the Northwest, principles can be applied to other areas. Source: King County Department of Public Works, Surface Water Management Division, 700 Fifth Avenue, Suite 2200, Seattle, WA 98104 or call (206) 296-6519 (soft cover - $21.65)

Biotechnical & Soil Engineering Slope Stabilization. 1996. An excellent reference guide for bioengineering techniques by D. Gray and R. Sotir. Includes four illustrated case studies. Source: John Wiley and Sons. (hardback - $64.95).

Water Bioengineering Techniques. 1994. A technical guide originally published in German by H.M. Schiechtl and R. Stern. Covers the many different techniques used in Europe; very good resource. Source: Blackwell Science, 239 Main St., Cambridge, MA 02142 (800) 215-1000 (hardback-$64.95).

Soil Bioengineering for Upland Slope Protection and Erosion Reduction. Chapter 18 - Natural Resources Conservation Service Engineering Field Handbook. 1992. This guide is geared toward upland bioengineering but some information can still be applicable to riparian situations.

Streambank and Shoreline Protection. Chapter 16 - Natural Resources Conservation Service Engineering Field Handbook. 1996. This guide is geared specifically for riparian and shoreline bioengineering. Source: See your local NRCS Conservationist .

'Natural' Channel Design: Perspectives and Practice. 1994. A compilation of the Proceedings of the First International Conference on Guidelines for "Natural Channel Systems" held in Ontario, Canada. This 465 page publication covers both design and policy issues - D. Shrubsole eds. Source: (See IECA under organizations) (soft cover - $44.95).

Riparian Ecosystem Recovery in Arid Lands: Strategies and References. A 160 page guide to holistic riparian recovery in the Southwest by M. Briggs. Covers critical topics pertaining to arid riparian restoration such as salinity issues. Published by the University of Arizona Press, Tucson, AZ. (soft cover - $20).

Interagency Riparian/Wetland Plant Development Project. This multi-agency project is aimed at researching plants and techniques for restoration of riparian and wetland ecosystems in the Great Basin and Intermountain West. Project is based at the USDA NRCS Plant Materials Center in Aberdeen, ID. The following publications are available upon request:

Riparian/Wetland Project Information Series

No. 2 - Selection and acquisition of woody plant species and materials for riparian corridors and shorelines.
No. 3 - Use of willow and cottonwood cuttings for vegetating shorelines and riparian areas.
No. 4 - How to plant willows and cottonwoods for riparian rehabilitation.
No. 5 - Collection, establishment, and evaluation of unrooted woody cuttings to obtain performance tested ecotypes of native willows and cottonwoods.
No. 6 - Seed and live transplant collection procedures for seven wetland plant species.
No. 7 - Use of greenhouse propagated wetland plants versus live transplants to vegetate constructed or created wetlands.
No. 8 - Constructed wetland system for water quality improvement of irrigation wastewater.
No. 9 - Design criteria for riparian areas of the Intermountain region.
No. 10 - Seed germination enhancement of *Carex nebrascensis* (Nebraska Sedge)
No. 11 - Getting "bang for your buck" on your next wetland project.
No. 12 - Guidelines for planting, establishment, and maintenance of constructed wetlands systems.
No. 13 - A reference guide for the collection and use of ten common wetland plants of the Great Basin and Intermountain West.

Idaho NRCS Plant Materials Technical Note

No. 6 - The Stinger, a tool to plant unrooted hardwood cuttings of willow and cottonwood species for riparian or shoreline erosion control or rehabilitation.

No. 23 - How to plant willows and cottonwoods for riparian rehabilitation. (Describes planting methods for willows and cottonwoods in riparian revegetation projects in detail and includes technical references).

Riparian/Wetland Project Plant Guides

***Carex nebrascensis*, Nebraska Sedge** — wetland plant fact sheet. Interagency Riparian/Wetland Plant Development Project, Plant Materials Center, USDA Natural Resources Conservation Service, Box 296, Aberdeen, ID.

***Eleocharis palustris*, Creeping spikerush** — wetland plant fact sheet. Interagency Riparian/Wetland Plant Development Project, Plant Materials Center, USDA Natural Resources Conservation Service, Box 296, Aberdeen, ID.

***Juncus balticus*, Baltic rush** — wetland plant fact sheet. Interagency Riparian/Wetland Plant Development Project, Plant Materials Center, USDA Natural Resources Conservation Service, Box 296, Aberdeen, ID.

***Scirpus acutus*, Hardstem bulrush** — wetland plant fact sheet. Interagency Riparian/Wetland Plant Development Project, Plant Materials Center, USDA Natural Resources Conservation Service, Box 296, Aberdeen, ID.

***Scirpus maritimus*, Alkali bulrush** — wetland plant fact sheet. Interagency Riparian/Wetland Plant Development Project, Plant Materials Center, USDA Natural Resources Conservation Service, Box 296, Aberdeen, ID.

***Scirpus pungens*, Common threesquare** — wetland plant fact sheet. Interagency Riparian/Wetland Plant Development Project, Plant Materials Center, USDA Natural Resources Conservation Service, Box 296, Aberdeen, ID.

Available from: Interagency Riparian/Wetland Plant Development Project, Plant Materials Center, USDA Natural Resources Conservation Service, Box 296, Aberdeen, ID 83210 (208) 397-4133.

GENERAL BACKGROUND

A View of the River. 1994. An easy to read description of rivers based on the lifetime work of L. Leopold. Published by Harvard University Press, Cambridge, MA. (hardback - $40).

Water in Environmental Planning. 1978. An excellent 818 page hydrological resource authored by L. Leopold and T. Dunne. Published by W.H Freeman and Company, New York. (hardback-$60).

Stream Hydrology: An Introduction for Ecologists. 1992. A useful 532 page book that explains what hydrologic data to gather and how to use it. Authored by N.D. Gordon, T.A. McMahon, and B.L. Finlayson. Published by John Wiley and Sons, New York.(hardback - $69.95).

RESTORATION PERIODICALS

Restoration and Management Notes. A biannual publication published by the Society for Ecological Restoration (refer to Organizations). Covers all types of restoration activities. Source: Journal Division, 114 N. Murray St., Madison, WI 53715 (1 year subscription - $27).

Watershed Protection Techniques. A quarterly journal on urban watershed restoration and protection techniques. Source: Center for Watershed Restoration, 8737 Colesville Road, Suite 300, Silver Springs, MD. 20910 (1 year subscription - $48).

Land and Water. A magazine covering topics such as erosion control, aquascaping and bioengineering. Source: Land and Water, P.O. Box 1197, Fort Dodge, IA 50501 (1 year subscription -$14).

Erosion Control. Official journal of the International Erosion Control Association (refer to Organizations). Published seven times a year. Source: Erosion Control, PO Box 3100, Santa Barbara, CA 93130 (1 year subscription-$36).

LAND USE MANAGEMENT AND BEST MANAGEMENT PRACTICES

Site Planning for Urban Stream Protection. 1995. An excellent 232 page resource on protecting urban streams by T. Schueler. Source: Center for Watershed Restoration, 8737 Colesville Road, Suite 300, Silver Springs, MD 20910 or call (301) 589-1890 (soft cover -$35).

Riparian Road Guide: Managing Roads to Enhance Riparian Areas. 1994. A 32 page booklet on road building to minimize impacts on riparian areas. Source: Terrene Institute, 4 Herbert St., Alexandria, VA 22305 or call (703) 548-5473. (soft cover - $10.95).

Restoring The Range 1995. A 40 page supplement to the Citizen's Streambank Restoration Handbook by J. West, published by the Izaak Walton League of America, Save Our Streams Program, 707 Conservation Lane, Gaithersburg, MD 20878-2983 or call (301) 548-0150 (notebook-$20; price includes the Citizen's Streambank Restoration Handbook).

Idaho Forestry Best Management Practices: Compilation of Research on Their Effectiveness. 1996. A good assessment of forestry BMP by K.A. Seyedbagheri. Source: Rocky Mountain Research Station, 324 25th Street, Ogden, UT 84401. (General Technical Report INT-GTR-339). (soft cover - free).

ASSESSMENT AND MONITORING

Process for Assessing Proper Functioning Condition. 1993. Good process for assessing whether a riparian area is functioning properly. Source: Bureau of Land Management, Service Center, SC-657B, P.O.B. 25047, Denver, CO 80225-0047. (Technical Report 1737-9 1993). (soft cover - free).

Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish. 1989. Discusses various habitat assessment and sampling approaches for fresh water streams and rivers. Source: U.S. Environmental Protection Agency, Assessment and Watershed Protection Division, 4503f, 401 M Street, SW, Washington, DC 20460 or call (202) 260-7081 (EPA 444/4-89-001). (soft cover - free).

Methods for Evaluating Riparian Habitats With Application to Management. 1987. Good resource for scientific monitoring of riparian areas. Source: Rocky Mountain Research Station, 324 25th Street, Ogden, UT 84401. (General Technical Report INT-221). (soft cover - free).

Inventory and Monitoring of Riparian Areas. 1989. Another good resource for monitoring riparian areas. Source: Bureau of Land Management, Service Center, SC-658B, P.O.B. 25047, Denver, CO 80225-0047. (Technical Report 1737-3 1989). (soft cover - free).

Water Quality Indicators Guide: Surface Waters. Simplified approach to assessing water quality based on indicators without the use of elaborate chemical testing procedures. Source: Terrene Institute, orders accepted via phone (703) 548-5473 with payment by credit cards, checks or purchase orders (soft cover - $26.95).

Field Manual for Water Quality Sampling. A handy little field reference to provide for consistent sampling protocols. Source: Arizona Water Resources Research Center, College of Agriculture, 350 N. Campbell Avenue, University of Arizona, Tucson, AZ 85721 (520) 792-9591.(soft cover - $10).

A Monitor's Guide to Aquatic Macroinvertebrates. 1992. A 46-page layperson's guide to identifying aquatic insect larvae including an easy-to-use key. Source: Izaak Walton League of America, Save Our Streams Program, 707 Conservation Lane, Gaithersburg, MD. (301) 548-0150. (soft cover - $5).

HORTICULTURAL INFORMATION

Hortus West. A western United States native plant directory and journal. Source: Hortus West, P.O.Box 2870, Wilsonville OR 97070-9957 or call (800) 704-7927. (1 year subscription $9.00 or single copy $6.45).

Field Guide to the Willows of East-Central Idaho. 1985. Great guide for willows that occur in the Intermountain West by Steven Brunsfeld and Frederic Johnson. Source: Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow, ID 83843. (Bulletin #39) ($20 - each).

Planting Guide for Utah. 1994. Good seeding guide for grasses and upland woody plants. Source: Cooperative Extension Service, Utah State University, Logan, UT 84322. (Extension Circular 433).

Native Trees of the Intermountain Region. Good guide for both upland and riparian tree species. Source: Cooperative Extension Service, Utah State University, Logan, UT 84322. (Extension Circular 407).

Classification and Management of Montana's Riparian and Wetland Sites. 1995. Good regional classification system for Montana by P.L.Hansen and others. Source: The University of Montana, School of Forestry and Montana Forest and Conservation Experiment Station, Missoula, MT. (Miscellaneous Publication No. 54).

Riparian Community Type Classification of Utah and Southeastern Idaho.1989. Good regional classification system by W.G. Padgett. Source: Rocky Mountain Research Station, 324 25th Street, Ogden, UT 84401. (R4-Ecol-89-01) (soft cover - free).

ORGANIZATIONS

Society for Ecological Restoration (SER).
A non-profit organization dedicated to ecological restoration including both upland and riparian landscapes. Contact: SER, University of Wisconsin-Madison Arboretum, 1207 Seminole Highway, Madison, WI 53711. (608) 262-9547.

International Erosion Control Association (IECA). A non-profit organization dedicated to erosion and sediment control. Publishes a directory of erosion control product suppliers. Contact: IECA, Box 774904, Steamboat Springs, CO 80477-4904. (800) 455-4322.

References

Allen, H.H. and J.R. Leech. 1997. *Bioengineering guidelines for streambank erosion control.* Environmental Impact Research Program Technical Report. U.S. Army Corps of Engineers Waterways Experiment Station. Vicksburg, MS.

Bentrup, G. 1996. Bioengineered shoreline protection for an urban recreation pond. *Land and Water* 40(1):11-13.

Beschta, R.L. and W.S. Platts. 1986. Morphological features of small streams: significance and function. *Water Resources Bulletin* 22(3):369-379.

Best, L.B. and D.F. Stauffer. 1980. Habitat selection by birds of riparian communities: evaluating the effects of habitat alterations. *Journal of Wildlife Management* 44(1): 1-15.

Binford, M.W. and M.J. Buchenau. 1993. Riparian greenways and water resource. pp. 69-104 in D.S. Smith and P.C. Hellmund eds., *Ecology of greenways: design and function of linear conservation areas.* University of Minnesota Press, Minneapolis, MN.

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