USDA United States Department of Agriculture

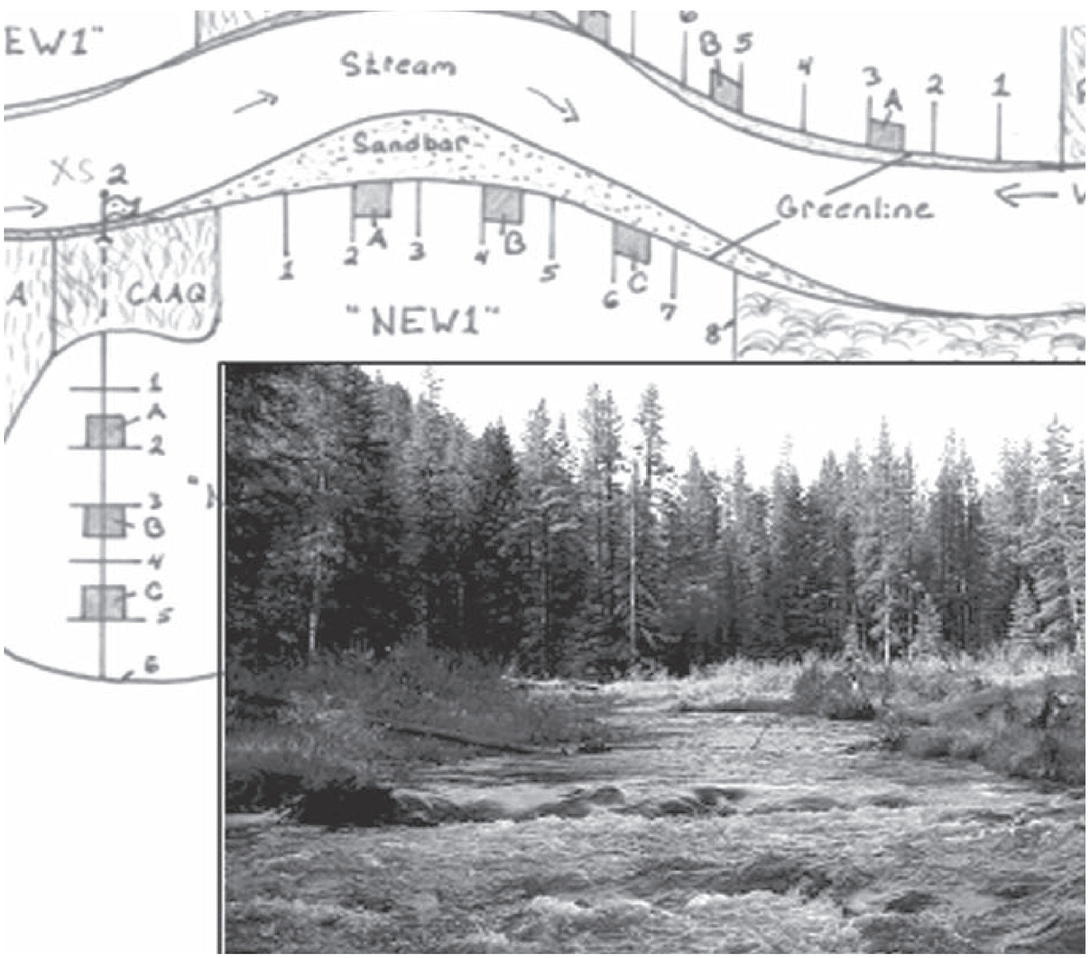
Forest Service

Rocky Mountain Research Station

General Technical Report RMRS-GTR-121

March 2004

Guide to Effective Monitoring of Aquatic and Riparian Resources



Abstract

Kershner, Jeffrey L.; Archer, Eric K.; Coles-Ritchie, Marc; Cowley, Ervin R.; Henderson, Richard C.; Kratz, Kim; Quimby, Charles M.; Turner, David L.; Ulmer, Linda C.; Vinson, Mark R. 2004. **Guide to effective monitoring of aquatic and riparian resources**. Gen. Tech. Rep. RMRS-GTR-121. Fort Collins, CO: U.S. Department of Agriculture, Rocky Mountain Research Station. 57 p.

This monitoring plan for aquatic and riparian resources was developed in response to monitoring needs addressed in the Biological Opinions for bull trout (U.S. Department of the Interior, Fish and Wildlife Service 1998) and steelhead (U.S. Department of Commerce, National Marine Fisheries Service). It provides a consistent framework for implementing the effectiveness monitoring of aquatic and riparian resources within the range of the Pacific Anadromous Fish Strategy (PACFISH) and the Inland Fish Strategy (INFISH). The primary objective is to evaluate the effect of land management activities on aquatic and riparian communities at multiple scales and to determine whether PACFISH/INFISH management practices are effective in maintaining or improving the structure and function of riparian and aquatic conditions at both the landscape and watershed scales on Federal lands throughout the upper Columbia River Basin.

A list of attributes thought to be important in defining aquatic and riparian habitat conditions and their relationship with listed species were identified. The list of attributes was then translated into measurable criteria and compiled to form sampling protocols for both stream channel parameters (Part II) and vegetation parameters (Part III). These sampling methods were tested for variability, and the results are documented in two other publications "Testing Common Stream Sampling Methods for Broad-Scale, Long-Term Monitoring." (Archer and others 2004) and "The Repeatability of Riparian Vegetation Sampling Methods: How Useful Are These Techniques for Broad-Scale Monitoring?" (Coles-Ritchie and others, in preparation).

Keywords: effectiveness monitoring, stream habitat, riparian habitat, monitoring strategy, aquatic sampling, vegetation sampling, watershed conditions, critical riparian area

The Authors

Jeffrey L. Kershner is a Washington Office Aquatic Ecologist with the U.S. Department of Agriculture, Forest Service, Fish and Aquatic Ecology Unit in Logan, UT. He completed a B.S. degree in 1976 at Humbolt State University, Arcata, CA, in fisheries. He earned an M.S. degree in natural resources from Humbolt State University in 1982, and a Ph.D. degree in ecology from the University of California, Davis, in 1991.

Eric K. Archer joined the Forest Service as a Fisheries Biologist in 1999. He is the Supervisor of Field Operations and Data Analyst for the Effectiveness Monitoring Project in Logan, UT. Eric received a B.S. degree in fisheries management in 1996 from Utah State University, Logan, and an M.S. degree in aquatic ecology in 1999 from Utah State University, Logan.

Marc Coles-Ritchie is a Riparian Vegetation Ecologist for the U. S. Department of Agriculture, Forest Service, Fish and Aquatic Ecology Unit in Logan, UT. He received a B.A. degree in comparative literature from the University of Massachusetts and an M.S. degree in environmental studies from Bard College, which included research on the harvest of tropical forest materials in Ecuador. Marc is completing a Ph.D. degree in vegetation ecology at Utah State University, Logan.

Ervin R. Cowley is a Rangeland Management Specialist with the Idaho State Office, Bureau of Land Management in Boise, ID. He received a B.S. degree in range management from Utah State University, Logan. Ervin began working for the BLM in 1965 and presently is the Soil, Water, and Air and Riparian Management Program Leader for the BLM in Idaho.

Richard C. Henderson earned his B.S. degree in fisheries biology from Colorado State University in Fort Collins in 1992. In 1998 he received his M.S. degree in fisheries biology from Utah State University, Logan. He is currently a Fisheries Biologist for the U.S. Department of Agriculture, Forest Service, Fish and Aquatic Ecology Unit in Logan, UT.

Kim Kratz is the Watershed Policy Coordinator for the Habitat Conservation Division, NOAA Fisheries. Kim received his Ph.D. degree in population and community ecology from the University of California, Santa Barbara.

Charles M. Quimby earned his B.S. degree from the University of Arizona in 1970 with a major in rangeland management and a minor in wildlife management. He earned his M.S. degree in watershed management with emphasis on water quality and natural resource recreation from the University of Arizona in 1976. He is currently Rangeland Program Manager with the U.S. Department of Agriculture, Forest Service, Rocky Mountain Region.

David L. Turner is a Rocky Mountain Research Station Mathematical Statistician with the U.S. Department of Agriculture, Forest Service, in Logan, UT. Prior to joining the Forest Service in 1989 he was a tenured Associate Professor in the Applied Statistics Department at Utah State University for 14 years. He completed a B.S. degree in statistics at Colorado State University, Fort Collins. He earned M.S. and Ph.D. degrees in statistics at Colorado State University, Fort Collins, in 1973 and 1975. He has been consulting with researchers on the design, analysis, and salvage of studies since 1969. He speializes in the analysis of messy data, applying modern statistical techniques to Forest Service problems.

Linda C. Ulmer is an Aquatic Ecologist with the U.S. Department of Agriculture, Forest Service. Linda received a B.S. degree in marine biology from Farleigh Dickinson University and an M.S. degree in marine biology from California State University, Long Beach. Linda joined the Forest Service in 1989 after 11 years with California Department of Fish and Game. She is currently serving as the Columbia River Basin Anadromous Coordinator in Portland, OR.

Mark R. Vinson is an Ecologist with the U.S. Department of the Interior, Bureau of Land Management, in Logan, UT. He completed a B.S degree in water resources at the University of Wisconsin, Stevens Point; an M.S degree in biology at Idaho State University, Pocatello; and a Ph.D. degree in watershed science at Utah State University, Logan.

Guide to Effective Monitoring of Aquatic and Riparian Resources

Jeffrey L. Kershner
Eric K. Archer
Marc Coles-Ritchie
Ervin R. Cowley
Richard C. Henderson
Kim Kratz
Charles M. Quimby
David L. Turner
Linda C. Ulmer
Mark R. Vinson

Contents

Executive Summary

This plan was prepared at the request of the Regional Foresters in Regions 1, 4, and 6 of the USDA Forest Service, the State Directors of the USDI Bureau of Land Management in Idaho and Oregon, the Director of the Pacific Region of the U.S. Fish and Wildlife Service, and the Director of the National Marine Fisheries Service in the Northwest Regional Office. Part I of this document provides a consistent framework for implementing the effectiveness monitoring of aquatic and riparian resources within the range of the Pacific Anadromous Fish Strategy (PACFISH) and the Inland Fish Strategy (INFISH), and is directed by the Biological Opinions for salmon, steelhead, and bull trout. Under the direction from these strategies, the effectiveness monitoring plan is intended to evaluate the effect of land management activities on aquatic and riparian communities at multiple scales and will assess whether management direction, implemented through PACFISH/INFISH and the Biological Opinions (PIBO), is effective in maintaining or improving aquatic and riparian conditions at both the landscape and watershed scales on Federal lands.

Parts II and III of this document contain the protocols for measuring specific aquatic and riparian attributes that describe habitat conditions.

Part I: A Plan to Monitor Aquatic and Riparian Resources (PACFISH/ INFISH) and Biological Opinions for Bull Trout, Salmon, and Steelhead

Jeffrey L. Kershner
Marc Coles-Ritchie
Ervin Cowley
Richard C. Henderson
Kim Kratz
Charles Quimby
David L. Turner
Linda C. Ulmer
Mark R. Vinson

Part I Acknowledgments

The authors acknowledge a number of people for their comments and review. Brett Roper, Gina Lampman, Dave Hohler, and Bob Hamner of U.S. Department of Agriculture, Forest Service; and Tim Burton, Ron Wiley, and Karl Stein of the U.S. Department of the Interior, Bureau of Land Management provided helpful feedback and comments on earlier drafts. Doug Young of U.S. Department of the Interior, Fish and Wildlife Service contributed a number of ideas to the original plan. Ann Carlson, Jim Frazier, Amy Lind, Joanne Fites, and Ken Roby of the Sierra Framework Aquatic Monitoring group helped to develop many of the ideas related to the stressor-response model. Tony Olson (U.S. Environmental Protection Agency) and Tom Edwards (U.S. Department of the Interior, Geological Survey) assisted with the overall sample design. Tom Quigley, currently Director, Pacific Northwest Research Station, U.S. Department of Agriculture, Forest Service, provided valuable insight into document consistency. We especially thank our peer reviewers Peter Kiffney, Michael Pollock, and Phil Roni (U.S. Department of Commerce, National Marine Fisheries Service); Rick Woodsmith and Steve Wondzell (U.S. Department of Agriculture, Forest Service); and Steve Ralph (U.S. Environmental Protection Agency/U.S. Department of the Interior, National Park Service liaison) for their helpful suggestions and insights. Finally, we thank the Interagency Implementation Team and the Regional executives for moving forward with this monitoring effort.

Purpose and Need

This document provides a consistent framework for implementing the effectiveness monitoring of aquatic and riparian resources within the range of the Pacific Anadromous Fish Strategy (PACFISH) and the Inland Fish Strategy (INFISH), and it is directed by the Biological Opinions (PIBO) for salmon, steelheead, and bull trout (fig. I-1). Under the direction from these strategies, the effectiveness monitoring plan is intended to evaluate the effect of land management activities on aquatic and riparian communities at multiple scales, and the plan will assess whether management direction, implemented through PACFISH/INFISH and PIBO, is effective in maintaining or improving aquatic and riparian conditions at both the landscape and watershed scales on Federal lands. This document will serve as *The Effectiveness Monitoring Module—PIBO Monitoring Plan* that will guide the aquatic and riparian monitoring at the landscape scale.

At the landscape scale, the effectiveness monitoring plan is intended to answer the question, "Are key biological and physical attributes, processes, and functions of upslope, riparian, and aquatic systems being degraded, maintained, or restored within the geographic range of PIBO?" At the watershed scale, monitoring will be used to assess the condition of individual watersheds and evaluate the extent to which management practices are effective in maintaining or restoring key ecological indicators.

Figure I-1—Map of PACFISH/INFISH study area (enclosed in bold line).

The need for this monitoring plan is based on direction provided in the bull trout, salmon, and steelhead Biological Opinions issued by the U.S. Department of the Interior, Fish and Wildlife Service (USFWS) and the U.S. Department of Commerce, National Marine Fisheries Service (USNMFS). Direction in the Biological Opinions identified requirements for the U.S. Department of Agriculture, Forest Service (USFS) and the U.S. Department of the Interior, Bureau of Land Management (USBLM) to develop a mechanism for improved accountability and oversight for activities that may influence habitat for these "listed" fish across their range. This plan was developed at the request of the Regional Foresters of Regions 1, 4, and 6 of the Forest Service, the State Directors of the U.S. Department of the Interior, Bureau of Land Management in Idaho and Oregon, the Director of the Pacific Region of the U.S. Fish and Wildlife Service, and the Director of the National Marine Fisheries Service in the Northwest Regional Office. Implementation of this plan began in 1998, and the concepts and ideas were tested and evaluated though 2002. Full implementation of this plan began in FY 2003.

This plan is not intended to replace or supercede all effectiveness monitoring that currently exists within the PIBO area. It provides a framework to answer questions related to aquatic and riparian systems at multiple scales and provides some needed consistency in approach and analysis (fig. I-2). Effectiveness monitoring that addresses specific questions related to Forest and District planning and/or activity monitoring should continue. Forest or District offices of the USFS and USBLM may want to reexamine, and potentially modify, their efforts where there is overlap with the broad-scale effort in order to improve efficiency.

Introduction

The decline of native fish species in Western North America has prompted new interest in monitoring the relationships between land management activities and aquatic and riparian ecosystems. The condition of the aquatic and riparian habitats in any place and at any scale is the integrated product of the ecosystem processes, function, and structure. Analysis of watershed conditions requires considering the degree to which key processes that create and maintain habitat are intact and functional through time. The basic components of aquatic ecosystems that need to be evaluated include basin geomorphology, hydrologic function, upland and riparian conditions, in-stream habitat conditions, water quality, and biological integrity (Karr and Chu 1997; Naiman and others 1992). Ecologically healthy watersheds have lateral, longitudinal, and vertical connections between system components, and they exhibit

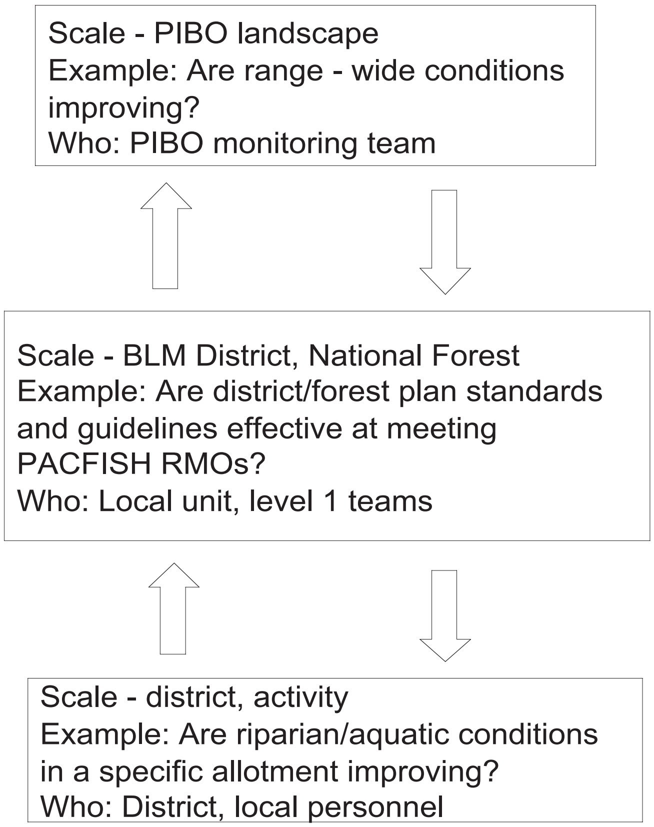


Figure I-2—Responsibilities of organizational units within BLM/Forest Service for effectiveness monitoring.

a range of spatial and temporal connectivity. Consequently, watersheds exist in a variety of states and exhibit considerable variation (Ebersole and others 1997; Reeves and others 1995). Successful monitoring of these relationships must be sensitive to the dynamic nature of ecosystem processes across spatial and temporal scales.

While there has been considerable research documenting the effects of various land use practices on watershed function, most of these efforts have been attempted at relatively small spatial and temporal scales. There are few existing efforts to evaluate anthropogenic effects on aquatic resources at larger scales (Larsen and others 2001; Whittier and Paulsen 1992). Currently, the Environmental and Assessment Program (EMAP, USEPA) and the North American Water Quality Assessment Program (NAWQA, USGS) are the primary large-scale monitoring programs being implemented in the United States, but the purpose and goals of these efforts are somewhat different than the plan outlined here. Multiscalar monitoring plans specifically focused on relationships between anthropogenic activities and watershed function are in development by land management agencies but are not yet fully operational (for example, the Northwest Forest Plan, Ringold and others 1999, and the Sierra Province Assessment and Monitoring Effort). This plan has tried to incorporate many of the ideas and concepts that have been developed as part of these other efforts. There is considerable overlap in the goals and objectives of these monitoring efforts, and we have attempted to use this existing foundation wherever possible and expand these concepts to fit the situation in the PIBO area.

Reviews of past monitoring efforts have indicated that a number of key steps must be present in any plan for it to be successful (Conquest and others 1994; MacDonald and others 1991; Noon and others 1997). These steps include, but are not limited to, clear goals and objectives, a conceptual model linking the stressors to consequences, consistent and reliable measurement protocols, a study design that has the potential to detect differences, and clear linkage between monitoring results and management decisions. We believe that a monitoring plan framework developed by Noon and others (1997) is a logical framework, and we have incorporated many of the ideas that were developed by them in the following plan.

Goal and Objectives

Goal

Our Goal is to design a monitoring plan within the PIBO area with the capability to determine whether PACFISH/INFISH management practices are effective in maintaining or restoring the structure and function of riparian and aquatic systems.

Objectives/Study Questions

1. Determine whether a suite of biological and physical attributes, processes, and functions of upland, riparian, and aquatic systems are being degraded, maintained, or restored across the PIBO landscape.
2. Determine the direction and rate of change in riparian and aquatic habitats over time as a function of management practices.
3. Determine if specific Designated Management Area (DMA) practices related to livestock grazing are maintaining or restoring riparian vegetation structure and function.

Guiding Principles and Assumptions

1. Develop an effectiveness monitoring plan that is cost effective and practical.
2. Develop an effectiveness monitoring framework that incorporates measurable, repeatable methods that will be useful in answering monitoring questions on Federal lands at different scales.

3. The implementation of CRA practices will mitigate the grazing-related effects of human-caused stressors.

Approach

The condition of the aquatic and riparian ecosystem is the integrated product of ecosystem processes, rates, and attributes. The central premise of this approach is that a variety of stressors exert significant influence on the structure and function of aquatic and riparian ecosystems and that the addition of anthropogenic stressors may change the timing, magnitude, and duration of ecosystem response. The combined result is manifested in the current condition of watersheds throughout the PIBO area.

This stressor-response model forms the foundation for the effectiveness monitoring plan. This model is one part of a broader framework developed by Noon and others (1997) that describes the key components of a monitoring plan. An exhaustive list of potential stressors was developed as part of the Sierra-Nevada Ecosystem Aquatic Monitoring effort and used as a starting point to identify stressors that may influence riparian and aquatic habitats in the PIBO area (table I-1).

Conceptual models linking stressors to a set of biophysical consequences in aquatic and riparian systems were developed as part of the Sierra Province Assessment and Monitoring effort and the Northwest Forest Plan. We reviewed these models and developed a composite model that best fits the situation in the PIBO area (fig. I-3). At the bioregional scale, geology, climate, and topography influence broad-scale vegetation development, the type, frequency, and magnitude of disturbances, and other ecosystem processes such as hydrologic and nutrient cycling, carbon flux and storage, primary productivity, site productivity, and trophic dynamics. These processes directly influence processes and functions occurring at the watershed scale. Lines connecting these components are bidirectional, indicating that influences may occur between processes and scales. The consequences of stressors on watershed processes in uplands, riparian areas, and streams are integrated and ultimately influence components of aquatic biodiversity.

The list of the biophysical consequences was used to develop potential indicators that could be used to measure the response of aquatic and riparian communities to the anthropogenic stresses (appendix I-A). We used a set of rating criteria developed by the Sierra Province Aquatic and Riparian Monitoring Plan (in preparation) to evaluate the feasibility and usefulness of each indicator (table I-2). The final indicators reflect stressors/indicators associated with uplands, riparian-flood-plain systems, and in-channel subsystems (table I-3). Once this set of indicators was selected, we developed a full description for each indicator including the biological and physical importance, the relationship of the indicator to management, field methods, and a description of how data have been analyzed and interpreted in past studies (appendix I-A). These descriptions were used to guide the study design and sampling efforts.

Objective 1

Study question: Are priority biological and physical attributes, processes, and functions of riparian and aquatic systems degraded, maintained, restored in the PIBO area? Additional questions will also be tested.

Study Design and Methods

We propose an "extensive" approach to monitoring by subsampling a fixed percentage of the 6^{th} hydrologic unit code (HUC) watersheds within the PIBO area on a yearly basis. We will stratify the sample area by using geology, watershed size, elevation, precipitation, and vegetation as our primary stratification criteria, and "managed" and "reference" as secondary

Table I-1—Aquatic and riparian ecosystem stressors in the PIBO area. Stressors are divided into two categories relative to their relationship to human activities and scale.

Stressors that are a direct result of human activities
1. Impermeable ground surfaces—urbanization, campgrounds, pavement, and so forth
2. Water pollution—eutrophication, herbicides, toxic spills, and so forth
3. Direct human land/resource use—recreation, hunting, fishing, hiking, and so forth
4. Roads and log landings in upland and riparian areas, especially stream crossings, culverts, and so forth
5. Dams and water diversions, and so forth
6. Air pollution
7. Mining effects
8. Vegetation management—timber harvest, prescribed fire, fire suppression, wildlife habitat conversion, and so forth
9. Livestock grazing
10. Introduced (exotic) species
Large-scale environmental stressors that can be influenced spatially and temporally by human activities
• Climate change
• Drought
• Flood
• Mass earth movement
• Wildfire
• Insects/pathogens
• Invasive species

Watershed Processes and Functions

Bioregional conditions
Geology,
climate,
topography

↓

Processes
Speciation, nutrient flow, species
interactions, disturbance, sedimentation

↓

	Ecosystem process		*Stressors*		*Consequences*
	General process	Key process	Human influenced	Human caused	
Upslope	Vegetation growth, mortality, succession	Wood production, transport	Fire, insects, pathogens	Forest management, recreation, grazing	Fragmentation, debris recruitment, nutrient cycling, altered species composition
	Soil cycle	Sediment production, transport, erosion, nutrient cycle, mass wasting, debris flows	Mass wasting, debris flows, surface erosion	Forest management, roads, mining, grazing, recreation development	Nutrient cycling, soil moisture, formation rates, sediment regime
	Hydrologic cycle	Water storage, yield, precipitation	Precipitation, floods, drought	Forest management, mining, grazing, roads	Changes in runoff timing magnitude, water storage, routing
Riparian/floodplain	Vegetation growth, mortality, succession	Wood production, transport, community structure, regeneration	Fire, insects, pathogens, herbivory	Forest management, recreation, grazing	Changes in species composition, direct habitat loss, change in riparian microclimate, change in nutrient cycle, change in woody debris recruitment
	Soil cycle	Sediment production, transport, erosion, nutrient cycling,	Mass wasting, debris flows, erosion, flooding	Forest management, mining, recreation, roads	Changes in sediment regime, soil moisture
	Hydrologic cycle	Water storage, yield	Flooding, drought	Forest management, roads, recreation, grazing, mining, diversion, impoundment	Change in water temperature, hydrologic regime, runoff timing and magnitude, toxins
	Energy exchange	Heat delivery	Insulation, shading	Forest management, grazing	Changes in microclimate, water temperature
	Chemical/nutrient turnover	Chemical/nutrient delivery	Deposition, erosion, transport, storage	Forest management	Changes in nutrient production, introduction of toxins
Stream	Hydrologic cycle	Water timing, quantity, hyporheic exchange	Flooding, drought	Diversion, impoundment	Changes in water quality, temperature, debris transport, habitat loss
	Energy exchange	Heat delivery	Insulation, shading	Forest management	Changes in water temperature
	Channel structure	Sediment, wood delivery, habitat formation	Scour, deposition, debris transport, channel migration	Dredging, mining, grazing, forest management, recreation	Habitat loss, change in stream channel morphology, sediment regime
	Chemical/nutrient turnover	Delivery of chemicals/ nutrients	CPOM/FPOM input, erosion, toxins	Forest management, grazing, recreation, waste disposal, mining	Changes in nutrient cycle, water quality

↘ ↓ ↙

Aquatic communities

Figure I-3—Conceptual model of processes and stressors that influence processes, functions, and potential consequences at the watershed scale.

Table I-2—Review criteria used in the initial screening of indicators for the PIBO effectiveness monitoring plan. Criteria were evaluated at four spatial scales: site, watershed, basin, and PIBO area.

1. What is the availability of existing data? - none, low, moderate, high.
2. How relevant is the indicator to our original goals, objectives, and questions? - none, low, moderate, high, indirect.
3. Can the results be consistently interpreted within known reference conditions or contexts? - no, yes.
4. Is change detectable at scale of interest? - no, yes.
5. How sensitive is the indicator to stressors? - low, moderate, high.
6. How confident are we that the indicator represents a function or process of interest? - none, low, moderate, high.
7. Is there a direct measure of the stressor available? - no, yes.
8. Are there existing methods available to measure the indicator? - no, yes.
9. Can the indicator be applied at multiple spatial scales? no, yes (which scales?)
10. Are the metrics associated with the indicator repeatable (and doable)? - no, yes.
11. What is the relative cost? - low, moderate, high

Table I-3—Final indicator selection summary showing relationship to stressors, a composite usability ranking, and an indication of how the data will be gathered.

Indicator	Direct/indirect[a]	Usability	Data collection[b]
Land use history and current management (upland and riparian)			
Equivalent road acres, harvest history	D	High	All[c]
Road density—hydrologically connected	D	High	All[c]
Number of culverts and stream crossings	D	High	Office, field[c]
Culvert failure rate	D	High	Office, field
Mining history/extent	D	Med	Office, field
Fire frequency	D	Med/high	Office, field
Roads: landslide frequency, size, location	D	Med	Office, field[c]
Livestock management history	D	med	Office, field[c]
Riparian/floodplain habitat			
Fragmentation of riparian vegetation— high contrast	I	High	Rm, field
Seral stage / structural complexity of riparian	I	High	Rm, field
Flood-plain interactions/connectivity	I	Med/high	Field
Effective ground cover	D	Med	Field[c]
In-channel/community integrity			
Invertebrate community structure	I	Med/high	Field[c]
Water quality - direct measures	I	Med	Field[c]
Water temperature - direct measures	I	High	Field[c]
Distribution of large woody debris	I	High	Field[c]
Cross section mapping	I	High	Field[c]
Width-to-depth ratio, frequency of large pools, longitudinal profiles, residual pool depth, bank angles, percent undercut bank, substrate composition, bank stability	I	High	Field, rm[c]

[a]Direct (D) or indirect (I) measure of a stressor.
[b]Remote sensing (rm) = aerial photos, maps, infrared, and satellite imagery; office = information on file in Forest offices or that can be gathered through library research; field = requires field data collection; all = all three of these techniques are used.
[c]Data are quantitative, measured, and not estimated.

strata. We will test whether our stratification criteria contribute significant value to our analysis using analysis of covariance. If stratification criteria are not meaningful, we will combine samples where appropriate.

We will develop 177 blocks of 20 contiguous watersheds throughout the PACFISH/INFISH area. Each year we will randomly choose 20 percent of the blocks and then subsample seven of the watersheds within each block. We will repeat this process over a 5-year period until we have sampled approximately one-half of the potential watersheds that have perennial streams and greater than 50 percent Federal ownership above the sample reach. We will then resample the same watersheds over subsequent 5-year periods. This design is represented as a rotating panel that is serially augmented and alternates over a given period (Urquhart and others 1998). Initially, we will randomly select the subsample of reference and managed watersheds within the group. Our goal will be to select an even number of "reference" and "managed" watersheds for sampling. Because the number of "reference" watersheds is generally low, we will sample as many as possible within the group, up to half of the total number of watersheds.

We will work with individual field units to verify the status and condition of each watershed. Watersheds that do not meet sampling criteria will be dropped from sampling and alternates chosen. For example, watersheds that appear to fit sampling criteria on the map, but have intermittent flow during the sampling season, will be dropped in favor of a watershed having perennial stream flow. This will allow us to maximize crew and sampling efficiency within given areas while meeting our assumption of randomness.

The sample watersheds will be selected from the current list of watersheds developed during consultation with both the USNMFS and the USFWS to track implementation monitoring within the sample watersheds during year 1. In subsequent years, the random sample of effectiveness monitoring watersheds will trigger the selection of implementation monitoring in the same watersheds. This will allow us to determine whether the key management practices have been fully implemented. At this time, only watersheds having greater than 50 percent Federal land ownership will be considered for sampling to reduce the variability associated with mixed-ownership management.

Sample watersheds will be *a priori* divided into two analysis categories—reference and managed—that exhibit a range of land management activities. We will establish category ownership by developing a set of screening criteria using management activities and the percentage of those activities that currently exist in the watershed. In addition, we will also use information from other water quality assessments and the Inland West Strategy (where data are available) to further define management categories. If we determine that reference watersheds are unavailable throughout a basin, we will gather information from field units on the status and distribution of riparian and aquatic habitats that have been minimally influenced by land management activities and convene expert panels to evaluate these data and establish "reference" conditions for these areas (fig. I-4).

We will use the "stream" as our sampling unit within the watershed, and stream reaches will be our sample locations. We will potentially use two reach types in the survey:

1. Response reaches, which have less than a 2 percent gradient and respond to sediment and wood input by adjusting channel form.
2. Transition reach, which have a 2 to 3 percent gradient, are generally the transition between response reaches and transport reaches, and show little visible effect in channel form from sediment and debris inputs.

Initial reach determinations will be made from U.S. Geological Information System (GIS) maps available for each watershed. We will select a minimum of one reach within each watershed. Potential integrator reaches that are influenced by beaver activity will be excluded from sampling. This reach will normally be

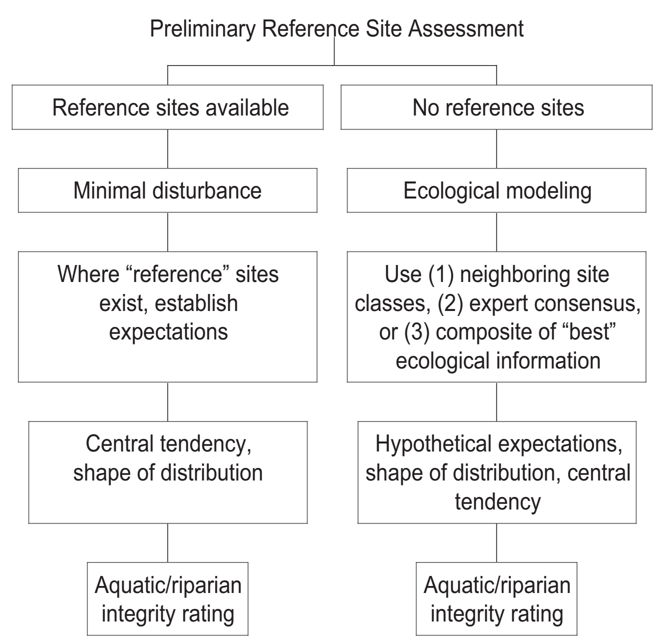


Figure I-4—Approach to establishing reference conditions (modified from Barbour and others 1995).

the most downstream reach in the watershed and should represent a response reach wherever possible. This “integrator” reach should be a minimum of 20 times the bankfull width, but never less than 80 m. An integrator reach will never have a gradient greater than 3 percent. In general, these reach types represent pool-riffle channels that should have the greatest sensitivity to increases in sediment supply and peak flows (Montgomery and MacDonald 2002). In composite watersheds where there are multiple small streams entering a large stream (greater than 4th order) we will randomly select one stream and sample the most downstream reach. At each watershed we will collect information on management history indicators, in-channel and water quality indicators, and riparian community indicators.

Analyses

See objective 2.

Objective 2

Study question: What is the direction and rate of change in aquatic and riparian habitats over time?

Study Design and Methods

In addition to our annual random sampling, we will select a fixed number of watersheds from each strata to track over time. This will allow us to determine the rate and direction of change in managed and reference watersheds, which will allow us to better estimate the “year” effect and to project how long it will take for the expected changes from management to occur. These “sentinel” sites will be sampled yearly. We anticipate that there will be 50 of these watersheds in the annual sample, divided equally between the two categories. We will use the same sample reaches and transects for our field measurements. Sample reaches and transects will have permanent survey monuments and be geospatially located to facilitate finding these sites through time.

Once the final indicators were selected (table I-3), we developed a description of all methods for both land use history variables and habitat variables. A complete description of the methods for assessing land use history is in development, while a description of the methods used to assess stream and aquatic habitat is found in Part II, and the methods for assessing riparian communities are found in Part III.

A quality control plan was developed to test the variability of our methods, the variability between crews, and seasonal variability (Archer and others, in press; Coles-Ritchie and others, in preparation).

Analyses

We will evaluate questions 1 and 2 using a variety of analyses. Our initial design is an incomplete randomized block analysis of variance where:

- Group represents potential strata (for example, geology, precipitation, ecoregion).
- Years are the incomplete blocks; in other words, a random subset of sites (selected without replacement) are visited each year.
- Each site will eventually be visited at 5-year (or more) intervals, depending on funding.
- Sentinel sites will be visited every year but by different crews (in other words, crews change virtually every year).
- The ANOVA breakdown would be as follows:

Source
Group
Site (group)
Year
Year x group
Year x site (group)
Crew (year)
Crew (year) x site (group)
Residual

This analysis will be used to determine if watershed condition, as expressed by the indicators, is changing over time. Results of these analyses will be used to display the trajectories of watershed condition across the PIBO landscape. In addition, we will evaluate the distribution of watershed condition indicators among the selected reference and managed watersheds by evaluating the frequency distribution of condition of watersheds across the whole PACFISH/INFISH region. Patterns of ecological functions are spatially and temporally dynamic. Hence, watershed condition will be defined by comparing individual indicators or static estimates of watershed condition with the natural range of watershed function and integrity. How rapidly the frequency distribution changes will depend on a variety of factors, including current conditions, natural disturbances, intensity of management activity, and degree of degradation from which a watershed is recovering. Under natural conditions, watersheds across the landscape ranged from diverse, productive biotic communities, to relatively simple, unproductive systems (Overton and others 1995; Reeves and others 1995). If the aquatic conservation strategy of PACFISH/INFISH is effective, it should create a landscape of managed watersheds that trends toward improved functioning over time (fig. I-5).

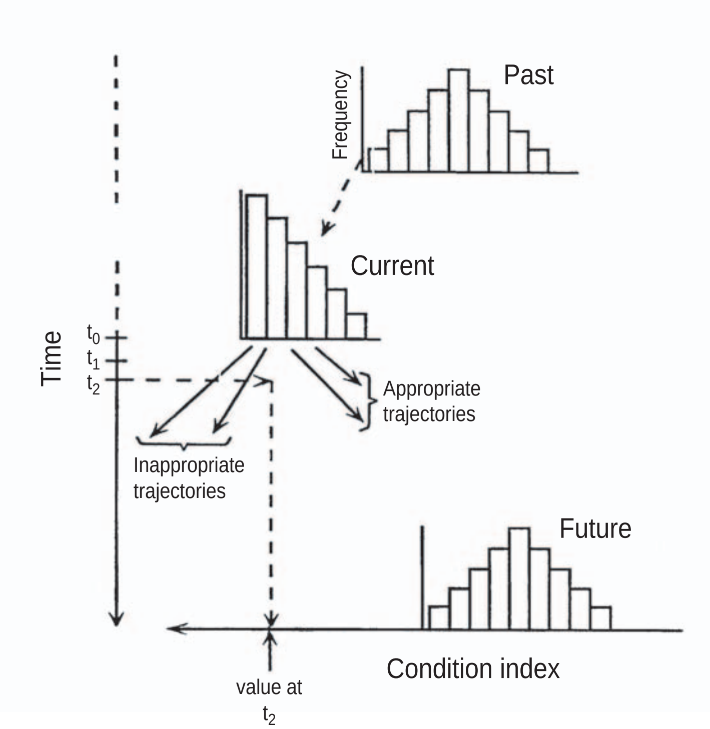


Figure I-5—Hypothetical change in frequency distribution moving from historic, to current, to expected change. Target distribution does not equal historic distribution (adapted from Noon and others 1997).

Exploratory analyses will assess the relationships of the variables used in our comparative analyses. This has two purposes: first, we can evaluate the contribution of the indicators to explain pattern and process; and second, it should allow us to validate the value of the stratifications that we *a priori* identified. These types of analyses may include cluster analysis, discriminant functions analysis, ordination, and regression.

Annual Reporting

Data from sentinel sites will be used in combination with our previous data set to project trends and rates of change in aquatic and riparian community characteristics across the PIBO landscape. These data will be used to forecast the outcomes of management changes over time, and we could potentially use this information to project watershed recovery rates within similar geographic areas. For example, long-term data from sentinel sites in some strata may indicate that channel response to changes in management may be slow due to the influence of the geology or climate in an area. By understanding this relationship, managers could potentially use this information to promote recovery by making more substantive changes in management practices or by identifying restoration activities that accelerate recovery.

Data will be annually summarized for all sample watersheds into an aggregate rating for each sample strata. Comparative analyses will be summarized by stratum to determine differences in watershed condition between the managed and reference watersheds. Initially, strata where frequency distributions for variables are similar and where less than 25 percent of the variables are significantly different between managed and reference watersheds will be considered "maintained or restored." Watersheds where differences are apparent in the shapes of the distributions and/or more than 25 percent of the variables are significantly different between managed and reference sites will be subject to further analyses. This "further analysis" categorization triggers an examination of the individual management watersheds within the strata to determine causation. These watersheds will be subject to review by District Managers/Forest Supervisors and interagency review teams. Local managers can review the current conditions of the watershed, determine whether current management practices are being implemented correctly, and evaluate whether changes are needed.

Objective 3

Study question: Are site-specific DMA practices being implemented, and are they effective in maintaining or restoring riparian habitats (grazing as an example)?

DMA practices are designed to protect aquatic and riparian habitats from land use effects. A basic assumption underlying the DMA concept is that land use activities can be mitigated by implementing these practices. Best Management Practices (BMP) are generally included as DMA practices but are specifically designed to protect water quality. DMA monitoring is an evaluation of whether or not the implementation of the practices over time is actually moving specific resource conditions toward desired conditions (related to the PACFISH Riparian Management Objectives).

DMA indicators are selected to be directly and rapidly responsive to the land use, although in practice this may be difficult to achieve. For example, riparian hardwood recruitment and retention is responsive to grazing (both livestock and big game) and presumably to the implementation objective for residual stubble height. While the indicator is responsive to grazing impacts, it may also be affected by ground-water availability (which in turn can be affected by roads or logging). However, if the site objectives are related to the need to increase woody vegetation, and grazing impacts are a concern, the use of the riparian hardwood recruitment/retention indicator may be the best choice available.

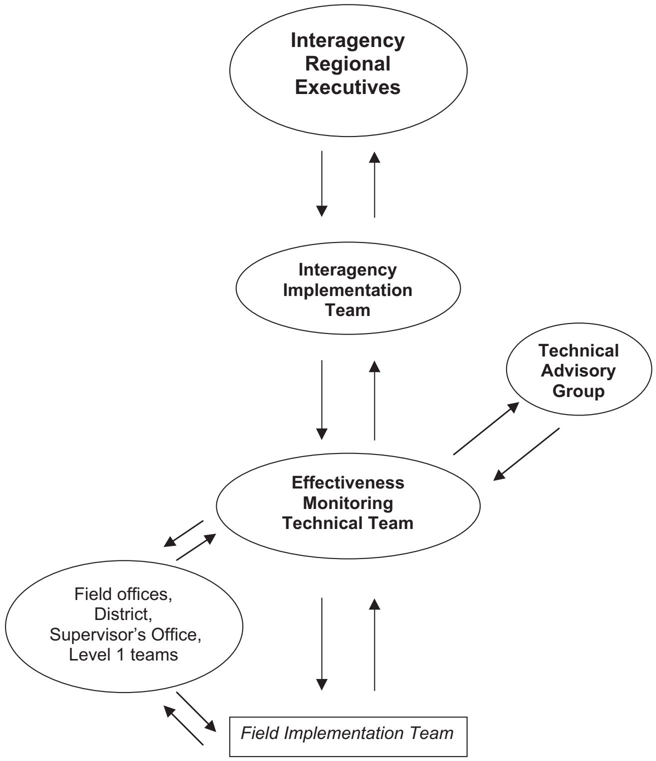


Figure I-6—Organizational structure of PIBO effectiveness monitoring team.

Study Design and Methods

To date, only the monitoring protocol for grazing is specifically developed. Each pasture that contains a riparian area will have one or more key areas where Implementation Monitoring is to occur. These key areas will be monitored to determine if the end-of-season grazing implementation standard has been achieved.

The sampling framework for grazing practice effectiveness monitoring will be the same as the strategy outlined for question 1. Grazing effectiveness monitoring will be conducted within the same watersheds selected to answer objective 1 (where livestock grazing is present). In watersheds that are grazed, we will sample DMAs within one pasture containing significant amounts of riparian vegetation-dominated habitat. We will exclude small special management pastures—such as on-off allotments, holding pastures, cow camps, pastures containing only forested riparian areas with little or no grass-dominated vegetation, and riparian exclosures—and place them in a separate category. Sample reaches will be chosen by field unit personnel. If more than one DMA is present, we will randomly choose one sample site. Composite watersheds (watersheds not having a clearly defined topographic outlet) will be sampled using a similar procedure. Grazing response reaches should be a minimum of 110 m (Winward 2000). If a response reach is unavailable within the first pasture, then we will sample a transition reach within the same pasture. Only riparian community and streambank indicators will be measured in the grazing reach.

Analyses

The analyses to answer this question are similar to the comparative analyses outline under objectives 1 and 2. In addition, analysis of covariance may be attempted to look at the influence of the stubble height Key Management Practices (KMP) on meeting effectiveness monitoring objectives.

Data Summary, Decision Support, and Adaptive Management

Because DMA monitoring is designed to provide short-term feedback on the effectiveness of specific management practices, this information must be rapidly summarized and analyzed to provide feedback to managers. Data will be summarized by watershed and made available to local field personnel on an annual basis. In addition, summaries and analyses of riparian community indicators by strata will be included so that managers can evaluate the results of their management against similar prescriptions in proximity to their sites. This should give managers information to make changes, if necessary, to the residual stubble height standards in their allotments. Data will also be used in the analyses and reporting described in question 1.

Project Structure

The effectiveness monitoring plan provides the conceptual framework, sample design, core indicators, and analysis to evaluate riparian and in-channel conditions and assess watershed conditions across the PACFISH/INFISH area. Regional executives from the BLM, NMFS, FWS, and Forest Service oversee the monitoring efforts related to PACFISH/INFISH and the Biological Opinions. Their direct representatives are the Interagency Implementation Team. The Effectiveness Monitoring Technical Team is an interagency team responsible for the development of the effectiveness monitoring plan and provides guidance to the Field Implementation Team. Technical oversight and peer review are conducted by the Technical Advisory Group, which is composed of scientists and managers from agencies and academia. The Effectiveness Monitoring Field Implementation Team develops sampling protocols, analyzes and interprets data, and reports findings to agency managers. This team will report directly to the Effectiveness Monitoring Technical Team. We propose a centralized structure to ensure all elements of data quality control and quality assurance are maintained. Local field units will interact with the Effectiveness Monitoring Field Teams to validate assumptions, define indicator relevance and importance, and coordinate logistical needs for data collection. The Effectiveness Monitoring Field Team will provide assistance to local field units when requested and provide each field unit with a copy of field and office protocols, sampling locations and maps, technical data and analysis, and an annual report of monitoring activities.

Effectiveness Monitoring Field Team responsibilities are:

- Develop and implement the effectiveness monitoring plan.
- Develop and apply a sampling scheme to select sampled watersheds.
- Train field implementation teams, and coordinate data acquisition efforts.
- Maintain a corporate data structure for acquired information.
- Compile and analyze data to establish status and trend information for resource conditions within the PACFISH/INFISH area.
- Report monitoring results annually to agency executives.
- Make recommendations to adapt the effectiveness monitoring program to include new or refined indicators developed through statistical analyses and other research results as they become available.
- Advise managers on observed effectiveness of key management practices.
- Coordinate logistics for annual data collection with administrative units.
- Compile, verify, and summarize indicator data for all watersheds sampled in the region.
- Develop and maintain a quality control program for monitoring data.
- Work with the Technical Advisory Team and the Effectiveness Monitoring Technical Team to modify sampling methods and protocols where needed.

Local field-unit staff will interact with the teams to refine local indicators, give relative weighting to indicators in assessments, contribute technical support to data acquisition and interpretation, and work with the technical team to develop predictive models.

Because watershed condition assessments will be subject to local interpretation, appropriate documentation must accompany each assessment to describe how core indicators are applied and which additional indicators, if any, are integrated into watershed condition assessments. Proper documentation and oversight of this process will be critical to ensure that the database will have value when aggregated at the regional scales.

Data Quality Assurance and Quality Control

Quality assurance and quality control measures for collecting data and assessing watershed condition are built into the organizational and implementation structure for the effectiveness monitoring plan (Archer and others, in press; Coles-Ritchie and others, in preparation). Quality-control measures will include: (1) developing and using standardized protocols for data collection; (2) testing the ability of crews to obtain consistent results with field protocols; (3) documenting data sources and the assumptions used to develop indicator reference conditions, weights, and relations used in the analysis; and (4) annual review of protocols, protocol testing, and project design.

Results of quality control testing have been provided to outside peer reviewers for comment and review. Objectives of outside review are to validate the information and assumptions used in the process, to gain internal team understanding and support of the assessment results and the process used, and to provide feedback on information and research gaps, with suggestions for future work.

Timelines

The PIBO effectiveness monitoring project underwent pilot testing for 3 years. In 2001 and 2002 the project sampled at 50 percent of projected full implementation (table I-4). The first year of full implementation is projected was 2003. At full implementation 250 “extensive” watersheds and 50 “sentinel” watersheds will be sampled annually. Approximately 50 percent of the watersheds meeting the Federal ownership criteria will be sampled over a 5-year sampling period. At year 6, a new sampling cycle will begin, and the same watersheds will be sampled over the next 5-year cycle. During a typical forest planning cycle (15 years) approximately 50 percent of the watersheds in the PIBO will be sampled two to four times.

Conclusions

One of the largest problems with monitoring plans of this type is the truncation of monitoring before enough data are gathered for interpretation (Reid 2001). This project is designed to be long term, and many of the changes, as a result of changes in management, will most likely not occur during a short period (1 to 5 years). Some of these changes will be dependent on the recurrence intervals of major flood events (greater than 25 years), fire frequencies, and forest succession.

Table I-4—Projected sampling cycle for sentinel and extensive monitoring watersheds in the PIBO area.

Watershed	2001	2002	2003	2004	2005	2006	2007
Sentinel	25	25	50	50	50	50	50
Group 1	125					250[a]	
Group 2		125					250
Group 3			250				
Group 4				250			
Group 5					250		

[a]An additional suite of 125 watersheds will be selected out of this group.

Long-term monitoring will be the only way that we will be able to detect whether changes in past management are indeed influencing watershed conditions.

This plan should be viewed as a "living" document and should evolve as new information becomes available. While we envision the basic sampling scheme to remain intact, it may be necessary to modify our design or sampling to accommodate new information. For example, one question that arose during the pilot study was, "Are conditions at the integrator reach reflective of conditions in the watershed as a whole?" This has been addressed by other efforts in a variety of ways. In the Aquatic Riparian Effectiveness Monitoring Plan (AREMP, in preparation), multiple reaches are selected within a watershed to develop a watershed characterization. In the EMAP program (Kaufmann and others 1999) random reaches are selected that "represent" conditions for a particular watershed. We will subsample a number of our "intensive" watersheds to determine whether the conditions at the integrator sites reflect conditions within the watershed. In addition, we will sample multiple response reaches and transport reaches throughout the watershed and use these data to compute the variability associated with measured variables. We will statistically determine if the error associated with increased sample sizes appears to decrease at some threshold. If we can detect a threshold, then we will adjust our sample strategy in the sentinel watersheds. If we are unable to detect significant differences between integrator reaches and watershed reach summaries, then we will discontinue whole watershed sampling.

Finally, the intent of this plan is to provide information that will help managers to understand whether actions that have been implemented on the ground are maintaining or restoring stream habitat. This plan will only succeed if the results from this monitoring are transmitted in a timely manner and result in positive change.

Glossary

Aquatic community – an association of interacting assemblages in a given water body, the biotic component of an ecosystem.

Biogeographic regions – any geographical region characterized by a distinctive flora and/or fauna.

Biological integrity – functionally defined as the condition of an aquatic community inhabiting unimpaired water bodies of a specified habitat as measured by an evaluation of multiple attributes of the aquatic biota. Three critical components of biological integrity are that the biota is (1) the product of the evolutionary process for that locality or site, (2) inclusive of a broad range of biological and ecological characteristics such as taxonomic richness and composition, atrophic structure, and (3) is found in the study biogeographic region.

Biological monitoring or biomonitoring – the use of a biological entity as a detector and its response as a measure to determine environmental conditions. Toxicity tests and ambient biological surveys are common biomonitoring methods.

Community – any portion of a biological community. The community component may pertain to the taxonomic group (fish, invertebrates, algae plants), the taxonomic category (phylum, order, family, genus, species, stock), the feeding strategy (herbivore, omnivore, predator), or the organizational level (individual, population, assemblage) of a biological entity within the aquatic or riparian community.

Confidence interval – an interval that has the stated probability (for example, 95 percent) of containing the true value of a fixed (but unknown) parameter.

Designated Monitoring Area (DMA) – areas with pastures that represent the condition of riparian areas affected by grazing within the pasture. Location of effectiveness monitoring for vegetation and bank parameters.

Degradation – any alteration of ecosystems such that chemical, physical, or biological attributes are adversely affected.

Ecological integrity – the condition of an unimpaired ecosystem as measured by combined chemical, physical (including habitat), and biological attributes.

Effectiveness monitoring – monitoring to determine whether the correct implementation of land use practices is "effective" at moving resource condition in some desired direction.

Historical data – data sets existing from previous studies, which can range from handwritten field notes to published journal articles.

Impact – a change in the chemical, physical (including habitat), or biological quality or condition of a water body caused by external sources.

Integrator reach – generally the downstream-most reach within a 6th code watershed that is less than 2 percent gradient.

Macroinvertebrates – animals without backbones of a size large enough to be seen by the unaided eye and that can be retained by a U.S. Standard No. 30 sieve (28 meshes per inch, 0.595 mm openings).

Managed site – the location under study of which the condition is unknown and suspected of being adversely affected by anthropogenic influence.

Metric – a calculated term or enumeration representing some aspect of biological assemblage structure, function, or other measurable aspect; a characteristic of the biota that changes in some predictable way with increased human influence; combinations of these attributes or metrics provide valuable synthetic assessments of the status of water resources.

Nonpoint source – the origin of pollution in diffuse sources such as agriculture, forestry, and urbanization. Such pollution is transported by rainfall or snowmelt runoff carrying pollutants overland or through the soil.

Population – an aggregate of individuals of a biological species that are geographically isolated from other members of the species and are actually or potentially interbreeding.

Quality assurance (QA) – includes quality control functions and involves a totally integrated program for ensuring the reliability of monitoring and measurement data; the process of management review and oversight at the planning, implementation, and completion stages of environmental data collection activities. Its goal is to assure that the data provided are of the quality needed and claimed.

Quality control (QC) – refers to the routine application of procedures for obtaining prescribed standards of performance in the monitoring and measurements process; focuses on the detailed technical activities needed to achieve data of the quality specified by data quality objectives. Quality control is implemented at the bench or field level.

Reference condition – the set of selected measurements or conditions of watersheds characteristic that are minimally influenced by anthropogenic stressors.

Reference site – a specific locality that is minimally influenced and is representative of the expected ecological integrity of other localities in the same watershed or nearby watersheds.

Riparian zone – transitional areas between terrestrial and aquatic ecosystems, distinguished by gradients in biophysical conditions, ecological processes, and biota. They are areas through which surface and subsurface hydrology connect water bodies with adjacent uplands. They include those portions of terrestrial ecosystems that significantly influence exchanges of energy and matter with aquatic ecosystems (in other words, a zone of influence). Riparian areas are adjacent to perennial, intermittent, and ephemeral streams, lakes, and estuarine-marine shorelines (National Research Council 2002).

Sentinel watershed – watersheds that are annually sampled.

Stressor – A disturbance that alters resources or acts as a physiological disrupter such that the limits of an ecosystem or population to adapt may be shifted, and if the magnitude and duration are significant, the system moves into a new state.

Taxa richness – refers to the number of distinct species or kinds (taxa) that are found in an assemblage, community, or sample.

Transition reach – a stream reach that is generally between 2 and 3 percent gradient.

Appendix I-A

Potential indicators for each biotic or physical consequence for PIBO effectiveness monitoring effort (adapted from Sierra Nevada Framework aquatic monitoring plan).

Biotic or physical consequence	Potential indicators
Changes in runoff timing/magnitude	• Hydrographs - peak flow, frequency, and so forth • Watershed/near-stream road density • Elongation of stream into ditches (length) • Number of culverts and stream crossings[a] • Culvert failure rate • Number of dams and diversions, acres of reservoirs[a] • Length of perennial stream (ratio to intermittent)[a] • Lake/pond water level • Mining history/extent[a] • Ground-water condition[a]
Direct habitat loss/fragmentation and change	• Soil quality - compaction, cover, organics[a] • Fragmentation of riparian vegetation - high contrast • Fragmentation of riparian vegetation - low contrast • Seral stage/structural complexity of riparian[a] • Native riparian community mosaic, composition[a] (spatial extent, mosaic, nonriparian openings width of obligate riparian, root density) • In-stream/lake aquatic vegetation • Fire frequency[a] • Fish/wildlife populations parameters (natality, survival, and mortality rates, movements)[a] • Fish/wildlife distribution, abundance, connectivity[a] • Timber harvest history • Location/size of recreation sites • Location/size of other disturbance
Changes in nutrient production/cycles	• Chemical and nutrient content of water • Invertebrate community structure[a] • Instream-channel carbon load • Fire frequency • Primary productivity/algal community • Native riparian community mosaic, composition[a]
Introduction of toxins in water and potability	• Number of reported toxic spills - type and quantity • Water quality - direct measures • Sublethal/mortality effects on vertebrates[a] • Invertebrate community structure[a] • Seral stage/structural complexity of riparian[a] • Number of culverts and stream crossings[a]
Changes in fish/wildlife population parameters	• Fish/wildlife population parameters (natality, survival, and mortality rates, movements for priority species)[a] • Fish/wildlife distribution, abundance, connectivity[a] • Genetic diversity/similarity • Fish health • Angler/hunter surveys
Changes in community structure/ composition	• Community composition/integrity metrics • Special habitats distribution and abundance[a] • Fish stocking history
Changes in sediment regime	• Instream - channel sediment measures • Channel morphology[a] • Slope erosion indicators[a]

(con.)

Appendix I-A (Con.)

Changes in woody debris recruitment/ transport	• Frequency, distribution, arrangement of LWD • Large tree density/diameter • Seral stage/structural complexity of riparian[a] • Slope erosion indicators[a] • Number of dams and diversions, acres of reservoirs[a]
Changes in water temperature	• Direct measures[a] • Canopy closure - over stream and riparian[a] • Presence/distribution of special thermal habitats (cold pools, hot springs, and so forth) • Fish/wildlife distribution, abundance, connectivity[a] • Length of perennial stream, ratio to intermittent[a]
Changes in stream channel morphology	• Habitat mapping (fast/slow water) • Width-to-depth ratio, frequency of large pools, longitudinal profiles, residual pool depth, bank angles, shore depth, substrate, and so forth[a] • Flood-plain interactions/connectivity • Number of dams and diversions, acres of reservoirs[a] • Animal Unit Months (cattle and pack stock) [a] • Mining history/extent[a] • Root density/bank stability
Changes in soil moisture/hydrologic regime	• Native riparian community mosaic composition[a] • Soil quality - moisture, compaction, organics[a] • Presence/absence of a defined stream channel, width-to-depth ratio, frequency of large pools, longitudinal profiles, residual pool depth, bank angles, shore depth, substrate, and so forth[a] • Flood-plain interactions/connectivity • Number of dams and diversions, acres of reservoirs[a] • Animal Unit Months (cattle and pack stock)[a] • Ground-water condition[a]
Changes in riparian microclimate	• Direct measures (temperature and humidity)[a] • Canopy closure - over stream and riparian[a] • Seral stage/structural complexity of riparian[a] • Fish/wildlife distribution, abundance, connectivity[a]

[a]Indicator is useful for monitoring more than one consequence.

Part II:

Effectiveness Monitoring for Streams and Riparian Areas Within the Upper Columbia River Basin: Sampling Protocol for Integrator Reaches Stream Channel Parameters—2001

Richard Henderson
Eric Archer
Jeffrey L. Kershner

Part II Note

This document describes the sampling protocol used in 2001 and evaluated in the companion publication Archer and others (2004). Many of the methods have since been modified following additional testing and review. In addition, other methods that have we are currently testing were not included. See our website at http://www.fs.fed.us/biology/fishecology/emp/ for the most recent version.

Part II Acknowledgments

The authors thank everyone who helped in developing and testing this protocol. First, we thank Tim Burton, Kerry Overton, Sherri Wollrab, Darren Olsen, Jack Schmidt, Charles Hawkins, and many others for their advice and review of the various drafts. We especially appreciate the critical input from over 50 summer technicians who were invaluable in refining, clarifying, and evaluating the methods. We also thank Kate Dircksen and Emily Hall for their artistic drawings, and Deanna Vinson for final edits. Finally, thanks to Regions 1, 4, and 6 of the Forest Service, U.S. Department of Agriculture, and the Idaho and Oregon/Washington State Offices of the Bureau of Land Management, Department of the Interior, for funding the monitoring effort.

Introduction

An interagency team representing the U.S. Department of Agriculture, Forest Service (USDA FS), the U.S. Department of the Interior, Bureau of Land Management (USDI BLM), the U.S. Department of Commerce, National Marine Fisheries Service, U.S. Department of the Interior, Fish and Wildlife Service (USDI FWS) was convened to develop a large-scale monitoring program with the primary objective of determining whether PACFISH/INFISH management practices are effective in maintaining or restoring the structure and function of riparian and aquatic habitats throughout the upper Columbia River Basin. A list of attributes that were thought to be important in defining aquatic habitat conditions and their relationship with listed species were identified. The team also specifically stated that existing methods be used to measure each attribute. This sampling protocol for stream channel parameters (which is part of the "Plan to Monitor Aquatic and Riparian Resources in the Area of PACFISH/INFISH and the Biological Opinions for Bull Trout, Salmon, and Steelhead") is the result of that interagency effort.

The general sampling methods used by the program and described in this report were taken from existing sampling protocols. The following list includes the original citations for each of the methods used:

- Harrelson and others (1994)—Reach layout, gradient, sinuosity, site map, and channel cross-sections
- Wolman (1954); Overton and others (1997)—Streambed particle counts
- Platts and others (1987)—Bank angle and undercut banks
- Bauer and Burton (1993); Platts and others (1987)—Bank stability
- Overton and others (1997)—Defining habitat units and large woody debris
- Lisle (1987)—Residual pool depths
- Hawkins, Charles; Vinson, Mark; Ostermiller, Jeff (personal communication)—Macroinvertebrates
- Stevenson, Jan; Hawkins, Charles (personal communication)—Periphyton

The individual methods were initially modified to describe each attribute at a reach scale and increase repeatability between observers. Additional changes were made following 2 years of use, evaluation, and peer review.

Finally, the protocol and the individual methods were designed and tested specifically to sample a stream "reach" and to monitor the effects of management activities in a specific set of stream types. Reach lengths are a minimum of 20 bankfull channel widths in length and range from 80 to 300 m. All reaches are within unconstrained valley bottoms with gradients less than 3 percent and have wadeable channels with bankfull widths between 1 and 15 m. We feel strongly that it should not be used in other stream types without additional review and testing.

Sampling Order

1. Locate the flag at the downstream end of the reach.
2. Identify the pool tail near the flag and mark the exact downstream end of the reach.
3. Measure alkalinity, conductivity, and take a Global Positioning System (GPS) reading.
4. Measure the average bankfull width at each of the riffles.
5. Determine the reach length by measuring along the thalweg and placing transect flags.
6. Conduct pool sampling (pool-tail depth, maximum depth, length).
7. Conduct particle size counts in the riffles.
8. Measure channel cross-sections.
9. Conduct transect sampling (bank angle, undercut depth, and bank stability).
10. Measure and count large woody debris.
11. Finish site maps, gradient, and sinuosity.
12. Review all forms (especially Form 1) for completeness.
13. Review all entries in the data logger.
14. Check to make sure you have all equipment and forms.

Establishing the Sample Reach

After arriving at the site, locate the flag at the downstream end of the reach. Identify the pool tail near the flag and mark the exact downstream end of the reach. Next, examine the bankfull indicators (described below) throughout the reach to identify the bankfull elevation. For a more thorough discussion see Harrelson and others (1994).

1. Examine streambanks for an active flood plain. This is a relatively flat, depositional area that is commonly vegetated and above the current water level.
2. Examine depositional features such as point bars. The highest elevation of a point bar usually indicates the lowest possible elevation for bankfull stage.
3. A break in slope of the banks and/or change in the particle size distribution from coarser bed load particles to finer particles deposited during bank overflow conditions.
4. Define an elevation where mature key riparian woody vegetation exists. The lowest elevation of birch, alder, and dogwood can be useful, whereas willows are often found below the bankfull elevation.

5. Examine the ceiling of undercut banks. This elevation is normally below the bankfull stage.

6. Stream channels actively attempt to reform bankfull features such as flood plains after shifts or down cutting in the channel. Be careful not to confuse old flood plains and terraces with the present indicators.

7. Depositional features can form both above and below the bankfull elevation when unusual flows occur during years preceding the survey. Large floods can form bars that extend above bankfull, whereas several years of low flows can result in bars forming below bankfull elevation.

Then measure the bankfull width at a representative point within each of the first four riffles. Record the four bankfull widths on Form 1 and calculate an average. Use the average width to determine the width category from table II-1. The minimum stream length is defined for each width category and is equal to 20 times the width category. The upstream and downstream boundaries of the reach are located at a pool tail crest. Therefore, the upstream boundary is located at the first pool tail encountered after the minimum length has been attained.

Alkalinity and Conductivity

Conductivity

Measure conductivity once at each reach using a hand-held conductivity meter. Measure immediately upon arrival and before walking through the channel and disturbing the sediment. Take the reading near the surface, in flowing water, and record in parts per million (ppm) on Form 1 and in the electronic data recorder. Recalibrate the conductivity meter at the beginning of each 8-day sampling period.

Alkalinity

Measure and record both total alkalinity and P alkalinity once at the same time and location as conductivity. Record measurements to the nearest 4 ppm. Specific instructions are found in the water testing kit.

Pools

Pool Length and Residual Pool Depth

Objectives

- Quantify the relative length of pool habitat in each reach.
- Determine the average residual depth of pools.

Where to take measurements

Sample every pool within the sample reach that meets the following criteria for summer pool conditions:

1. Pools are bounded by a head crest (upstream break in slope) and a tail crest (downstream break in slope).
2. Only consider main-channel pools (the thalweg runs through the pool) and not backwater pools.
3. Pools are concave in profile.
4. Pools occupy greater than half of the wetted channel width.
5. Pool depth is at least 1.5 times the pool tail depth.
6. Pool length is greater than its width.

How to take measurements

1. Measure the pool length, maximum depth, and pool tail crest depth for each pool.
2. Measure pool length along the thalweg between the head crest and tail crest and record to the nearest centimeter.
3. The maximum depth represents the deepest point in the pool and is found by probing with a depth rod until the deepest point is located. The pool tail crest depth is measured at the maximum depth along the pool tail crest. Record both maximum pool depth and pool tail crest depths to the nearest centimeter.

Percent Surface Fines in Pool Tails

Objective

- Quantify the percentage of fine sediments on the surface of pool tail substrate.

Where to take measurements

1. Take measurements in the first four scour pools in each reach.

Table II-1—Width categories.

Average bankfull width	Width category	Minimum reach length
m		*m*
0 to 4	4	80
4.1 to 6	6	120
6.1 to 8	8	160
8.1 to 10	10	200
10.1 to 12	12	240
12.1 to 14	14	280

2. Only sample scour pools that meet the criteria described below, even if that means less than four pools are sampled.

3. Take three grid measurements within each pool tail.

How to take measurements

1. Measure surface fines in all pools that are formed by scouring, but not in pools formed by damming (such as a log or debris pile).

2. Sample within the wetted, flowing area of the pool tail (in other words, not in stagnant water).

3. The sampling area extends from the pool tail crest upstream a distance equal to 10 percent of the pool length. Divide the sampling area into three zones, taking one sample in each zone. See figure II-1 to determine how to define each zone.

4. Randomly toss the 14- by 14-inch grid once into each zone. Count the number of intersections where the substrate under the intersection (49 intersections and the upstream right corner = 50) is less than or equal to 6 mm. Use a Plexiglas viewer to reduce the glare.

5. Vegetation may be growing under the grid, hindering the identification of particle size. First, attempt to identify the particle size by moving the vegetation. If this is not possible, then list the number of nonmeasurable intersections on the data form.

Streambed Particle Size Distribution

Pebble Counts

Objective

- Determine the percent fines less than 6 mm in diameter (D), D16, D50 (median particle size), and D84 within riffles/runs.

Where to take measurements

1. Take measurements within the first four riffle/runs that meet the following criteria. If one of the first four riffles/runs does not meet these criteria, use the next upstream riffle/run if it is within the reach. Only sample riffle/runs that meet these criteria, even if fewer than four are sampled.

2. The riffle/run must be at least one-half as long (as measured along the thalweg) as the bankfull width "category."

3. Sample in both channels when a side channel is present.

How to take measurements

1. Divide 100 by the number of riffles/runs to be sampled to determine the number of particles to sample in each unit (for example, four riffle/run habitat units = 25 particle counts per unit, and three riffle/run habitat units = 33 particle counts per unit).

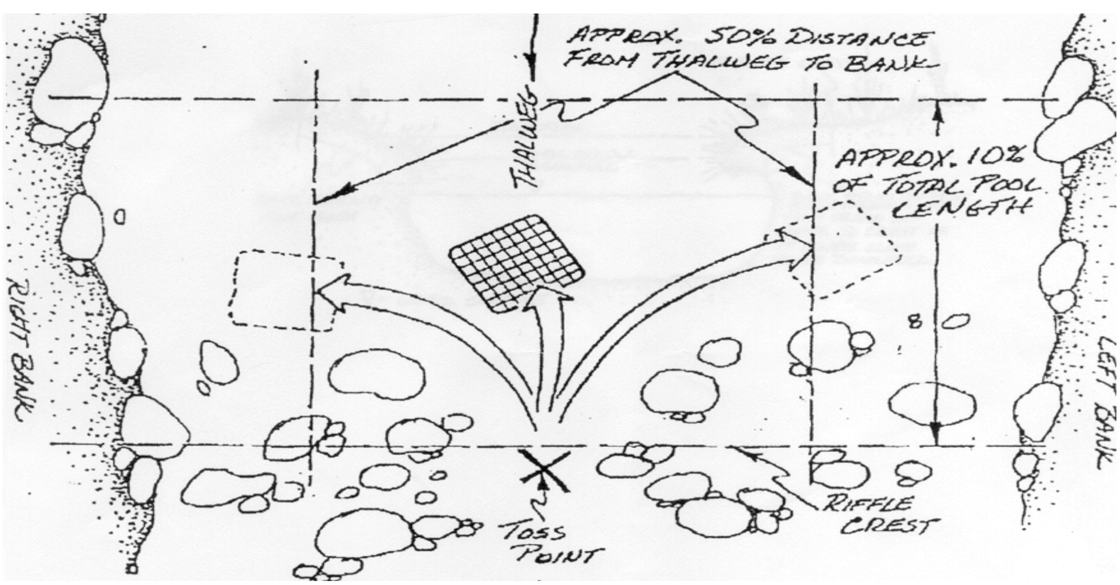


Figure II-1—Location of pool tail fines grid tosses in the pool tail showing the three sections and distance upstream from the riffle crest.

2. Sample throughout each habitat unit by establishing four evenly spaced transects perpendicular to the streamflow. First, determine the length of the riffle by pacing its length. Walk back, placing flags at 20, 40, 60, and 80 percent of the riffles' length to establish transect locations.

3. You must measure a minimum of 100 particles in each reach. Visually determine the number of heel-to-toe steps needed between each particle measurement so that the desired number of particles are sampled in each habitat unit. For example, measure six to seven particles per transect when there are four riffles, and eight to nine particles per transect for three riffles.

4. If less than 25 particles were sampled after the fourth transect, randomly choose a fifth transect and sample with the same spacing pattern used for the previous transects.

5. Sample the entire streambed width at each transect starting with the heel of the boot at the point where the streambed and streambank meet. Never sample a particle on the streambank or on slump blocks.

6. The upstream and downstream boundaries of the riffle are rarely perpendicular to the channel. Only sample particles within the riffle, and discontinue sampling when the transect crosses into pool habitat.

7. Depositional features are considered streambed material. End the count at the bankfull elevation when depositional features extend above bankfull or at the point where a depositional feature becomes greater than 50 percent vegetated with perennial species (fig. II-2).

8. Sample the particle at the toe of the foot. Reach down with the forefinger (without looking down) and pick up the first particle touched. Measure the middle width (B axis) of the particle in mm. Visualize the B axis as the smallest width of a hole that the particle could pass through.

9. Record particles less than or equal to 4 mm as 4 mm. Record the width of larger particles to the nearest millimeter.

10. Record the number of riffle/runs sampled on Form 1 and in the data logger.

Channel Cross-Sections

Entrenchment

Objective

- Determine bankfull and wetted widths, width-to-depth ratios, and the entrenchment ratio.

Where to take measurements

1. Measure one cross-section and flood-prone width within the first four riffle/runs that meet the following guidelines. If one of the first four riffles/runs does not meet these criteria, use the next upstream riffle/run if it is within the reach boundaries. Only sample riffle/runs that meet these criteria, even if fewer than four are sampled.

2. The channel must be relatively straight and have clearly defined bankfull indicators along at least one streambank. Do not sample a riffle/run if the entire length of the riffle/run occurs at a meander or the bankfull elevation cannot be determined.

3. When a side channel is present, use the main channel to determine if the channel is straight or meandered.

4. There are no minimum length criteria for the riffle/run.

5. Locate cross-sections at the widest part of the riffle. Measure widths between bankfull elevations with the tape stretched perpendicular to the channel. If islands are present, subtract the width of the island above the bankfull elevation from the total width of both channels.

6. Do not sample areas where human/animal crossings or old channels exist, thereby increasing the channel width.

7. Take measurements at the point where one pool ends and the other begins when riffle/runs are not present.

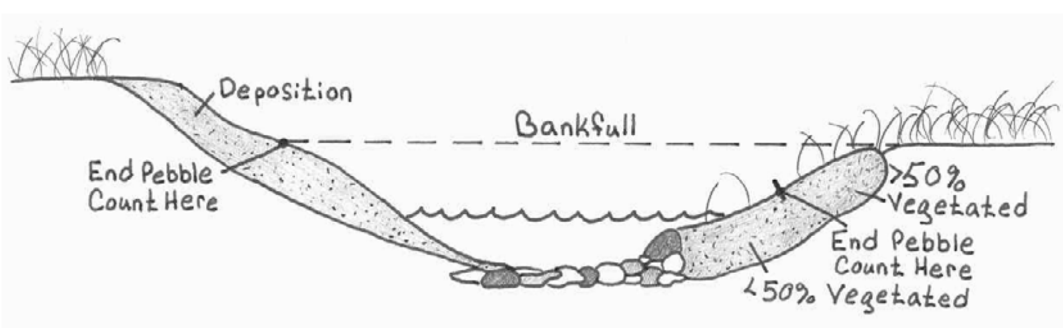


Figure II-2—End pebble counts at the bankfull elevation when depositional features extend above bankfull (left side). End pebble counts where the depositional feature becomes greater than 50 percent vegetated (right side).

How to take measurements

1. Determine and flag the bankfull elevation on each bank. Stretch the tape perpendicular to the channel between bankfull elevations with the "zero" end of the tape on the left bank (RL) looking downstream. Make sure the tape is straight and not bowed. Measure and record bankfull width in meters to the nearest centimeter.

2. Take a minimum of 10 equally spaced depth measurements starting at bankfull on the left bank and including bankfull on the opposite bank. Calculate the distance between measurements by dividing the bankfull width by 10. Randomly chose the location of the first measurement (using the random number table on the data logger) between bankfull on the left bank and the distance of the interval calculated above (fig. II-3).

3. At each depth measurement record the distance along the tape and the depth from the streambed to the bankfull elevation in centimeters. At the bankfull location of each bank, record the location along the tape and a depth of "0."

4. In addition, record the location and depth (to bankfull elevation) at the left and right wetted edges, maximum depth, and the riffle number. Record the maximum bankfull depth and riffle number on Form 1.

5. Measure only to the edge of the bank when an undercut exists. Do not measure beneath the undercut.

6. Measure islands lower than the bankfull elevation as described above. For islands higher than bankfull, measure the two channels separately using the techniques described above. Make sure to record a "0" depth at bankfull for both channels. Also record "island" in comment column.

7. Measure the flood-prone width at each cross-section. The flood-prone width is the width of the channel at twice the maximum bankfull depth as determined during the cross-section measurement.

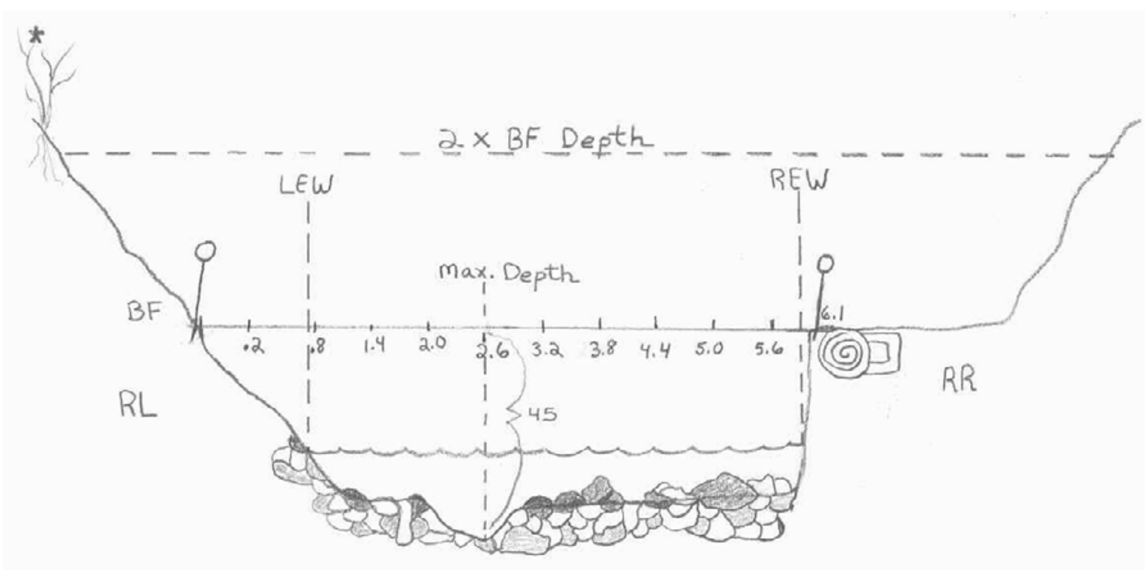
8. In wide meadows the flood-prone width can be large. Do not obtain a precise measurement if it is greater than three times the bankfull width. Record the measurement as 100 m.

Channel Transects

General Transect Measurements

Objective

- To define the location for measurements of bank angle, bank stability, undercut depth, bank type, bank material, and vegetation community type.



Random number =	0.2 m	Left edge water	Right edge water	Maximum depth
Bankfull width =	6.4 m	0.3	6.1	2.7
Interval =	0.6 m	20	20	45
Entrenchment width =	10.0 m			

Distance on tape (m)	0	0.2	0.8	1.4	2.0	2.6	3.2	3.8	4.4	5.0	5.6	6.1
Bankfull depth (cm)	0	10	30	40	38	44	40	35	33	30	30	0

Figure II-3—Channel cross-section showing measurements.

Where to take measurements

1. The distance between transects is the “width category” used to determine reach length. Chose a random number (k) between zero and the “width category” value from a random number table. Establish the first transect (k) meters upstream from the bottom of the reach. Place subsequent transects at regular intervals (one “width category” value) as measured along the thalweg. Place flags in both banks.

2. Measure all variables on both the right and left banks at each transect.

3. When a side channel is present, and it both leaves and re-enters the main channel within the reach:

   a. Measure the maximum bankfull depth of the side channel 1 m down from the upstream end, in the middle, and 1 m up from the downstream end.
   b. Collect transect measurements on the outside bank of the side channel if the average of the three depths is greater than or equal to one-half of the average maximum bankfull depth calculated from channel cross-sections.
   c. If not, take measurements on the bank of the island associated with the main channel.

4. When a side channel or old channel enters or leaves the main channel, but this channel either began or ended outside the reach:

   a. Only take measurements if the bank is associated with the main channel. Otherwise enter 999 for all transect measurements.
   b. Measure newly forming banks at the junction with old channels if the bank height is greater than or equal to the bankfull elevation.
   c. If the height of the newly formed bank is less than the bankfull elevation and the bank behind it is associated with the side channel, enter 999.

5. In a few limited situations where a tight meander occurs, the transect may cross a point bar without intersecting the actual bank (located behind the point bar). Enter 999 in this situation.

6. Depositional features such as point bars are considered depositional when perennial vegetation cover is less than 50 percent and considered streambank when greater than or equal to 50 percent vegetated.

Bank Angle (Normal and Undercut)

Objective

- Quantify bank angle and the frequency of undercut banks within the reach.

Where to take measurements

1. These methods were describe by Platts and others (1987) and have been more thoroughly defined to increase measurement precision. The bank angle methodology is complex and describes many different situations. The process will be easier if you use the following steps at each location before taking measurements.

Define these locations at each flag.

√ The location where the streambed and bank meet—The streambed is composed of particles that are transported by the stream during high flows. The bank is normally composed of finer material and is consistent with the soil type throughout the riparian area.

√ Scour line (SL)—Locate the scour line by examining features along the streambank. The ceiling of undercut banks, limit of sod forming vegetation, and limit of perennial vegetation are useful in identifying the SL. On depositional features such as point bars, the SL is often defined by the limit of perennial vegetation, or by an indentation in the bar (locally steep area) just above the SL.

√ Bankfull elevation—Use indicators described in the “Establishing the Sample Reach” section.

√ First flat, depositional feature—This feature defines the upper boundary of the streambank that will be assessed for both bank angle and stability. Stop the measurement at the first flat, depositional feature beginning at the bankfull elevation up to twice the bankfull elevation. If this feature is not present, stop the measurement at twice the bankfull elevation.

2. Determine whether slumping has occurred and if the slump block is still attached to the streambank. If so, use the rules described for “nonundercut” banks (# 1 below) to identify the measurement location.

3. If the bank is inaccessible at a transect (in other words, dense vegetation or a debris jam), record 999.

How to take measurements

1. For a nonundercut bank, lay a depth rod along the bank and perpendicular to the channel at the exact location of the transect flag. Place a clinometer on top of the depth rod (not on the sides) and record the angle to the nearest degree.

   a. If the bank slopes away from the streambed, the bank angle is greater than 90° from horizontal. To obtain the actual angle for these banks, subtract the value on the clinometer from 180 (for example, the clinometer reading is 30; 180 - 30 = 150°).
   b. Measure the angle from the base of the bank (where the streambed and bank meet) up to the first flat, flood-plain like surface located at or above the bankfull elevation but at less than twice the maximum bankfull elevation. Add the average maximum bankfull depth

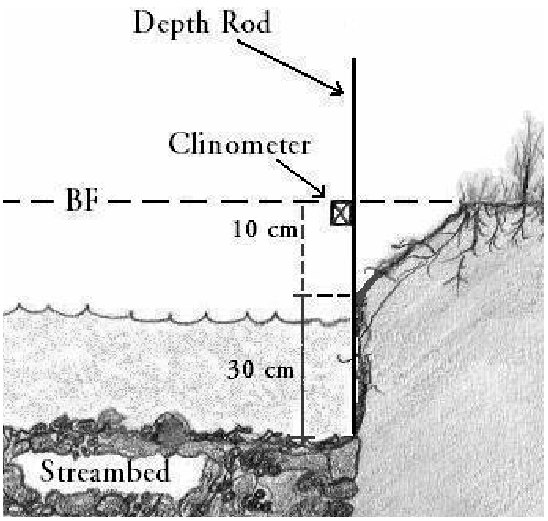
from cross-sections to the bankfull elevation at each transect to determine the upper limit for bank measurements.

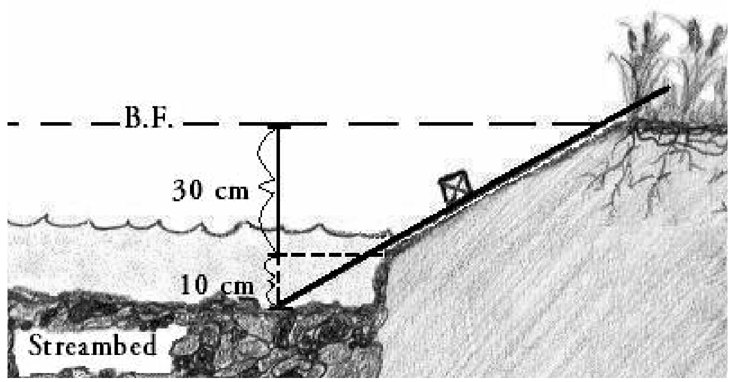
c. Streambanks are rarely one continuous angle from the streambed to the first flat, depositional feature. When a bank has more than one angle, consider each angle with a vertical height of greater than or equal to 10 cm.

d. Some banks rise steeply from the streambed and then become less steep near the flat floodplain like surface (convex). Measure the angle of the lower portion of the bank if it is taller than the upper portion (fig. II-4). Similarly, measure the angle of the upper portion of the bank if it is taller (fig. II-5).

e. The same concept applies to concave shaped banks.

f. It is difficult to accurately measure the angle when the bank rises in a stair-step fashion. A stair-step bank is defined as three or more separate angles each greater than or equal to 10 cm in vertical height. This applies to concave, convex, and relatively straight banks. Measure the average angle by laying the depth rod along the outer corner of the steps (fig. II-6). The bottom of the depth rod will be on the streambed and not where the streambed and bank meet.





Figures II-4 and II-5—Measure the tallest angle when the bank has two dominant angles.

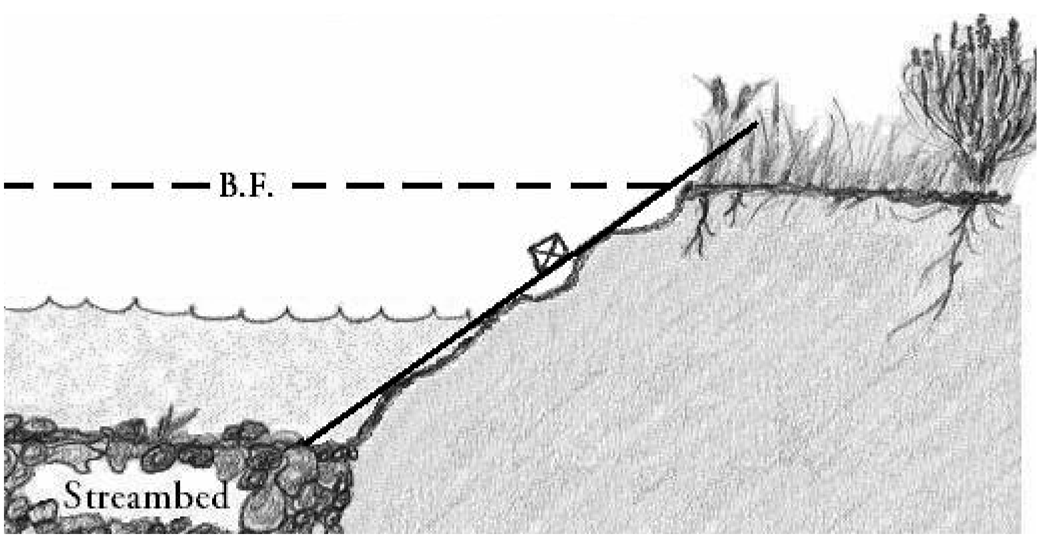


Figure II-6—Measure the angle of banks with three or more angles by laying the rod along outer edges.

g. Depositional features are not considered part of the bank. On unvegetated depositional features such as point bars, start the measurement at the point where the top of the depositional feature and streambank meet (fig. II-7).
h. Do not measure if the deposition ends at or above the first flat, flood-plainlike feature and record 999 (fig. II-8).
i. Use the point where the depositional feature becomes greater than 50 percent vegetated (perennial species) to define were the deposition ends and bank begins (fig. II-2).
j. Use the rules from bank stability to define the location of bank angle measurements when slump blocks are still attached to the bank. Include the slump block if the bottom of the fracture feature is elevationally above the SL (fig. II-9). Measure the angle of the fracture feature behind the slump block if the bottom of the fracture feature is elevationally equal to or below the SL (fig. II-10).

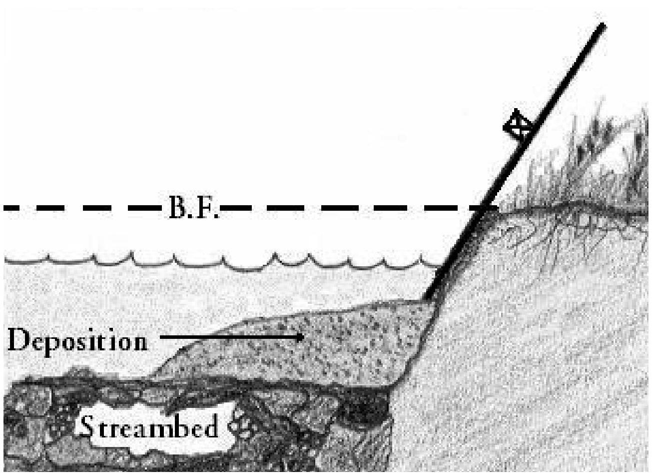


Figure II-7—Begin measuring the angle from the point where the deposit and bank meet.

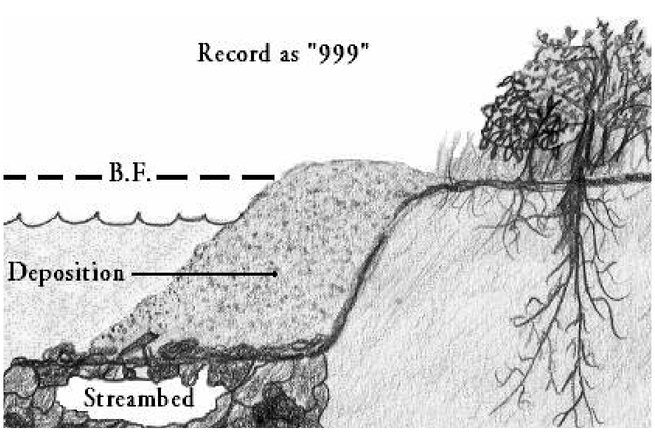


Figure II-8—Do not measure an angle when the deposit covers the first flat, flood-plain-like feature. Record 999 for bank angle.

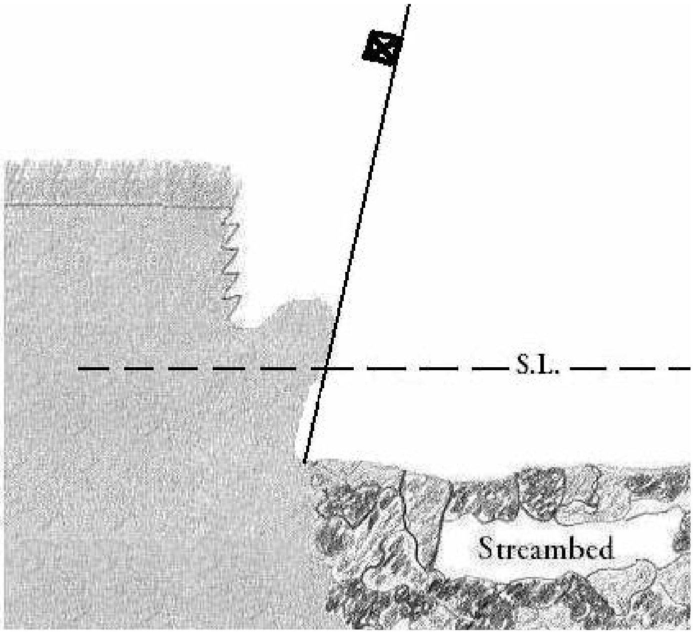
k. As with slump blocks, view logs (greater than or equal to 10 cm) and rocks (greater than or equal to 15 cm) as part of the bank if they are embedded within the bank. If the rock or log is partially embedded, consider it embedded if the bottom of the space between the rock/log and the bank is elevationally above the SL. Measure the bank behind the rock/log if the space is elevationally below the SL.

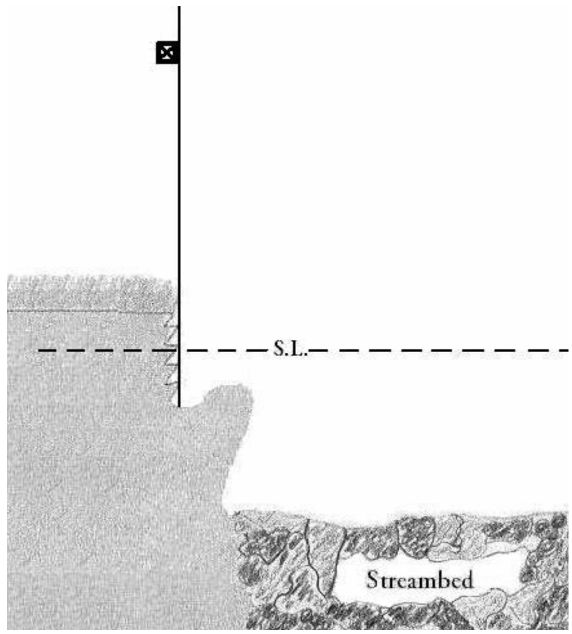
2. If the bank is undercut or vertical (less than 90°), the bank angle can be read directly from the clinometer. Measure from underneath the overhang using the following criteria:

a. The undercut must be greater than or equal to 5 cm deep, greater than or equal to 10 cm in height, and greater than 10 cm in width.
b. Overhanging bank angles are measured from the deepest point of the undercut up to the ceiling of the overhang (fig. II-11).
c. Occasionally, the back of the undercut will be a consistent depth, thereby lacking a deepest point (fig. II-12). Place the depth rod at the highest elevation, resulting in the smallest angle (angle B).
d. Enter the angle as "1°" if the deepest part of the undercut is elevationally above the ceiling (fig. II-13).
e. In some situations, there will be an undercut with a ceiling below bankfull and a second undercut with a ceiling above bankfull. Measure the lower undercut and ignore the upper one.

3. Take a horizontal undercut depth measurement using the following criteria:

a. Measure undercut depths at the same location as the bank angle. After measuring the angle, leave the end of the rod against the deepest point of the undercut and drop the rod until it is horizontal to the water surface and perpendicular to the stream channel. Measure the distance from the deepest point to the outer edge of the bank to the nearest centimeter (fig. II-11).
b. The previous criteria are for typical undercut banks where the ceiling of the overhang is below or equal to the bankfull elevation. In situations with active erosion or cut banks, the ceiling of the overhang may be above the bankfull elevation. These banks are measured similar to nonundercut banks. Place the bottom of the depth rod where the streambed and streambank meet and the top at the outer edge of the bank above the undercut. Record the undercut depth as 999 when the angle is less than 90° (fig. II-14 and II-15).





Figures II-9 and II-10—Location of bank angle measurements with a slump block still attached and relative to the scour line.

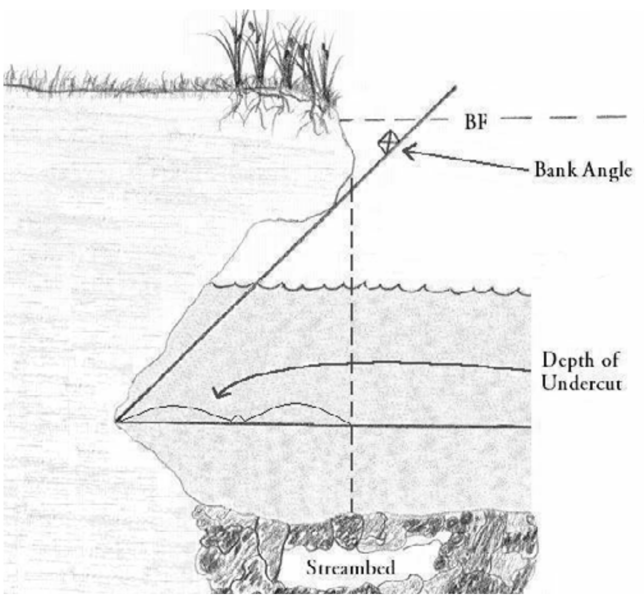


Figure II-11—Measure undercut bank angle from the deepest point to the ceiling of the undercut and depth from the deepest point to the outer edge of the bank in centimeters.

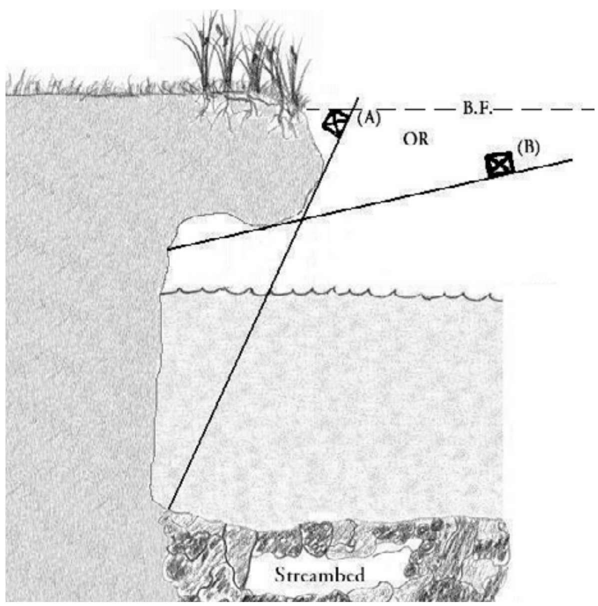


Figure II-12—Undercut banks with a constant depth are measured with the base of the depth rod at the highest elevation (angle B, not angle A).

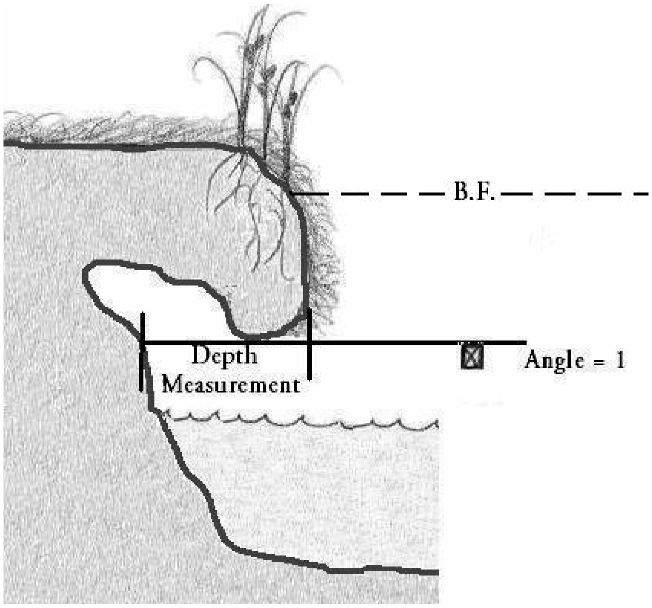


Figure II-13—Take the depth measurement with the depth rod horizontal and directly underneath the ceiling. Record the angle as 1°.

Bank Stability

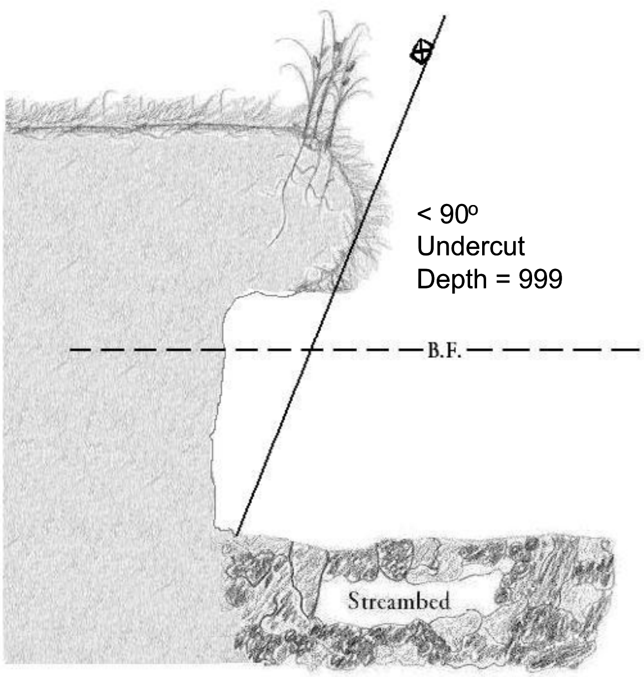
Objective

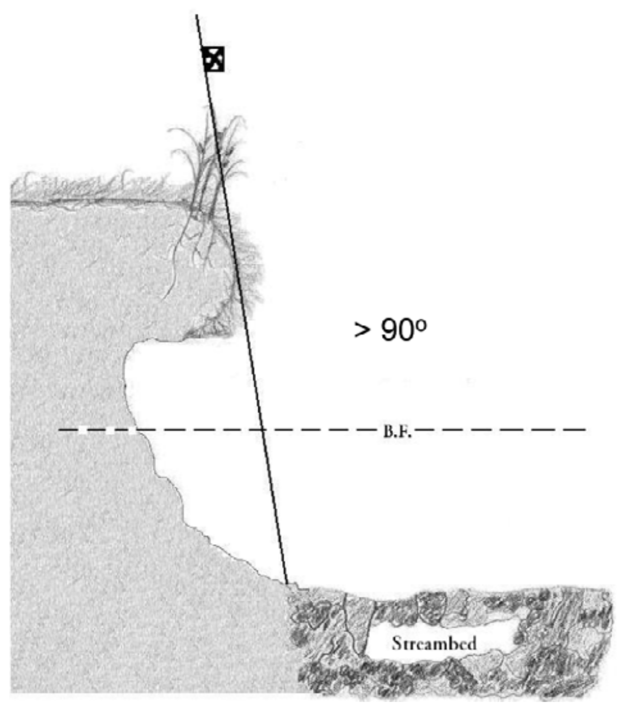
- Calculate the percent of the streambank that is stable.

Where to take measurements

This method was described by Bauer and Burton (1993) and Overton and others (1997). They have been modified and more thoroughly defined to increase measurement precision. The following guidelines define the area of bank to evaluate:

1. Evaluate streambank stability when water is at or below the SL.
2. The stability plot is 30 cm wide (15 cm on each side of the transect flag) and perpendicular to the streambank (not stream channel).
3. The sample area includes the portion of the streambank that is above the SL and at the steepest angle to the water surface. The measurement extends up to the first flat, depositional feature located at bankfull or up to twice the bankfull elevation (fig. II-16).
4. Unstable features are counted if greater than or equal to 10 cm at the widest point. Record the unstable





Figures II-14 and II-15—Undercut banks with the ceiling above bankfull are measured from where the streambed and bank meet to the outside edge of the undercut.

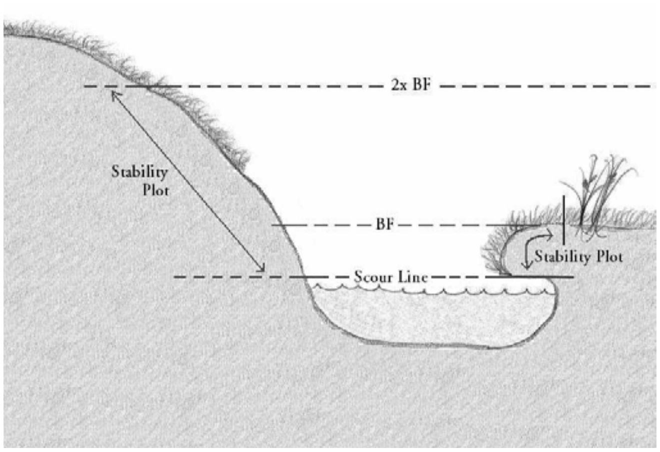


Figure II-16—Location of bank stability plots on banks that extend above two times bankfull (left) and banks with a flood plain at bankfull (right).

feature when both stable and unstable features occur at the same plot.

5. Hoof prints by themselves are not a sign of instability unless they move the bank by greater than or equal to 10 cm.

6. Slump blocks that have fractured but are still attached to the bank can be large enough to function as part of the bank. They may also have a flat, floodplainlike feature at or above bankfull. They are classified as a fracture feature and evaluated under Part III of the section "Streambank Stability Classification Key."

7. Do not evaluate the bank as fractured if the bottom of the fracture feature is elevationally above two times the bankfull elevation.

How to take measurements

1. Streambank cover is an assessment of the percent of bank protected. Banks are considered "covered" if they show any of the following features.

a. Perennial vegetation ground cover is greater than 50 percent (moss is not perennial).
b. Roots of vegetation cover more than 50 percent of the bank (deep rooted plants such as willows and sedges provide such root cover).
c. At least 50 percent of the bank surfaces are protected by rocks of cobble size (15 cm) or larger.
d. At least 50 percent of the bank surfaces are protected by logs of 10 cm in diameter or larger.
e. At least 50 percent of the bank surfaces are protected by a combination of the above.

2. Finally, use the classification key to assign and record a stability class as defined below:

- CS = Covered and stable (nonerosional). Streambanks are both covered and stable as defined above.
- CU = Covered and unstable (vulnerable). Streambanks are covered but unstable as defined above. These banks are typically observed in meadows where breakdown, slumping, and/or fracturing is present along the bank, yet vegetative cover is abundant.
- US = Uncovered and stable (vulnerable). Streambanks are uncovered but stable as defined above. Uncovered, stable banks are typical of banks trampled by concentrations of ungulates. Such trampling flattens the bank so that slumping and breakdown do not occur even though vegetative cover is significantly reduced or eliminated. This class also includes situations where the streambank is not present due to excessive deposition.
- UU = Uncovered and unstable (erosional and depositional). Streambanks are not covered or stable as defined above. These comprise the typical bare, eroding streambanks and include all banks at a steep angle to the water surface with little cover.
- FB = False bank. Streambanks have slumped in the past but have been stabilized by vegetation. These banks are usually lower than existing banks and generally provide no cover to fish.
- 999 = Unclassified. Areas along the bank where side channels, tributaries, springs, and so forth, cause an opening or where brush is too thick to make an assessment.

Streambank Stability Classification Key

Depositional bank—A streambank with deposition extending above the SL.
Scour bank—A streambank with no deposition or deposition is below or equal to the elevation of the SL.
Scour line—On undercut banks it is defined as the elevation of the ceiling of the undercut. On nonundercut scour banks and depositional banks it is defined as the lower limit of perennial vegetation.
Slump block—That piece of the bank that is detaching or has detached from the streambank.
Crack—A crack in the streambank (start of a fracture feature), but the slump block has not begun detaching from the bank.
Fractured—Slump block has at least partially broken from the bank and is separated from its original location by greater than or equal to 10 cm.
Fracture feature—The piece of the bank (usually vertical) exposed by the detaching of the slump block.
Covered—Perennial vegetation cover is greater than 50 percent, roots and root mats cover more than 50 percent of the bank, at least 50 percent of bank consists of rocks greater than or equal to 15 cm in size, or at least 50 percent of bank is covered by large woody debris (LWD) greater than or equal to 10 cm in diameter.

I. Streambank present ... go to II
Streambank absent (side channel, tributary, slew) ... 999

II. Streambank = Scour bank ... go to III
Streambank = Depositional bank (fig. II-17)
- Bank covered ... CS
- Bank not covered ... UU
- Bank not present due to excessive deposition ... US

III. Bank is not fractured, or the bank is fractured with the slump block no longer attached to the streambank and is either lying adjacent to the breakage or absent ... go to IV

Bank is fractured <u>with</u> the slump block still attached (fig. II-17)
- A. The bottom of the fracture feature is elevationally below the SL (view only the fracture feature behind the slump block)
  - Bank not covered
    - Bank angle within 10° of vertical (less than 80 m or greater than100 m) ... UU
    - Bank angle not within 10° of vertical ... US
  - Bank covered ... CS
- B. The bottom of the fracture feature behind the slump block is elevationally above the SL (view the bank as the slump block and fracture feature the vertical, exposed bank)
  - Bank not covered ... UU
  - Bank covered
    - Fracture feature not covered ... CU
    - Fracture feature covered (and reconnected to bank) ... FB

IV. No crack visible from the SL up to a point 15 cm behind the top of the bank. ... Go to V
A crack is visible within this area (fig. II-17)
- Bank is not covered ... UU
- Bank covered ... CU

V. Streambank does not display signs of instability, or if a fracture feature is present, the slump block is no longer attached to the streambank (fig. II-18)
- Bank not covered
  - Bank angle within 10° of vertical (less than 80 m or greater than100 m) ... UU
  - Bank angle not within 10° of vertical ... US
- Bank covered ... CS

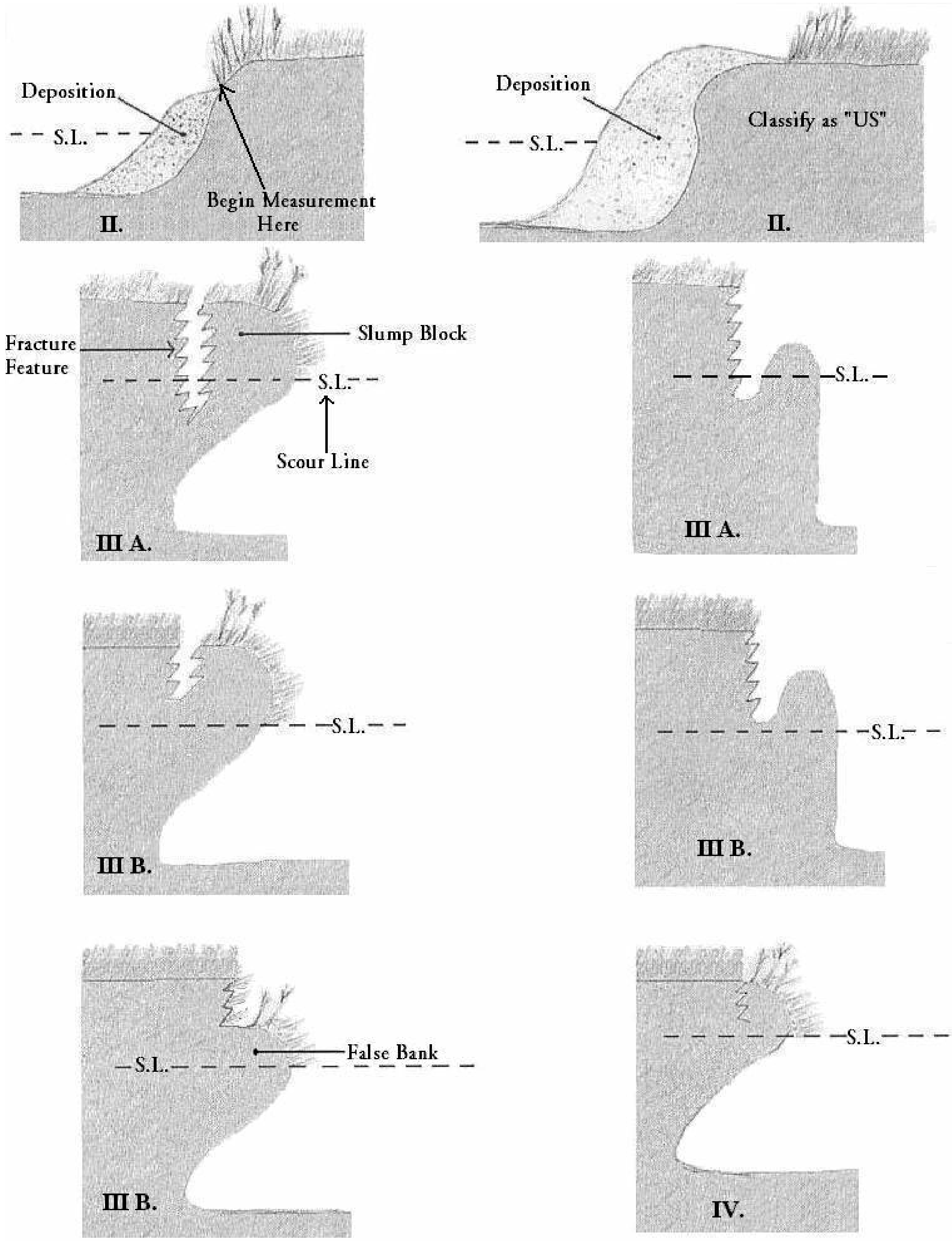


Figure II-17—Examples of bank instability types described in sections II, III, and IV in the Classification Key. The actual stability class chosen depends on whether the bank is covered or uncovered.

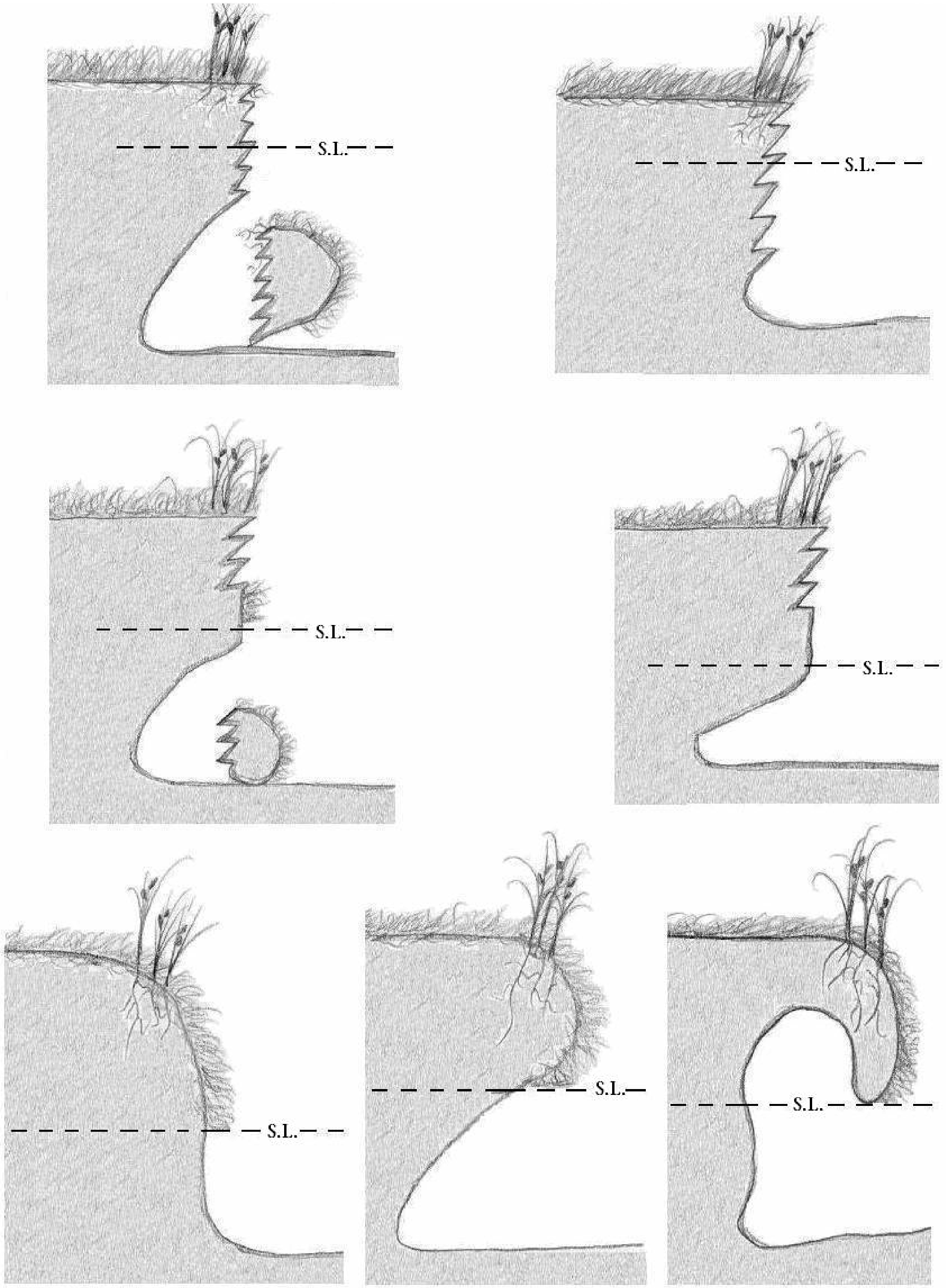


Figure II-18—Examples of bank stability types described in section V in the Classification Key.

Large Woody Debris

Large Woody Debris Counts

Objective

- Quantify the number and size of large woody debris pieces that are present within the bankfull channel.

Where to take measurements
Collect measurements along the entire reach.

How to take measurements
1. Consider all large woody debris within the bankfull channel. This includes "spanners" (single pieces of large woody debris that span the width of the stream but are located above the water) if they are below the bankfull elevation.
2. Estimate the length and diameter of all large woody debris pieces, including those lying singularly and those in aggregates. Each piece must be greater than 3 m in length OR have a length equal to or greater than two-thirds the wetted width of the stream. Each piece must be at least 10 cm in diameter one-third of the way up from the base.
3. Measure the length and circumference for every fifth piece at reaches with less than 20 pieces of wood and every tenth piece at reaches with greater than 20 pieces of wood.
4. Estimate and record the percentage (by volume) that is submerged at bankfull flows for each piece.

Reach Description Measurements

Sinuosity and Valley Length

Sinuosity is a measure of how much the stream channel meanders within the valley bottom. Measure the length of the stream channel along the thalweg and divide that length by the straight-line distance between the top and bottom of the sample reach. Measure the straight-line distance from the points where the thalweg crosses the top and bottom of the reach and record as "valley length." Record the data on Form 1.

Reach Gradient

Stream gradient is the elevation change from the water surface at the downstream end of the reach to the water surface at the upstream end (pool tail to pool tail). Measure the elevation change twice, with the level at a different position each time, and record to the nearest centimeter. Record the average if the two measurements are within 10 percent of each other. If not, take a third measurement and average it with one of the originals.

Part III:

Effectiveness Monitoring for Streams and Riparian Areas Within the Upper Columbia River Basin: Sampling Protocol for Integrator Reaches Vegetation Parameters

Marc Coles-Ritchie
Richard C. Henderson

Part III Note

This document describes the sampling protocol used in 2001 and evaluated in the companion publication Coles-Ritchie and others (in preparation). Many of the methods have since been modified following additional testing and review. Beginning in 2003, we began collecting species cover data instead of community type cover data for the greenline and riparian cross-secitons. See our website at http://www.fs.fed.us/biology/fishecology/emp/ for the most recent version

Part III Acknowledgment

We are indebted to Alma Winward for many of the methods and concepts contained in this protocol. We thank the many biological technicians who used these methods and provided valuable feedback. The drawings in this section were done by Emily Hall and Carrie Kennedy.

Introduction

An interagency team representing the U.S. Department of Agriculture, Forest Service (USDA FS), the U.S. Department of the Interior, Bureau of Land Management (USDI BLM), the U.S. Department of Commerce, National Marine Fisheries Service, U.S. Department of Interior, Fish and Wildlife Service (USDI FWS) was convened to develop a large-scale monitoring program with the primary objective of determining whether PACFISH/INFISH management practices are effective in maintaining or restoring the structure and function of riparian and aquatic habitats throughout the upper Columbia River Basin. A list of attributes that were thought to be important in defining aquatic habitat conditions and their relationship with listed species were identified. The team also specifically stated that existing methods be used to measure each attribute. This sampling protocol for vegetation parameters (which is part of the "Plan to Monitor Aquatic and Riparian Resources in the Area of PACFISH/INFISH and the Biological Opinions for Bull Trout, Salmon, and Steelhead") is the result of that interagency effort.

The sampling methods for this program were taken from existing sampling protocols. This vegetation sampling protocol is based on three methods developed by Winward (2000): (1) greenline composition, (2) vegetation cross-section composition, and (3) woody species regeneration. Another method is also used, effective ground cover assessment, which is based on soil quality monitoring methods developed by the USDA Forest Service Intermountain Region (R4). Modifications were made following 2 years of use, evaluation, and peer review.

The protocol and the individual methods were designed and tested specifically to sample a stream "reach" and to monitor the effects of management activities in a specific set of stream types. This is done by collecting data about the abundance of vegetation types and age classes of woody species at the reach scale. The vegetation sampling at a reach corresponds to 110 m of streambank. All reaches are within unconstrained valley bottoms with gradients less than 3 percent and have wadeable channels with bankfull widths between 1 and 15 m. We feel strongly that it should not be used in other stream types without additional review and testing.

Data, at the reach and basin scale, are analyzed to detect change over time as well as spatial variability due to environmental or management differences. The data analysis techniques are presented in separate documents.

Sampling Order

The riparian vegetation at each sample reach is assessed using four methods: greenline (Winward 2000), vegetation cross-section (Winward 2000), effective ground cover (Intermountain Region 1989), and woody species regeneration (Winward 2000). The greenline and vegetation cross-section methods estimate the cover of plant community types. Effective ground cover estimates ground cover in general categories. Woody species regeneration estimates the number of woody plants in different age classes. The following list outlines the order of things to do at each site, and the rest of this document explains these items in detail:

1. Determine which vegetation classification to use.
2. Identify dominant plants (using field guides) and community types (using vegetation classifications).
3. Establish and flag the sample area.
4. Collect greenline data.
5. Collect woody species regeneration data.
6. Collect vegetation cross-section data.
7. Collect effective ground cover data (in conjunction with vegetation cross-sections).
8. Collect greenline community type data at stream transects (with stream technicians).
9. Collect and label one specimen.

Riparian Vegetation Classifications

Riparian vegetation classifications have been developed for many portions of the Western United States. These classifications are based on data from multiple sites that have similar, repeating assemblages of species. A "community type" or "plant association" represents communities that have similar, but not necessarily identical, species composition in both the overstory and understory. The data collector should be familiar with the classification and its dichotomous key before collecting data at a site. Use the following riparian vegetation classifications within the Upper Columbia Basin (table III-1). It is important that the correct classification be used for each Region (table III-2). If the principal classification for the area does not cover all of the vegetation for a site, then the approved classifications for adjacent areas may be used (table III-2).

How to Use Vegetation Classifications

Use the key to help determine the possible community types for a given area of vegetation (a number of

Table III-1—Riparian vegetation classifications for the interior Pacific Northwestern United States.

Authors	Code	Riparian vegetation classification
Kovalchik (2001)	KOV-WA	Classification and Management of Eastern **Washington's** Riparian and Wetland Sites
Hansen and others (1995)	HANSEN	Classification and Management of **Montana's** Riparian and Wetland Sites
Crowe and Clausnitzer (1997)	CROWE	Mid-Montane Wetland Plant Associations of the **Malheur, Umatilla and Wallowa-Whitman** National Forests
Manning and Padgett (1995)	MANNING	Riparian Community Type Classification for Humboldt and Toiyabe National Forests, **Nevada** and Eastern California
Youngblood and others (1985)	YOUNGBLOOD	Riparian Community Type Classification of Eastern **Idaho** - Western Wyoming
Padgett and others (1989)	PADGETT	Riparian Community Type Classification of Utah and Southeastern **Idaho**
Kovalchik (1987)	KOV-OR	Riparian Zone Associations: **Deschutes, Ochoco, Fremont, and Winema** National Forests
Crawford (2001)	CRAWFORD	Initial Riparian and Wetland Vegetation Classification and Characterization of the Columbia Basin in **Washington**

steps) at a site. Read the description in the classification to see that it matches what you observe, especially the associated species and their cover values. If they are similar, then that is the community type to record. If not, go through the key again to see what other community types might describe the area of interest.

Establishing the Sample Area

1. Determine the number of steps you take over a 110-m distance. In a field or meadow measure 110 m and place a marker at each end. Walk the distance with a normal pace and record the number of steps taken. A clicker is useful to tally the steps. Walk the distance at least five times and determine the average number of steps per 110 m, which will be the length of the greenline sample area. This only needs to be done once at the beginning of the field season. You may want to check your steps per 110 m a few times during the field season and adjust your steps if necessary.

2. From the downstream end of the reach, determine the sample area by stepping off 110 m of streambank along the stream's right bank, as shown by the dashed lines in fig. III-1. This provides a representative area of streambank and riparian vegetation and a consistent 0.1-acre sample area for the woody species regeneration data.

3. Place yellow flags (noted in fig. III-1) at the number of steps that correspond to 0, 27.5, 55, 82.5, and 110 m (to determine this interval divide the total number of steps per 110 m by four). These flags identify the locations of the five vegetation cross-sections, as well as the extent of the sampling area for the greenline and woody species regeneration data collection (fig. III-1). Vegetation flags are one color (yellow), which is a different color than flags used by the stream technicians. It is preferable to place the flags on just one side of the stream (right bank whenever possible), which will help you relocate them. Note in fig. III-1 that the stream's right is the right bank while facing downstream.

Greenline

Objectives

- Estimate the percent cover of community types adjacent to the stream.
- Quantify ratings for successional status, bank stability, and/or wetland status based on the community types.
- Estimate the percent cover of woody vegetation adjacent to the stream.

Where to collect data

1. Begin at the upstream end of the greenline sampling area on the right bank (fig. III-1). Walk downstream and record the community types adjacent to the stream for each step. Continue to the downstream end of the reach. There will be multiple flags there because that is also the bottom of the reach for the stream crew.

2. Cross the stream perpendicular to the channel and record community types while walking upstream

Table III-2—List of appropriate classifications by geographical area.

Crew base state	Forest / BLM	State	District/field office	Principal riparian vegetation classification to use	Other helpful riparian vegetation classifications
OR	Deschutes	OR	All	Kov-OR	Crowe
	Ochoco	OR	All	Kov-OR	Crowe
	Malheur	OR	All	Crowe	Crawford
	Umatilla	OR	All	Crowe	Crawford
	Wallowa-Whitman	OR	All	Crowe	Crawford
	Okanogan	WA	All	Kov-WA	Hansen
	Colville	WA	All	Kov-WA	Hansen
	BLM Oregon-Washington	OR	Prineville	Crowe	Crawford, Kov-OR
		WA	Wenatchee	Crawford	Kov-WA
ID	Nez Perce	ID	All	Hansen	Kov-WA, Crowe, Youngblood
	Payette	ID	McCall - Krassil	Crowe	Youngblood, Hansen, Kov-WA
			New Meadows	Padgett	Youngblood, Crowe
			Council	Crowe	Padgett, Youngblood
			Weiser	Crowe	Padgett, Youngblood
	Boise	ID	Emmett	Crowe	Padgett, Youngblood
			Others	Padgett	Crowe, Youngblood
	Salmon-Challis	ID	All	Padgett	Crowe, Youngblood
	Sawtooth	ID	Southern	Manning	Padgett, Youngblood
			Northern	Padgett	Crowe, Youngblood
	Humboldt-Toiyabe	NV	All	Manning	Padgett
	BLM Idaho	ID	Salmon	Padgett	Crowe, Youngblood
			Challis	Padgett	Youngblood, Manning
			Cottonwood	Padgett	Crowe, Youngblood
MT	Idaho Panhandle	ID	All	Hansen	Kov-WA
	Clearwater	ID	All	Hansen	Kov-WA
	Flathead	MT	All	Hansen	
	Kootenai	MT	All	Hansen	
	Lolo	MT	All	Hansen	
	Beaverhead-Deerlodge	MT	All	Hansen	
	Helena	MT	All	Hansen	
	Bitterroot	MT	All	Hansen	
	BLM Montana	MT	Missoula	Hansen	

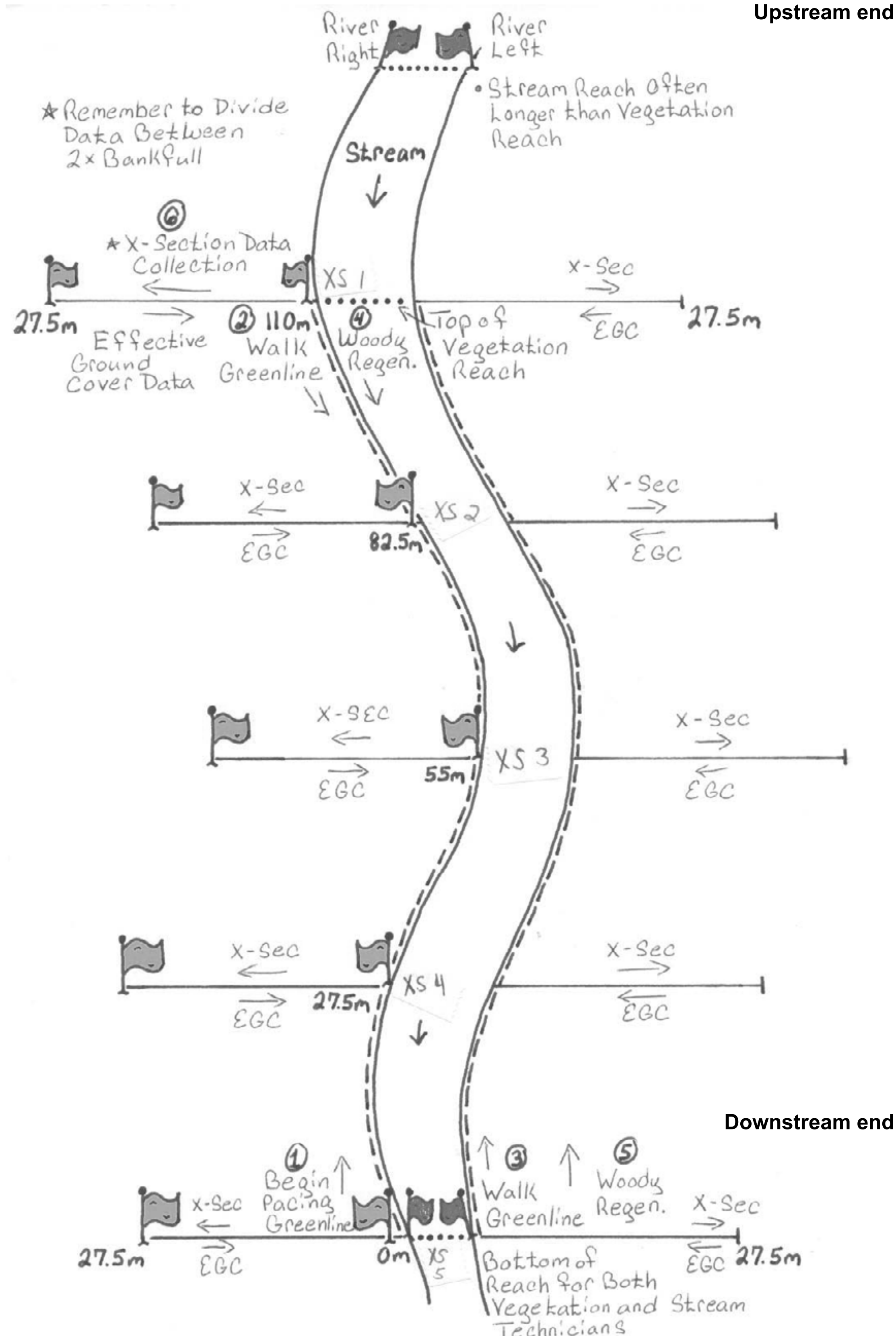


Figure III-1—Location for all vegetation sampling methods at a site.

along the left bank. Stop when perpendicular to your most upstream flag on the opposite bank. It does not matter that there are slightly different number of steps on each side. The upstream end of the greenline sampling area will probably not correspond to the top of the stream crew's upstream end point.

3. Define the greenline.
   a. The greenline is the first line of perennial vegetation adjacent to the stream channel that is at least 0.3 m (1 ft) wide (fig. III-2 and III-3).
   b. Define the greenline at the base of the first line of perennial vegetation on the streambank of interest. Most of the time, looking at the canopy (especially with sedges and other low growing vegetation) is sufficient to determine the greenline. But canopy alone is not the greenline.
   c. If plants are hanging over the edge of the stream, but are not the first line of rooted vegetation on that bank, then walk away from the stream until the first line of rooted perennial vegetation is encountered. At that rooted point, consider all the overstory and understory vegetation together to determine the community type (right side of fig. III-3).
   d. Early in the season the greenline may be partially submerged, while later in the summer the greenline may be some distance from the stream. Do not consider bare or sparsely vegetated ground between the greenline and the water (left side of fig. III-3).
   e. When banks are eroding or when a stream becomes entrenched, the greenline may be located high above the stream and consist of upland plants. In this case it is necessary to record nonriparian communities along the greenline because they are the first perennial vegetation adjacent to the stream. Record this nonriparian vegetation as "Upland" and note the dominant species in the comment line in the data logger (right side of fig. III-4 and III-5).
   f. Always sample the main banks of the channel, not islands. Figure III-2 identifies the location of the greenline in relation to islands and gravel bars. The stream technicians can help you determine what is an island and what is the main bank (they do that for the stream cross-sections). In general, a peninsula becomes an island when it is no longer connected on both ends by a strip of vegetation with at least 25 percent cover and greater than 0.3 m (1 ft) in width.
   g. Do not consider scattered forbs, grasses, or rushes on sandbars as the greenline (fig. III-6). Most aquatic species are not counted as the greenline because of their temporary nature, unless the classification has a community type for them (fig. III-6). Commonly observed species on sandbars or in the water that are usually not community types include:

- *Catabrosia aquatica* (brookgrass)
- *Cardamine* spp. (bittercress)
- *Mentha arvensis* (field mint)
- *Mimulus guttatus* (yellow monkey-flower)
- *Veronica americana* (American speedwel)
- *Alopecurus aequalis* (shortawn foxtail)
- *Alopecurus geniculatus* (water foxtail)
- *Juncus ensifolius* (sword-leaf rush)

How to collect data

1. Determine greenline community types at the scale of each step (0.3 m by 1 step), which is different than for the vegetation cross-sections. Use a modified line-intercept method to tally the number of steps in each community type.

2. Record steps of vegetation as you walk approximately parallel to the stream, not for steps that are perpendicular to the stream. In general there should be one step of vegetation for each step of stream (fig. III-2 and III-6).

3. Use the classification keys to help you decide on the community type. The key does not determine the community type, as would a key for species identification. The key only suggests what community types to consider. Consult the descriptions to determine the appropriate community type. When two key leads fit, then look at both descriptions to see which fits best. If you cannot see that one fits better than another then use the one that appears first in the key.

4. For each step, first look up to see if there is an overstory and use that information as you go through the key. If vegetation hangs over the greenline then it is considered part of the community at that step. When the keys ask for the dominant overstory species, they generally refer to the species with the highest cover. That usually means at least 25 percent cover, but it varies in the different classifications.

5. Record the community type name on Form 5 (appendix III-B) the first time it is encountered and use dots to record the number of steps. When that community type is encountered again, add dots to the tally of steps for that community type.

6. To be counted as a step of a community type, the vegetation must cover at least one full step. Scattered plants on a sandbar are not counted.

7. Only record data for community types described in the classifications or new communities for which you collect species data (see "Undescribed or New Communities" section). Do not record any physical features as

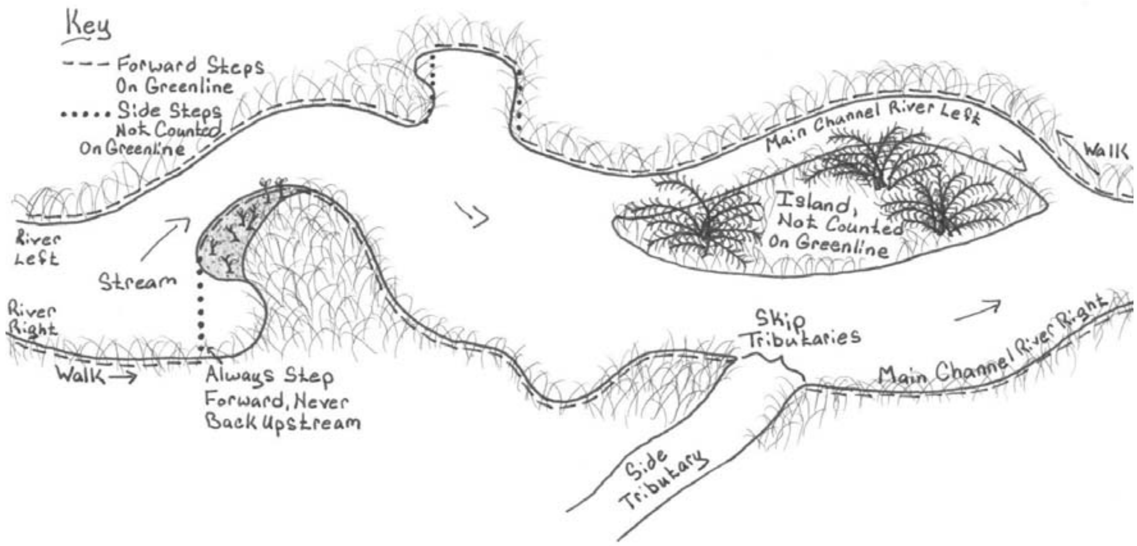


Figure III-2—The location of the greenline in relation to various bank features. Greenline data are only collected where there is a dashed line. Greenline data are not collected where there is a dotted line.

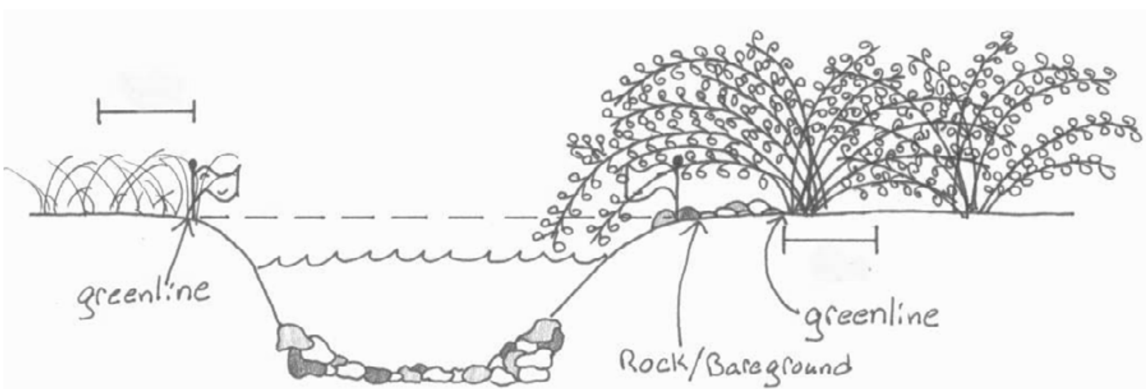


Figure III-3—Location of greenline. Note that the greenline is located on rooted vegetation, not rocks or bare ground underneath the canopy.

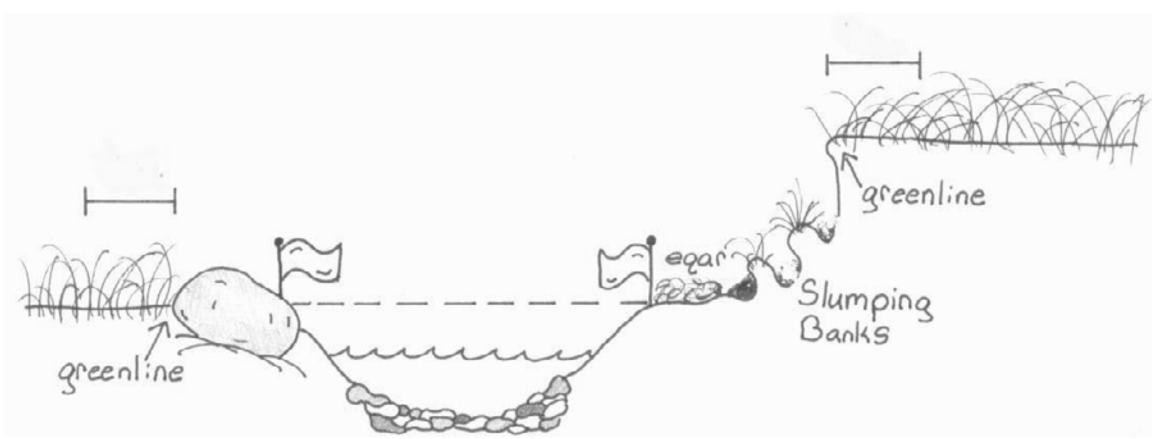


Figure III-4—Location of greenline on banks with boulders, bare bank, and upland vegetation.

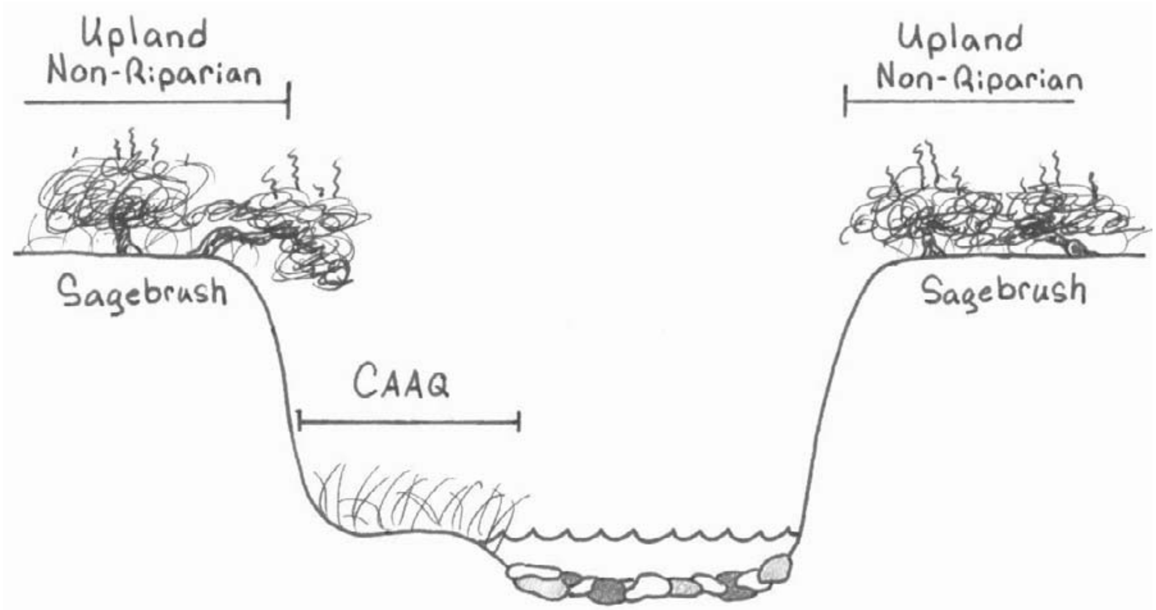


Figure III-5—Example of banks with upland vegetation. For the right bank there is no riparian vegetation, so record *upland* for the greenline and for one step on the cross-section.

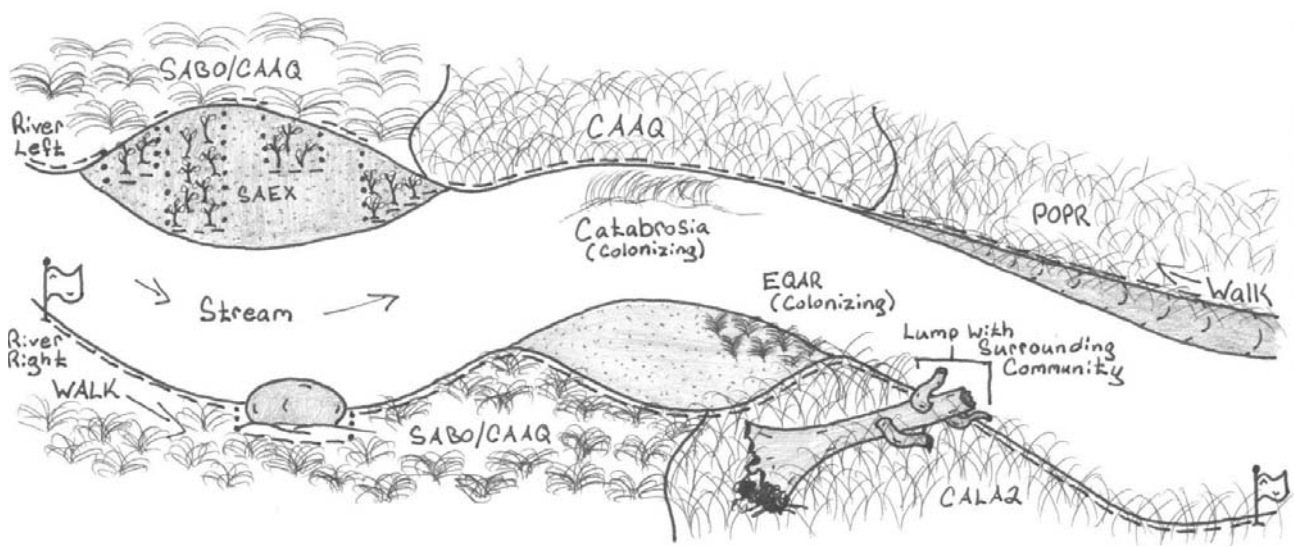


Figure III-6—Example of how community types are sampled along the greenline. Greenline data are only collected where there is a dashed line. Greenline data are not collected where there is a dotted line.

greenline data, but you can note them in the comment lines.

8. The greenline may zig-zag back and forth because of the dynamic state of the stream environment. If you must step away from or toward the stream to find the greenline do not tally the steps moving perpendicular to the stream. Tally only the forward steps that correspond to a step of stream (fig. III-2 and III-6).

9. When encountering an obstacle such as a bush or boulder, step around the obstacle but tally only the forward steps (fig. III-6 and III-7). If the obstacle is vegetation, look at the area where you would have stepped to determine the community type. At locations with dense greenline vegetation it may be easier to walk in the stream as you record the data (fig. III-7).

Vegetation Cross-Sections

Objectives

- Estimate the percent cover of community types throughout the riparian area.
- Quantify a wetland rating based on the different community types present in the riparian area.

Where to collect data

1. Sample five vegetation cross-sections within each reach (fig. III-1). The first and last cross-sections correspond to the upstream and downstream ends of the greenline sampling area, respectively. Cross-sections 2, 3, and 4 are located at ¼, ½, and ¾ of the way down from the upstream end of the greenline sample area (fig. III-8).
2. The vegetation cross-section extends across the riparian area perpendicular to the valley bottom, not necessarily perpendicular to the stream.
3. The vegetation cross-section forms a continuous line across the riparian area, but does not include the stream.
4. Use a compass to determine the direction of the valley bottom where the sample reach is located. Add 90° to the bearing and align the compass spindle to the new bearing. Use this bearing for all five cross-sections and record it on the data sheet. Always begin at, and include, the greenline and walk toward the edge of the riparian area in the direction of the compass bearing.
5. Then walk back to the greenline collecting Effective Ground Cover data (see "Effective Ground Cover" section below). Cross the channel, ignoring the steps in the channel, and continue the cross-section in the opposite direction of the compass bearing until the riparian vegetation ends or 27.5 m.

How to collect data

1. Use a modification of the line-intercept method to collect data. This is similar, but not exactly the same, as the method for the greenline.
2. As you walk through communities record the number of steps for each community type on Form 6 (appendix III-B). For the cross-sections consider a larger spatial scale than for the greenline (fig. III-8). Do not look at the scale of each step, but rather consider the vegetation in an area of at least a few square meters and look for multiple individuals. This will help you identify boundaries between different communities. There may be only one community or there may be several, but there should not be a different community type for each step (that is too small of a scale). This is especially important when trees or shrubs are scattered. Try to draw an imaginary line between the different communities and ignore small variability within those communities. A lone individual plant would not determine the community type because one individual does not make a community. Look for the dominant vegetation with multiple individuals (in other words, a community).
3. Include the greenline vegetation in the cross-section, but do not record any data between the greenline and stream. Do not record anything for the stream either.
4. A cross-section may cross the stream numerous times if the channel is very sinuous (fig. III-9). Ignore the steps when you cross the stream, and continue the data collection where you exit the stream channel.
5. Cross-sections may be close together if the channel is very sinuous (fig. III-9), however, they should not cross since they use the same bearing and are therefore parallel.

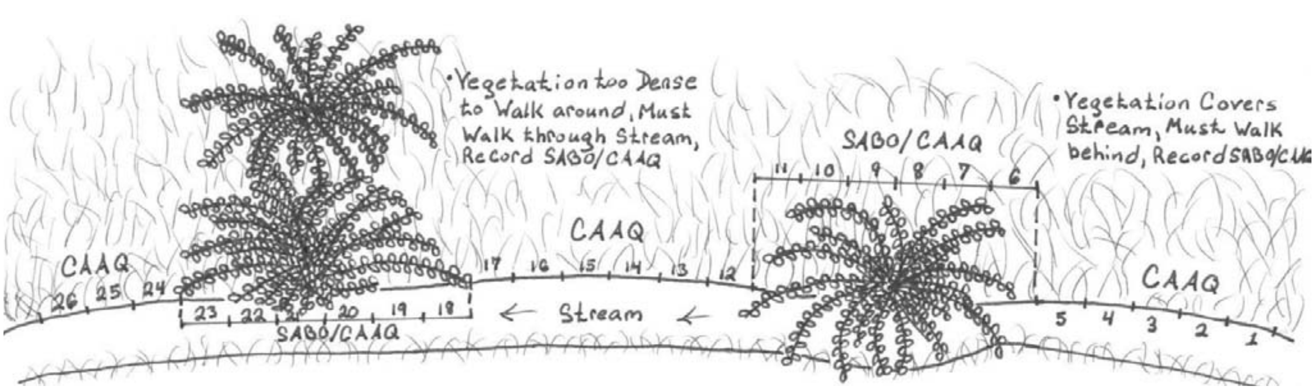


Figure III-7—How to walk and tally steps when obstacles are encountered. Only the numbered steps (solid line) are recorded. The unnumbered steps (dashed line) are not recorded.

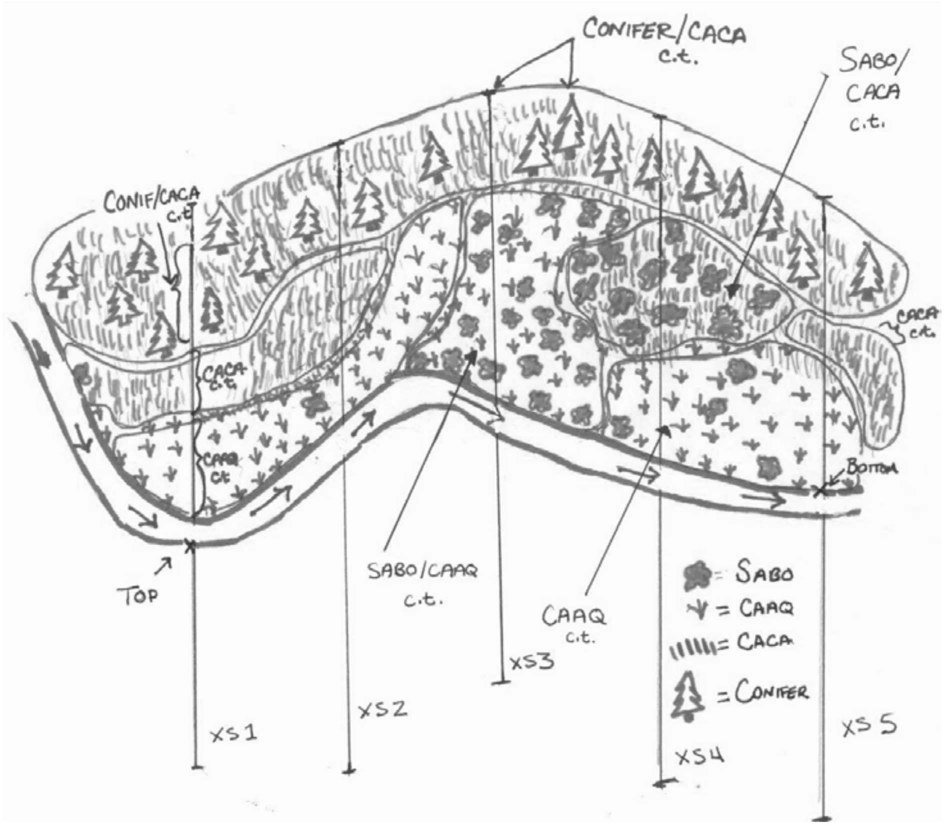


Figure III-8—Lines represent vegetation cross-sections going through different communities (some of which are encircled). Note that woody plants with less than 25 percent cover are in a separate community type than areas with greater than 25 percent cover.

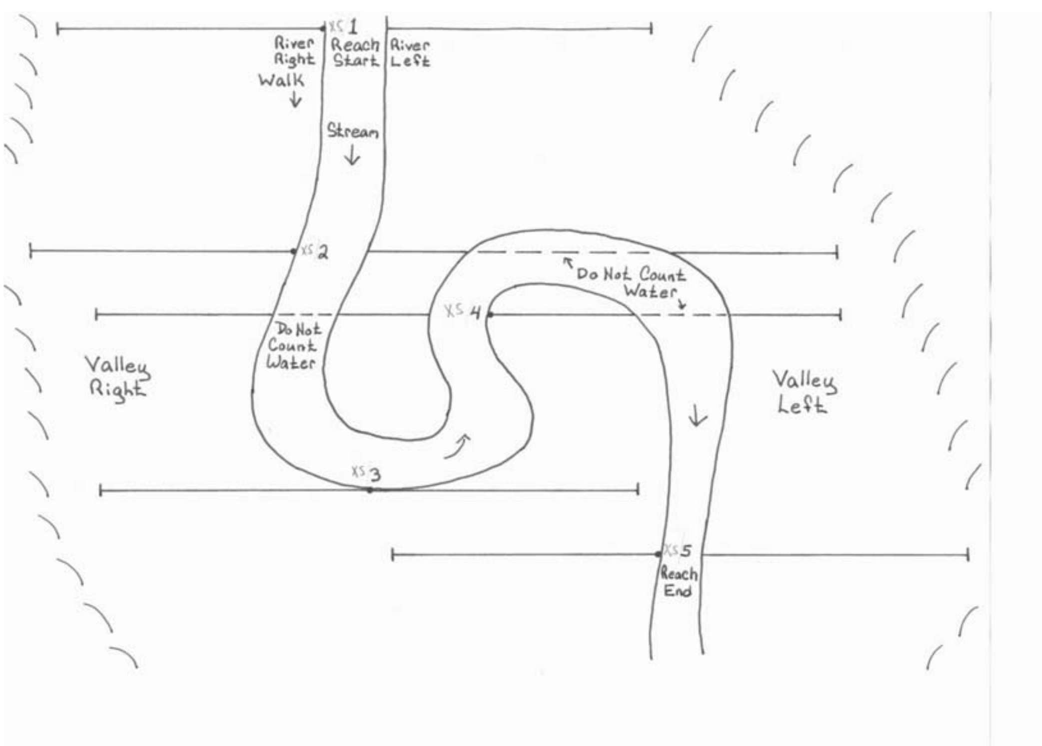


Figure III-9—Example of cross-sections on a very sinuous stream.

6. If there is no riparian vegetation in the cross-section (right side of fig. III-5), then record just one step as "upland" on each side of the stream and record the dominant species (*Artemisia tridentata*, *Juniperus osteosperma*, and so forth) in the comment line of the data logger.

7. Each cross-section extends the width of the riparian zone up to a maximum distance of 27.5 m on each side of the stream. Stop recording community type data at 27.5 m, even when the riparian area continues, and estimate the additional width of the riparian area using the following categories (fig. III-10):

0 = Riparian area ends before 27.5 m are stepped
1 = Additional distance is less than distance walked (less than the 27.5 m)
2 = Additional distance is 1x to 2x the distance walked (27.5 to 55 m)
3 = Additional distance is 2x to 4x distance walked (55 to 110 m) or
4 = Additional distance is greater than 4x distance walked (more than 110 m)

8. Distinguish the steps that are in the zone of flow at two times the bankfull depth, or "twice bankfull" (fig. III-11). The stream technicians will flag or show you the point at which the twice-bankfull elevation is exceeded along your five cross-sections. Record steps between the stream and that point as "within twice bankfull" (or "w") and steps beyond that point as "beyond twice bankfull" (or "b")

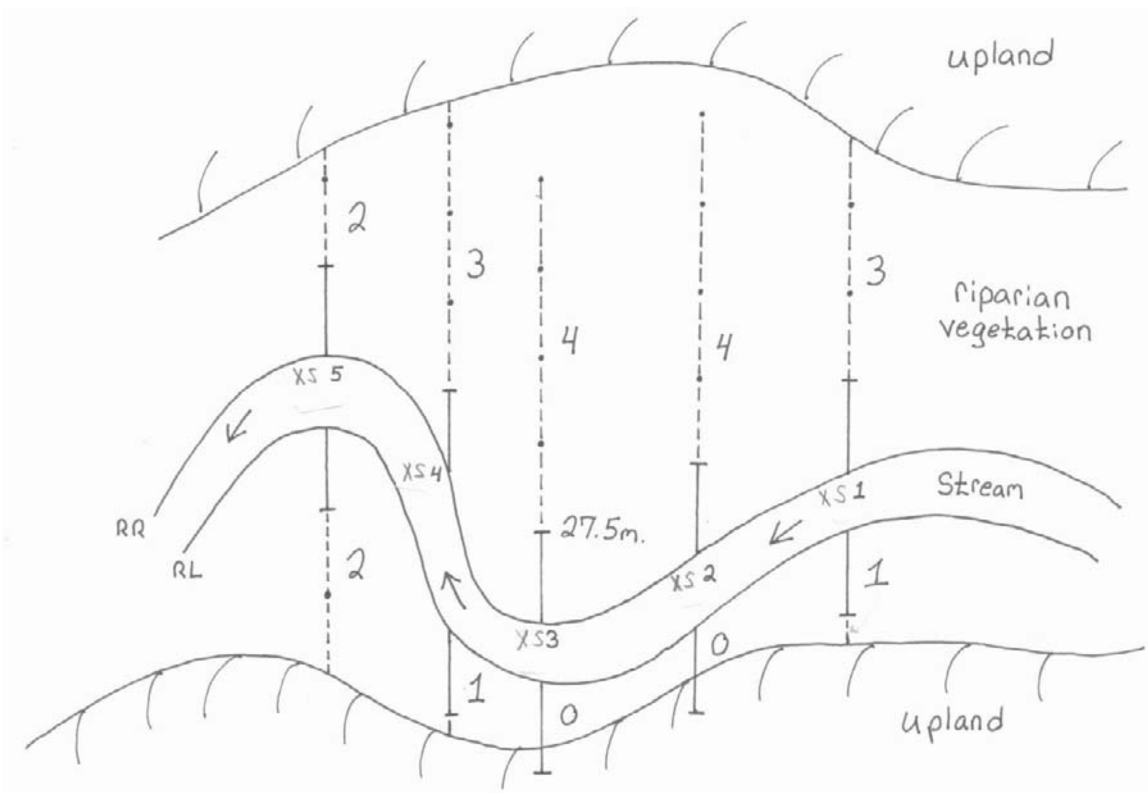


Figure III-10—Estimations of distances of riparian vegetation on cross-sections.

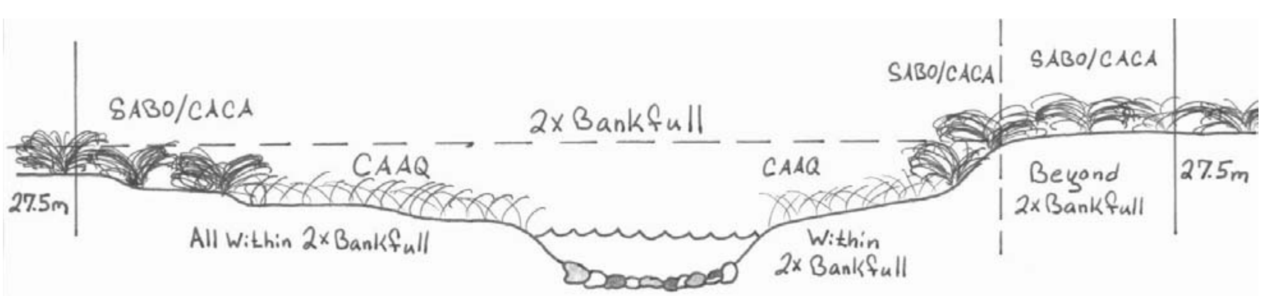


Figure III-11—Example of vegetation cross-section area within and beyond twice-bankfull.

in the corresponding part of the sheet. Once you cross the twice bankfull point do not record any more steps as within twice bankfull even if the elevation drops down again (fig. III-12). Some of the same community types can be in both the "within" and "beyond" sections, while other community types will only be in one of the sections (fig. III-11).

9. If the riparian area is less than 27.5 m wide, it will be necessary to determine exactly where the riparian area ends. We define the edge of the riparian area as the point where the vegetation changes from riparian communities (plants that require moist conditions to survive) to upland communities (plants that survive with moisture only from precipitation). Use the community type classification to determine the edge of the riparian area, based on the presence and percent cover of riparian species. Riparian species normally decrease in percent cover as one approaches the edge of the riparian area. The point where they become less than 25 percent (or what the key requires) will be the edge of the riparian zone. There may be riparian species outside of the riparian zone, but they will be less than 25 percent cover. Other clues to determine the edge of the riparian area:

a. Changes in landform generally correspond to a change in the ground water depth and therefore a change in soil moisture. Such changes in elevation and slope will affect vegetation and often correspond to the edge of the riparian area. Figure III-13 shows changes in landform that correspond to changes in vegetation and the edge of the riparian zone.
b. The presence of nonriparian species (*Artemisa tridentata, Chrysothamnus* spp., and so forth) may indicate that the area is never flooded or wet. Do not collect data for nonriparian plant communities.

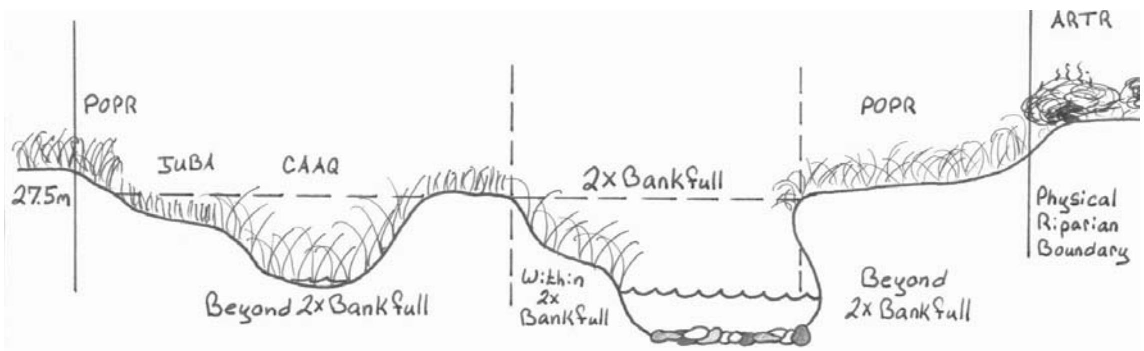


Figure III-12—Example of vegetation cross-section. Note that while community types may drop below two times bankfull after crossing the two times bankfull marker, they are still recorded as beyond two times bankfull.

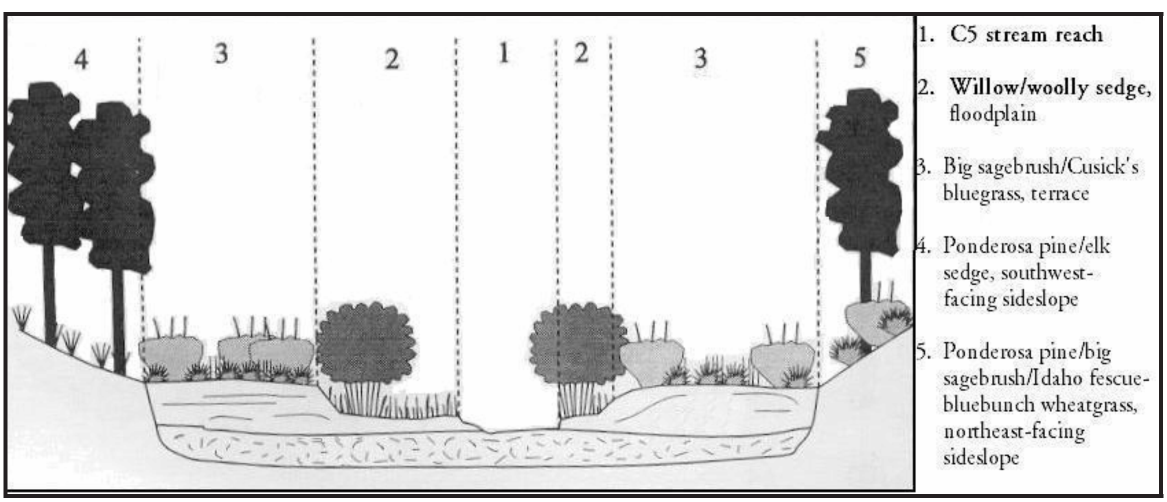


Figure III-13—Diagram showing changes in topography that correspond to different community types and the edge of the riparian area (from Crowe and Clausnitzer 1997).

c. There are some species that occur often in the transition zone between riparian and upland areas. Consult regional classifications and guides to determine what those indicator species are in each area. Some of these transition species, depending on the region, include: *Dasiphora floribunda,* formerly *Potentilla fruticosa* (shrubby cinquefoil), *Artemisia cana* (silver sagebrush), *Populus tremuloides* (quaking aspen), and *Rosa* spp. (rose species).

d. Some species are rhizomatous and can spread underground from the riparian zone into the upland zone, while still being connected to the riparian area where there is water. These species include: *Juncus balticus* (baltic rush) and *Equisetum* spp. (horsetail) among others. Use the classification to determine if the percent cover is high enough to consider it riparian.

e. Riparian species may grow outside of the riparian area because of a seep, another drainage, or water concentration along a road. Do not include that vegetation when it is not a part of the riparian area being sampled.

f. If a seep extends up a slope, do not continue the cross-section up the slope. Draw an imaginary line extending the edge of the rest of the riparian area and cut off the seep from the area of data collection.

g. Use caution with "facultative" wetland species such as *Poa pratensis*, which are capable of growing in both dry and wet conditions.

Undescribed or "New" Communities: for Greenline or Vegetation Cross-Section Data Collection

Undescribed communities will occasionally be encountered. When you encounter vegetation that does not seem to be in the classifications for your area, use the following rules, in the order they are presented:

1. Review the community type descriptions (especially the average cover and constancy data) again to determine if the vegetation could fit a named community type. It is important that this information is thoroughly reviewed in order to avoid extra work in collecting and analyzing data.

2. If you do not find the community in the primary classification for the area where you are working, look in approved classifications that cover adjacent areas. If there is a community type that matches, with a similar species list, then use that community type and note the author of the classification.

3. If you cannot find a community type that fits and the unknown community is two or fewer steps, lump the unknown community with adjacent community types.

4. If the three guidelines above do not result in a named community type, then collect data on this "new community" in the following manner:

a. Record the number of steps of the new community and name it "new1," "new2," and so forth, in the order encountered at the reach (start with new1 for each reach with a new community).

b. Tie flagging at the beginning and end of the new community so that you can return later to collect detailed data. When all other data collection is complete, return to collect new community data.

c. Determine where to set up three plots, identified as "a," "b," and "c," by dividing the distance of the new community by four. Walk that number of steps from the edge of the community and set up the first ½- x ½- m plot in front of your toe (fig. III-14). The other two plots will be that number of steps further, so that there are three plots within the new community. There will not be a plot at the beginning or end of the new community because those are transition zones between communities.

d. Use Form 8, "New Community Species Data," (appendix III-B) to record the cover of all species within the plots, using the cover classes listed on the data sheet. If you do not know the species then collect a specimen.

e. If this community is encountered again at this stream then you may use the same "new" name without having to collect more species data.

f. For all new communities collect a specimen of the species with the highest cover in the three plots combined (see instructions for specimen collection below).

g. In the data logger, enter new communities as "new1," "new2," and so forth. If it says this is not a valid type, then hit ok to use it anyway.

Note 1 - You should have few "new" communities because the classifications include most plant communities, and because describing new communities is a difficult process. If possible you should "fit" the vegetation in an existing community type (in other words someone else has already done the detailed species work for you). On the other hand, it is important to document new communities so that we have data on them that we can add to the existing classifications.

Note 2 - If you do document new communities, write a description of them in your notebook and talk to

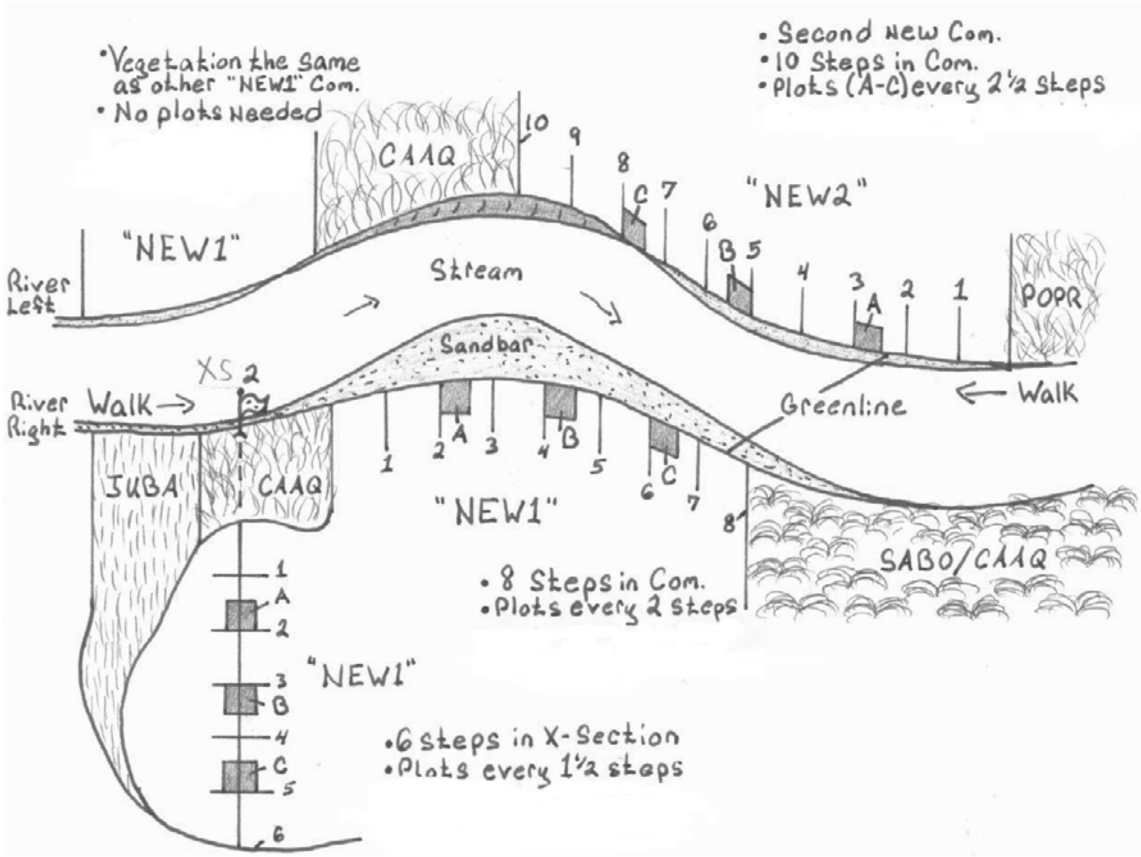


Figure III-14—Collecting new community data on cross-sections and greenline.

other vegetation technicians and Forest Service ecologists about the "new" communities to see if they have observed similar communities, or if they might fit within already classified communities.

Note 3 - Not all species in the community type will be present in every community that fits within that community type. If the combination of species at a site are similar to a described community type but the cover of those species seems different, you may still use that community type, and make a note of the major differences on the data sheet and in the comment line of the data logger.

Effective Ground Cover

Objective

- Estimate the area with cover that inhibits erosion versus the amount of bare ground within the riparian area.

Where to collect data

Measure this parameter in conjunction with each of the five vegetation cross-sections.

How to collect data

1. Collect ground cover data at each step while returning to the stream, along each vegetation cross-section.
2. The area considered is a 2 cm diameter circle (size of a quarter) located directly in front of your big toe (fig. III-15).
3. Record the point as bare ground if greater than 50 percent of the area is bare ground (that is, less than 50 percent of the area is covered by plants, plant litter, or rock). Stagnant water with no vegetation is also considered bare ground. Do not include moving water as bare ground. If there is a side channel or small tributary then skip those steps.
4. The point is considered covered if one or a combination of the following categories comprise greater than 50 percent of the area. Record the cover category that is dominant.

   a. Live Vegetation - herbaceous vegetation, shrubs, or trees with branches less than 1 m above the ground. Branches above 1 m are not considered vegetative cover for this method. Bare ground under a tree with a canopy above

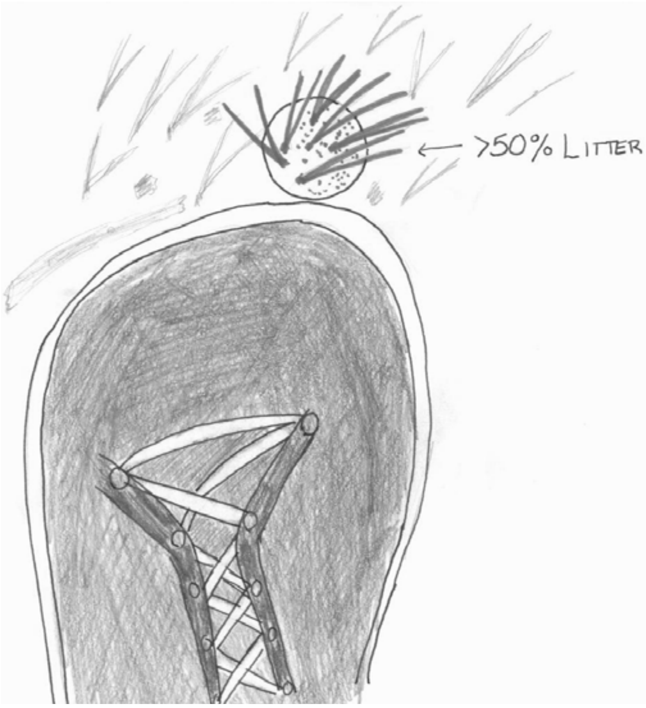


Figure III-15—Area of consideration for recording effective ground cover.

1 m is not considered live vegetation, except for the trunk area.

b. Litter - dead plant material such as matted grasses, leaves, twigs, branches, and so forth.

c. Rock - rocks greater than 25 mm.

Woody Species Regeneration

Objective

- Estimate the ratio of individuals in different age classes of shrubs and trees to determine how much regeneration of woody plants is occurring.

Where to collect data

Collect woody species regeneration data along the length of the greenline (110 m) on both sides of the stream for a 6-ft wide area, centered over the rooted greenline (fig. III-16).

How to collect data

1. Identify plants rooted within 3 ft of either side of the point where the greenline vegetation comes out of the ground. Use a 6-ft pole to determine this area.
2. Do not count individuals with overhanging branches that are not rooted within 3 ft of the greenline.
3. Record the age class and species of each woody individual on Form 7 (appendix III-B).
4. In narrow streams (less than 1 m wide) do not let the 6-ft pole go more than one-half way across the channel in order to not count the same area twice. This will also prevent you from counting plants located on the opposite bank.
5. Some species will not be counted because of our inability to age them, such as colonial or rhizomatous species. These species include: *Salix exigua, Salix wolfii*, *Salix planifolia*, *Salix commutata, Salix eastwoodiae, Cornus sericea,* and species of *Vaccinium, Symphoricarpos, Spiraea, Phyllodoce,* and *Arctostaphylos,* among others. Consult Crowe and Clausnitzer (1997) appendix III-D, "Rooting Habit" column, to determine if a species is rhizomatous and therefore not counted.
6. For mature individuals, distinguish whether they are greater than 1 m tall or less than 1 m tall.
7. If there are more than 50 individuals of one species age class, stop counting at 50 and record that there are more than 50 individuals.
8. Estimate the age of woody individuals using one of two methods, depending on whether they produce many basal stems or just one stem (or a few).

   a. Multiple-stemmed species grow additional stems over time rather than adding growth rings to existing stems. In general, the more stems it has the older it is. For multiple-stemmed species use table III-3 to estimate their age. Stems rooted within 12 inches are considered the same individual. Multiple-stemmed species are primarily *Salix* species (that are nonrhizomatous).

   b. Single-stemmed species add growth rings to the existing stems each year. These species do not put on a new stem each year, although they may have more than one stem. The plant grows taller and thicker stems as it gets older. The following species tend to grow as single-stemmed individuals: *Betula occidentalis, Prunus virginiana,* and most species of *Alnus, Populus, Pinus, Picea, Abies,* and *Crataegus*. Use table III-4 to estimate the age of each tree-like woody individual. If possible, look at nearby individuals of the same species to compare the size of mature to young. The height listed in meters is only a rough guideline.

The terms may not always seem appropriate, but don't let that bother you. For example, mature individuals can be a range of sizes. Just follow the protocol.

Plant Communities at Stream Transects

Objective

- Determine the relationship of stream data and greenline vegetation at the 20 stream transects.

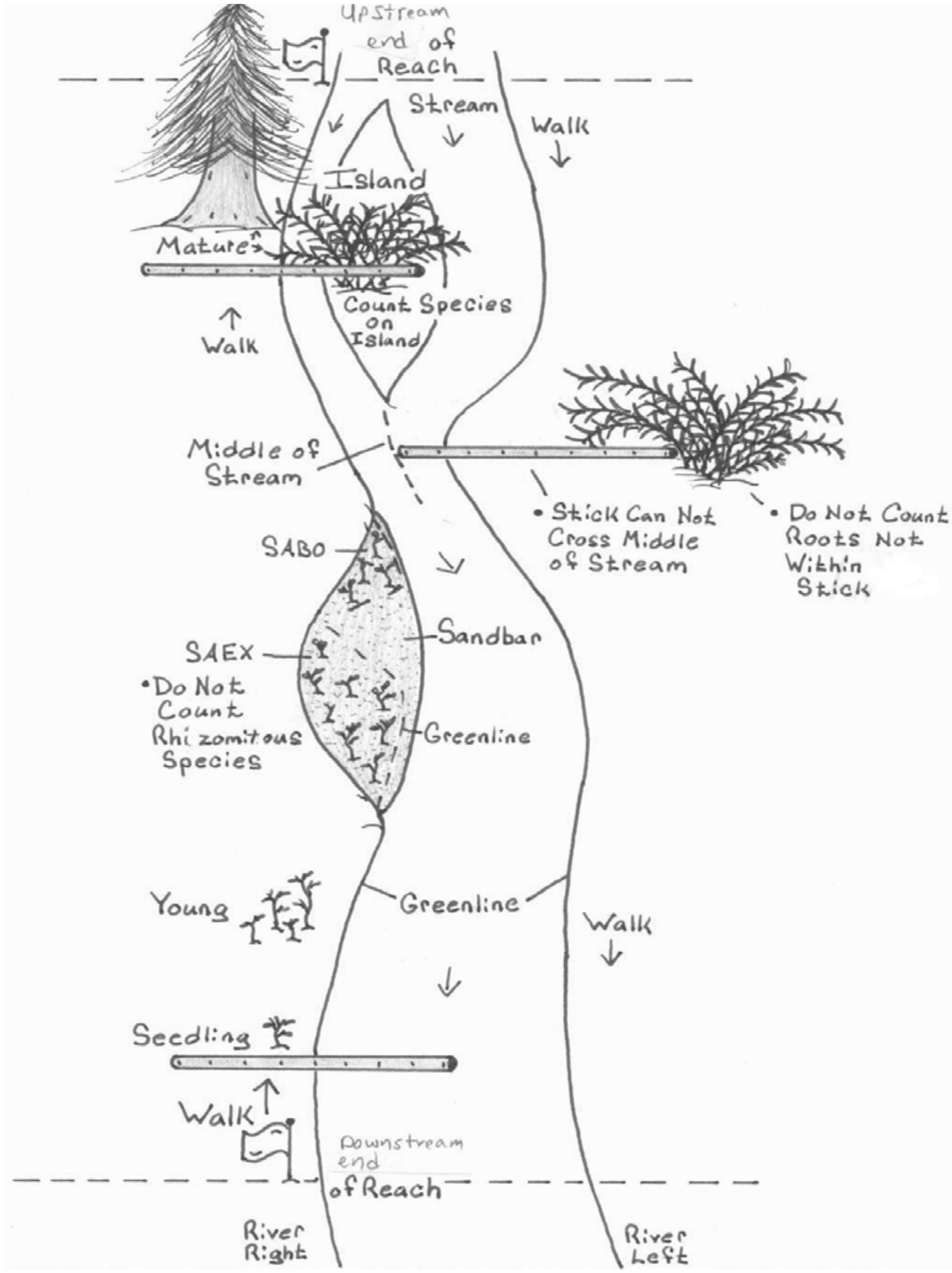


Figure III-16—Data collected on woody species regeneration.

Table III-3—Multiple-stemmed species (shrubs).

Number of stems (at ground level)	Age class
1	Seedling/sprout
2 to 10	Young
Greater than 10; greater than 1/2 alive	Mature
Greater than 10; greater than 1/2 dead	Decadent

Table III-4—Single-stemmed species (treelike).

Height	Age class
Less than 1/2 mature height; less than 0.3 m tall	Seedling/sprout
Less than 1/2 mature height; 0.3 to 2 m tall	Young
Near full height; greater than 2 m tall	Mature

Where to collect data

1. The vegetation technician records the community type at each stream transect. Most of these transects will be in the area where you have already collected greenline data, so you will have already determined the community types. If the stream reach extends upstream of the greenline sample area then you may see some different community types.

2. Each stream transect is marked by two flags, one on each bank, which are perpendicular to the channel. Imagine a line connecting those two flags and determine where that line intersects the greenline on each side of the stream. Those two points on the greenline are the center of an approximately one step by one step area for which you will determine the community type (fig. III-17).

How to Collect Data

1. Follow the instructions for the greenline method to determine the community type.

2. In addition, use the classes below to determine the total cover of vegetation in that one step by one step plot.

3. Cover classes (Daubenmire 1959).

   a. 1 = 0 to 5 percent cover—not used because there is not enough cover to be the greenline.
   b. 2 = 5 to 25 percent cover
   c. 3 = 25 to 50 percent cover
   d. 4 = 50 to 75 percent cover
   e. 5 = 75 to 95 percent cover
   f. 6 = 95 to 100 percent cover

4. There is no data sheet for this method. Record these data in the "Stream" application of the data logger under "Transects/GLComTyp." It is best to collect these data with the stream technicians as they are doing their stream transects.

Collecting Specimens

When to collect plant specimens

1. At each reach collect a specimen of an abundant species that helps to determine a community type.

2. If you are unsure of a species that is important in determining a community type, collect a specimen. It is not necessary to collect species that have low cover values.

3. For each "new" community, collect a specimen of the most abundant species based on the data from the three plots that you sample.

How to collect specimens

1. Follow the 1 in 20 rule (in other words, only collect a specimen if there are 20 more individuals present). This will prevent you from harming an endangered species.

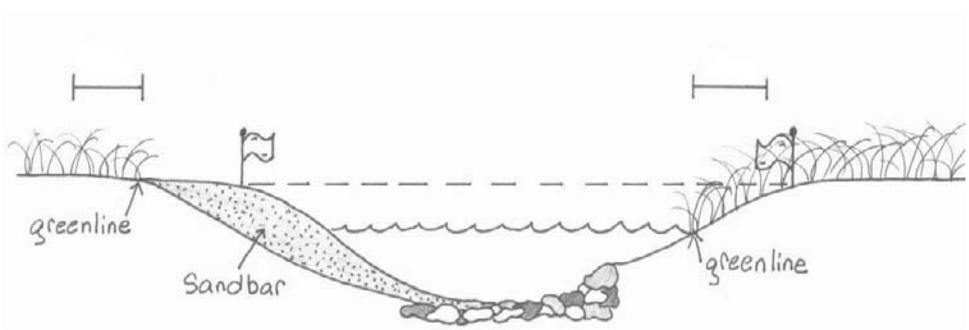


Figure III-17—Sampling areas at stream transects. Note that data are collected at the intersection of stream transects and the greenline, not at the flag positions.

2. For each specimen, fill out and attach the "Plant Label" provided.

3. Collect as much of the plant as you can, including roots (if possible) of sedges, grasses, and other herbaceous plants. Try to collect a specimen with a flower or mature fruits. For woody plants collect branches with leaves and flowers/fruits if possible. Collect two individuals or branches (under one label) so that we can dissect some without destroying everything.

4. For new communities, take a photo of the new community that includes the species from which you collected a specimen and record the photo number on the plant label.

5. Place the labeled specimens between newspaper and then between the felt blotters in the plant press. Specimens that are not well labeled are useless. It is essential that you note on the label the community type, or new community number, that you recorded it under.

6. Key out unknown species (a microscope may be necessary) as soon as possible. If you are able to identify the plant then make the change on the label. Also review the classification to identify the community type and make the change on the data sheet and data logger if you still have them. If you no longer have access to the data sheet and data logger, or you cannot identify the species, then pass the labeled specimen on to the vegetation supervisor.

References for Parts I, II, and III

Archer, E. K.; Roper, B. B.; Henderson, R. C.; Mellison, S. C.; Kershner, J. L. [In press]. Testing common stream sampling methods: how useful are these techniques for broad-scale, long-term monitoring? Gen. Tech. Rep. Fort Collins, CO, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Barbour, M. T.; Stribling, J. B.; Karr, J. R. 1995. The multimetric approach for establishing biocriteria and measuring biological condition. In: Davis, W. S.; Simon, T. P., eds. Biological assessment and criteria: tools for water resource planning and decision making. Boca Raton, FL: Lewis Publishers: 63–80.

Bauer, S. B.; Burton, T. A. 1993. Monitoring protocols to evaluate water quality effects of grazing management of Western rangeland streams. EPA 910/R-9-93-017. Seattle, WA: U.S. Environmental Protection Agency, Water Division, Surface Water Branch, Region 10. 179 p.

Coles-Ritchie, M. C.; Henderson, R. C.; Archer, E. A.; Kennedy, C.; Kershner, J. L. [In preparation]. The repeatability of riparian vegetation sampling methods: how useful are these techniques for broad-scale, long-term monitoring? Gen. Tech. Rep. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Conquest, L. C.; Ralph S. C.; Naiman, R. J. 1994. Implementation of large-scale stream monitoring efforts: sampling design and data analysis issues. In: Loeb, S.; Spacie A., eds. Biological monitoring of aquatic systems. Boca Raton, FL: CRC Press. 381 p.

Crawford, R. C. 2001. Initial riparian and wetland vegetation classification and characterization of the Columbia Basin in Washington. Olympia, WA: Washington State Department of Natural Resources. 83 p.

Crowe, E. A.; Clausnitzer, R. R. 1997. Mid-montane wetland plant associations of the Malheur, Umatilla and Wallowa-Whitman National Forests. R6-NR-ECOL-TP-22-97. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 299 p.

Daubenmire, R. F. 1959. Plants and environment: a textbook of plant autecology. New York: John Wiley & Sons. 422 p.

Ebersole, J. L.; Liss, W. J.; Frissell, C. A. 1997. Restoration of stream habitats in the Western United States: restoration and re-expression of habitat capacity. Environmental Management. 21: 1–14.

Hansen, P. L.; Pfister, R. D.; Boggs, K.; Cook, B. J.; Joy, J.; Hinckley, D. K. 1995. Classification and management of Montana's riparian and wetland sites. Missoula, MT: University of Montana, School of Forestry. 646 p.

Harrelson, C. C.; Rawlins, C. L.; Potyondy, J. P. 1994. Stream channel reference sites: an illustrated guide to field technique. Gen. Tech. Rep. RM-245. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 61 p.

Karr, J. R.; Chu, E. W. 1997. Biological monitoring: essential foundation for ecological risk assessment. Human and Ecological Risk Assessment. 3(6): 993–1004.

Kaufmann, P. R.; Levine, P.; Robison, E. G.; Seeliger, C.; Peck, D. V. 1999. Quantifying physical habitat in wadeable streams. U.S. EPA/620/R99/03. Corvallis, OR. 158 p.

Kovalchik, B. L. 1987. Riparian zone associations: Deschutes, Ochoco, Fremont, and Winema National Forests. Tech. Pap. R6-Ecol-279-87. Portland OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 171 p.

Kovalchik, B. L. 2001. Classification and management of aquatic, riparian and wetland sites on the National Forests of eastern Washington's riparian and wetland sites. Colville, WA: U.S. Department of Agriculture, Forest Service, Region 6. 439 p.

Larsen, D. P.; Kincaid, T. M.; Jacobs, S. E.; Urquhart, N. S. 2001. Designs for evaluating local and regional scale trends. Bioscience. 51: 1069–1078.

Lisle, T. E. 1987. Using "residual depths" to monitor pool depths independently of discharge. Res. Note PSW-394. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 4 p.

MacDonald, L. H.; Smart, A. W.; Wissmar, R. C. 1991. Monitoring guidelines to evaluate effects of forestry activities on streams in the Pacific Northwest and Alaska. U.S. EPA 910/9-91-001. Seattle, WA. 166 p.

Manning, M. E.; Padgett, W. G. 1995. Riparian community type classification for Humboldt and Toiyabe National Forests, Nevada and Eastern California. R4-ECOL-95-01. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Region. 274 p.

Montgomery, D. R.; MacDonald L. H. 2002. Diagnostic approach to stream channel assessment and monitoring. Journal of the American Water Resources Association. 1: 1–16.

Naiman, R. J.; Beechie, T. J.; Benda, L. E.; Berg, D. R.; Bisson P. A.; MacDonald, L. H.; O'Conner, M. D.; Olson, P. L.; Steel, E. A. 1992. Fundamental elements of ecologically healthy watersheds in the Pacific Northwest Coastal Ecoregion. In: Watershed management: balancing sustainability and environmental change. New York: Springer-Verlag: 127–188.

National Research Council. 2002. Riparian areas: functions and strategies for management. Washington, DC: National Academy Press. 436 p.

Noon, B. R.; Raphael, M. G.; Spies, T. A.; Olsen, A. R. 1997. Conceptual basis for designing and effectiveness monitoring program. In: Mulder, B. S.; Noon, B. R.; Olsen, A. R.; Palmer, C. J.; Raphael, M. G.; Reeves, G. H.; Spies, T. A.; Welsh, H. H., Jr. The strategy and designing of the effectiveness monitoring program for the Northwest Forest Plan. Gen. Tech. Rep. PNW-GTR. Portland, OR: U.S. Department of Agriculture, Forest Service Pacific Northwest Station: 17–36.

Overton, C. K.; McIntyre, J. D.; Armstrong, R.; Whitwell, S. L.; Duncan, K. A. 1995. User's guide to fish habitat descriptions that represent natural conditions in the Salmon River Basin, Idaho. Gen. Tech. Rep. INT-GTR-322. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 142 p.

Overton, C. K.; Wollrab, S. P.; Roberts, B. C.; Radko, M. A. 1997. R1/R4 (Northern and Intermountain Regions) fish and fish habitat standard inventory procedures handbook. Gen. Tech. Rep. INT-

GTR-346. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 142 p.

PACFISH (Pacific Anadromous Fisheries Habitat), U.S. Forest Service and U.S. Bureau of Land Management. 1994. Environmental assessment for the implementation of interim strategies for managing anadromous fish-producing watersheds in eastern Oregon, Washington, Idaho, and portions of California. Washington, DC: U.S. Department of Agriculture, Forest Service. 68 p.

Padgett, W. G.; Youngblood, A. P.; Winward A. H. 1989. Riparian community type classification of Utah and Southeastern Idaho. R4-ECOL-89-01. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Region. 191 p.

Platts, W. S.; Armour, C.; Booth, G. D.; Bryant, M.; Bufford, J. L.; Cuplin, P.; Jensen, S.; Lienkaemper, G. W.; Minshall, G. W.; Monsen, S. P.; Nelson, R. L.; Sedell, J. R.; Tuhy, J. S. 1987. Methods for evaluating riparian habitats with applications to management. Gen.Tech. Rep. INT-221. Ogden, UT: U.S. Department of Agriculture, Forest, Service, Intermountain Research Station. 177 p.

Reeves, G. H.; Benda, L. E.; Burnett, K. M.; Bisson, P. A.; Sedell, J. R. 1995. A disturbance-based ecosystem approach to maintaining and restoring freshwater habitats of the evolutionary significant units of anadromous salmonids in the Pacific Northwest. American Fisheries Society Symposium. 17: 334–349.

Reid, L. M. 2001. The epidemiology of monitoring. Journal of the American Water Resources Association. 37: 815–820.

Ringold, P. L.; Mulder, B.; Alegria, J.; Czaplewski, R. L.; Tolle, T.; Burnett, K. 1999. Establishing a regional monitoring strategy: the Pacific Northwest Forest Plan. Environmental Management. 23: 179–192.

Urquhart, N. S.; Paulsen, S. G.; Larsen, D. P. 1998. Monitoring for policy-relevant regional trends over time. Ecological Applications. 8: 246–257.

U.S. Department of Agriculture, Forest Service, Intermountain Region. 1989. Soil quality monitoring methods. Internal publication. Ogden, UT. 60 p.

U.S. Department of the Interior, Fish and Wildlife Service. 1998. Endangered and threatened wildlife and plants: determination of threatened status for the Klamath River and Columbia River distinct population segments of bull trout final rule. Federal Register June 10, 1998 (Volume 63, Number 111, Pages 31647–31674) 50 CFR Part 17, RIN 1018-AB94.

Whittier, T. R.; Paulsen, S. G. 1992. The surface waters component of the Environmental Monitoring and Assessment Program (EMAP): an overview. Journal of Aquatic Ecosystem Health. 1: 119–126.

Winward, A. H. 2000. Monitoring the vegetation resources in riparian areas. Gen. Tech. Rep. RMRS-GTR-47. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 49 p.

Wolman, M. G. 1954. A method of sampling coarse riverbed material. Transactions of the American Geophysical Union. 35: 951–956.

Youngblood, A. P.; Padgett, W. G.; Winward, A. H. 1985. Riparian community type classification of Eastern Idaho - Western Wyoming. R4-ECOL-85-01. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Region. 78 p.

Appendix III-A (Equipment List)

Gear everyone has (verify that you have it with √):

	Hand lens
	Ruler
	Neck string
	Plot string
	Clicker
	Compass
	Probe
	Tweezers
	Clipboard
	Microscope
	Plant labels
	Pencils
	Plant press with cardboard and felt (you need to get newspaper)
	Yellow flags
	Flagging
	Plastic zip-lock bags for specimens
	Protocol
	Notebook (pocket size)
	Six-foot pole
	Vests

Books (mark which you have with √):

	Field Guide to the Willows of East Central Idaho (Brunsfeld and Johnson 1985)
	Initial Riparian and Wetland Vegetation Classification and Characterization of the Columbia Basin In Washington (Crawford 2001)
	Mid-Montane Wetland Plant Associations of the Malheur, Umatilla and Wallowa-Whitman National Forests (Crowe and Clausnitzer 1997)
	The Willows of Montana (Dorn 1970)
	Classification and Management of Montana's Riparian and Wetland Sites (Hansen and others 1996)
	Plant Identification Terminology (Harris and Harris 1999)
	Willows of Montana (Heinze 1992)
	Flora of the Pacific Northwest (Hitchcock and Cronquist 1998)
	Field Guide to Intermountain Sedges (Hurd and others 1998)
	Field Guide to Intermountain Rushes (Hurd and others 1997)
	Riparian Zone Associations -- Deschutes, Ochoco, Fremont, and Winema National Forests (Kovalchik 1987)
	Classification and Management of Aquatic, Riparian and Wetland Sites On the National Forests of Eastern Washington (Part 1: the Series Descriptions) Final Draft (Kovalchik 2001)
	Major Indicator Shrubs and Herbs In Riparian Zones On National Forests of Central Oregon (Kovalchik and others 1988)
	Riparian Community Type Classification For Humboldt and Toiyabe National Forests, Nevada and Eastern California (Manning and Padgett 1995)
	Riparian Community Type Classification of Utah and Southeastern Idaho (Padgett and others 1989)
	Monitoring the Vegetation Resources In Riparian Areas (Winward 2000)
	Riparian Community Type Classification of Eastern Idaho -- Western Wyoming (Youngblood and others 1985)
	Riparian Wetland Plant Associations of Southwestern Idaho (Jankovsky-Jones and others 2001)

Form 5
Green-Line Vegetation Data

Stream Name: ____________________ Data Collector: ____________________

Reach ID #: ____________________ Steps per 110 m: ____________________

Riparian Vegetation Classification Used (circle): Kov-OR, Crowe, Kov-WA, Hansen, Padgett, Youngblood, Manning, Crawford, other: ____________________

Community Type	# of Steps on Right Bank	# of Steps on Left Bank	Total
Comments:			

Greenline Options

- Record community type or new community only, no physical variables (note them in comments).
- For "new" communities write new1, new2, and so forth, and then use form "New Community Species Data."

Form 6
Riparian Vegetation Cross-Sections & Effective Ground Cover

Stream Name: ______________________________ Data Collector: __________________________________

Reach ID #: ________________________________ Compass Bearing (face downstream): _______________

Cross-Sections (Xs)

Community type	XS 1 R	XS 1 L	XS 1 total	XS 2 R	XS 2 L	XS 2 total	XS 3 R	XS 3 L	XS 3 total	XS 4 R	XS 4 L	XS 4 total	XS 5 R	XS 5 L	XS 5 total
Within 2x bankfull															
Beyond 2x bankfull															
Additional distance > 27.5 m (use key)			xxxxx			xxxxx			xxxxx			xxxxx			xxxxx

0 = none, 1 = < distance stepped, 2 = 1x to 2x distance stepped, 3 = 2x to 4x distance stepped, 4 = > 4x distance stepped

Measured distance of
1 right cross-section: ____ ____ ____ ____ ____

Effective Ground Cover

Ground Cover	XS 1 R	XS 1 L	XS 1 Total	XS 2 R	XS 2 L	XS 2 Total	XS 3 R	XS 3 L	XS 3 Total	XS 4 R	XS 4 L	XS 4 Total	XS 5 R	XS 5 L	XS 5 Total
Live vegetation less than 1 m															
Litter															
Bare ground															
Rock > 2.5 cm															
Ponded water															

Form 7
Woody Regeneration

Stream Name: ____________________ Data Collector: ____________________

Reach ID: ____________________ Date: ____________________

Woody Individuals Count
(all shrubs and trees rooted one meter within either side of greenline)

Species	Seedling/sprout	Young	Mature < 1m	Mature >1m	Decadent	Dead

Multi-stemmed species (shrubs)
Seedling/Sprout = 1 Stem
Young = 2 to10 Stems
Mature = Greater than 10 Stems, greater than ½ alive
Decadent = Greater than 10 Stems, less than ½ alive

Single stemmed species (tree-like)
Seedling/Sprout less than ¼ Mature Height, less than 0.3 meters tall
Young less than ½ Mature Height, 0.3 to 2 meters tall
Mature greater than ½ Mature Height, greater than 2 meters tall
Dead greater than ½ Mature Height, and dead

Form 8
New Community Species Data

Data Collector:	Date:
Stream:	Reach ID:
Greenline or Cross Section (circle one)	New Community # (1, 2, 3, 4, 5, 6, 7, circle one)
Adjacent Community Types (2):	Plot (a,b,c, and so forth):
Size of new community (if only a few steps, lump with adjacent community types):	

Herbaceous (grasses, forbs, sedges, rushes)	Species	Cover Class	Specimen collected yes or no (collect the most abundant)	Specimen ID#
Shrubs				
Trees				
Cover Classes: 1=0-5%, 2=5-25%, 3=25-50%, 4=0-75%, 5=75-95%, 6=95-100%				

PLANT LABEL
Species ID in field: ____________________________
Reach ID: ____________________________________
Community type recorded as: __________________
% Cover: ____________________________________
Associated species: ___________________________
continued_____________________________________
Habitat (circle): in water - streambank - meadow
- forest - riparian boundary - other____________
Collector: ____________________________________
Photo #/s:____________________________________

FOLD HERE

PLANT LABEL
Species ID in field: ____________________________
Reach ID: ____________________________________
Community type recorded as: __________________
% Cover: ____________________________________
Associated species: ___________________________
continued_____________________________________
Habitat (circle): in water - streambank - meadow
- forest - riparian boundary - other_____________
Collector: ____________________________________
Photo #/s:_____________________________________

FOLD HERE

PLANT LABEL
Species ID in field: ____________________________
Reach ID: ____________________________________
Community type recorded as: __________________
% Cover: ____________________________________
Associated species: ___________________________
continued_____________________________________
Habitat (circle): in water - streambank - meadow
- forest - riparian boundary - other____________
Collector: _____________________________________
Photo #/s:_____________________________________

FOLD HERE

PLANT LABEL
Species ID in field: ____________________________
Reach ID: ____________________________________
Community type recorded as: __________________
% Cover: ____________________________________
Associated tpecies: ___________________________
continued_____________________________________
Habitat (circle): in water - streambank - meadow
- forest - riparian boundary - other_____________
Collector: _____________________________________
Photo #/s:_____________________________________

FOLD HERE

You may order additional copies of this publication by sending your mailing information in label form through one of the following media. Please specify the publication title and number.

Telephone	(970) 498-1392
FAX	(970) 498-1396
E-mail	rschneider@fs.fed.us
Web site	http://www.fs.fed.us/rm
Mailing Address	Publications Distribution Rocky Mountain Research Station 240 West Prospect Road Fort Collins, CO 80526

RMRS
ROCKY MOUNTAIN RESEARCH STATION

The Rocky Mountain Research Station develops scientific information and technology to improve management, protection, and use of the forests and rangelands. Research is designed to meet the needs of National Forest managers, Federal and State agencies, public and private organizations, academic institutions, industry, and individuals.

Studies accelerate solutions to problems involving ecosystems, range, forests, water, recreation, fire, resource inventory, land reclamation, community sustainability, forest engineering technology, multiple use economics, wildlife and fish habitat, and forest insects and diseases. Studies are conducted cooperatively, and applications may be found worldwide.

Research Locations

Flagstaff, Arizona
Fort Collins, Colorado*
Boise, Idaho
Moscow, Idaho
Bozeman, Montana
Missoula, Montana
Lincoln, Nebraska
Reno, Nevada
Albuquerque, New Mexico
Rapid City, South Dakota
Logan, Utah
Ogden, Utah
Provo, Utah
Laramie, Wyoming

*Station Headquarters, Natural Resources Research Center,
2150 Centre Avenue, Building A, Fort Collins, CO 80526