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A Regional Guidebook for Conducting Functional Assessments of Forested Wetlands and Riparian Areas in the Ozark Mountains Region of Arkansas

Charles V. Klimas, Elizabeth O. Murray, Henry Langston, Jody Pagan, Theo Witsell, and Thomas Foti

September 2008

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Environmental Laboratory

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Abstract: Section 404 of the Clean Water Act directs the U.S. Army Corps of Engineers to administer a regulatory program for permitting the discharge of dredged or fill material in "waters of the United States." As part of the permit review process, the impact of discharging dredged or fill material on wetland functions must be assessed. In 1996, a National Action Plan to Implement the Hydrogeomorphic Approach for developing Regional Guidebooks to assess wetland functions was published. The Hydrogeomorphic Approach is a collection of concepts and methods for developing functional indices and subsequently using them to assess the capacity of a wetland to perform functions relative to similar wetlands in a region. This report, one of a series of Regional Guidebooks that will be published in accordance with the National Action Plan, applies the Hydrogeomorphic Approach to wetland and riparian forests in the Ozark Mountains Region of Arkansas in a planning and ecosystem restoration context.

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Corps of Engineers Research Report Summary, September 2008

Assessing Wetland Functions

A Regional Guidebook for Conducting Functional Assessments of Forested Wetlands and Riparian Areas in the Ozark Mountains Region of Arkansas (ERDC/EL TR-08-31)

ISSUE: Section 404 of the Clean Water Act directs the U.S. Army Corps of Engineers to administer a regulatory program for permitting the discharge of dredged or fill material in "waters of the United States." As part of the permit review process, the impact of discharging dredged or fill material on wetland functions must be assessed. On 16 August 1996, a National Action Plan to Implement the Hydrogeomorphic Approach (NAP) for developing Regional Guidebooks to assess wetland functions was published. This report is one of a series of Regional Guidebooks that will be published in accordance with the National Action Plan.

RESEARCH OBJECTIVE: The objective of this research was to develop a Regional Guidebook for applying the Hydrogeomorphic Approach to Forested Wetlands and Riparian Areas in the Ozark Mountains Region of Arkansas in a planning and ecosystem restoration context.

SUMMARY: The Hydrogeomorphic (HGM) Approach is a collection of concepts and methods for developing functional indices and subsequently using them to assess the capacity of a wetland to perform functions relative to similar wetlands in a region. The Approach was initially designed to be used in the context of the Clean Water Act Section 404 Regulatory Program permit review sequence to consider alternatives, minimize impacts, assess unavoidable project impacts, determine mitigation requirements, and monitor the success of mitigation projects. However, a variety of other potential applications for the Approach have been identified, including determining minimal effects under the Food Security Act, designing mitigation projects, and managing wetlands.

AVAILABILITY OF REPORT: The report is available at the following Web sites: *http://el.erdc.usace.army.mil/wetlands/pubs.html,* *http://el.erdc.usace.army.mil/emrrp/techtran.html*, or *http://itl.erdc.usace.army.mil/library/.* The report is also available on Interlibrary Loan Service from the U.S. Army Engineer Research and Development Center (ERDC) *http://libweb.wes .army.mil/lib/library.htm*.

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Preface

This Regional Guidebook was developed as a cooperative effort between the Arkansas Multi-Agency Wetland Planning Team (MAWPT) and Region 6 of the Environmental Protection Agency, which provided funding through the Wetland Grants 104(b)(3) program for States, Tribes, and Local Governments. Charles V. Klimas (Charles Klimas & Associates, Inc.) directed the field studies and prepared the guidebook manuscript, under contract to the Arkansas Game and Fish Commission MAWPT Coordination Office. Elizabeth O. Murray (MAWPT Coordinator, Arkansas Game and Fish Commission) prepared most of the figures. All of the persons listed as authors of this guidebook were involved in every aspect of the project, including classification, field sampling, and model testing, and otherwise contributed materially to production of the document. The affiliations of the other authors are as follows: Thomas Foti (Arkansas Natural Heritage Commission, retired), Jody Pagan (Five Oaks Wildlife Services, Stuttgart AR, formerly with the Natural Resources Conservation Service), Theo Witsell (Arkansas Natural Heritage Commission), and Henry Langston (Arkansas Highway and Transportation Department). Other representatives of the MAWPT member agencies provided technical oversight for the project, and together with other organizations, participated in the field studies, and in the workshops that produced the wetland classification system, community characterizations, and assessment models used in this document. D.J. Klimas archived and summarized the field data and generated the data summary graphs in this report. All maps throughout the document showing elevation, topography, or hill-shade data were created with TOPO! (©2004 National Geographic).

Participants in this project included representatives of federal agencies (U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, Natural Resources Conservation Service), Arkansas State agencies (Arkansas Natural Heritage Commission, Arkansas Game and Fish Commission, Arkansas Natural Resources Commission, Arkansas State Highway and Transportation Department, Arkansas Forestry Commission, Arkansas Department of Environmental Quality, University of Arkansas Cooperative Extension Service), state University personnel, and private sector representatives. Ken Brazil (Arkansas Natural Resources Commission), Tom Foti, Elizabeth Murray, and Jeff Raasch (former MAWPT Coordinator, now with Texas Parks and Wildlife) provided administrative continuity and coordination among participating and funding agencies, in addition to their direct technical participation.

This document was prepared in accordance with guidelines established by the Engineer Research and Development Center (ERDC), Waterways

Experiment Station (WES) in Vicksburg, Mississippi. In addition, the methods and protocols used to develop this document were closely coordinated with similar projects undertaken in the Delta Region of Mississippi (the Yazoo Basin) and in other regions of Arkansas. Therefore, portions of the text and some figures are similar or identical to sections of those HGM Guidebooks (Smith and Klimas 2002, Klimas et al. 2004, 2005, 2006). It should also be noted that the Western Kentucky Regional Guidebook (Ainslie et al.1999) served as a template for the development of the Delta Guidebooks and portions of this one. Parts of the discussion in the Western Kentucky document are included here without significant modification, particularly portions of the wildlife section originally developed by Tom Roberts (Tennessee Technological University) and basic information on the HGM Approach and wetland functions originally developed by R. Daniel Smith, ERDC.

1 Introduction

The Hydrogeomorphic (HGM) Approach is a method for developing functional indices and the protocols used to apply these indices to the assessment of wetland functions at a site-specific scale. The HGM Approach initially was designed to be used in the context of the Clean Water Act, Section 404 Regulatory Program, to analyze project alternatives, minimize impacts, assess unavoidable impacts, determine mitigation requirements, and monitor the success of compensatory mitigation. However, a variety of other potential uses have been identified, including the determination of minimal effects under the Food Security Act, design of wetland restoration projects, and management of wetlands.

In the HGM Approach, the functional indices and assessment protocols used to assess a specific type of wetland in a specific geographic region are published in a document referred to as a Regional Guidebook. Guidelines for preparing Regional Guidebooks were published in the National Action Plan (National Interagency Implementation Team 1996) developed cooperatively by the U.S. Army Corps of Engineers (USACE), U.S. Environmental Protection Agency (USEPA), U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), Federal Highway Administration (FHWA), and U.S. Fish and Wildlife Service (USFWS). The Action Plan, available online at *http://www.epa.gov/OWOW/wetlands/science/hgm.html*, outlines a strategy for developing Regional Guidebooks throughout the United States, provides guidelines and a specific set of tasks required to develop a Regional Guidebook under the HGM Approach, and solicits the cooperation and participation of Federal, State, and local agencies, academia, and the private sector.

This report is a Regional Guidebook developed for assessing the most common types of wetlands and riparian forests that occur in the Ozark Mountains Region of Arkansas. Normally, a Regional Guidebook focuses on a single regional wetland subclass (the term for wetland types in HGM terminology); however, a different approach has been employed in this Regional Guidebook: multiple regional wetland subclasses are considered. The rationale for this approach is that this region is a complex landscape where subtle differences in terrain and water movement result in distinctly different functions being performed by wetlands that are in close proximity to or contiguous with one another. Further, massive flood control, navigation, and drainage works instituted in the 20th century have dramatically affected many of the wetlands in the region. For these reasons, it is most sensible to deal with their classification and assessment in a single integrated Regional Guidebook. This does not mean that wetlands of different hydrogeomorphic classes and regional wetland subclasses are lumped for assessment purposes, but rather that the factors influencing their functions and the indicators employed in their evaluation are best developed and presented in a unified manner.

This Regional Guidebook addresses various objectives:

- To characterize selected regional wetland subclasses in the Ozark Mountains Region of Arkansas.

- To present the rationale used to select functions to be assessed in these regional subclasses.

- To present the rationale used to select assessment variables and metrics.

- To present the rationale used to develop assessment models.

- To describe the protocols for applying the functional indices to the assessment of wetland functions.

This report is organized in the following manner. Chapter 1 provides the background, objectives, and organization of the document. Chapter 2 gives a brief overview of the major components of the HGM Approach, including the procedures recommended for development and application of Regional Guide-books. Chapter 3 characterizes the regional wetland subclasses in the Ozark Mountains Region of Arkansas included in this guidebook. Chapter 4 discusses the wetland functions, assessment variables, and functional indices used in the guidebook from a generic perspective. Chapter 5 applies the assessment models to specific regional wetland subclasses and defines the relationship of assessment variables to reference data. Chapter 6 outlines the assessment protocol for conducting a functional assessment of regional wetland subclasses in the Ozark Mountains Region of Arkansas. Appendix A presents preliminary project documentation and field sampling guidance. Field data forms are presented in Appendix B. Appendix C contains alternate field forms, and Appendix D contains demonstration printouts of calculation spreadsheets. Spatial data that may be useful in the application of this guidebook are listed in Appendix E. Common and scientific names of plant species referenced in the text and data forms are listed in Appendix F.

While it is possible to assess the functions of selected regional wetland subclasses in the Ozark Mountains Region of Arkansas using only the information contained in Chapter 6 and the appendices, it is strongly suggested that, prior to conducting an assessment, users also familiarize themselves with the information and documentation provided in Chapters 2-5.

2 Overview of the Hydrogeomorphic Approach

Development and Application Phases

The HGM Approach consists of four components: (a) the HGM classification, (b) reference wetlands, (c) assessment variables and assessment models from which functional indices are derived, and (d) assessment protocols. The HGM Approach is conducted in two phases. An interdisciplinary Assessment Team of experts carries out the Development Phase of the HGM Approach. The task of the Assessment Team is to develop and integrate the classification, reference wetland information, assessment variables, models, and protocols of the HGM Approach into a Regional Guidebook (Figure 1).

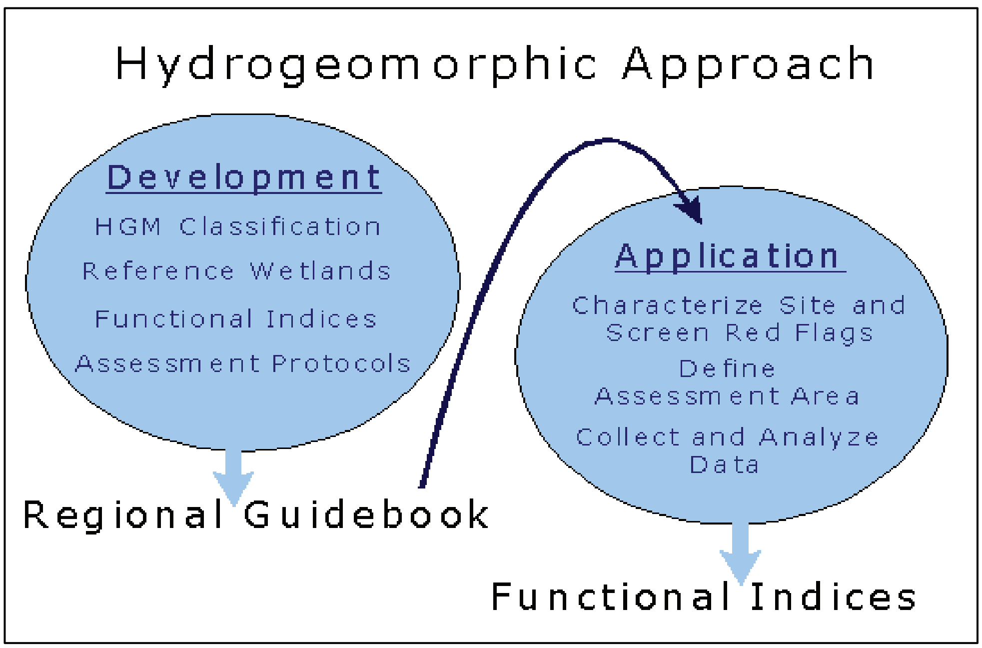

Figure 1. Development and Application Phases of the HGM Approach (from Ainslie et al. 1999)

In developing a Regional Guidebook, the team completes the tasks outlined in the National Action Plan (National Interagency Implementation Team 1996). After the team is organized and trained, its first task is to classify the wetlands of the region of interest into regional wetland subclasses using the principles and criteria of Hydrogeomorphic Classification (Brinson 1993a; Smith et al. 1995). Next, focusing on a specific regional wetland subclass, the team develops an ecological characterization or functional profile of the subclass. The Assessment Team then identifies the important wetland functions, conceptualizes assessment models, identifies assessment variables to represent the characteristics and processes that influence each function, and defines metrics for quantifying assessment variables. Next, reference wetlands are identified to represent the range of variability exhibited by the regional subclass, and field data are collected and used to calibrate assessment variables and indices resulting from assessment models. Finally, the team develops the assessment protocols necessary for regulators, managers, consultants, and other end users to apply the indices to the assessment of wetland functions in the context of 404 Permit review.

During the Application Phase, the assessment variables, models, and protocols are used to assess wetland functions. This involves two steps. The first is to apply the assessment protocols outlined in the Regional Guidebook to complete the following tasks:

- Define assessment objectives.
- Characterize the project site.
- Screen for red flags.
- Define the Wetland Assessment Area.
- Collect field data.
- Analyze field data.

The second step involves applying the results of the assessment at various decision-making points in the planning or permit review sequence, such as alternatives analysis, impact minimization, assessment of unavoidable impacts, determination of compensatory mitigation, design and monitoring of mitigation, comparison of wetland management alternatives or results, determination of restoration potential, or identification of acquisition or mitigation sites.

Each of the components of the HGM Approach that are developed and integrated into the Regional Guidebook is discussed briefly in the following paragraphs. More extensive treatment of these components can be found in Brinson (1993a,1993b; 1995, 1996), Brinson et al. (1995, 1996, 1998), Hauer and Smith (1998), and Smith et al. (1995).

Hydrogeomorphic Classification

Wetland ecosystems share a number of common attributes including hydrophytic vegetation, hydric soils, and relatively long periods of inundation or saturation by water. In spite of these common attributes, wetlands occur in a variety of climatic, geologic, and physiographic settings and exhibit a wide range of physical, chemical, and biological characteristics and processes (Cowardin et al. 1979; Mitch and Gosselink 1993). The variability of wetlands makes it challenging to develop assessment methods that are both accurate (i.e., sensitive to significant changes in function) and practical (i.e., can be completed in the relatively short time frame normally available for conducting assessments). "Generic" wetland assessment methods have been developed to assess multiple wetland types throughout the United States. In general these methods can be applied quickly, but lack the resolution necessary to detect significant changes in function. One way to achieve an appropriate level of resolution within a limited time frame is to employ a wetland classification system structured to support functional assessment objectives (Smith et al. 1995).

The HGM classification was developed specifically to accomplish this task (Brinson 1993a). It identifies groups of wetlands that function similarly using three criteria that fundamentally influence how wetlands function: geomorphic setting, water source, and hydrodynamics. Geomorphic setting refers to the position of the wetland in the landscape. Water source refers to the primary origin of the water that sustains wetland characteristics, such as precipitation, floodwater, or groundwater. Hydrodynamics refers to the level of energy with which water moves through the wetland, and the direction of water movement.

Based on these three criteria, any number of functional wetland groups can be identified at different spatial or temporal scales. For example, at a continental scale, Brinson (1993a,1993b) identified five hydrogeomorphic wetland classes. These were later expanded to the seven classes described in Table 1 (Smith et al. 1995).

Generally, the level of variability encompassed by wetlands at the continental scale of hydrogeomorphic classification is too great to allow development of assessment indices that can be applied rapidly and still retain the level of sensitivity necessary to detect changes in function at a level of resolution appropriate to the 404 permit review. In order to reduce both inter- and intraregional variability, the three classification criteria must be applied at a smaller, regional geographic scale, thus creating regional wetland subclasses. In many parts of the country, existing wetland classifications can serve as a starting point for identifying these regional subclasses (e.g., Golet and Larson 1974; Stewart and Kantrud 1971; Wharton et al. 1982). Regional subclasses, like the continental scale wetland classes, are distinguished on the basis of geomorphic setting, water source, and hydrodynamics. Examples of potential regional subclasses are shown in Table 2. In addition, certain ecosystem or landscape characteristics may be useful for distinguishing regional subclasses. For example, depression subclasses might be based on water source (i.e., groundwater versus surface water) or the degree of connection between the wetland and other surface waters (i.e., the flow

Table 1 **Hydrogeomorphic wetland classes**	
HGM Wetland Class	**Definition**
Depression	Depressional wetlands occur in topographic depressions (i.e., closed elevation contours) that allow the accumulation of surface water. Depressional wetlands may have any combination of inlets and outlets, or lack them completely. Potential water sources are precipitation, overland flow, streams, or groundwater flow from adjacent uplands. The predominant direction of flow is from the higher elevations toward the center of the depression. The predominant hydrodynamics are vertical fluctuations that may occur over a range of time, from a few days to many months. Depressional wetlands may lose water through evapotranspiration, intermittent or perennial outlets, or recharge to groundwater. Prairie potholes, playa lakes, and cypress domes are common examples of depressional wetlands.
Tidal Fringe	Tidal fringe wetlands occur along coasts and estuaries and are under the influence of sea level. They intergrade landward with riverine wetlands where tidal current diminishes and riverflow becomes the dominant water source. Additional water sources may be groundwater discharge and precipitation. Because tidal fringe wetlands are frequently flooded and water table elevations are controlled mainly by sea surface elevation, tidal fringe wetlands seldom dry for significant periods. Tidal fringe wetlands lose water by tidal exchange, by overland flow to tidal creek channels, and by evapotranspiration. Organic matter normally accumulates in higher elevation marsh areas where flooding is less frequent and the wetlands are isolated from shoreline wave erosion by intervening areas of low marsh or dunes. *Spartina alterniflora* salt marshes are a common example of tidal fringe wetlands.
Lacustrine Fringe	Lacustrine fringe wetlands are adjacent to lakes where the water elevation of the lake maintains the water table in the wetland. Additional sources of water are precipitation and groundwater discharge, the latter dominating where lacustrine fringe wetlands intergrade with uplands or slope wetlands. Surface water flow is bidirectional. Lacustrine wetlands lose water by evapotranspiration and by flow returning to the lake after flooding. Organic matter may accumulate in areas sufficiently protected from shoreline wave erosion. Unimpounded marshes bordering the Great Lakes are an example of lacustrine fringe wetlands.
Slope	Slope wetlands are found in association with the discharge of groundwater to the land surface or on sites with saturated overland flow with no channel formation. They normally occur on slightly to steeply sloping land. The predominant source of water is groundwater or interflow discharging at the land surface. Precipitation is often a secondary contributing source of water. Hydrodynamics are dominated by downslope unidirectional water flow. Slope wetlands can occur in nearly flat landscapes if groundwater discharge is a dominant source to the wetland surface. Slope wetlands lose water primarily by saturated subsurface flows, surface flows, and by evapotranspiration. They may develop channels, but the channels serve only to convey water away from the slope wetland. Slope wetlands are distinguished from depression wetlands by the lack of a closed topographic depression and the predominance of the groundwater/interflow water source. Fens are a common example of slope wetlands.
Mineral Soil Flats	Mineral soil flats are most common on interfluves, extensive relic lake bottoms, or large alluvial terraces where the main source of water is precipitation. They receive virtually no groundwater discharge, which distinguishes them from depressions and slopes. Dominant hydrodynamics are vertical fluctuations. Mineral soil flats lose water by evapotranspiration, overland flow, and seepage to underlying groundwater. They are distinguished from flat non-wetland areas by their poor vertical drainage due to impermeable layers (e.g., hardpans), slow lateral drainage, and low hydraulic gradients. Pine flatwoods with hydric soils are an example of mineral soil flat wetlands.
	(Continued)

Table 1 (Concluded)

HGM Wetland Class	Definition
Organic Soil Flats	Organic soil flats, or extensive peatlands, differ from mineral soil flats in part because their elevation and topography are controlled by vertical accretion of organic matter. They occur commonly on flat interfluves, but may also be located where depressions have become filled with peat to form a relatively large flat surface. Water source is dominated by precipitation, while water loss is by overland flow and seepage to underlying groundwater. They occur in relatively humid climates. Raised bogs share many of these characteristics but may be considered a separate class because of their convex upward form and distinct edaphic conditions for plants. Portions of the Everglades and northern Minnesota peatlands are examples of organic soil flat wetlands.
Riverine	Riverine wetlands occur in floodplains and riparian corridors in association with stream channels. Dominant water sources are overbank or backwater flow from the channel. Additional sources may be interflow, overland flow from adjacent uplands, tributary inflow, and precipitation. When overbank flow occurs, surface flows down the floodplain may dominate hydrodynamics. In headwaters, riverine wetlands often intergrade with slope, depressional, poorly drained flat wetlands, or uplands as the channel (bed) and bank disappear. Perennial flow is not required. Riverine wetlands lose surface water via the return of floodwater to the channel after flooding and through surface flow to the channel during rainfall events. They lose subsurface water by discharge to the channel, movement to deeper groundwater, and evapotranspiration. Bottomland hardwood forests on floodplains are examples of riverine wetlands.

Table 2
Potential regional wetland subclasses in relation to classification criteria

Classification Criteria			Potential Regional Wetland Subclasses	
Geomorphic Setting	**Dominant Water Source**	**Dominant Hydrodynamics**	**Eastern USA**	**Western USA/Alaska**
Depression	Groundwater or interflow	Vertical	Prairie pothole marshes, Carolina bays	California vernal pools
Fringe (tidal)	Ocean	Bidirectional, horizontal	Chesapeake Bay and Gulf of Mexico tidal marshes	San Francisco Bay marshes
Fringe (lacustrine)	Lake	Bidirectional, horizontal	Great Lakes marshes	Flathead Lake marshes
Slope	Groundwater	Unidirectional, horizontal	Fens	Avalanche chutes
Flat (mineral soil)	Precipitation	Vertical	Wet pine flatwoods	Large playas
Flat (organic soil)	Precipitation	Vertical	Peat bogs; portions of Everglades	Peatlands over permafrost
Riverine	Overbank flow from channels	Unidirectional, horizontal	Bottomland hardwood forests	Riparian wetlands

Note: Adapted from Smith et al. 1995, Rheinhardt et al. 1997.

of surface water in or out of the depression through defined channels). Tidal fringe subclasses might be based on salinity gradients (Shafer and Yozzo 1998). Slope subclasses might be based on the degree of slope or landscape position.

Riverine subclasses might be based on position in the watershed, stream order, watershed size, channel gradient, or floodplain width. Regional Guidebooks include a thorough characterization of the regional wetland subclass in terms of geomorphic setting, water sources, hydrodynamics, vegetation, soil, and other features that were taken into consideration during the classification process.

Reference Wetlands

Reference wetlands are the wetland sites selected to represent the range of variability that occurs in a regional wetland subclass as a result of natural processes and disturbance (e.g., succession, channel migration, fire, erosion, and sedimentation) as well as anthropogenic alteration (e.g., grazing, timber harvest, clearing). The reference domain is the geographic area occupied by the reference wetlands (Smith et al. 1995, Smith 2001). Ideally, the geographic extent of the reference domain will mirror the geographic area encompassed by the regional wetland subclass; however, this is not always possible due to time and resource constraints.

Reference wetlands serve several purposes. First, they establish a basis for defining what constitutes a characteristic and sustainable level of function across the suite of functions selected for a regional wetland subclass. Second, reference wetlands establish the range and variability of conditions exhibited by assessment variables, and provide the data necessary for calibrating assessment variables and models. Finally, they provide a concrete physical representation of wetland ecosystems that can be observed and remeasured as needed.

Reference standard wetlands are the subset of reference wetlands that perform the suite of functions selected for the regional subclass at a level that is characteristic of the least altered wetland sites in the least altered landscapes. Table 3 outlines the terms used by the HGM Approach in the context of reference wetlands.

Table 3
Reference Wetland Terms and Definitions

Term	Definition
Reference Domain	The geographic area from which reference wetlands representing the regional wetland subclass are selected.
Reference Wetlands	A group of wetlands that encompass the known range of variability in the regional wetland subclass resulting from natural processes and human alteration.
Reference Standard Wetlands	The subset of reference wetlands that perform a representative suite of functions at a level that is both sustainable and characteristic of the least human altered wetland sites in the least human altered landscapes. By definition, the functional capacity index for all functions in a reference standard wetland is 1.0.
Reference Standard Wetland Variable Condition	The range of conditions exhibited by assessment variables in reference standard wetlands. By definition, reference standard conditions receive a variable subindex score of 1.0.

Assessment Models and Functional Indices

In the HGM Approach, an assessment model is a simple representation of a function performed by a wetland ecosystem. The assessment model defines the relationship between the characteristics and processes of the wetland ecosystem and the surrounding landscape that influence the functional capacity of a wetland ecosystem. Characteristics and processes are represented in the assessment model by assessment variables. Functional capacity is the ability of a wetland to perform a specific function relative to the ability of reference standard wetlands to perform the same function. Application of assessment models results in a Functional Capacity Index (FCI) ranging from 0.0 to 1.0. Wetlands with an FCI of 1.0 perform the assessed function at a level that is characteristic of reference standard wetlands. A lower FCI indicates that the wetland is performing a function at a level below the level that is characteristic of reference standard wetlands.

For example, the following equation shows an assessment model that could be used to assess the capacity of a wetland to detain floodwater.

$$FCI = V_{FREQ} \times \left[\frac{\left(V_{LOG} + V_{GVC} + V_{SSD} + V_{TDEN} \right)}{4} \right] \tag{1}$$

The assessment model has five assessment variables: frequency of flooding (V_{FREQ}), which represents the frequency at which a wetland is inundated by overbank flooding, and the assessment variables of log density (V_{LOG}), ground vegetation cover (V_{GVC}), shrub and sapling density (V_{SSD}), and tree stem density (V_{TDEN}) that together represent resistance to flow of floodwater through the wetland.

Assessment variables occur in a variety of states or conditions. The state or condition of an assessment variable is indicated by the value of the metric used to assess a variable, and the metric used is normally one commonly used in ecological studies. For example, tree basal area (m^2/ha) is the metric used to assess tree biomass in a wetland, with larger numbers usually indicating greater stand maturity and increasing functionality for several different wetland functions where tree biomass is an important consideration.

Based on the metric value, an assessment variable is assigned a variable subindex. When the metric value of an assessment variable is within the range of conditions exhibited by reference standard wetlands, a variable subindex of 1.0 is assigned. As the metric value deflects, in either direction, from the reference standard condition, the variable subindex decreases based on a defined relationship between metric values and functional capacity. Thus, as the metric value deviates from the conditions documented in reference standard wetlands, it receives a progressively lower subindex reflecting the decreased functional capacity of the wetland. Figure 2 illustrates the relationship between metric values of tree density (V_{TDEN}) and the variable subindex for an example wetland subclass. As shown in the graph, tree densities of 200 to 400 stems/ha represent reference standard conditions, based on field studies, and a variable subindex of

1.0 is assigned for assessment models where tree density is a component. Where tree densities are higher or lower than those found in reference standard conditions, a lesser variable subindex value is assigned.

Assessment Protocol

All of the steps described in the preceding sections concern development of the assessment tools and the rationale used to produce this Regional Guidebook. Although users of the guidebook should be familiar with this process, their primary concern will be the protocol for application of the assessment procedures. The assessment protocol is a defined set of tasks, along with specific instructions, that allows resource professionals to assess the functions of a particular wetland area using the assessment models and functional indices in the Regional Guidebook. The first task includes characterizing the wetland ecosystem and the surrounding landscape, describing the proposed project and its potential impacts, and identifying the wetland areas to be assessed. The second task is collecting the field data for assessment variables. The final task is an analysis that involves calculation of functional indices. These steps are described in detail in Chapter 6, and the required data forms, spreadsheets, and supporting digital spatial data are provided in Appendices A through E.

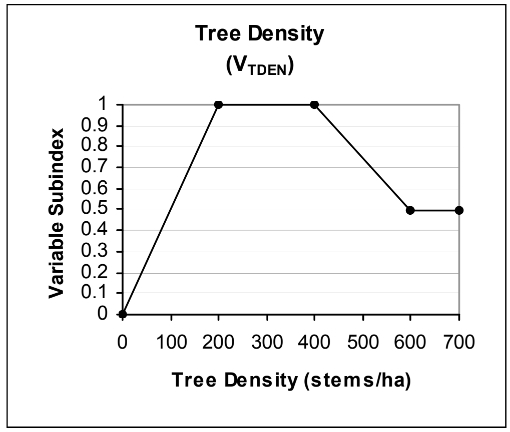

Figure 2. Example subindex graph for the Tree Density (V_{TDEN}) assessment variable for a particular wetland subclass

3 Characterization of Wetland Subclasses in the Ozark Mountains Region of Arkansas

Reference Domain

The reference domain for this guidebook (i.e. the area from which reference data were collected and to which the guidebook can be applied) is the Ozark Mountains Wetland Planning Region. It is one of five Wetland Planning Regions (WPR) established by the Arkansas Multi-Agency Wetland Planning Team (1997), which generally reflect the major physiographic divisions within the state (Figure 3). This guidebook applies specifically to that portion of the Ozark Mountains that lies within the state of Arkansas, but the mountains also extend into eastern Oklahoma and occupy much of southern Missouri. Within Arkansas, the Ozarks are bounded on the east by the alluvial valley of the Mississippi River (the Delta Wetland Planning Region) and on the south by the Arkansas Valley Wetland Planning Region.

While the wetlands of the adjacent lowland WPAs are primarily those of broad floodplains, the Ozark Mountains WPA is characterized by relatively narrow riparian zones and fairly small depression and seep wetlands. In this regard, it is similar in many ways to the Ouachita Mountains WPA. However, the limestone geology typical of much of the Ozarks creates unique wetland environments associated with springs, seeps, and sinkholes where the calcareous substrate and high-pH waters support unusual plant and animal communities.

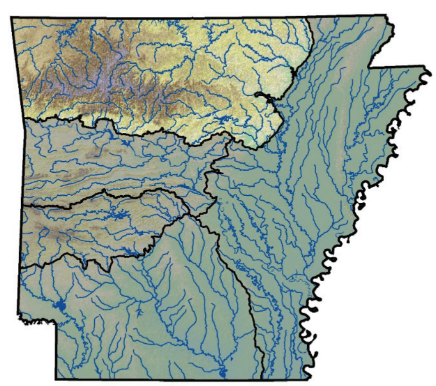

Figure 3. Location of the Ozark Mountains Wetland Planning Region of Arkansas

Reservoir construction and agricultural practices have eliminated or severely degraded many of the wetlands and riparian areas in the Ozarks. However, much of the region is within public ownership, so many of the remaining unique communities receive some measure of protection and management.

The following sections review major concepts that have bearing on the classification and functions of wetlands and riparian communities in the modern landscape of the Ozark Mountains Region of Arkansas. Descriptions of the wetland classes and subclasses that occur in the region and guidelines for recognizing them in the field are presented as the final section of this chapter.

Climate

Climate within the Ozark Mountains Region of Arkansas can vary considerably over short distances due to topographic influences, but generally the area has mild winters and hot summers. At Gilbert in the central part of the region, normal rainfall is highest in May (5.19 in.) and lowest in July (2.62 in.), but rainfall is generally abundant year-round. Mean daily maximum temperatures range from 94.4°F in July to 50.8°F in January. Mean daily minimum temperatures range from 64.6°F in July to 23.7°F in January. Annual snowfall averages more than a foot on the highest Ozark elevations, and ice storms are infrequent, but destructive, occurrences (Southern Regional Climate Center 2007).

Physiography and Geology

The Ozark Mountains Region as defined in this document conforms to the Ozark Mountains Wetland Planning Region used by state agencies to coordinate wetland mitigation, restoration, protection, and management (Arkansas Multi-Agency Wetland Planning Team 1997). The boundaries of the state Wetland Planning Regions were established based on watershed boundaries and wetland characteristics which often, but not always, reflect physiographic divisions. In this case, the Ozark Mountains Wetland Planning Region incorporates various major land units (Figure 4).

The two principal ecoregions comprising the Ozark Mountains Wetland Planning Region are the Boston Mountains and the Ozark Highlands (Woods et al. 2004). Both are made up of plateaus that have been eroded and deeply dissected by streams, giving them a rugged, mountainous character. The various plateaus have been uplifted to different elevations, and usually are sharply separated by escarpments. A section of the Arkansas Valley Ecoregion that abuts the southern edge of the Boston Mountains is included in the Ozark Mountains Wetland Planning Region, because it has similar terrain and geology as the Boston Mountains, and numerous streams that originate in the mountains cross through the Arkansas Valley Hills en route to the Arkansas Valley floor.

The Boston Mountains are carved from the highest of the plateaus in northern Arkansas. They are made up of Pennsylvanian sandstone, siltstone, and shale (Figure 5). The rock strata are not strongly deformed, but they have been uplifted dramatically and the resulting erosion has produced the most rugged terrain in the state. The sandstones and shales of the Atoka Formation dominate in the Lower Boston Mountains and the Arkansas Valley Hills. The Upper Boston Mountains, which are more geologically complex and reach higher elevations than the Lower Bostons, also include extensive areas of the Atoka

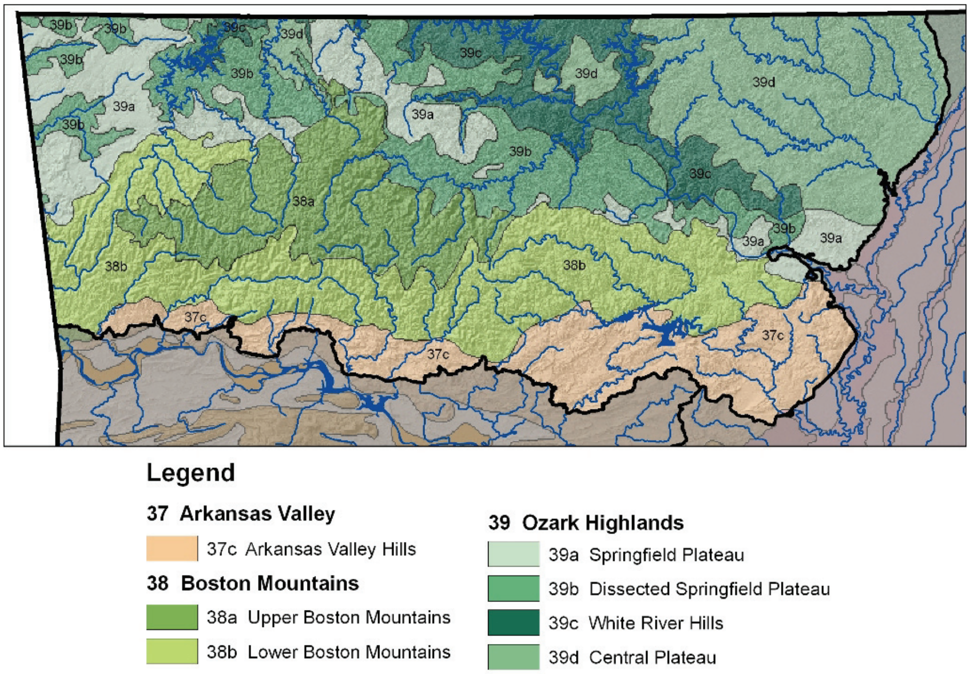

Figure 4. Ecoregions of the Ozark Mountains Wetland Planning Region (adapted from Woods et al. 2004)

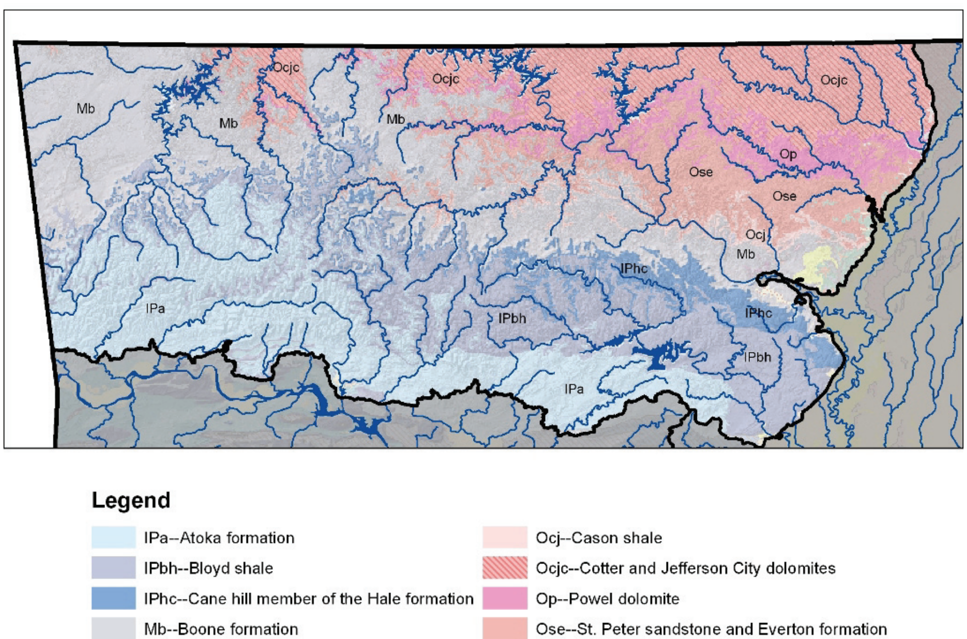

Figure 5. Surficial geology of the Ozark Mountains Wetland Planning Region (adapted from Haley 1993)

Formation, but in many areas the surface rocks are from shale-dominated portions of the Boyd and Hale Formations.

Like the Boston Mountains, the Ozark Highlands are a series of uplifted plateaus, but they are lower and often less dissected, having large areas of relatively flat or rolling terrain in contrast to the steep slopes and deep valleys to the south. The Ozark Highlands ecoregion is also distinctly different geologically, being underlain by limestone and dolomite. These rocks are highly fractured and soluble, and as a result, the Ozark Highlands have numerous karst features, such as sinkholes and caves.

The extensive Springfield Plateau and Dissected Springfield Plateau ecoregions dominate the western half of the Ozark Highlands. Both are underlain by cherty limestone, but they differ in topography, the former being nearly level, while the latter is rugged. In the White River Hills and Central Plateau ecoregions of the eastern Ozark Highlands, dolomite occurs commonly in addition to limestone. The deeply dissected White River Hills include a fairly significant amount of recent (Holocene) alluvium and Pleistocene alluvial terraces along the White River, though it is not extensive enough to map at the scale of Figure 5. The Central Plateau ecoregion is much less rugged, being mostly rolling or hilly.

Fluvial Geomorphology

Numerous streams have incised deeply into the mountains and plateaus of the Ozark Mountains, creating narrow valleys and redepositing the eroded materials as alluvial sediments. In most cases, valley floors are narrow, and alluvial surfaces are not extensive. In the most confined valleys, where the stream channel is nearly as wide as the valley floor, the only significant alluvial deposits are linear marginal bars consisting of coarse sand and gravel. Wider valleys are occupied mostly by point bar deposits that form on the inside (convex) bend of stream channels as they erode the opposite (concave) bank and gradually migrate back and forth across the valley floor. Because this process tends to proceed in stages, the point bar surface is a series of arcuate ridges (natural levee deposits) where significant vertical accretion occurred during overbank flows, separated by low swales. Point bars are approximately as thick as the stream that deposited them, and tend to be sorted vertically with the coarsest materials deeper in the bar and the finest materials on the surface. Very fine sediments accumulate in the swales when floodwaters are ponded within them.

Where extensive repeated ponding occurs behind high streamfront natural levees over a long period of time, fine-grained materials may accumulate sufficiently to blanket the ridge and swale topography with a fairly level backswamp deposit. A similar process can occur where segments of stream channel are abandoned within the floodplain due to sudden changes in the course of the stream, and they gradually fill with fine sediments. Both of these processes have the potential to create poorly drained wetland environments, but neither is commonly seen within the Ozark Mountains Region.

In some valleys within the Ozark Mountains Region, remnant alluvial landforms persist along the valley walls above the elevation of the active floodplain. These terraces are segments of former floodplains consisting of the same point bar, natural levee, backswamp, and abandoned channel deposits that make up the modern floodplain, or in some cases they were formed by scour of bedrock by stream flows. In either case, they were active floodplain at some time in the past, before the stream incised more deeply into the valley and established a new floodplain. This process occurred repeatedly, and the largest stream in the region, the White River, is flanked in places by at least four distinct depositional terraces, the highest and oldest of which is mid-Pleistocene in age (Dunbar and Coulters 1989a). On at least one tributary to the White River, the North Fork River, multiple scour terraces in bedrock are recognized above the alluvial terraces, and some of these may be several million years old (Dunbar and Coulters 1989b).

Soils

The diverse geology, geomorphology, and topography of the Ozark Mountains region is reflected in highly variable soils (Figure 6). The relatively rugged terrain of the Boston Mountains typically is mantled with thin, rocky silt loams and sandy loams. The characteristic soils derived from sandstone are associations that include the Linker or Mountainburg Series, with the latter being more typical of steeper slopes and ridgetops. The Enders Series is typically a component of associations found on shale substrates or interbedded shale and sandstone, and is deeper and contains more clay than the sandstone-derived soils.

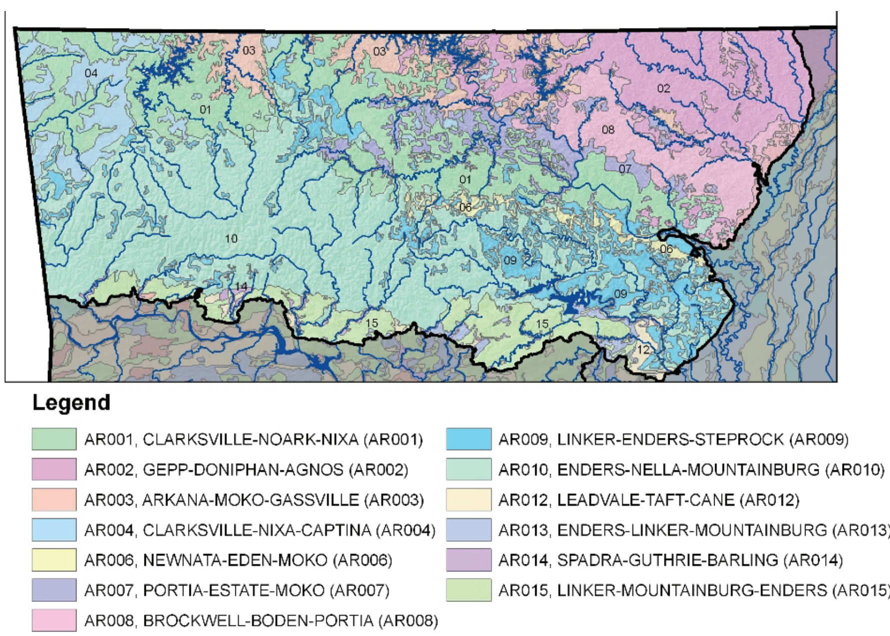

Figure 6. Principal soil associations of the Ozark Mountains Wetland Planning Region (adapted from U.S. Department of Agriculture, Natural Resources Conservation Service (USDA NRCS) 1995)

Soils of the Ozark Highlands tend to be deep and well-drained, but vary widely in chemistry and texture depending on the predominant bedrock type. They are generally clayey and have a high base status where they are derived from limestone or dolomite, as occurs over much of the Central and Springfield Plateaus where Gepp, Clarksville, and Portia soils are characteristic components of the predominant associations. However, where sandstone is the principal bedrock, as in the southern parts of the Central Plateau and parts of the White River Hills, sandy loams that are mildly to strongly acidic such as the Brockwell Series predominate.

Descriptions of the individual soil series that occur within each association can be found at *http://soils.usda.gov/technical/classification/scfile/index.html*

Hydrology

The Ozark Mountains Wetland Planning Region (WPR) is divided into four Wetland Planning Areas (WPAs) that reflect major watershed boundaries and physiographic variation (Arkansas Multi-Agency Wetland Planning Team 1997) (Figure 7).

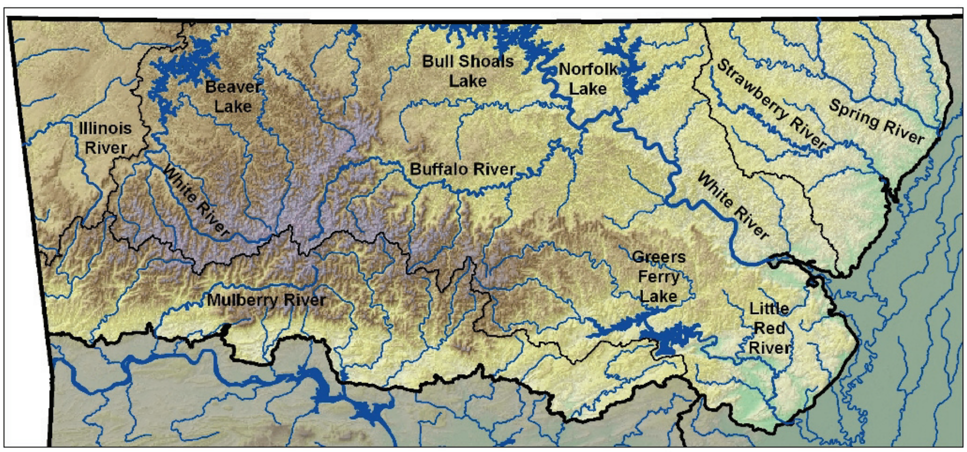

Figure 7. Drainage network of the Ozark Mountains Wetland Planning Region and boundaries of the included Wetland Planning Areas

The Illinois River WPA is in the northwest corner of the state. A few large streams, including the Illinois River, arise in this WPA and flow west into Oklahoma or north into Missouri. A variety of small private lakes have been constructed in this region, but there are few large wetlands. Much of the hydrology of the area that supports wetlands is the product of underground flow that dissolves the bedrock and creates springs and spring runs with small wetlands in the immediate vicinity of the discharge points. Some sinks once supported larger wetlands, but many of these have been damaged or destroyed, often having been filled with debris or converted to cattle ponds.

The southern edge of the Ozark Mountains is within the Southern Boston WPA. The streams in this area drain the flanks of the Boston Mountains to the Arkansas River. Because much of the area is under the control of the U.S. Forest Service, there are numerous relatively intact streams supporting high-quality riparian communities, such as the Mulberry River, Cadron Creek, and Hurricane Creek. In addition, there are a number of relatively uncommon wetlands on sandstone outcrops and in mountaintop depressions.

In the northeastern corner of the Ozark Mountains WPR is the Spring/Strawberry Rivers WPA. The Strawberry arises in Missouri and is confined between bedrock with narrow riparian areas for most of its length within Arkansas, but as it nears the Delta, its valley broadens and it supports lowland forests similar to those along the larger rivers to the east. The Spring River once had more extensive wetlands associated with it, but these have been largely eliminated by low dams placed at intervals along the channel. Calcareous seeps and riparian woodlands are common along many of the smaller tributaries to these major streams.

The Upper White River WPA occupies most of the northern and central part of the Ozark Mountains Region. The numerous small streams in the Upper White River WPA are deeply entrenched in the rugged landscape and have narrow but diverse riparian areas. However, the principal stream in the region, the White River, has been highly modified by dams, and long reaches that once supported wetlands are now inundated by reservoirs.

The White River arises in the western part of the WPA, loops farther west and north into Missouri, then back into north-central Arkansas where it flows southeast to eventually exit the mountains into the Delta Region, and then on to empty into the Mississippi River. Within the Ozarks, the river passes through three large reservoirs built and operated by the Corps of Engineers (Rathburn 1987). Farthest upstream is 31,000-acre Beaver Lake, completed in 1966. Below that is Table Rock Lake, completed in 1958 with 52,000 surface acres, nearly all of which are within Missouri. Next in the reservoir system is Bull Shoals Lake, most of which is in Arkansas, completed in 1951 with more than 71,000 acres. A short distance downstream of Bull Shoals Dam the North Fork of the White River is confluent with the mainstem, and about 5 miles up the tributary stream is 30,000-acre Norfolk Lake, the oldest of the upper White River reservoirs, built in 1941. Another federal reservoir, Greers Ferry Lake, is on the Little Red River in the southeastern part of the WPA. This 40,500-acre reservoir was completed in 1962. The Little Red River empties into the White River in the Delta WPA, far downstream of the reservoir, but like the other reservoirs, Greers Ferry Lake is a component of the White River Basin Flood Control Plan, authorized by Congress in 1937. Though the original impetus for the authorizing legislation was flood control, the Little Rock District, Corps of Engineers, manages all five of the lakes in the system as multipurpose projects that also produce hydropower and provide recreation.

One major tributary to the upper White River remains free-flowing. The Buffalo River is one of the few undammed rivers of its size in the lower 48 states, and it was the first to receive National River status (in 1972). Because it is confined between steep cliffs through much of its length, it has a fairly narrow riparian area, but the riparian zone is relatively intact due to the federal protection that applies to most of the river corridor.

Vegetation

The natural vegetation of most of the Ozark Mountains WPR is oak-hickory or oak-hickory-pine forest (Foti 1974). Major exceptions to this are the prairies that once were common in northwestern Arkansas, and the cedar glades that occur wherever bedrock outcrops occur, especially in the Salem and Springfield plateaus. The original prairies, dominated by big bluestem (*Andropogon gerardii*), little bluestem (*A. scoparius*), Indian grass (*Sorghastrum nutans*) and other grass and forb species, have been almost entirely converted to agricultural uses (Tucker 1990). Cedar glades remain common, and may support sparse woody vegetation mixed with prairie species, or they may be largely bare rock, with stunted trees and shrubs occurring in scattered thickets. Typically, the woody vegetation is dominated by red cedar (*Juniperus virginiana*) and often includes winged elm (*Ulmus alata*), sumacs (*Rhus spp.*) and stunted oaks (*Quercus spp.)* and hickories (*Carya spp.*).

Most dry upland slopes in the Ozark Mountains WPR support a mixture of oaks, usually including white oak (*Quercus alba*) , southern red oak (*Q. falcata*), and black oak (*Q. velutina*), and a variety of hickories, including mockernut (*Carya tomentosa*), pignut (*C. glabra*), and shagbark hickory (*C. ovata*). Flowering dogwood (*Cornus florida*) is a common understory tree. Shortleaf pine (*Pinus echinata*) is an important component of the upland forests of the Lower Boston Mountains, particularly on south-facing slopes, and it is present, but less abundant, on similar sites in the Upper Boston Mountains and the Ozark Highlands. On the driest slopes and ridges, the species mix typically includes post oak (*Q. stellata*) and blackjack oak (*Q. marilandica*).

On north-facing slopes and where soils are deep, white oak often shares dominance with northern red oak (*Q. rubra*) and various hickories. Black walnut (*Juglans nigra*) and sugar maple (*Acer saccharum*) are characteristic, but not usually abundant, in these mesic communities. Some of the deepest, most protected ravines and canyons may support American beech (*Fagus grandifolia*), cucumber magnolia (*Magnolia accuminata*), umbrella magnolia (*M. tripetela*), and basswood (*Tilia americana*) among the oak and hickory dominants.

Narrow riparian plant communities flank mountain streams. Shrub thickets of witch hazel (*Hamamelis vernalis*) and alder (*Alnus serrulata*) typically line the banks and colonize in-stream gravel bars. Small floodplains that form intermittently along the streamcourse, usually where tributary streams are confluent, may support tree species such as red maple (*Acer rubrum*), ironwood (*Carpinus caroliniana*), and sweetgum (*Liquidambar styraciflua*). In some instances, small, narrow alluvial terraces may be present along the valley walls. These usually are occupied by the more mesic oak species.

As streams widen and become less steep, floodplain and terrace systems become more continuous features flanking the channel. Streambanks and gravel bars support various willows (*Salix spp.*) as well as river birch (*Betula nigra*), sycamore (*Platanus occidentalis*), and cottonwood (*Populus deltoides*). Silver maple (*Acer saccharinum*), red maple, sweetgum, green ash (*Fraxinus pennsylvanica*), and American elm (*Ulmus americana*) are common floodplain species. Various oaks and hickories occupy the terraces, along with sweetgum and green ash.

Wetland plant communities occur in a variety of settings other than floodplain and riparian environments. Wet prairies persist in a few isolated locations, mostly in the Illinois River WPA. Where karst features are common, wetlands may be found in sinkholes, which can support open marsh, shrub swamps, or seasonally wet forests, depending on their depth and water source. Spring runs, where underground streams discharge from dissolution caves in limestone, and seeps, where groundwater flows to the surface through fractured chert or limestone, both support small, but unusual, wetland plant communities.

Similarly small and isolated wetlands occur in non-karst settings. Herbaceous and shrub wetlands occur in sandstone glades, where water accumulates in pockets on exposed bedrock. Mountaintop depressions occur in non-karst settings in the Boston Mountains. Typically, they are dominated by species such as overcup oak (*Q. lyrata*) and pin oak (*Q. palustris*) that are far disjunct from their principal distribution in the lowlands of the Delta and Arkansas Valley WPRs.

Definition and Identification of the HGM Classes and Subclasses

Brinson (1993a) identified five wetland classes based on hydrogeomorphic criteria, as described in Chapter 2. These are Flat, Riverine, Depression, Slope, and Fringe wetlands, and all five classes are represented in the Ozark Mountains WPR. Within each class, one or more subclasses are recognized, and various individual community types may occur within each subclass. Wetlands often intergrade or have unusual characteristics, therefore a set of specific criteria have been established to assist the user in assigning any particular wetland to the appropriate class (Figure 8). Subclass and community type designations can best be assigned using the descriptions of wetlands and their typical landscape positions as presented in the following paragraphs and summarized in Table 4.

Key to Wetland Classes
of the
Ozark Mountains Region of Arkansas

1. Wetland is within the 5-year floodplain of a stream 2
1. Wetland is not within the 5-year floodplain of a stream............................4
   2. Wetland is not in a topographic depression or impounded ......Riverine
   2. Wetland is in a topographic depression or impounded........................3
3. Wetland is associated with a beaver impoundment, or with a shallow impoundment managed principally for wildlife (e.g. greentree reservoirs or moist soil units)..................Riverine
3. Wetland is an impoundment or depression other than above 4
   4. Wetland is associated with a water body that has permanent open water more than 2 m deep in most years......... Fringe
   4. Wetland is not associated with a water body that has permanent open water more than 2 m deep in most years.................5
5. Wetland topography is flat or sloping, principal water source is precipitation or groundwater 6
5. Wetland is associated with a water body that is ephemeral, or less than 2 m deep in most years ....Depression
6. Topography is flat, principal water source is precipitation.................... Flat
6. Topography is sloping to flat, principal water source is groundwater discharge or subsurface flow....................................... Slope

Figure 8. Key to Wetland Classes in the Ozark Mountains Region of Arkansas

Table 4
Hydrogeomorphic classification of wetlands in the Ozark Mountains Region of Arkansas, and typical geomorphic settings of community types

WETLAND CLASSES, SUBCLASSES, & COMMUNITIES	TYPICAL HYDROGEOMORPHIC SETTING
CLASS: FLAT	
SUBCLASS: NON-ALKALI FLAT	
Hardwood Flat	High terraces with restricted drainage and shallow basins, not subject to regular stream flooding (not within the 5-year floodplain).
Wet Tallgrass Prairie	High terraces, non-alluvial flats, and poorly-drained basins, not subject to regular stream flooding (not within the 5-year floodplain).
CLASS: RIVERINE	
SUBCLASS: HIGH-GRADIENT RIVERINE	
High-Gradient Riparian Zone	Narrow floodplains, streambanks, and terraces along headwater and other low-order streams (within the 5-year floodplain).
SUBCLASS: MID-GRADIENT RIVERINE	
Mid-Gradient Floodplain	Point bar and natural levee deposits within the 5-year floodplain of streams transitioning from headwaters to broad basins.
Mid-Gradient Backwater	Backswamp deposits within the 5-year floodplain near the confluence of two streams.
SUBCLASS: LOW-GRADIENT RIVERINE	
Low-Gradient Overbank	Point bar and natural levee deposits immediately adjacent to meandering streams (within the 5-year floodplain).
Low-Gradient Backwater	Point bar and backswamp deposits of meandering streams where floodwaters are impeded from returning to the channel (within the 5-year floodplain).
	(Sheet 1 of 3)

Table 4 (Continued)	
SUBCLASS: IMPOUNDED RIVERINE	
Beaver Complex	All flowing waters.
SUBCLASS: SPRING RUN	
Spring Run	Discharge points of subterranean streams from mountainsides.
CLASS: DEPRESSION	
SUBCLASS: CONNECTED DEPRESSION	
Floodplain Depression	Abandoned channels and large swales in former and current meander features of larger rivers (within the 5-year floodplain).
SUBCLASS: UNCONNECTED DEPRESSION	
Mountaintop Depression	Depressions in uplands reflecting the concave shape of underlying rock strata.
Sinkhole	Depressions in uplands formed by dissolution of underlying limestone or collapse of a subsurface limestone cavern.
CLASS: FRINGE	
SUBCLASS: CONNECTED LACUSTRINE FRINGE	
SUBCLASS: RESERVOIR FRINGE	
Reservoir Shore	Fluctuation zone of a man-made reservoir manipulated for water supply, power production, and other purposes. Mostly on former hillslopes of valleys impounded by large dams.
SUBCLASS: UNCONNECTED LACUSTRINE FRINGE	
Unconnected Lake Margin	Natural and man-made lakes where water levels are not actively managed, and that are not within the 1-5 year flood return interval of a larger stream.
	(Sheet 2 of 3)

Table 4 (Concluded)	
CLASS: SLOPE	
SUBCLASS: NON-CALCAREOUS SLOPE	
Wet-Weather Seep	Slopes and adjacent colluvial deposits at seasonal aquifer discharge points, usually at the contact between permeable and less-permeable strata, or where fractures occur.
Sandstone Glade	Sandstone outcrops with relatively flat, slightly sloping surfaces that receive water from seepage sources at the upslope edge of the rock.
SUBCLASS: CALCAREOUS SLOPE	
Calcareous Perennial Seep	Lower slopes, usually adjacent to streams, where groundwater is discharged from calcareous bedrock.
	(Sheet 3 of 3)

Some of the criteria that are used in Figure 8 and Table 4 require some elaboration. For example, a fundamental criterion is that a wetland must be in the 5-year floodplain of a stream system to be included within the Riverine Class. This flood return interval is regarded as sufficient to support major functions that involve periodic connection to stream systems. It was also selected as a practical consideration because, where flood return intervals are mapped, the 5-year return interval is a commonly used increment.

The classification system recognizes that certain sites functioning primarily as fringe or depression wetlands also are regularly affected by stream flooding, and therefore have a riverine functional component. This is incorporated in the classification system by establishing "river-connected" subclasses within the Fringe and Depression Classes. Similarly, sites that function primarily as riverine wetlands and flats often incorporate small, shallow depressions, sometimes characterized as vernal pools and microdepressions. These features are regarded as normal components of the riverine and flat ecosystems, and are not separated into the Depression Class unless they meet specific criteria. Other significant criteria relating to classification are elaborated in the wetland descriptions below.

The following sections briefly describe the classification system developed for this guidebook for wetlands in the Ozark Mountains Region of Arkansas. All of the wetland types that occur in the Region are described below, but assessment models and supporting reference data were developed for only a subset of these types, as described in Chapter 4. Additional details, including photos and distribution maps, for each of the wetlands described below, as well as wetlands in the other regions of the state, can be found on the Arkansas Multi-Agency Wetland Planning Team web site (www.mawpt.org).

Class: Flat

Subclass: Non-Alkali Flat

Flats with neutral and acid soils can occur on stream terraces and on level uplands (Figure 9). Because wet flats are maintained by precipitation rather than flooding, many were relatively easy to convert to agriculture with fairly minor changes to drainage conditions, and most of the more extensive flat areas have been cleared.

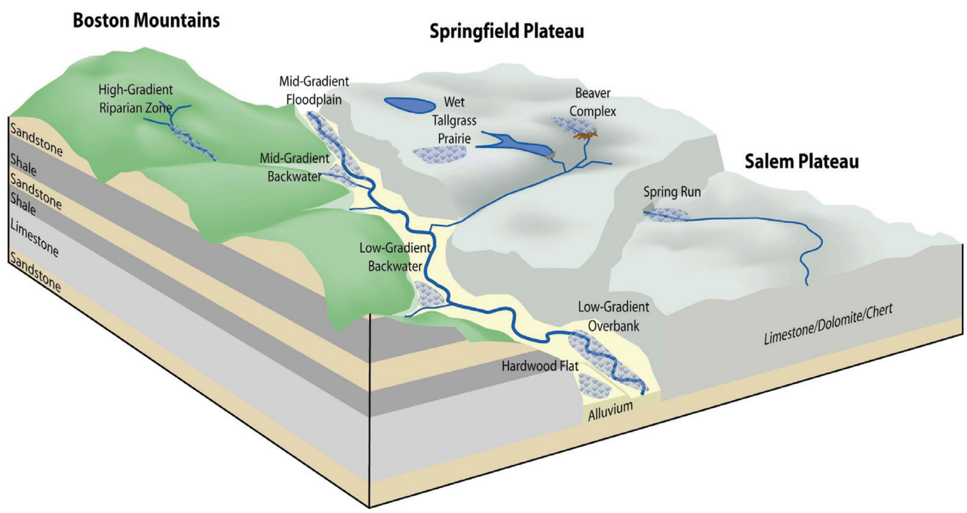

Figure 9. Typical landscape positions of flat and riverine wetlands within the Ozark Mountains Wetland Planning Region

Community Types:

Hardwood Flat

Hardwood flats occur on fairly level terrain that is not within the 5-year floodplain of stream systems, but nevertheless remains wet throughout winter and spring due to rainfall that collects in small shallow pools. In most parts of Arkansas, the combination of flat surfaces and poorly drained soils outside the active floodplain is found most commonly on stream terraces. Within the Ozark Mountains Region, most valleys are narrow and have only narrow, fragmented terrace systems, and many of those are well-drained and do not support wetlands. The most extensive terraces are along the White River (Dunbar and Coulters 1989a), and many of these may have soils capable of supporting hardwood flat wetlands. However, nearly all of the large White River terraces were inundated by the reservoirs built in the mid-20th century. Most other potential hardwood flat sites have been cleared for agriculture. Where small fragments of hardwood flat forests remain, they are dominated by a mix of mesic species such as water oak (*Q. nigra*), white oak, bitternut hickory (*C. cordiformis*), white ash (*F. americana*), and sweetgum. Shortleaf pine is a consistent component, but not a dominant.

Wet Tallgrass Prairie

Extensive expanses of prairie occurred in northwestern and north-central Arkansas prior to European settlement. Most of the prairies were on relatively shallow soils, and were dominated by typical tallgrass prairie species such as big bluestem, Indiangrass, and little bluestem. On sites with particularly poor drainage wetland species also occur, such as beakrush (*Rhynchospora* spp.). All of these prairie communities have been drastically reduced by fire supression and conversion to agriculture, and there are few remnants in good condition. The rarity of these wetlands dictates that all remaining examples be considered critically important as habitat for uncommon plant species, and they are best assessed using a strictly floristic approach and site-specific evaluation of the drainage, soils, management programs, and proposed impacts. Therefore, assessment models for this community type are not included in this guidebook.

Class: Riverine

Riverine wetlands are those areas directly flooded by streams at least once in five years on average (i.e., they are within the 5-year floodplain). Depressions and fringe wetlands that are within the 5-year floodplain are not included in the Riverine Class, but beaver ponds are usually considered to be riverine because they typically maintain a constant inflow and outflow. One riverine community type, the spring run, is uniquely associated with karst geology. All other riverine wetlands in the Ozark Mountains Region are classified into one of five subclasses based on stream gradient and landscape position, as illustrated in Figure 9. The classification of streams into high-, mid-, and low-gradient is intended to reflect changes in geomorphic and vegetation characteristics as streams transition from headwaters to lowlands, but the classification is not rigidly defined. The community-type descriptions below, as well as the general cross sections presented in Figure 10 and the typical geomorphic surface dimensions summarized in Table 5 can be used to assist in assigning riverine wetlands to the most appropriate subclass for assessment purposes.

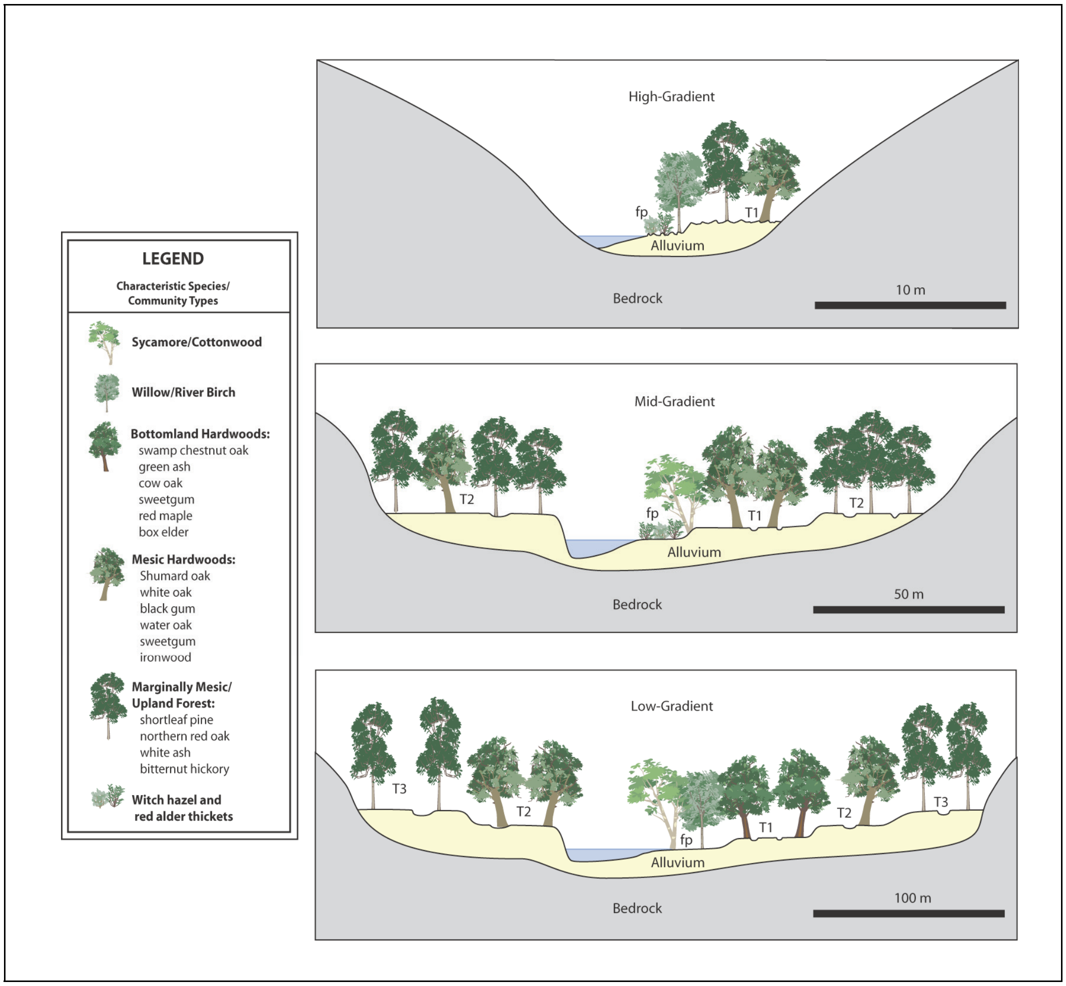

Figure 10. Geomorphic settings and average dimensions of features associated with riverine subclasses in the Ozark Mountains Wetland Planning Region. Symbols: fp (floodplain), T1 (terrace 1), T2 (terrace 2), T3 (terrace 3). See Table 5 for additional information

Table 5
Dimensions[1] of stream channels and alluvial terraces in the Ozark Mountains Region of Arkansas

PARAMETER	HIGH-GRADIENT RIVERINE	MID-GRADIENT RIVERINE	LOW-GRADIENT RIVERINE
STREAM ORDER[2]	0 – 3	3 – 5	> 4
BANKFULL CHANNEL			
WIDTH (m) Range (mean)	1.0 – 12.0 (2.63)	2.5 – 50.0 (17.33)	12.0 – 60.0 (38.86)
MAXIMUM DEPTH (m) Range (mean)	0.02 – 0.35 (0.09)	0.02 – 3.0 (1.12)	0.30 – 2.0 (1.47)
AVERAGE DEPTH (m) Range (mean)	0.02 – 0.15 (0.05)	0.02 – 2.0 (0.68)	0.30 – 1.8 (1.03)
FLOODPLAIN WIDTH (m) Range (mean)	0.0 – 3.0 (1.40)	0.0 – 66.0 (8.92)	20.0 – 90.0 (30.0)
TERRACE 1 (lowest) (% of sites with this terrace present)	53%	75%	86%
HEIGHT (m) Range (mean)	0.25 – 0.75 (0.6)	0.5 – 6.0 (1.9)	0.75 – 4.0 (2.06)
WIDTH (m) Range (mean)	4.0 – 25.0 (6.0)	4.0 – 200.0 (39.27)	5.0 – 60.0 (22.5)
TERRACE 2 (% of sites with this terrace present)	(uncommon)	55%	86%
HEIGHT (m) Range (mean)		1.5 –1.0 (3.36)	1.75 – 8.0 (3.54)
WIDTH (m) Range / (mean)		5.0 – 800.0 (109.18)	10.0 – 80.0 (54.0)
TERRACE 3 (% of sites with this terrace present)	0%	23%	43%
HEIGHT (m) Range (mean)		2.5 – 15.0 (6.10)	3.0 – 3.5 (3.25)
WIDTH (m) Range (mean)		25.0 – 200.0 (67.0)	50.0 – 100.0 (75.0)

[1] Based on sample data collected during this study. The numbers reported in this table reflect conditions in the central reaches of each gradient zone, i.e., they do not include sample data from the largest river channels nor extreme headwater reaches. All dimensions are measured with reference to the bankfull channel as defined by Dunne and Leopold (1978).

[2] Stream orders are general ranges that usually encompass the subclass, but may overlap. Users should also read the subclass descriptions and compare dimensions in this table to determine correct classification.

Subclass: High-Gradient Riverine

Community Type:

High-Gradient Riparian Zone

High-gradient riparian zones usually are found along small stream channels and in steep, narrow valleys. This zone is recognized by examining stream order, channel morphology, landscape position, and geomorphic features. Generally, streams categorized as high-gradient are high in the landscape, including intermittent streams, cascades, and step-pool channels, most of which would typically be described as headwaters. Usually these streams occupy V-shaped valleys where valley sideslopes extend directly to the streambank. Most flows are confined within the channel banks, and riparian and wetland vegetation tends to occur as a narrow strip along the bankline. In the steepest settings the typical condition is that there is no significant zone of alluvial deposition, but as the channel system develops and valley slopes become more gentle, alluvial surfaces become common, though they are rarely extensive. Small floodplains and low terraces often develop where logs within the channel cause channel widening, then sediment accumulation, and the formation of small bars that are quickly colonized by wetland and riparian vegetation. These patchy plant communities may persist for long periods after the initiating log has rotted away. A longer-lived phenomenon occurs where debris flows have formed cobble- or boulder-bars, creating short terraces of extremely coarse materials, sometimes capped with a thin soil layer. These may occur at any point along the channel, usually where the channel flattens or the valley widens slightly, and they may be fairly high and wide relative to other terraces. Finally, a permanent complex of terraces and floodplain usually can be found at the confluence of any two channels, except in the steepest terrain. None of the surfaces described above is likely to be continuous for any significant distance along the channel, and normally no more than two terrace levels are found at any one point in high-gradient systems.

Where terrace or floodplain deposits occur in high-gradient systems, the accumulation of alluvium is very limited in extent, but distinct communities of riparian and wetland plant species are present. Water willow (*Justicia americana*) and sedges often occur in patches within or immediately adjacent to the channel. The more fine-grained terraces, low cobble bars, and streambanks support riparian species such as sycamore, river birch, red maple, ironwood, and American elm, as well as a variety of mesic upland species such as white oak and northern red oak. Usually, the coarser cobble bars are colonized by pioneer woody species, such as willows, witch hazel, and alders, but the oldest and highest cobble bars are occupied by shortleaf pine and various oaks typical of droughty sites. The overall character of an intact, functional high-gradient system, then, is a small stream with a narrow, bankline riparian community, punctuated by intermittent bars and terraces of varying character and extent, depending on their age and origins. An intact buffer of upland vegetation is usually considered essential to proper functioning of headwater riparian systems (Fowler 1994, Meyer et al. 2003, Semlitsch and Bodie 2003).

Subclass: Mid-Gradient Riverine

Community Types:

Mid-Gradient Floodplain

Mid-gradient riverine wetlands occur within the 5-year floodplain of stream reaches in valleys that are wide and flat enough to accumulate fairly continuous, but not laterally extensive, deposits of alluvial material flanking the stream channel. Typically, these are reaches that do not meander extensively, but have moved across the valley floor sufficiently to create a zone of alluvial deposition that is considerably wider than the active channel zone.

Mid-gradient streams usually have fairly small floodplains and one or two low terrace units that are nearly continuous along the channel, though they often alternate from one side of the channel to the other. Silver maple, river birch, and sycamore usually dominate on bars and streambanks, but other alluvial surfaces in the valley can support a diverse array of species. Lowland species such as water oak, green ash, American elm, sweetgum, and red maple often dominate the lowest parts of the active floodplain while more mesic species such as white oak, northern red oak, white ash, blackgum (*Nyssa sylvatica*), and bitternut hickory predominate on higher floodplain sites and terraces.

Mid-Gradient Backwater

Mid-gradient backwater wetlands can be found at the confluence of streams where high flows on the larger channel cause backwater flooding in the lower reaches of the mid-gradient tributary. Mid-gradient backwater systems are dominated by flood-tolerant species such as lowland oaks and green ash, and do not support the mesic-site species commonly present on other mid-gradient floodplains.

Backwaters on mid-gradient streams can occur throughout the Ozark Mountains WPR, but usually are only very small inclusions within more extensive mid-gradient floodplains. One extensive site occurs at the confluence of the Buffalo and White Rivers within the Ozark National Forest. Because of the limited distribution of this type, this guidebook does not include models specific to mid-gradient backwater wetlands. Instead, the limited reference data collected from mid-gradient backwater sites are combined with those from mid-gradient floodplains, and both mid-gradient riverine community types are assessed using a single set of models.

Subclass: Low-Gradient Riverine

Community Types:

Low-Gradient Overbank

The Low-Gradient Overbank community type occurs where floodwaters move through quickly and at high velocities, which typically happens on the point bars and natural levee deposits of floodplains and along terrace margins in riverfront areas. Overbank areas often experience scouring or deep deposition of coarse sediments, and litter and other detritus may be completely swept from a site or accumulate in large debris piles. Within the Ozark Mountains Region, sycamore is consistently present on sandy and gravelly riverfront sites, often sharing dominance with cottonwood, while willows and silver maple tend to colonize more fine-textured deposits along the channel. Older, higher terrain off-channel typically include species such as water oak, American elm, box elder (*Acer negundo*), and hackberry (*Celtis occidentalis*).

Low-Gradient Backwater

Low-gradient backwater communities occur where floodwaters back up into lowland areas during floods and are impeded from draining off of the site and remain ponded for extended periods. This usually happens either where natural levees adjacent to the stream channel act as barriers to return flows, or along streams that are forced out of their banks by high flows on larger downstream channels to which they are tributary. In either case, flow velocities are mostly minimal, and fine sediments tend to accumulate. The finer soils make it possible for floodwaters and rain to pond on the floodplain surface in vernal pools and microdepressions.

Plant communities of low-gradient backwater areas in the Ozark Mountains Region include most of the same species found in the low-gradient overbank sites, except for the riverfront cottonwood and sycamore. In addition, green ash, sweetgum, and persimmon (*Diospyros virginica*) are common components.

Subclass: Impounded Riverine

Community Type:

Beaver Complex

Beaver complexes once were nearly ubiquitous here and elsewhere in the continental United States, but became relatively uncommon during the past two centuries following the near extirpation of beaver. Usually, they consist of a series of impounded pools on flowing streams. Beaver cut trees for dams and food, and they have preferences for certain species (e.g. sweetgum), which alters the composition of forests within their foraging range. Tree cutting and tree mortality from flooding create patches of dead timber surrounded by open water, shrub swamps, or marshes. Beaver complexes may be abandoned when the animals exhaust local food resources, or when they are trapped out. Following abandonment, the dams deteriorate, water levels fall, and different plants colonize the former ponds. When beaver re-occupy the area, the configuration changes again, the result being that systems with active beaver populations are in a constant state of flux.

There are no HGM models specific to beaver complexes, but the recommended approach is to regard them as a fully functional component of any riverine system being assessed. See Chapter 6 for a discussion of how to handle beaver complexes within the context of a functional assessment.

Subclass: Spring Run

Community Type:

Spring Run

Spring run wetlands occur where subterranean streams emerge from caves in the mountains. They maintain fairly constant flows and water temperatures. These and other factors make spring run systems unique, and they often support small wetlands with plants and animals not found in other headwater systems. Watercress (*Nasturtium officianale*) is a common component species. Many spring runs have been a focus of human activity in historic and pre-historic times. Livestock grazing and impoundment or diversion for water supplies or mill operations have had major impacts on many spring run wetlands and adjacent riparian systems.

Spring runs are essentially gravel-bottom channel systems, and their component wetlands are herbaceous. Because they carry no fine sediments, they have no significant alluvial surfaces in proximity to the spring other than small gravel and sand bars. The characteristics of any adjacent riparian system are independent of the influence of the spring run. No HGM models have been developed that apply to spring runs. Their condition and the influence of potential impacts must be assessed on a case-by-case basis, with consideration of water quality and unique plant and animal populations.

Class: Depression

Depression wetlands occur in topographic low points where water accumulates and remains for extended periods. Sources of water may include precipitation, runoff, groundwater, and stream flooding. In the Ozark Mountains Region, depressions may be of various origins. They can be created by stream channel migration, which leaves behind abandoned channels, abandoned courses, and large swales. They also occur in upland terrain, where concave features in the rock strata are reflected in the surface topography. Depressions contain wetlands when they hold water for extended periods due to their size, depth, and ability to collect surface and subsurface flows from an area much larger than the depression itself. They tend to fill during the winter and spring, and dry very slowly. Prolonged rains may fill them periodically during the growing season, after which they again dry very slowly. Smaller, shallower features that fill primarily due to direct precipitation inputs and dry out within days or weeks are generally considered to be vernal pools, and are classified as components of flat or riverine wetlands rather than depressions. In the Ozark Mountains Region of

Arkansas, there are two subclasses in the Depression Class (Table 4). Figure 11 illustrates the landscape positions where wetlands in the Depression Class typically are found. Because the depressional community types in the region are often represented by only a few intact examples, or only by highly disturbed examples, reference data are insufficient to develop assessment models for the depression subclasses.

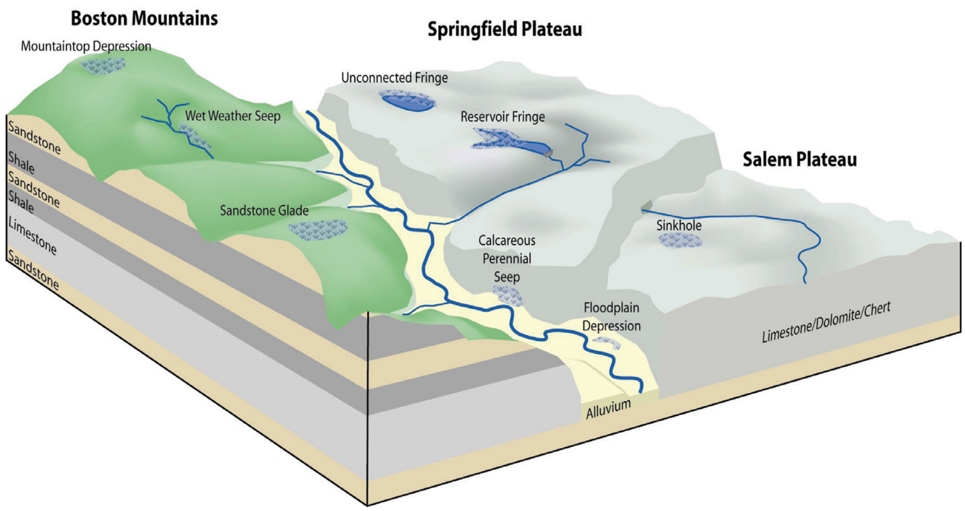

Figure 11. Typical landscape positions of depression, fringe, and slope wetlands within the Ozark Mountains Wetland Planning Region

Subclass: Connected Depression

Community Type:

Floodplain Depression

Floodplain depression wetlands are usually found in remnants of abandoned stream channels, or in broad swales left behind by migrating channels. They are inundated during the more common (1–5-year) flood events. Because they are most likely to be associated with large streams, which create large swales and abandoned channels, most of the connected depressions that were in the Ozark Mountains Region prior to the mid-20th century were likely along the White River, and were submerged by the creation of the major Corps reservoirs. The few connected depressions that remain today are dominated by species typical of riverine settings, such as river birch and silver maple.

Subclass: Unconnected Depression

Community Type:

Mountaintop Depression

Mountaintop depressions are uncommon, small (0.2 ha to about 1 ha) features that occur where the surface rock strata form a bowl-shaped catchment that collects local drainage. They support plants that are typical of floodplain and swamp sites of lowlands, such as buttonbush (*Cephalanthus occidentalis*), pin oak, and overcup oak. Although none of these species are uncommon in the state, their occurrence within the mountains is highly unusual. Most of the known mountaintop depressions are in the Boston Mountains.

Community Type:

Sinkhole

Sinkholes form where surface or near-surface limestone bedrock is dissolved by groundwater, therefore they are largely restricted to the rolling uplands of the Ozark Highlands, north of the Buffalo River. They may be the result of gradual subsidence, or they may be created abruptly when the roof of a cavern collapses. In either case, when sufficient soil has collected in the sinkhole to seal the bottom and allow rainwater and local runoff to collect and stand, wetland plants can become established. Deep sinkholes have open water with a perimeter wetland of emergent and floating-leaved plants. Shallow sinks which commonly dry out in late summer may support shrub-dominated wetlands, and very shallow sinks may be forested with typical floodplain tree species. Most of the sinkhole wetlands in Arkansas are in very poor condition, having been modified to serve as water sources for livestock and wildlife.

Class: Fringe

Fringe wetlands occur along the margins of lakes. By convention, a lake must be more than 2 m deep; otherwise associated wetlands are classified as depressions.

Elsewhere in Arkansas, natural lakes occur mostly in the abandoned channels (oxbows) of large rivers, and where those features are within the active 5-year floodplain, they usually contain Connected Fringe wetlands. Within the Ozark Mountains Region, large oxbows may have existed in the White River floodplain prior to construction of the large federal reservoirs, but no such features remain today. However, the reservoirs themselves and various other impoundments support fringe wetlands that are classified in two different subclasses and community types (Table 4). No assessment models have been developed for any of the fringe wetland subclasses in Arkansas, primarily because no single reference system can reflect the range of variability they exhibit. In particular, many water bodies that support fringe wetlands are subject to water level controls, but the resulting fluctuation patterns are highly variable depending on the purpose of the control structure. Figure 11 illustrates typical landscape positions where fringe wetlands may occur.

Subclass: Reservoir Fringe

Community Type:

Reservoir Shore

Man-made reservoirs in the Ozarks that were formed by damming perennial streams include municipal water storage reservoirs, recreational lakes in State Parks and residential areas, and the five major reservoirs built and operated by the Corps of Engineers. In almost all cases, these lakes are managed specifically to modify natural patterns of water flow, therefore their shoreline habitats are subjected to inundation at times and for durations not often found in nature. Steep reservoir shores usually support little perennial wetland vegetation other than a narrow fringe of willows. The most extensive wetlands within reservoirs usually occur where tributary streams enter the lake, and sediments accumulate to form deltas. These sites may be colonized by various marsh species, and sometimes willows or buttonbush, but even these areas are vulnerable to extended drawdowns, ice accumulation, erosion due to boat wakes, and similar impacts.

Subclass: Unconnected Lacustrine Fringe

Community Type:

Unconnected Lake Margin

Unconnected lakes are lakes that are not inundated by a river on a regular basis (that is, they are not within the 1–5-year floodplain) such as oxbow lakes that remain on alluvial terraces above the active floodplain of a stream. No such natural systems occur in the Ozark Mountains Region, but fringe wetlands associated with certain man-made ponds are usually classified as Unconnected Lake Margin rather than Reservoir Shore. These are generally wetlands in farm ponds, where local runoff is stored behind small earthen dams, as opposed to larger reservoirs where perennial stream flows are actively manipulated. Unconnected Lake Margin wetlands often occur as a series of concentric zones of floating-leaved and emergent forbs and sedges. Left undisturbed, a woody plant zone dominated by willows will develop along the upper margin of the saturated perimeter. However, most farm ponds are maintained with minimal shoreline vegetation.

Class: Slope

Slope wetlands occur where groundwater discharge or shallow subsurface flow create saturated conditions on a slope. Two subclasses comprising three community types occur in the Ozark Mountains Region (Table 4). The subclasses are separated by water chemistry (calcareous versus non-calcareous) and each community type differs from the others in vegetation structure and composition. Numerous uncommon herbaceous species are associated with these sites, and they are particularly vulnerable to degradation due to modification of hydrology, soil disturbance, and invasion by exotic plant species. Because of the high variablity in structure and composition among slope wetlands in the Ozark

Mountains Region, no assessment models have been developed for these subclasses, and impacts must be evaluated based on site-specific consideration of floristic composition and hydrology.

Figure 11 illustrates common landscape positions where wetlands in the Slope Class are found.

Subclass: Non-Calcareous Slope

Two community types are recognized in the non-calcareous slope wetland subclass in the Ozark Mountains Region.

Community Types:

Wet-Weather Seep

Wet weather seeps are slope wetlands with groundwater sources that cease flowing during dry periods. Tree species present are usually those typical of mesic, non-wetland sites, such as American beech and blackgum, but the shrub and understory layers usually include characteristic seep species, such as alders, American holly (*Ilex opaca*), spicebush (*Lindera benzoin*), witch hazels (*Hamamelis virginiana, H. vernalis*), and highbush blueberry (*Vaccinium arboreum*). The groundcover layer is usually very diverse, and may include numerous species that are uncommon elsewhere in the region, such as Indian paintbrush (*Castilleja coccinea*) and orange coneflower (*Rudbeckia fulgida var.umbrosa*).

Sandstone Glade

Sandstone glade wetlands occur on sandstone outcrops, mostly in the western Boston Mountains. The exposed bedrock slabs are tilted only slightly (2- to 6-percent slopes) and receive seepage along the upslope edge. The result is that soil and organic material accumulate only in pockets within the rock, and these pockets remain wet most of the time. Sandstone glade wetlands have no tree canopy or significant shrub layer. However, the herbaceous communities on these sites are highly diverse and variable, and often include a number of species that are considered to be sensitive in Arkansas, or nationally, and other species that are far from their normal habitats. The composition of the herbaceous communities varies widely among individual glades, and even among microhabitats within a single glade. The wettest pockets may be dominated by sphagnum mosses (*Sphagnum spp.*). Areas with relatively deep soil deposits and less moisture can support prairie species such as big bluestem, little bluestem, and milkweeds (*Asclepias spp.*). Still other sites contain insectivorous species typical of coastal plain bog environments, such as sundews (*Drosera spp.*) and bladderworts (*Utricularia spp.*). These and other compositional groupings may all be found in some glades, but be completely absent from others. Evidently the distribution of individual species has been influenced by various factors, including water chemistry, fire, and grazing history.

Subclass: Calcareous Slope

One community type is recognized in the calcareous slope wetland subclass in the Ozark Mountains Region.

Community Type:

Calcareous Perennial Seep

Perennial calcareous seeps occur on lower slopes, often directly adjacent to small streams within the Salem and Springfield Plateaus, where they are variously referred to as fens, seep-fens, streamside seep-fens, and sedge-shrub fens. Calcium-rich groundwater discharging from limestone bedrock maintains saturated conditions within the root zone, causing woody vegetation to be sparse and highly susceptible to windthrow, while simultaneously encouraging development of unusually diverse herbaceous plant communities. Numerous sedges (*Carex spp.*) and ferns are characteristic, but a wide variety of flowering forbs typically are present. Common component species include monkey flower (*Mimulus ringens*), loosestrife (*Lysimachia quadrifolia*), and white turtlehead (*Chelone glabra*).

4 Wetland Functions and Assessment Models

This Regional Guidebook contains six sets of assessment models applicable to wetlands and riparian areas in the Ozark Mountains Region of Arkansas. The term "wetland" is used here as inclusive of riparian areas that may not be jurisdictional wetlands, but which can be assessed using the same procedures used for jurisdictional areas. Not all of the wetland subclasses and community types described in Chapter 3 and Table 4 can be assessed using the models presented here. The excluded subclasses and community types are as follows:

a. Only forested wetlands and (or sites that could support forested wetlands) should be assessed using these models – no appropriate models have been developed for wet prairie systems, which must be evaluated on a case-by-case basis with a focus on floristics and site integrity.

b. No models are available at this time to assess fringe, depressions, or slope wetlands, because the high degree of variability, especially with respect to water regimes and vegetation structure, makes it difficult to draw general relationships from the available reference data. Further, some of the community types in these classes are so unique (e.g. sandstone glades) that they can be considered "red flag" systems that should be protected regardless of their current condition. Others are so highly altered in almost every instance (e.g. sinks) that evaluation of their functionality is beyond the scope of rapid assessment approaches.

c. No models are available that are specific to managed wildlife impoundments (greentree reservoirs and moist soil management units). These features are not commonly proposed for the Ozarks, but if existing wetlands are proposed to be converted to managed impoundments, the models appropriate to the impact area (most likely either Low-Gradient Riverine or Hardwood Flat) can be used to assess the functional change likely to occur due to altered water regimes (see Section 6 – "Apply Assessment Results").

The Ozark Mountains wetlands that can be assessed with the models presented here include all of the subclasses and community types not specifically excluded in the preceding paragraphs, and represent most of the common forested wetland types in the region.

Based on the preceding discussion, the four wetland subclasses and community types for which assessment models are presented in this chapter are the following:

- Hardwood Flat.
- High-Gradient Riverine.
- Mid-Gradient Riverine.
- Low-Gradient Riverine.

Note that because the Hardwood Flat is the only community type within the Flat subclass that can be assessed using this guidebook (wet prairies are excluded as described above), Hardwood Flats will be referred to as a subclass for the remainder of this document to avoid confusion.

The wetland functions that can be assessed using this guidebook were identified by participants in a workshop held in Arkansas in 1997. That group selected hydrologic, biogeochemical, and habitat functions that are important and measurable in Arkansas wetlands from a suite of potential functions identified in "A Guidebook for Application of Hydrogeomorphic Assessments to Riverine Wetlands" (Brinson et al. 1995). Based on the workshop recommendations, this regional guidebook provides models and reference data required to determine the extent to which forested wetlands of the Ozark Mountains Region perform the following functions:

- Detain Floodwater.
- Detain Precipitation.
- Cycle Nutrients.
- Export Organic Carbon.
- Maintain Plant Communities.
- Provide Habitat for Fish and Wildlife.

It should be noted that not all functions are performed by each regional wetland subclass. Thus, assessment models for each subclass may not include all six functions. In addition, the form of the assessment model that is used to assess functions can vary from subclass to subclass.

Functional scores or indices represent a measure of ecosystem integrity, where the index drops as a wetland exhibits deviation from the reference standard condition for variables that contribute to the function. If there is no deviation, the score is 1, but as the deviation increases, the score becomes a fraction that approaches zero. This is true, even if the actual function might be increasing, but in an unsustainable manner. For instance, a hydrologic change in a forested wetland could stress trees and lead to a large amount of crown dieback, and therefore an increase in woody debris, which would lead to an increase in the actual export of organic carbon to nearby aquatic ecosystems. However, the functional score or index would actually decrease, because this woody-debris spike is a deviation from the amount typical in healthy mature forests of the subclass within the reference domain, hence a deviation from ecosystem integrity.

In this chapter, function is discussed generally in terms of the following topics:

- *Definition and applicability*. This section defines the function, identifies the subclasses where the function is assessed, and identifies an independent quantitative measure that can be used to validate the functional index.
- *Rationale for selecting the function.* This section discusses the reasons a function was selected for assessment, and the onsite and offsite effects that may occur as a result of lost functional capacity.
- *Characteristics and processes that influence the function.* This section describes the characteristics and processes of the wetland and the surrounding landscape that influence the function, and lays the groundwork for the description of assessment variables.
- *General form of the assessment model.* This section presents the structure of the general assessment model and briefly describes the constituent variables.

The specific form of the assessment models used to assess functions for each regional wetland subclass and the functional capacity subindex curves are presented in Chapter 5. Chapter 6 presents detailed descriptions of assessment variables and the methods used to measure or estimate their values.

Function 1: Detain Floodwater

Definition and applicability

This function reflects the ability of wetlands to store, convey, and reduce the velocity of floodwater as it moves through a wetland. The potential effects of this reduction are damping of the downstream flood hydrograph, maintenance of post-flood base-flow, and deposition of suspended sediments from the water column to the wetland. This function is assessed for the following regional wetland subclasses in the Ozark Mountains Region of Arkansas:

- High-Gradient Riverine
- Mid-Gradient Riverine
- Low-Gradient Riverine

The recommended procedure for assessing this function involves estimation of "roughness" within the wetland, and deviation from the expected flood frequency pattern for the site. A potential independent, quantitative measure for validating the functional index is the volume of water stored per unit area per unit time (m^3/ha/time) at a discharge equivalent to the average annual peak event.

Rationale for selecting the function

The capacity of wetlands to temporarily store and convey floodwater has been extensively documented (Dewey and Kropper Engineers 1964, Campbell and Johnson 1975, Novitski 1978, Thomas and Hanson 1981, Ogawa and Male 1983, 1986; Demissie and Kahn 1993). Generally, floodwater interaction with wetlands dampens and broadens the flood wave, which reduces peak discharge downstream. Similarly, wetlands can reduce the velocity of water currents and, as a result, reduce erosion (Ritter et al. 1995). Some portion of the floodwater volume detained within floodplain wetlands is likely to be evaporated or transpired, reducing the overall volume of water moving downstream. The portion of the detained flow that infiltrates into the alluvial aquifer, or which returns to the channel very slowly via low-gradient surface routes, may be sufficiently delayed that it contributes significantly to the maintenance of baseflow in some streams long after flooding has ceased (Terry et al. 1979, Saucier 1994). Retention of particulates also is an important component of the flood detention function, because sediment deposition directly alters the physical characteristics of the wetland (including hydrologic attributes) and influences downstream water quality.

This function deals specifically with the physical influences on flow and sediment dynamics described above. Floodwater interaction with floodplain wetlands influences a variety of other wetland functions in the Ozark Mountains Region of Arkansas, including nutrient mobility and storage, and the quality of habitat for plants and animals. The role of flooding in maintaining these functions is considered separately in other sections of this chapter.

Characteristics and processes that influence the function

The capacity of a wetland to detain and moderate floodwaters is related to the characteristics of the particular flood event, the configuration and slope of the floodplain and channel, and the physical obstructions present within the wetland that interfere with flows. The intensity, duration, and spatial extent of precipitation events affect the magnitude of the stream discharge response. Typically, rainfall events of higher intensity, longer duration, and greater spatial extent result in greater flood peaks. Watershed characteristics such as size and shape, channel and watershed slopes, drainage density, and the presence of wetlands and lakes have pronounced effects on the stormflow response (Dunne and Leopold 1978, Patton 1988, Brooks et al. 1991, Leopold 1994, Ritter et al. 1995). As the percentage of wetland area and/or reservoirs increases, the greater the flattening effect (i.e., attenuation) on the stormflow hydrograph. In general, these climatic and watershed characteristics are consistent within a given region.

The duration of water storage is secondarily influenced by the slope and roughness of the floodplain. Slope refers to the gradient of the floodplain across which floodwaters flow. Roughness refers to the resistance to flow created by vegetation, debris, and topographic relief. In general, duration increases as roughness increases and slope decreases.

Of the characteristics described above, only flood frequency and the roughness component can be reasonably incorporated into a rapid assessment. Most stream channels in the region are not close enough to a stream gage to ascribe detailed flood characteristics to any particular point on the ground. At best, we can estimate flood frequency for some sites, at least to the extent needed to classify a wetland as riverine or connected (i.e., within the 5-year floodplain). In cases where a change in flood frequency due to a proposed project can be estimated, that information can be used in the assessment of this function. Otherwise, the only element of the Floodwater Detention function that is assessed is roughness.

General form of the assessment model

The model for assessing the Detain Floodwater function includes five assessment variables, which are discussed in greater detail in Chapter 6:

V_{FREQ}: Change in frequency of flooding

V_{LOG}: Log density

V_{GVC}: Ground vegetation cover

V_{SSD}: Shrub-sapling density

V_{TDEN}: Tree density

The model can be expressed in a general form:

$$FCI = V_{FREQ} \times \left[\frac{(V_{LOG} + V_{GVC} + V_{SSD} + V_{TDEN})}{4} \right] \qquad (2)$$

The assessment model has two components: change in frequency of flooding (V_{FREQ}) and a compound expression that represents flow resistance (roughness) within the wetland. The flood frequency variable is employed as a multiplier, such that the significance of the roughness component is proportional to how often the wetland is inundated relative to the reference inundation frequency for the site.

The compound expression of flow resistance includes the major physical components of roughness that can be characterized readily at the level of a field assessment. They include elements that influence flow velocity differently depending on flood depth and time of year. For example, ground vegetation cover (V_{GVC}) and log density (V_{LOG}) can effectively disrupt shallow flows, while shrub and sapling density (V_{SSD}) have their greatest influence on flows that intercept understory canopies (usually 1–3 m deep), and tree stems (V_{TDENS}) interact with a full range of flood depths. Both tree stems and logs are equally effective in disrupting flows at all times of the year, while understory and ground cover interactions are less effective during winter floods than during the growing season. Other components of wetland structure contribute to roughness, but are not assessed here because they do not commonly influence flows to the same degree as the components described above (e.g. snag density).

Function 2: Detain Precipitation

Definition and applicability

This function is defined as the capacity of a wetland to store rainfall on-site, thereby maintaining wetland characteristics and moderating runoff to streams. This is accomplished chiefly by micro-depressional storage, infiltration, and absorption by organic material and soils. Both riverine and flat wetlands are assessed for this function. Four wetland subclasses are assessed for the precipitation detention function in the Ozark Mountains Region of Arkansas:

- Hardwood Flat
- High-Gradient Riverine
- Mid-Gradient Riverine
- Low-Gradient Riverine

The recommended procedure for assessing this function is estimation of available micro-depression storage, and characterization of the extent of organic surface accumulations available to improve absorption and infiltration. A potential independent direct measure would be calculation of on-site storage relative to runoff predicted by a storm hydrograph for a given rainfall event.

Rationale for selecting the function

Like the floodwater detention function, capture and detention of precipitation prevents erosion, dampens runoff peaks following storms, and helps maintain baseflow in streams (Meyer et al. 2003). The stream hydrograph has a strong influence on the development and maintenance of habitat structure and biotic diversity of adjacent ecosystems (Bovee 1982, Estes and Orsborn 1986, Stanford et al. 1996). In addition, on-site storage of precipitation may be important in maintaining wetland conditions on the site, independent of the influence of flooding. The presence of ponded surface water and recharge of soil moisture also have implications for plant and animal communities within the wetland, but these effects are assessed separately.

Characteristics and processes that influence the function

Flats and riverine wetlands capture precipitation and local runoff in micro-depressions and vernal pools. Micro-depressions are usually formed by channel migration processes, or tree wind-throw, which creates small, shallow depressions when root systems are pulled free of the soil. Vernal pools are usually found in ridge-and-swale topography, or they can be created by the gradual filling of once deeper depressions such as segments of abandoned channel. The presence of surface organic accumulations also reduces runoff and promotes infiltration. In the Ozark Mountains Region, flats and the alluvial surfaces flanking low- and mid-gradient streams may have significant microdepressional precipitation storage as well as a continuous organic layer on the ground surface. Along high-gradient streams, depressional storage is usually minimal or lacking, but organic material accumulations are sufficient to slow runoff and promote infiltration. Thus, in all of these settings, mechanisms are in place to effectively reduce the movement of precipitation as overland flow. Instead, the water is detained on-site, where it supports biological processes, contributes to subsurface water storage, and eventually helps maintain base-flow in nearby streams. Clearing of natural vegetation cover will remove the source of litter and the mechanism for developing new micro-depressions. Land use practices that involve ditching or land leveling can eliminate on-site storage and promote rapid runoff of precipitation.

General form of the assessment model

The assessment model for the Detain Precipitation function includes three assessment variables, which are discussed in greater detail in Chapter 6:

V_{POND}: Percent of area subject to ponding

V_{OHOR}: "O" horizon thickness

V_{LITTER}: Thickness of the litter layer

The model can be expressed in a general form:

$$FCI = \frac{\left[V_{POND} + \frac{(V_{OHOR} + V_{LITTER})}{2} \right]}{2} \tag{3}$$

The assessment model has two components, which are weighted equally. The percentage of the assessment area subject to ponding (V_{POND}) is based on a field estimate. It is not considered in assessments of high-gradient systems where microdepressional storage is negligible under reference standard conditions. The second component expression is an average based on field measures of organic matter accumulation on the soil surface, which are represented by the thickness of the O horizon (V_{OHOR}) and the percentage of the ground surface covered by litter (V_{LITTER}). Litter is sometimes a problematic variable to use, because it is seasonal in nature. However, litter is an important element in precipitation detention, and may be differentially exported from some riverine sites, therefore it is included in the model despite the inherent difficulties. If users of this guidebook determine that litter cannot be estimated reliably in the wetland being assessed (for example, if field work in two areas being compared will span several seasons), then litter can be removed from the model equation, and the model structure revised appropriately.

Function 3: Cycle Nutrients

Definition and applicability

This function refers to the ability of the wetland to convert nutrients from inorganic forms to organic forms and back through a variety of biogeochemical processes such as photosynthesis and microbial decomposition. In the context of this assessment procedure, it also includes the capacity of the wetland to permanently remove or temporarily immobilize elements and compounds that are imported to the wetland, particularly by floodwaters. The nutrient cycling function encompasses a complex web of chemical and biological activities that sustain the overall wetland ecosystem, and it is assessed in all wetland subclasses. The assessed subclasses discussed within this document include the following:

- Hardwood Flat
- High-Gradient Riverine
- Mid-Gradient Riverine
- Low-Gradient Riverine

The assessment procedure described here utilizes indicators of the presence and relative magnitude of organic material production and storage, including living vegetation strata, dead wood, detritus, and soil organic matter. Potential independent, quantitative measures for validating the functional index include net annual primary productivity (g/m^2), annual litter fall (g/m^2), or standing stock of living and/or dead biomass (g/m^2).

Rationale for selecting the function

In functional wetlands, nutrients are transferred among various components of the ecosystem, such that materials stored in each component are sufficient to maintain ecosystem processes (Ovington 1965, Pomeroy 1970). For example, an adequate supply of nutrients in the soil profile supports primary production, which makes plant community development and maintenance possible (Bormann and Likens 1970, Whittaker 1975, Perry 1994). The plant community, in turn, provides a pool of nutrients and source of energy for secondary production and also provides the habitat structure necessary to maintain the animal community (Fredrickson 1978, Wharton et al. 1982). Plant and animal communities serve as the source of detritus, which provides nutrients and energy necessary to maintain a characteristic community of decomposers. These decomposers, in turn, break down organic material into simpler elements and compounds that can then reenter the nutrient cycle (Reiners 1972, Dickinson and Pugh 1974, Pugh and Dickinson 1974, Schlesinger 1977, Singh and Gupta 1977, Hayes 1979, Harmon et al. 1986, Vogt et al.1986).

Characteristics and processes that influence the function

In wetlands, nutrients are stored within, and cycled among, four major compartments: (a) the soil, (b) primary producers such as vascular and nonvascular plants, (c) consumers such as animals, fungi, and bacteria, and (d) dead organic matter, such as leaf litter or woody debris, referred to as detritus. The transformation of nutrients within each compartment and the flow of nutrients between compartments are mediated by a complex variety of biogeochemical processes. For example, plant roots take up nutrients from the soil and detritus and incorporate them into the organic matter in plant tissues. Nutrients incorporated into herbaceous or deciduous parts of plants will turn over more rapidly than those incorporated into the woody parts of plants. However, ultimately, all plant tissues are either consumed or die and fall to the ground where they are decomposed by fungi and microorganisms and mineralized to again become available for uptake by plants.

Many of the processes involved in nutrient cycling within wetlands have been studied extensively in wetlands (Brinson et al. 1981). In the Southeast specifically, there is a rich literature on the standing stock, accumulation, and turnover of above- and below-ground biomass in forested wetlands (Conner and Day 1976, Day 1979, Mulholland 1981, Brown and Peterson 1983, Harmon et al. 1986, Brinson 1990).

In controlled field studies, the approach for assessing nutrient cycling is usually to measure the rate at which nutrients are transformed and transferred between compartments over an annual cycle (Kuenzler et al. 1980, Brinson et al. 1984, Harmon et al. 1986), which is not feasible as part of a rapid assessment procedure. The alternative is to estimate the standing stocks of living and dead biomass in each of the four compartments and assume that nutrient cycling is taking place at a characteristic level if the biomass in each compartment is similar to that in reference standard wetlands. In this case, estimation of consumer biomass (animals, etc.) is too complex for a rapid assessment approach, thus, the presence of these organisms is assumed based on the detrital and living plant biomass components.

General form of the assessment model

The model for assessing the Cycle Nutrients function includes the following assessment variables, which are discussed in greater detail in Chapter 6:

V_{TBA}: Tree basal area

V_{SSD}: Shrub-sapling density

V_{GVC}: Ground vegetation cover

V_{OHOR}: "O" horizon thickness

V_{AHOR}: "A" horizon thickness

V_{WD}: Woody debris biomass

V_{SNAG}: Snag density

The model can be expressed in a general form:

$$FCI = \frac{\left[\frac{\left(V_{TBA} + V_{SSD} + V_{GVC}\right)}{3} + \frac{\left(V_{OHOR} + V_{AHOR} + V_{WD} + V_{SNAG}\right)}{4}\right]}{2} \qquad (4)$$

The two constituent expressions within the model reflect the two major production and storage compartments: living and dead organic material. The first expression is composed of indicators of living biomass, expressed as tree basal area (V_{TBA}), shrub and sapling density (V_{SSD}) and ground vegetation cover (V_{GVC}). These various living components also reflect varying levels of nutrient availability and turnover rates, with the above-ground portion of ground cover biomass being largely recycled on an annual basis, while understory and tree components incorporate both short-term storage (leaves) as well as long-term storage (wood). Similarly, the second expression includes organic storage compartments that reflect various degrees of decay. Snag density (V_{SNAG}) and woody debris volume (V_{WD}) represent relatively long-term storage compartments that are gradually transferring nutrients into other components of the ecosystem through the mediating activities of fungi, bacteria, and higher plants. The thickness of the O horizon (V_{OHOR}) represents a shorter-term storage compartment of largely decomposed, but nutrient-rich, organics on the soil surface. The thickness of the A horizon (actually, the portion of the A where organic accumulation is apparent) (V_{AHOR}) represents a longer-term storage compartment, where nutrients that have been released from other compartments are held within the soil and are available for plant uptake, but are generally conserved within the system and not readily subject to export by runoff or floodwater.

All of these components are combined here in a simple arithmetic model, which weights each element equally. Note that one detrital component, litter accumulation, is not used in this model. This is a relatively transient component of the on-site nutrient capital, and may be readily exported. Therefore it is used as a nutrient-related assessment variable only in the carbon export function.

Function 4: Export Organic Carbon

Definition and applicability

This function is defined as the capacity of the wetland to export dissolved and particulate organic carbon, which may be vitally important to downstream aquatic systems. Mechanisms involved in mobilizing and exporting nutrients include leaching of litter, flushing, displacement, and erosion. This assessment procedure employs indicators of organic production, the presence of organic materials that may be mobilized during floods or groundwater discharge, and the occurrence of periodic flooding, to assess the organic export function of a wetland. An independent quantitative measure of this function is the mass of carbon exported per unit area per unit time ($g/m^2/yr$).

This function is assessed in the following river-connected wetlands in the Ozark Mountains Region of Arkansas:

- High-Gradient Riverine
- Mid-Gradient Riverine
- Low-Gradient Riverine

Rationale for selecting the function

The high productivity of river-connected wetlands and their interaction with streams make them important sources of dissolved and particulate organic carbon for aquatic food webs and biogeochemical processes in downstream aquatic habitats (Vannote et al. 1980, Elwood et al. 1983, Sedell et al. 1989). Dissolved organic carbon is a significant source of energy for the microbes that form the base of the detrital food web in aquatic ecosystems (Dahm 1981, Edwards 1987, Schlosser 1991, Wohl 2000).

Characteristics and processes that influence the function

Watersheds with a large proportion of wetlands generally have been found to export organic carbon at higher rates than watersheds with fewer wetlands. This is attributable to several factors: (a) the large amount of organic matter in the litter and soil layers that comes into contact with floodwaters, overland flow, or groundwater discharge; (b) relatively long periods of inundation or saturation and, consequently, contact between surface water and organic matter, thus allowing for significant leaching; (c) the ability of the labile carbon fraction to be rapidly leached from organic matter when exposed to water; and (d) the ability of floodwater and overland flow to transport dissolved and particulate organic carbon from the wetland to the stream channel or other down-gradient systems (Mulholland and Kuenzler 1979, Brinson et al. 1981, Elder and Mattraw 1982, Johnston et al. 1990).

General form of the assessment model

The model for assessing the Export Organic Carbon function includes eight assessment variables, which are discussed in greater detail in Chapter 6:

V_{FREQ}: Change in frequency of flooding

V_{OHOR}: "O" horizon thickness

V_{LITTER}: Thickness of the litter layer

V_{WD}: Woody debris biomass

V_{SNAG}: Snag density

V_{TBA}: Tree basal area

V_{SSD}: Shrub-sapling density

V_{GVC}: Ground vegetation cover

The general form of the assessment model follows:

$$FCI = V_{FREQ} \times \frac{\left[\frac{(V_{LITTER} + V_{OHOR} + V_{WD} + V_{SNAG})}{4}\right] + \left[\frac{V_{TBA} + V_{SSD} + V_{GVC}}{3}\right]}{2} \quad (5)$$

This model is similar to the model used to assess the nutrient cycling function in that it incorporates most of the same indicators of living and dead organic matter. The living tree, understory, and ground cover components (V_{TBA}, V_{SSD}, and V_{GVC}) primarily represent organic production, indicating that materials will be available for export in the future. The dead organic fraction represents the principal sources of exported material, represented by litter, snags, woody debris, and accumulation of the O horizon (V_{LITTER}, V_{SNAG}, V_{WD}, and V_{OHOR}).

This model differs from the nutrient cycling model in that materials stored in the soil are not included due to their relative immobility, and an export mechanism is a required component of this model. The export mechanism is flooding, and it is incorporated in the model as the change in flood frequency (V_{FREQ}) observed or anticipated due to the effects of a specific project or change in land management. This model also includes litter as a component of the dead organic fraction, despite the fact that it is a highly seasonal functional indicator that is difficult to estimate reliably, and therefore is not included in other models where it may seem appropriate. It is included in this model because it represents the most mobile dead organic material in the wetland, and because it may be the only component that is present in young or recently restored systems. If users of this guidebook determine that litter cannot be estimated reliably in the wetland being assessed (for example, if field work in two areas being compared will occur during different seasons), then litter can be removed from the model equation.

Function 5: Maintain Plant Communities

Definition and applicability

This function is defined as the capacity of a wetland to provide the environment necessary for characteristic plant community development and maintenance. In assessing this function, one must consider both the extant plant community as an indication of current conditions and the physical factors that determine whether or not a characteristic plant community is likely to be maintained in the future. Various approaches have been developed to describe and assess plant community characteristics that might be appropriately applied in developing independent measures of this function. However, none of these approaches alone can supply a "direct independent measure" of plant community function, because they are tools that are employed in more complex analyses that require familiarity with the regional vegetation and collection of appropriate sample data.

This function is assessed in the following subclasses in the Ozark Mountains Region of Arkansas:

- Hardwood Flat
- High-Gradient Riverine
- Mid-Gradient Riverine
- Low-Gradient Riverine

Rationale for selecting the function

The ability to maintain a characteristic plant community is important because of the intrinsic value of the plant community and the many attributes and processes of wetlands that are influenced by the plant community. For example, primary productivity, nutrient cycling, and the ability to provide a variety of habitats necessary to maintain local and regional diversity of animals are directly influenced by the plant community (Harris and Gosselink 1990). In addition, the plant community of a river-connected wetland influences the quality of the physical habitat, nutrient status, and biological diversity of downstream systems.

Characteristics and processes that influence the function

Numerous studies describe the environmental factors that influence the occurrence and characteristics of plant communities in wetlands (Robertson et al. 1978, 1984; Wharton et al. 1982; Robertson 1992; Smith 1996; Messina and Conner 1997; Hodges 1997). Hydrologic regime is usually cited as the principal factor controlling plant community attributes. Consequently, this factor is a fundamental consideration in the basic hydrogeomorphic classification scheme employed in this document. Soil characteristics also are significant determinants of plant community composition. In addition to physical factors, system dynamics and disturbance history are important in determining the condition of a wetland plant community at any particular time. These include past land use, timber harvest history, hydrologic changes, sediment deposition, and events such as storms, fire, beaver activity, insect outbreaks, and disease. Clearly, some characteristics of plant communities within a particular wetland subclass may be determined by factors too subtle or variable to be assessed using rapid field estimates. Therefore, this function is assessed primarily by considering the degree to which the existing plant community structure and composition are appropriate to site conditions and the expected stage of maturity for the site. Secondarily, in some subclasses, soil and hydrologic conditions are assessed to determine if fundamental requirements are met to maintain wetland conditions appropriate to the geomorphic setting.

General form of the assessment model

The model for assessing the Maintain Plant Communities function includes the following assessment variables, which are discussed in greater detail in Chapter 6:

V_{TBA}: Tree basal area

V_{TDEN}: Tree density

V_{COMP}: Composition of tallest woody stratum

V_{SOIL}: Soil integrity

V_{DUR}: Change in growing season flood duration

V_{POND}: Micro-depressional ponding

The model can be expressed in a general form:

$$FCI = \left\langle \left\{ \frac{\left[\frac{(V_{TBA} + V_{TDEN})}{2} + V_{COMP} \right]}{2} \right\} \times \left[\frac{(V_{SOIL} + V_{DUR} + V_{POND})}{3} \right] \right\rangle^{1/2} \quad (6)$$

The first expression of the model has two components. One component describes the structure of the overstory stratum of the plant community in terms of tree basal area and density (V_{TBA} and V_{TDENS}). Together these indicate whether the stand has a structure typical of a mature forest appropriate to the hydrogeomorphic setting. The second term of the expression considers plant species composition of the dominant stratum (V_{COMP}), which will be the overstory in most instances, but which may be the shrub or ground cover layers in communities that are in earlier (or arrested) stages of development. This allows recognition of the faster recovery trajectory likely to take place in planted restoration sites (versus abandoned fields).

The second expression of the model considers several factors that may be crucial to plant community maintenance under certain conditions. V_{SOIL} is a simple comparison of the soil on the site to the mapped or predicted soil type for the area and geomorphic setting. The V_{SOIL} variable allows recognition of sites where the native soils have been replaced or buried by materials inappropriate to the site, or where the native soils have been damaged significantly, as by compaction. The V_{DUR} variable allows recognition of changes in growing season flood duration in sites where project impacts or land use changes have occurred or are anticipated that will extend or reduce the amount of time that substrates are flooded during the growing season, which can have significant effects on plant community structure and composition. The V_{POND} variable focuses on a specific aspect of site alteration—the removal of microtopography and related ponding of water on flats and riverine wetlands. As described previously, ponding of precipitation is a crucial mechanism for maintaining wetland character in many wetlands in the Ozark Mountains Region of Arkansas, though it is not significant in high-gradient systems, and is not included in the High-Gradient Riverine assessment model for this function. Flooding is also critical for the maintenance of many plant communities within the region, but this relationship is considered separately as a basic classification factor.

Function 6: Provide Habitat for Fish and Wildlife

Definition and applicability

This function is defined as the ability of a wetland to support the fish and wildlife species that typically use wetlands during some part of their life cycles. Potential independent, quantitative measures of this function are animal inventory approaches, with data analysis usually employing comparisons between sites using a similarity index calculated from species composition and abundance (Odum 1950).

This function is assessed in the following subclasses in the Ozark Mountains Region of Arkansas:

- Hardwood Flat
- High-Gradient Riverine
- Mid-Gradient Riverine
- Low-Gradient Riverine

Rationale for selecting the function

Terrestrial, semi-aquatic, and aquatic animals use wetlands extensively. Maintenance of this function ensures habitat for a diversity of vertebrate organisms, contributes to secondary production, and maintains complex trophic interactions. Habitat functions span a range of temporal and spatial scales, and include the provision of refugia and habitat for wide-ranging or migratory animals as well as highly specialized habitats for endemic species. However, most wildlife and fish species found in wetlands of the Ozark Mountains Region of Arkansas depend on certain aspects of wetland structure and dynamics, such as periodic flooding or ponding of water, specific vegetation composition, and proximity to other habitats.

Characteristics and processes that influence the function

The quality and availability of habitats for fish and wildlife species in wetlands of the Ozark Mountains Region of Arkansas are dependent on a variety of factors operating at different scales. Habitat components that can be considered in a rapid field assessment include vegetation structure and composition; detrital elements; availability of water, both from precipitation and flooding; and spatial attributes such as patch size and connectivity.

Forested wetlands typically are floristically and hydrologically complex (Wharton et al. 1982). In most forested wetland systems, structural diversity in the vertical plane generally increases with vegetation maturity (Hunter 1990). On the horizontal plane, vegetation structure varies due to gap-phase regeneration dynamics and microsite variability. Such variability includes the interspersion of low ridges, swales, abandoned channel segments, and other features on floodplains that differentially flood or pond rainwater, and support distinctively different plant communities (see Chapter 3). This structural diversity provides habitat conditions and food resources that allow numerous animal species to coexist in the same area (Allen 1987, Schoener 1986).

Detrital components of the ecosystem are of considerable significance to animal populations in forested wetlands. Litter provides ideal habitat for small animals such as salamanders (Johnson 1987), and has a distinctive invertebrate fauna (Wharton et al. 1982). Logs and other woody debris provide cover and a moist environment for many species including invertebrates, small mammals, reptiles, and amphibians (Hunter 1990). Animals found in forested wetlands use logs as resting sites, cover, feeding platforms, and as sources of food (Harmon et al. 1986, Loeb 1993). Standing dead trees (snags) are used by numerous bird species, and several species are dependent on them (Scott et al. 1977). Stauffer and Best (1980) found that most cavity-nesting birds, particularly the primary cavity nesters such as woodpeckers, preferred snags to live trees. Mammals such as bats, squirrels, and raccoon also are dependent on snags to varying extents (Howard and Allen 1989), and most species of forest-dwelling mammals, reptiles, and amphibians, along with numerous invertebrates, seek shelter in cavities, at least occasionally (Hunter 1990).

In wetlands of the Ozark Mountains Region of Arkansas, hydrology is one of the major factors influencing wildlife habitat quality. A significant hydrologic component is precipitation, particularly where it is captured in vernal pools and small puddles. These sites are sources of surface water for various terrestrial animals, and provide reproductive habitat for invertebrates and amphibians, many of which are utilized as a food source by other animals (Wharton et al. 1982, Johnson 1987). Ponded breeding sites without predatory fish populations are very important for some species of salamanders and frogs (Johnson 1987).

While wetlands with temporary ponding of precipitation or saturation are important to many species precisely because they provide an environment that is isolated from many aquatic predators, large floodplain wetlands that are periodically stream-connected also provide vital habitat for some species. Wharton et al. (1982) provided an overview of fish use of bottomland hardwoods in the Piedmont and eastern Coastal Plain, and stated that at least 20 families comprising 53 species of fish use various portions of the floodplain for foraging and spawning. Baker and Killgore (1994) reported similar results from the Cache River drainage in Arkansas, where they found that most fish species exploit floodplain habitats at some time during the year, many for spawning and rearing. In addition to flooding itself, the complex environments of floodplains are of significance to fish. Wharton et al. (1982) listed numerous examples of fish species being associated with certain portions of the floodplain.

Just as topographic variations provide essential wetland habitats such as isolated temporary ponds and river-connected backwaters, they also provide sites that generally remain dry. Such sites are important to ground-dwelling species that cannot tolerate prolonged inundation. Wharton et al. (1982) stated that old natural levee ridges are extremely important to many floodplain species, because they provide winter hibernacula and refuge areas during periods of high water. Similarly, Tinkle (1959) found that natural levees were used extensively as egg-laying areas by many species of reptiles and amphibians.

One particularly complex component of wildlife habitat quality involves "landscape-level" features. This general term encompasses a wide variety of considerations, including the size of the "patch" that includes the assessment area, surrounding land uses, connections to other systems, and the scale and periodicity of disturbance (Hunter 1990, Morrison et al. 1992). It is generally assumed that reduction and fragmentation of forest habitat, coupled with changes in the remaining habitat, resulted in the loss of Bachman's warbler, and the red wolf, as well as severe declines in the black bear and Florida panther. The extent to which patch size affects animal populations has been most thoroughly investigated with respect to birds, but the results have been inconsistent (Stauffer and Best 1980, Blake and Karr 1984, Lynch and Whigham 1984, Askins et al. 1987, Sallabanks et al. 1998, Kilgo et al. 1997). However, the negative effects of forest fragmentation on some bird species have been well documented (Finch 1991). These species, referred to as "forest interior" species, apparently respond negatively to unfavorable environmental conditions or biotic interactions that occur in fragmented forests (Ambuel and Temple 1983). The point at which forest fragmentation affects different bird species has yet to be defined, and study results have been inconsistent (e.g. Temple 1986, Wakeley and Roberts 1996). Thus, the area needed to accommodate all the species typically associated with large patches of forested wetlands in the region can only be approximated. One such approximation (Mueller et al. 1995) identified three groups of birds that breed in the Mississippi Alluvial Valley with (presumably) similar needs relative to patch size. That study suggested that sustaining source breeding populations of individual species within the three groups requires 44 patches of 4,000 – 8,000 ha, 18 patches of 8,000 – 40,000 ha, and 12 patches larger than 40,000 ha. Species such as Swainson's warbler are in the first group; more sensitive species such as the cerulean warbler are in the second group; and those with very large home ranges (e.g., raptors such as the red-shouldered hawk) are in the third group.

Land use surrounding a tract of forest also has a major effect on avian populations. Recent studies (Thompson et al. 1992, Welsh and Healy 1993, Robinson et al. 1995, Sallabanks et al. 1998) suggest that bird populations respond to fragmentation differently in forest-dominated landscapes than in those in which the bulk of the forests have been permanently lost to agriculture or urbanization. Generally, these studies indicate that as the mix of feeding habitats (agricultural and suburban lands) and breeding habitats (forests and grasslands) increases, predators and nest parasites become increasingly successful, even if large blocks of habitat remain. Thus, in more open landscapes, block sizes need to be larger than in mostly forested ones. Conversely, Robinson (1996) estimated that as the percentage of the landscape that is forested increases above 70 percent (approximately), the size of the forest blocks within that landscape becomes less significant to bird populations. In a review of this issue, Hunter et al. (2001) indicated that blocks of approximately 2500 ha are adequate in landscapes with predominantly mixed forest cover (including pine plantations). Much of the Ozark Mountains Region meets this criterion (Rudis 2001).

In the case of the depression wetlands that typically occur as small patches within a matrix of drier sites, and where wetlands occur as narrow zones along mid-gradient streams, buffer zones (or adjacent, non-wetland habitats) are particularly important to amphibians and reptiles that spend parts of their life cycles outside the wetland (McWilliams and Bachman 1988, Burke and Gibbons 1995, Semlitsch and Bodie 1998, Boyd 2001, Gibbons and Buhlhmann 2001, Gibbons 2003). Recommendations for functional buffer widths are highly variable depending on the species involved, and the types of activities they pursue outside the wetland. Semlitsch and Jensen (2001) stressed that wetlands and adjacent uplands together are essential habitat for many semi-aquatic species. Boyd (2001) similarly recognizes sites adjacent to wetlands as part of the habitat base, and distinguishes between a fairly narrow zone of "general use," where feeding, basking, and some nesting may occur, and much wider zones reflecting the maximum travel distance reported for many species. Boyd determined that a buffer approximately 30 m wide is required to "provide some protection" to a large percentage of wetland-dependant species in Massachusetts, but does not meet the needs of a variety of animals that range well beyond that limit. Studies in other regions also have determined that much wider buffers may be required to accommodate the nesting or hibernation needs of many species, or to provide habitat for animals that spend the majority of their time in upland habitats, but must return to water to breed (Gibbons 2003). Recommended buffer widths for reptile and amphibian conservation range from 275 m for Carolina bay wetlands (Burke and Gibbons 1995) to 165 m in forest wetlands of Missouri (Semlitsch 1998) and 250 m in forest wetlands of central Tennessee (Miller 1995, Bailey and Bailey 2000).

The characteristics of the buffer zones (or adjacent habitats) determine whether they can be used effectively by the semi-aquatic species that depend on small wetlands of depressions, and along small and moderate-size streams. Because the "buffer" area is used as habitat for various activities, it should be dominated by native vegetation, and be without impediments to movement, such as busy roads, dense logging debris, or structures. Non-forest vegetation (such as old fields) in a naturally forested landscape can also represent a significant impediment to animal movement, particularly for emigrating juvenile amphibians (Rothermal and Semlitsch 2002).

General form of the assessment model

The model for assessing the “Provide Habitat for Fish and Wildlife” function includes the following assessment variables, which are discussed in greater detail in Chapter 6:

V_{FREQ}: Change in frequency of flooding

V_{DUR}: Change in growing season flood duration

V_{POND}: Micro-depressional ponding

V_{TCOMP}: Tree composition

V_{SNAG}: Snag density

V_{STRATA}: Number of vegetation layers

V_{TBA}: Tree basal area

V_{LOG}: Log density

V_{OHOR}: "O" horizon thickness

V_{PATCH}: Forest patch size

V_{BUF30}: Percent of wetland perimeter contiguous with a 30-m buffer zone

V_{BUF250}: Percent of wetland perimeter contiguous with a 250-m buffer zone

The model can be expressed in a general form:

$$FCI = \left\{ \left[\frac{(V_{FREQ} + V_{DUR} + V_{POND})}{3} \right] \times \left[\frac{(V_{TCOMP} + V_{STRATA} + V_{SNAG} + V_{TBA})}{4} \right] \times \left[\frac{(V_{LOG} + V_{OHOR})}{2} \right] \times \left[\begin{matrix} Landscape \\ Variables \end{matrix} \right] \right\}^{1/4} \quad (7)$$

The expressions within the model reflect the major habitat components described above. The first expression concerns hydrology, and includes indicators of both seasonal inundation, which allows river access by aquatic organisms (V_{DUR} and V_{FREQ}) as well as the periodic occurrence of temporary, isolated aquatic conditions (V_{POND}). This latter variable is not considered in assessments of High-Gradient Riverine systems, where ponding is not a common occurrence. The second expression includes four indicators of forest structure and diversity, specifically overstory basal area (V_{TBA}), overstory tree species composition (V_{TCOMP}), snag density (V_{SNAG}) and a measure of structural complexity (V_{STRATA}). Together these variables reflect a variety of conditions of importance to wildlife, including forest maturity and complexity, and the availability of food and cover. Habitat structure for animals associated with detrital components is indicated by two variables: the volume of logs per unit area (V_{LOG}) and the thickness of the O horizon (V_{OHOR}). Note that the litter layer, which is important to some species, is not included in the model due to its seasonality – instead, the O horizon is used as an indicator of litter accumulation, since it is a direct result of litter decay.

The final expression (Landscape Variables) may incorporate different terms, depending on the subclass being assessed. In the low-gradient riverine and flat subclasses, a single variable (V_{PATCH}) is used to represent the importance of large blocks of contiguous forest in systems that historically included hardwood wetlands. This focus is adopted to reflect regional and continental concerns about forest interior birds, as well as other animals adversely affected by habitat fragmentation. For high-gradient and mid-gradient riverine subclasses, the assessment of landscape characteristics focuses on the adequacy of buffer zones adjacent to the stream or wetland, particularly as they influence reptiles and amphibians. The expression incorporates consideration of a 30-m "general use" buffer zone (V_{BUF30}) as well as a 250-m buffer zone (V_{BUF250}) required to meet the specialized habitat requirements of many species.

5 Model Applicability and Reference Data

The assessment models described in Chapter 4 are applied to individual wetland subclasses in different ways. This is because not all of the assessment models and variables are applicable to all of the regional wetland subclasses. For example, the Detain Floodwater function and the Export Organic Carbon function are assessed for wetlands in the Riverine class, but not for the Hardwood Flat subclass, which does not interact with floodwaters and does not have a mechanism for exporting materials. Similarly, variables related to flood frequency and duration are not considered in assessing functions that are performed by Hardwood Flats, but do not involve flooding of those sites, such as the plant community and wildlife habitat functions. Also, the ponding variable used in some models is not considered in assessments of the High-Gradient Riverine system, as it is not a common feature on those sites under natural conditions. Finally, the landscape variables considered in the wildlife habitat model vary depending on the subclass under consideration.

Assessment models also differ among subclasses with regard to their associated reference data. Each subclass was the focus of detailed sampling during development of this guidebook, and the data collected for each subclass have been independently summarized for application. The following sections present information for each wetland subclass with regard to model applicability and reference data. For each subclass, each of the six potential functions available for assessment is listed, and the applicability of the assessment model is described. The model is identified as "Not Assessed" in cases where the wetland subclass does not perform the function as described in Chapter 4, or where it cannot be assessed with the methods and model available for rapid field assessment. For each wetland subclass, functional capacity subindex curves are presented for every assessment variable used in the applicable assessment models. The subindex curves were constructed based primarily on the field data, although published literature on old-growth forest characteristics (Meadows and Nowacki 1996, Batista and Platt 1997, Kennedy and Nowacki 1997, Tyrrell et al. 1998) and data from adjacent regions within Arkansas were used to resolve occasional ambiguities in the data set. Flood frequency and duration subindex curves are not based on field data, but rather are specifically designed to be used in situations where a project impact or change in land use is being assessed, and the "without project" condition is the reference condition.

Subclass: Hardwood Flat

Four functions are assessed for this subclass. The assessment models have been modified from the basic format presented in Chapter 4 to remove consideration of flood frequency and duration as variables. Figure 12 illustrates the relationship between the variable metrics and the subindex for each of the assessment models based on the reference data.

a. *Detain Floodwater*. Not Assessed

b. *Detain Precipitation*.

$$FCI = \frac{\left[V_{POND} + \frac{\left(V_{OHOR} + V_{LITTER}\right)}{2} \right]}{2} \tag{8}$$

c. *Cycle Nutrients*.

$$FCI = \frac{\left[\frac{\left(V_{TBA} + V_{SSD} + V_{GVC}\right)}{3} + \frac{\left(V_{OHOR} + V_{AHOR} + V_{WD} + V_{SNAG}\right)}{4} \right]}{2} \tag{9}$$

d. *Export Organic Carbon*. Not assessed.

e. *Maintain Plant Communities*. Applicable in the following modified format:

$$FCI = \left(\left\{ \frac{\left[\frac{\left(V_{TBA} + V_{TDEN}\right)}{2} + V_{COMP} \right]}{2} \right\} \times \left[\frac{\left(V_{SOIL} + V_{POND}\right)}{2} \right] \right)^{1/2} \tag{10}$$

f. *Provide Habitat for Fish and Wildlife.* Applicable in the following modified format:

$$FCI = \left\{ V_{POND} \times \left[\frac{\left(V_{TCOMP} + V_{STRATA} + V_{SNAG} + V_{TBA}\right)}{4} \right] \times \left[\frac{\left(V_{LOG} + V_{OHOR}\right)}{2} \right] \times V_{PATCH} \right\}^{1/4} \tag{11}$$

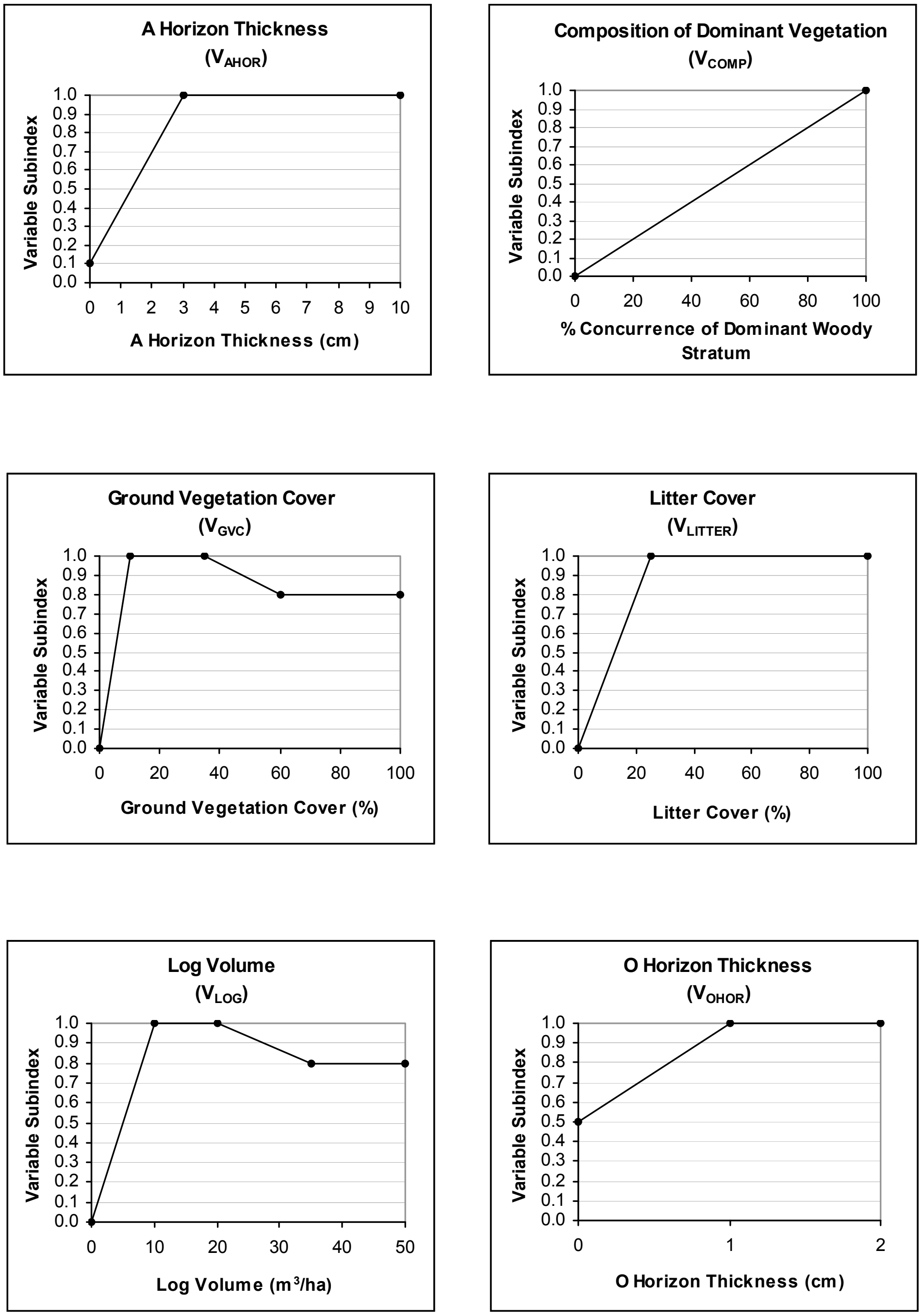

Figure 12. Subindex curves for Hardwood Flat wetlands (Sheet 1 of 3)

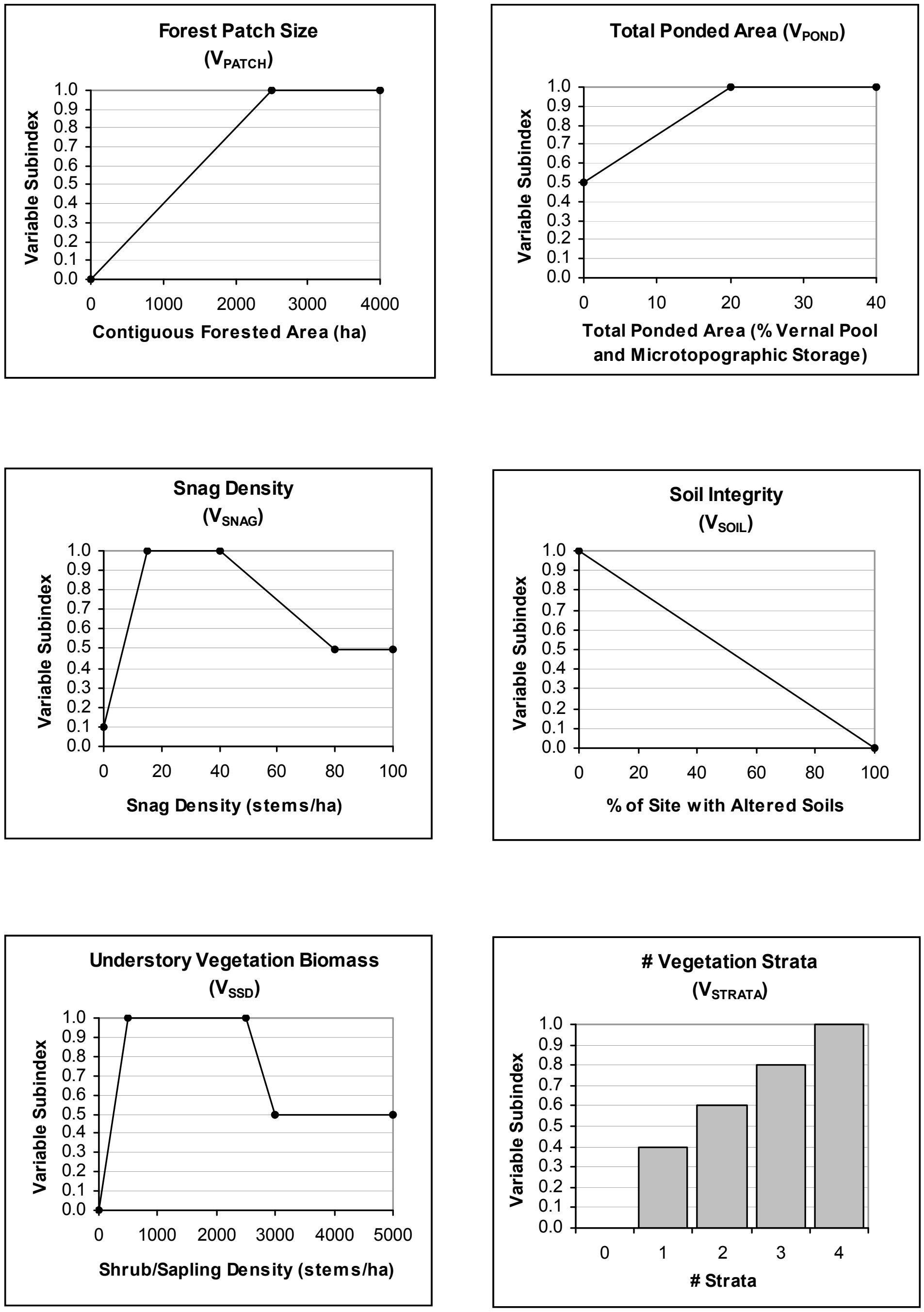

Figure 12. (Sheet 2 of 3)

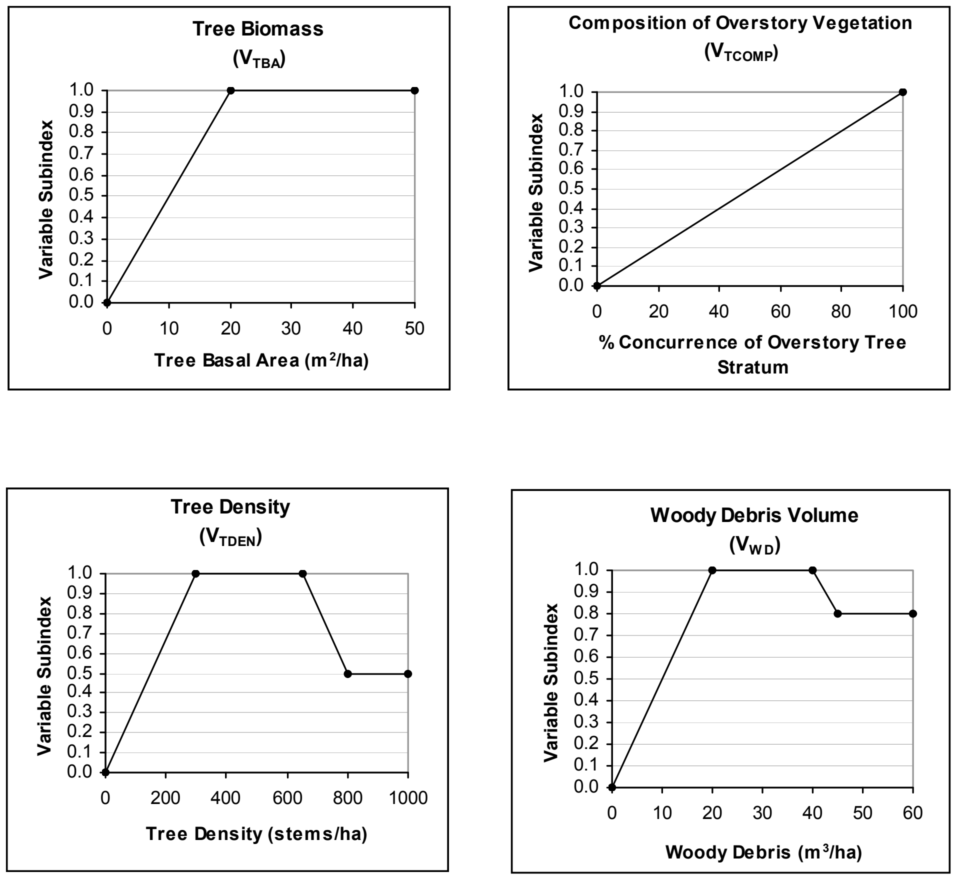

Figure 12. (Sheet 3 of 3)

Subclass: High-Gradient Riverine

All functions are assessed for this subclass using the general form of each assessment model presented in Chapter 4, except that ponding has been deleted as a variable. Figure 13 illustrates the relationship between the variable metrics and the subindex for each of the assessment variables based on the High-Gradient Riverine reference data.

a. Detain Floodwater

$$FCI = V_{FREQ} \times \left[\frac{(V_{LOG} + V_{GVC} + V_{SSD} + V_{TDEN})}{4} \right] \qquad (12)$$

b. Detain Precipitation

$$FCI = \frac{V_{OHOR} + V_{LITTER}}{2} \qquad (13)$$

c. Cycle Nutrients

$$FCI = \frac{\left[\frac{\left(V_{TBA} + V_{SSD} + V_{GVC} \right)}{3} + \frac{\left(V_{OHOR} + V_{AHOR} + V_{WD} + V_{SNAG} \right)}{4} \right]}{2} \tag{14}$$

d. Export Organic Carbon

$$FCI = V_{FREQ} \times \frac{\left[\frac{\left(V_{LITTER} + V_{OHOR} + V_{WD} + V_{SNAG} \right)}{4} \right] + \left[\frac{V_{TBA} + V_{SSD} + V_{GVC}}{3} \right]}{2} \tag{15}$$

e. Maintain Plant Communities

$$FCI = \left\langle \left\{ \frac{\left[\frac{\left(V_{TBA} + V_{TDEN} \right)}{2} + V_{COMP} \right]}{2} \right\} \times \left[\frac{\left(V_{SOIL} + V_{DUR} \right)}{2} \right] \right\rangle^{1/2} \tag{16}$$

f. Provide Habitat for Fish and Wildlife

$$FCI = \left\{ \left[\frac{\left(V_{FREQ} + V_{DUR} \right)}{2} \right] \times \left[\frac{\left(V_{TCOMP} + V_{STRATA} + V_{SNAG} + V_{TBA} \right)}{4} \right] \times \left[\frac{\left(V_{LOG} + V_{OHOR} \right)}{2} \right] \times \left[\frac{\left(V_{BUF30} + V_{BUF250} \right)}{2} \right] \right\}^{1/4} \tag{17}$$

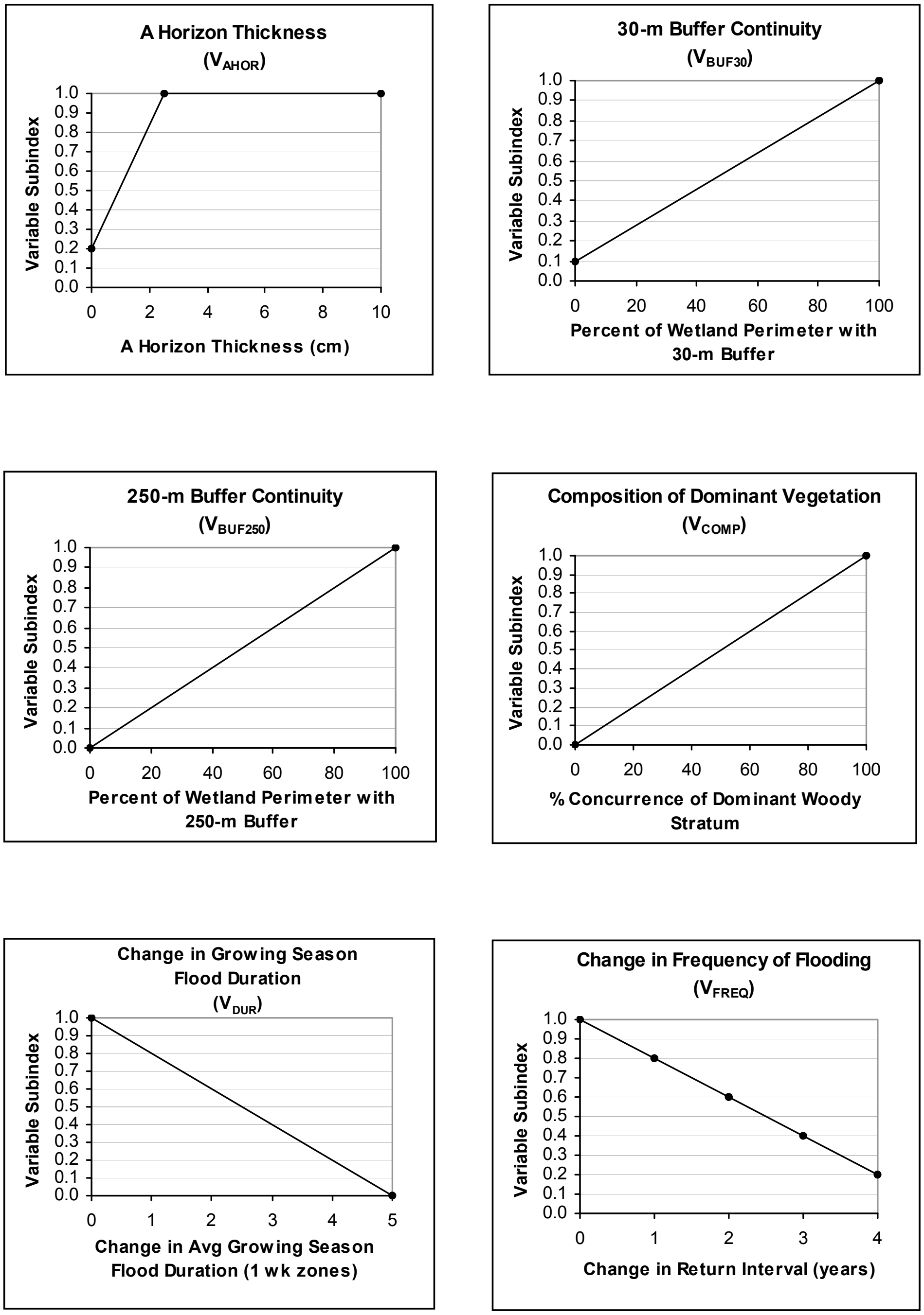

Figure 13. Subindex curves for High-gradient Riverine wetlands (Sheet 1 of 3)

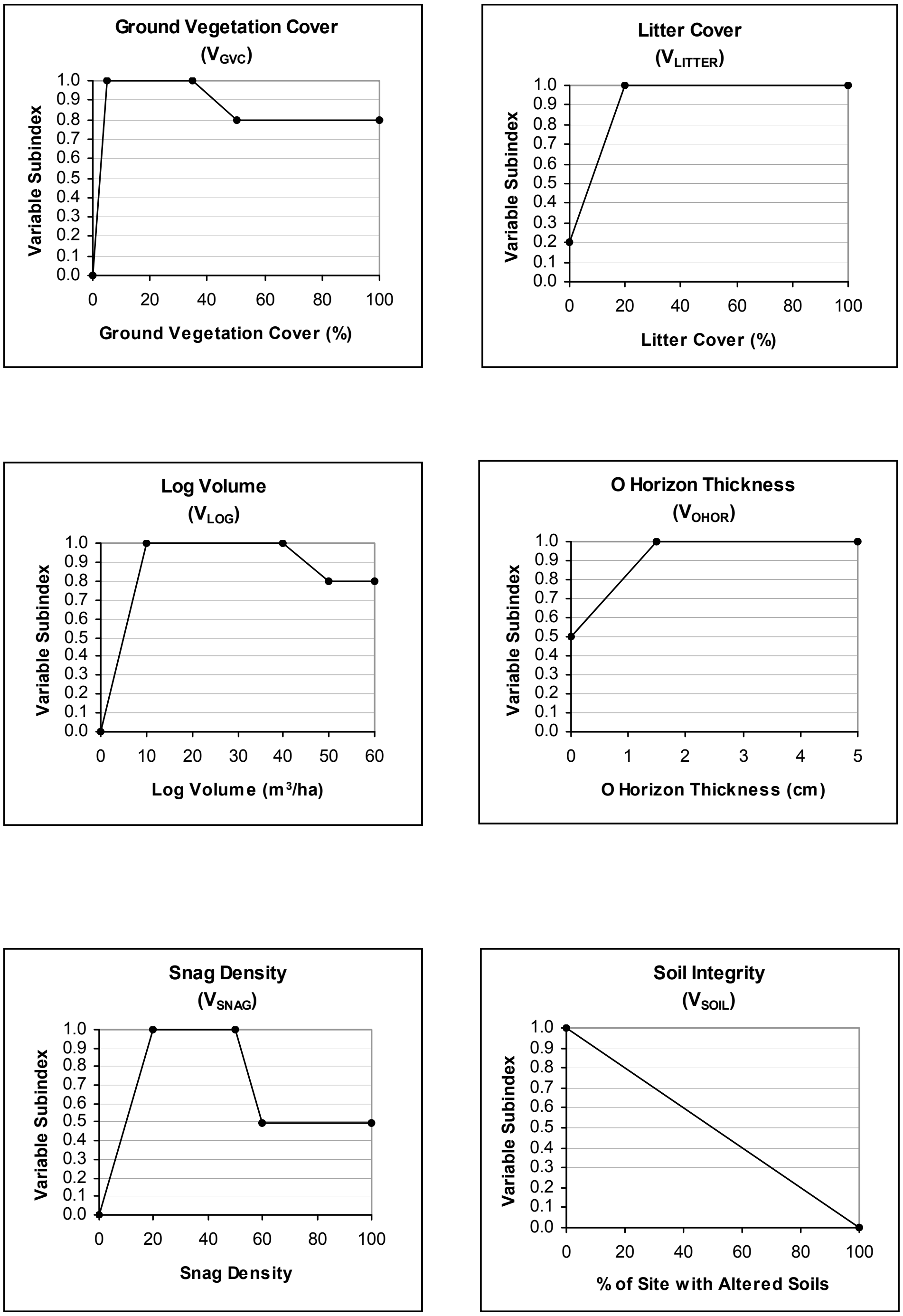

Figure 13. (Sheet 2 of 3)

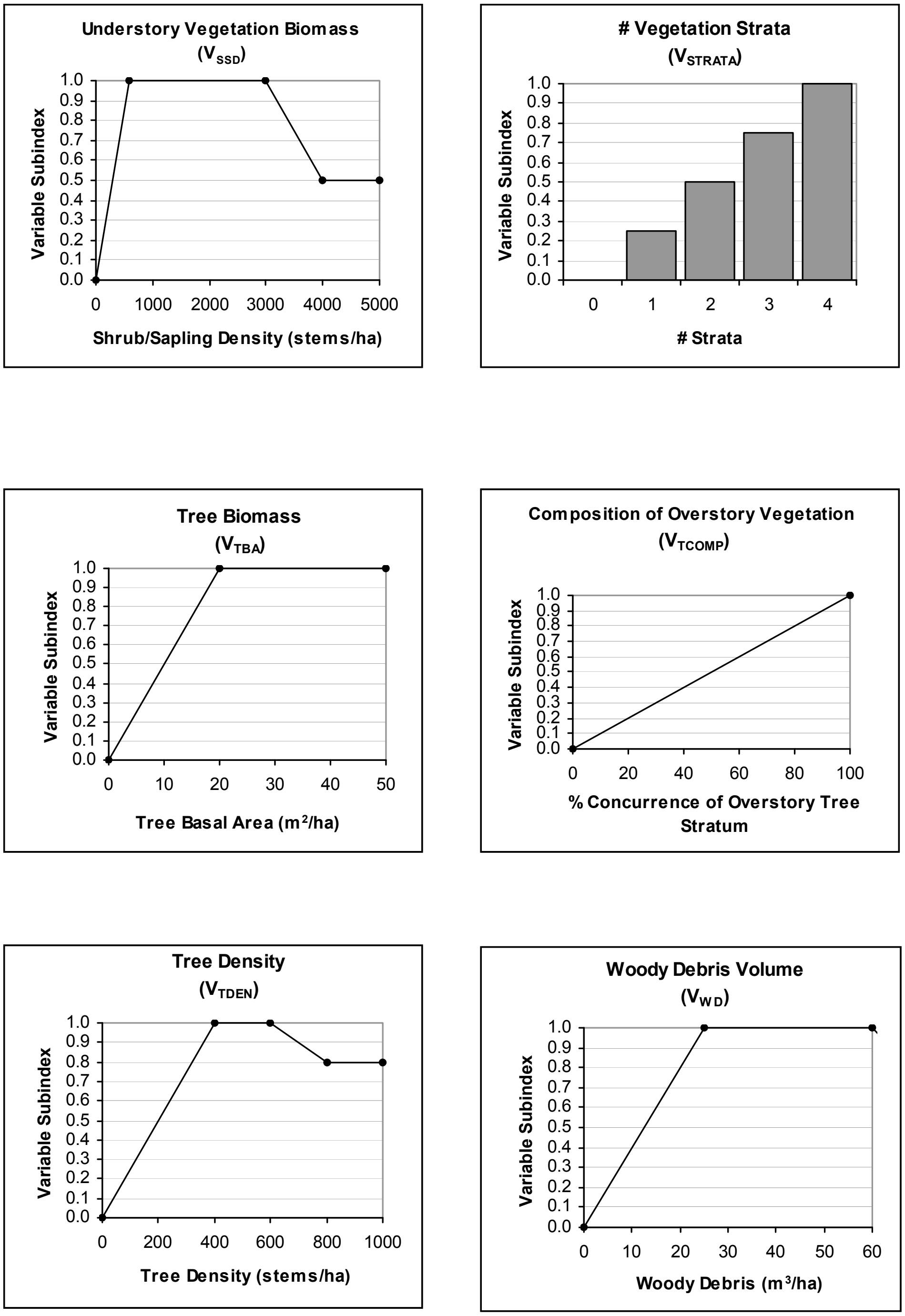

Figure 13. (Sheet 3 of 3)

Subclass: Mid-Gradient Riverine

All functions are assessed for this subclass using the general form of each assessment model presented in Chapter 4. Figure 14 illustrates the relationship between the variable metrics and the subindex for each of the assessment variables based on the mid-gradient riverine reference data.

a. Detain Floodwater

$$FCI = V_{FREQ} \times \left[\frac{(V_{LOG} + V_{GVC} + V_{SSD} + V_{TDEN})}{4} \right] \quad (12)$$

b. Detain Precipitation

$$FCI = \frac{\left[V_{POND} + \frac{(V_{OHOR} + V_{LITTER})}{2} \right]}{2} \quad (13)$$

c. Cycle Nutrients

$$FCI = \frac{\left[\frac{(V_{TBA} + V_{SSD} + V_{GVC})}{3} + \frac{(V_{OHOR} + V_{AHOR} + V_{WD} + V_{SNAG})}{4} \right]}{2} \quad (14)$$

d. Export Organic Carbon

$$FCI = V_{FREQ} \times \frac{\left[\frac{(V_{LITTER} + V_{OHOR} + V_{WD} + V_{SNAG})}{4} \right] + \left[\frac{V_{TBA} + V_{SSD} + V_{GVC}}{3} \right]}{2} \quad (15)$$

e. Maintain Plant Communities

$$FCI = \left\langle \left\{ \frac{\left[\frac{(V_{TBA} + V_{TDEN})}{2} + V_{COMP} \right]}{2} \right\} \times \left[\frac{(V_{SOIL} + V_{DUR} + V_{POND})}{3} \right] \right\rangle^{1/2} \quad (16)$$

f. Provide Habitat for Fish and Wildlife

$$FCI = \left\{ \left[\frac{(V_{FREQ} + V_{DUR} + V_{POND})}{3} \right] \times \left[\frac{(V_{TCOMP} + V_{STRATA} + V_{SNAG} + V_{TBA})}{4} \right] \times \left[\frac{(V_{LOG} + V_{OHOR})}{2} \right] \times \left[\frac{(V_{BUF30} + V_{BUF250})}{2} \right] \right\}^{1/4} \quad (17)$$

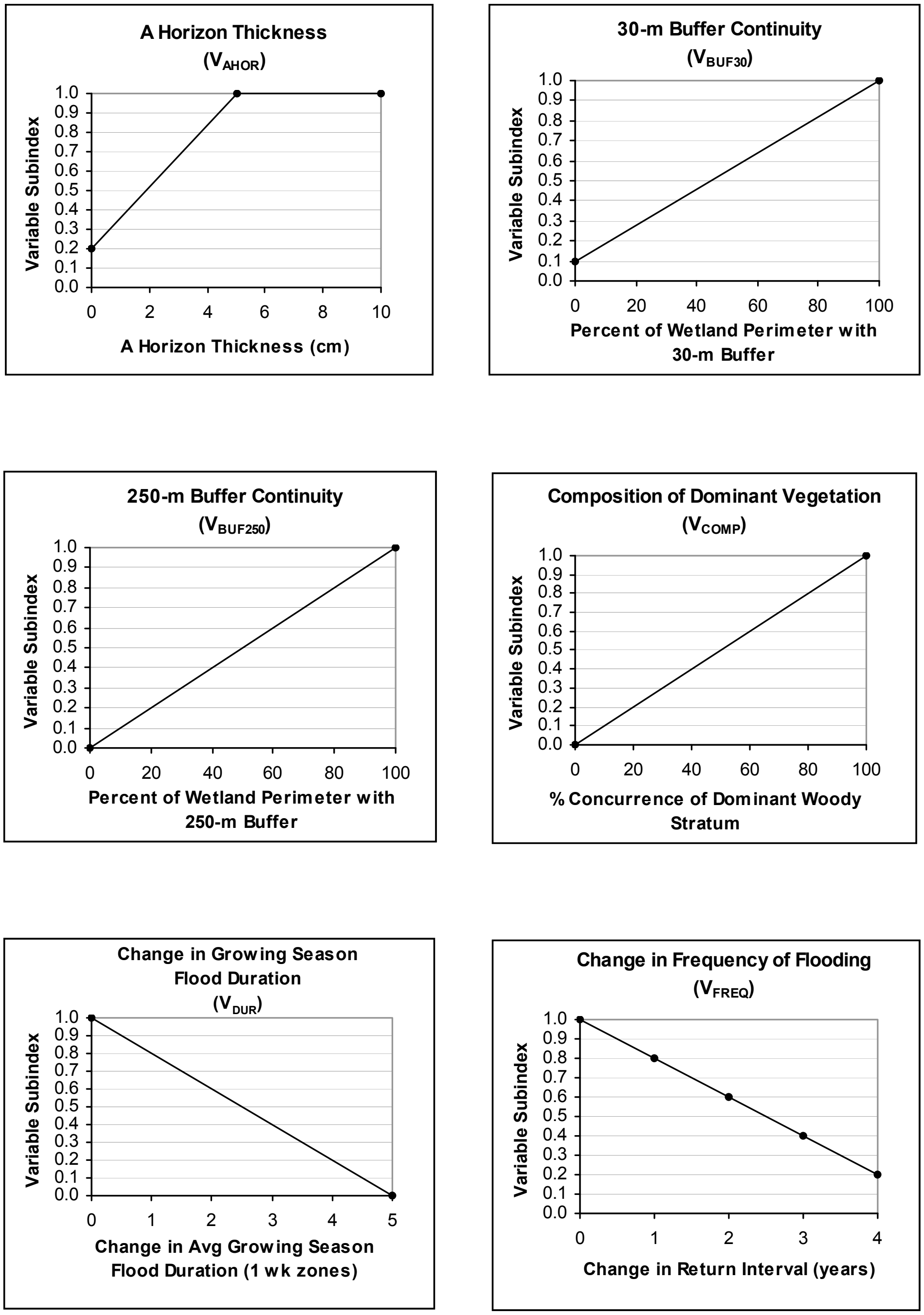

Figure 14. Subindex curves for Mid-gradient Riverine wetlands (Sheet 1 of 4)

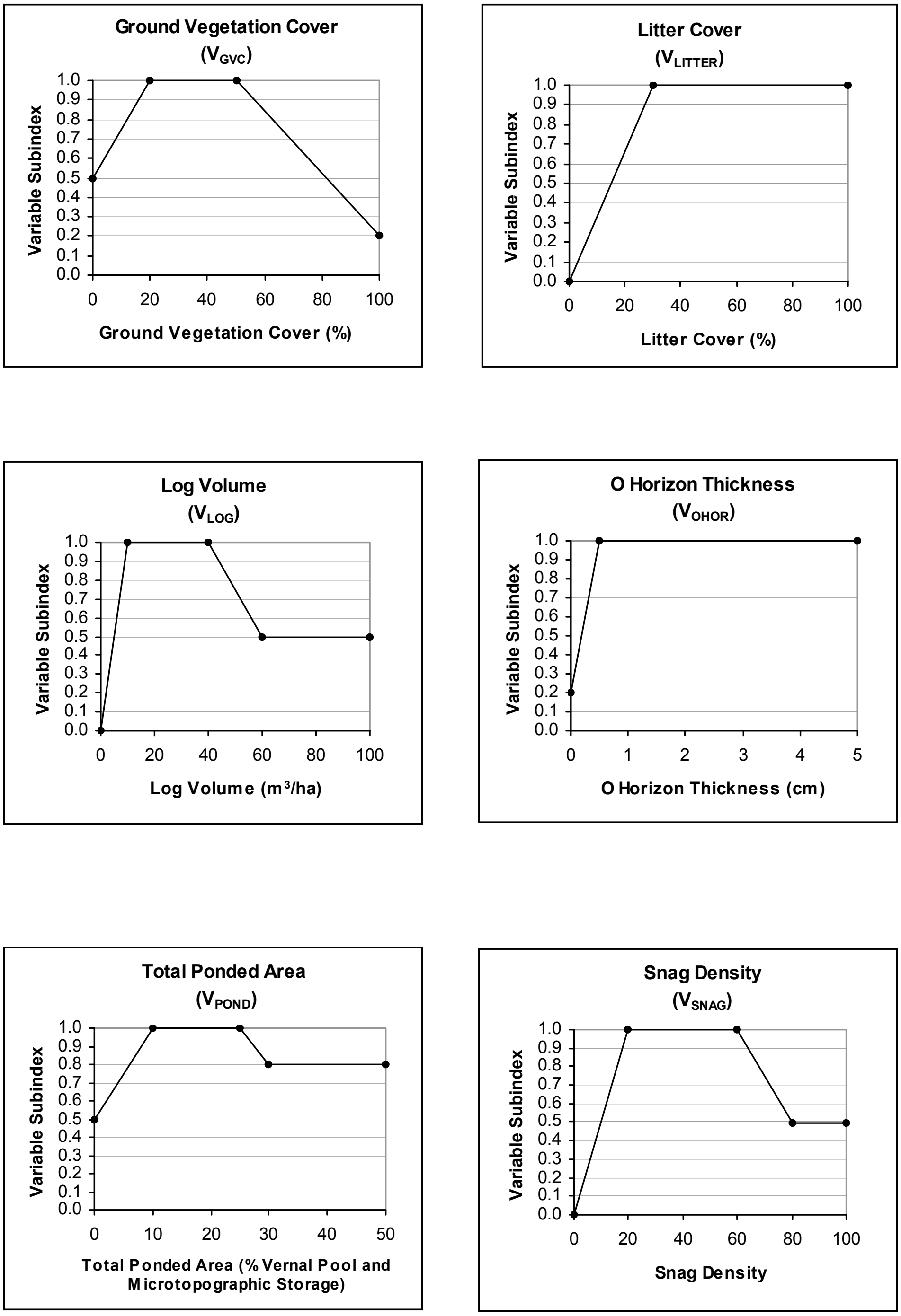

Figure 14. (Sheet 2 of 4)

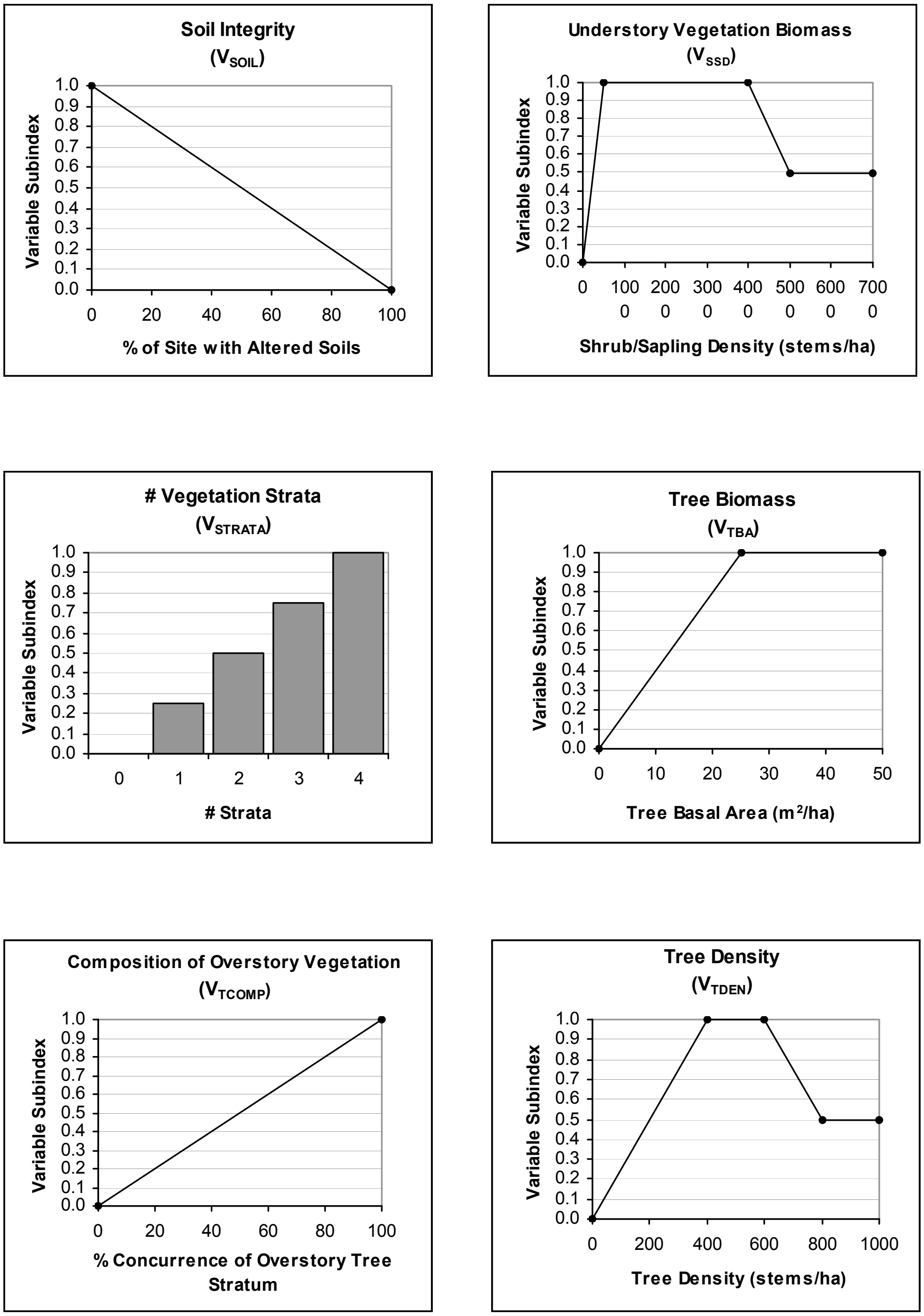

Figure 14. (Sheet 3 of 4)

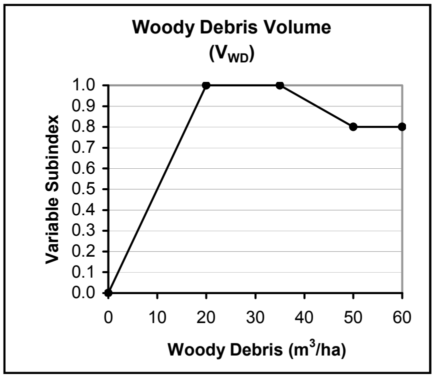

Figure 14. (Sheet 4 of 4)

Subclass: Low-Gradient Riverine

All functions are assessed for this subclass using the general form of each assessment model presented in Chapter 4 as follows. Figure 15 illustrates the relationship between the variable metrics and the subindex for each of the assessment variables based on the riverine overbank reference data.

a. Detain Floodwater.

$$FCI = V_{FREQ} \times \left[\frac{\left(V_{LOG} + V_{GVC} + V_{SSD} + V_{TDEN} \right)}{4} \right] \quad (18)$$

b. Detain Precipitation.

$$FCI = \frac{\left[V_{POND} + \frac{\left(V_{OHOR} + V_{LITTER} \right)}{2} \right]}{2} \quad (19)$$

c. Cycle Nutrients.

$$FCI = \frac{\left[\frac{\left(V_{TBA} + V_{SSD} + V_{GVC} \right)}{3} + \frac{\left(V_{OHOR} + V_{AHOR} + V_{WD} + V_{SNAG} \right)}{4} \right]}{2} \quad (20)$$

d. Export Organic Carbon.

$$FCI = V_{FREQ} \times \frac{\left[\frac{\left(V_{LITTER} + V_{OHOR} + V_{WD} + V_{SNAG} \right)}{4} \right] + \left[\frac{V_{TBA} + V_{SSD} + V_{GVC}}{3} \right]}{2} \quad (21)$$

e. Maintain Plant Communities.

$$FCI = \left\langle \left\{ \frac{\left[\frac{\left(V_{TBA} + V_{TDEN} \right)}{2} + V_{COMP} \right]}{2} \right\} \times \left[\frac{\left(V_{SOIL} + V_{DUR} + V_{POND} \right)}{3} \right] \right\rangle^{1/2} \quad (22)$$

f. Provide Habitat for Fish and Wildlife.

$$FCI = \left\{ \left[\frac{\left(V_{FREQ} + V_{DUR} + V_{POND} \right)}{3} \right] \times \left[\frac{\left(V_{TCOMP} + V_{STRATA} + V_{SNAG} + V_{TBA} \right)}{4} \right] \times \left[\frac{\left(V_{LOG} + V_{OHOR} \right)}{2} \right] \times V_{PATCH} \right\}^{1/4} \quad (23)$$

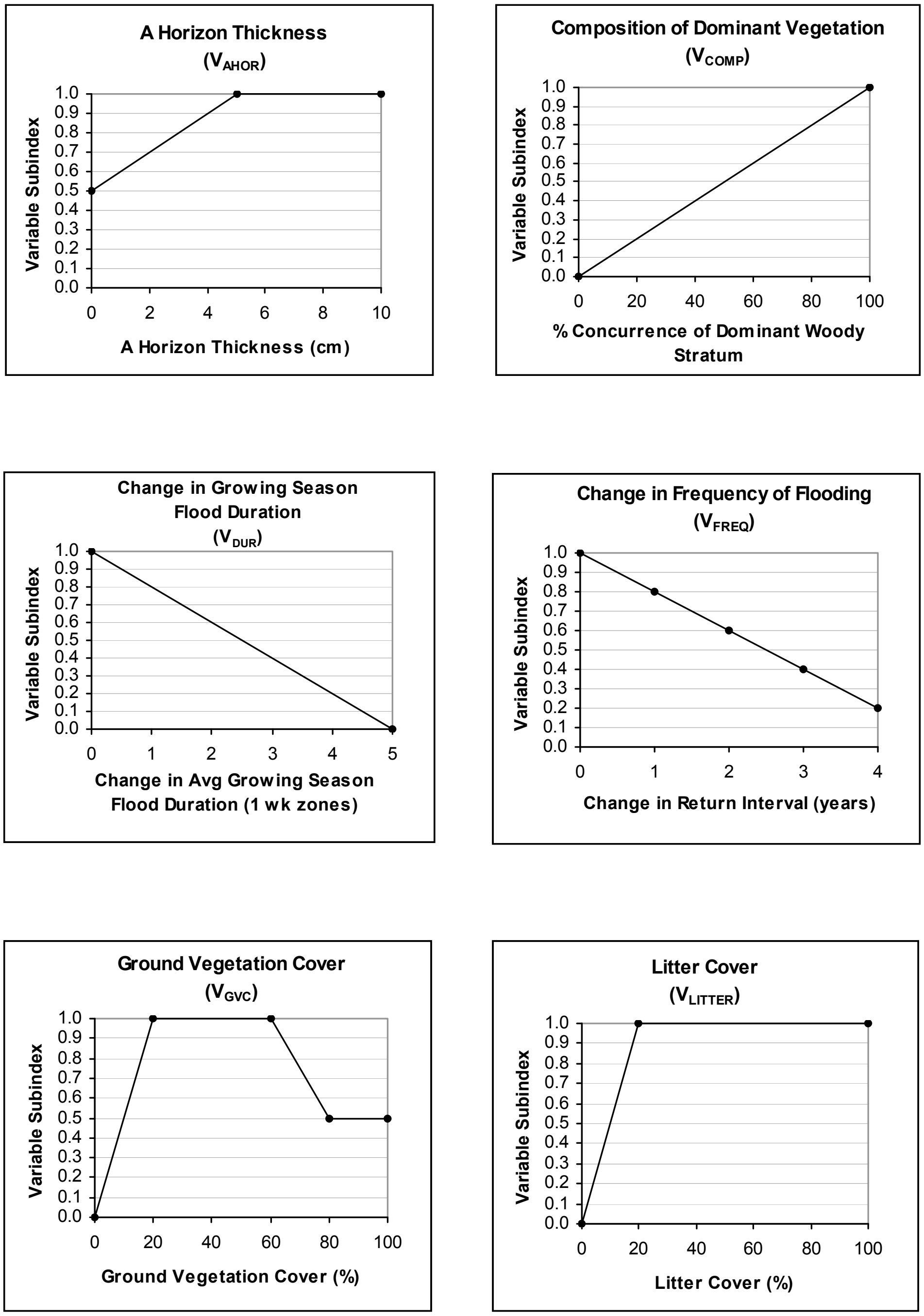

Figure 15. Subindex graphs for Low-Gradient Riverine wetlands (Sheet 1 of 3)

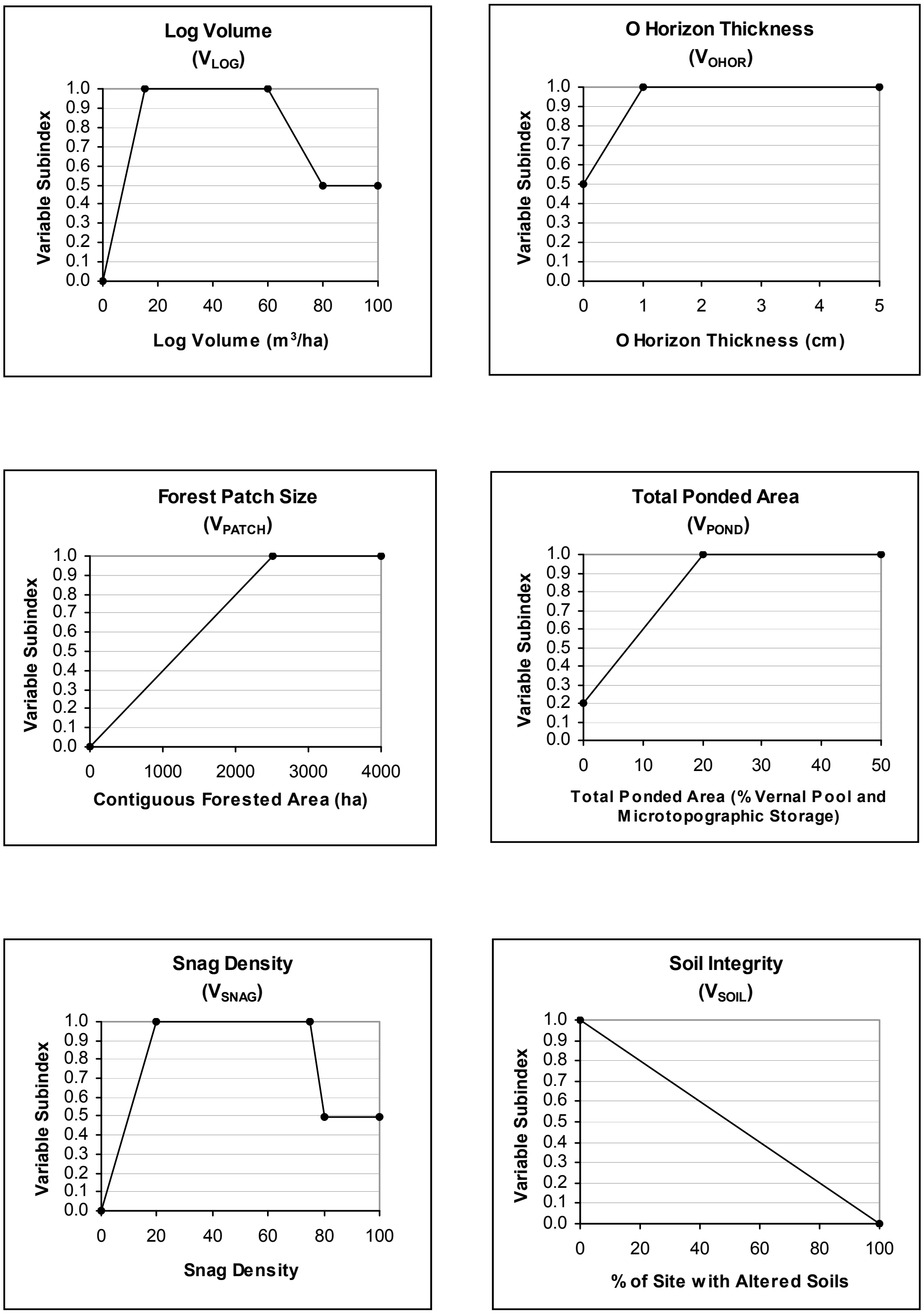

Figure 15. (Sheet 2 of 3)

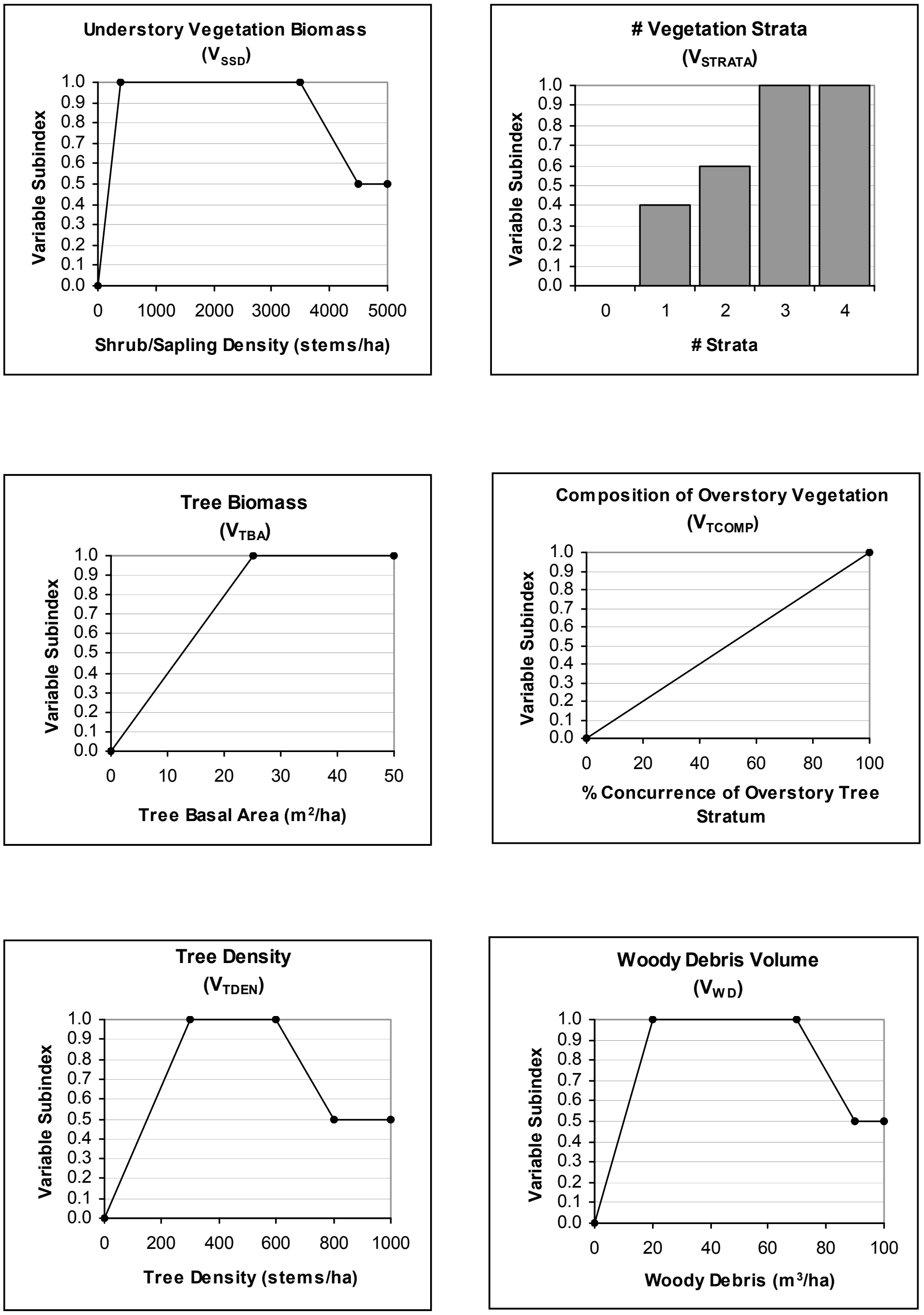

Figure 15. (Sheet 3 of 3)

6 Assessment Protocol

Introduction

Previous chapters of this Regional Guidebook have provided background information on the HGM approach, characterized regional wetland subclasses, and documented the variables, functional indices, and assessment models used to assess regional wetland subclasses in the Ozark Mountains Region of Arkansas. This chapter outlines the procedures for collecting and analyzing the data required to conduct an assessment.

In most cases, permit review, restoration planning, and similar assessment applications require that pre- and post-project conditions of wetlands at the project site be compared to estimate the loss or gain of function associated with the project. Both the pre- and post-project assessments should be completed at the project site before the proposed project has begun. Data for the pre-project assessment represents existing conditions at the project site, while data for the post-project assessment is normally based on a prediction of the conditions that can reasonably be expected to exist following proposed project impacts. A well-documented set of assumptions should be provided with the assessment to support the predicted post-project conditions used in making an assessment.

Where the proposed project involves wetland restoration or compensatory mitigation, this guidebook can also be used to assess the functional effectiveness of the proposed actions. The final section of this chapter provides recovery trajectory curves for selected variables that may be employed in that analysis.

A series of tasks are required to assess regional wetland subclasses in the Ozark Mountains Region of Arkansas using the HGM Approach:

- document the project purpose and characteristics
- screen for red flags
- define assessment objectives and identify regional wetland subclass(es) present, and assessment area boundaries
- collect field data
- analyze field data
- document assessment results
- apply assessment results

The following sections discuss each of these tasks in greater detail.

Document the Project Purpose and Characteristics

Data Form A1 (Project Information and Documentation – Appendix A) provides a checklist of information needed to conduct a complete assessment, and serves as a cover sheet for all compiled assessment maps, drawings, data forms, and other information. It requires a project name and identification of personnel involved in the assessment. It then prompts users to attach supporting information and documentation. The first step in this process is to develop a narrative explanation of the project, with supporting maps and graphics. This should include a description of the project purpose and project area features, which can include information on location, climate, surficial geology, geomorphic setting, surface and groundwater hydrology, vegetation, soils, land use, existing cultural alteration, proposed impacts, and any other characteristics and processes that have the potential to influence how wetlands at the project area perform functions. The accompanying maps and drawings should indicate the locations of the project area boundaries, jurisdictional wetlands, wetland assessment areas (see below), proposed impacts, roads, ditches, buildings, streams, soil types, plant communities, threatened or endangered species habitats, and other important features.

Many sources of information will be useful in characterizing a project area:

- aerial photographs
- topographic maps
- geomorphic maps
- county soil survey
- National Wetland Inventory maps
- Flood frequency maps
- Chapter 3 of this Regional Guidebook

For large projects or complex landscapes, it is usually a good idea to use aerial photos, flood maps, and geomorphic information to develop a preliminary classification of wetlands for the project area and vicinity prior to going to the field. Figure 16 illustrates this process for a typical lowland wetland complex. The rough wetland map can then be taken to the field to refine and revise the identification of wetland subclasses.

Attach the completed Project Description and supporting materials to Data Form A1.

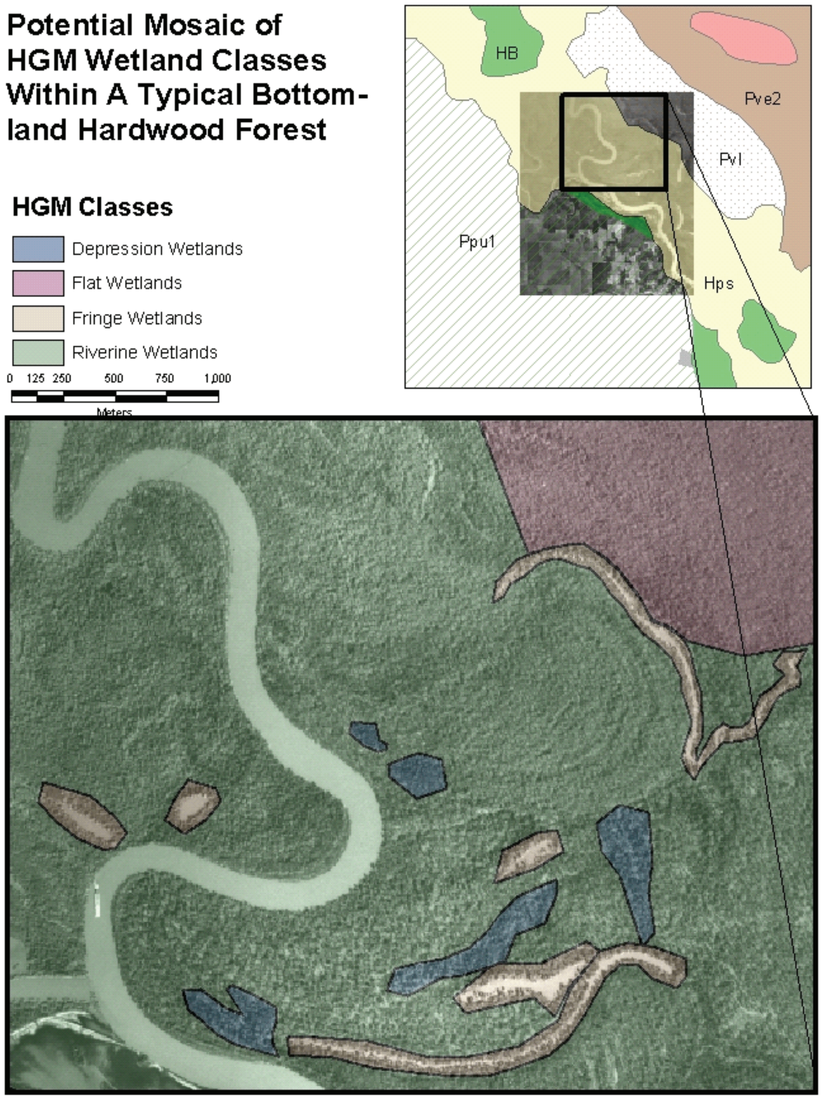

Figure 16. Example application of geomorphic mapping and aerial photography to develop a preliminary wetland classification for a proposed project area.

Screen for Red Flags

Red flags are features in the vicinity of the project area to which special recognition or protection has been assigned on the basis of objective criteria (Table 6). Many red flag features, based on national criteria or programs, are similar from region to region. Other red flag features are based on regional or local criteria. Screening for red flag features determines if the wetlands or other natural resources around the project area require special consideration or attention that may preempt or postpone conducting a wetland assessment. For example, if a proposed project has the potential to adversely affect threatened or endangered species, an assessment may be unnecessary since the project may be denied or modified based on the impacts to the protected species alone.

Table 6 Red Flag features and respective program/agency authority	
Red Flag Features	**Authority[1]**
Native lands and areas protected under American Indian Religious Freedom Act	A
Hazardous waste sites identified under CERCLA or RCRA	I
Areas providing critical habitat for species of special concern	C
Areas covered under the Farmland Protection Act	K
Floodplains, floodways, or floodprone areas	J
Areas with structures/artifacts of historic or archeological significance	G
Areas protected under the Land and Water Conservation Fund Act	K
National Wildlife Refuges and special management areas	C
Areas identified in the North American Waterfowl Management Plan	C, F
Areas identified as significant under the RAMSAR Treaty	H
Areas supporting rare or unique plant communities	C, H
Areas designated as sole source groundwater aquifers	I, L, M
Areas protected by the Safe Drinking Water Act	E, I, L
City, County, State, and National Parks	B, D, H, L
Areas supporting threatened or endangered species	C, F, H, I
Areas with unique geological features	H
Areas protected by the Wild and Scenic Rivers Act or Wilderness Act	D
State wetland mitigation banks	M

[1] Program Authority / Agency
A = Bureau of Indian Affairs
B = Arkansas State Parks
C = U.S. Fish and Wildlife Service
D = National Park Service (NPS)
E = Arkansas Department of Environmental Quality
F = Arkansas Game and Fish Commission
G = State Historic Preservation Officer (SHPO)
H = Arkansas Natural Heritage Commission
I = U.S. Environmental Protection Agency
J = Federal Emergency Management Administration
K = Natural Resource Conservation Service
L = Local Government Agencies
M = Arkansas Natural Resources Commission

Define Assessment Objectives, Identify Regional Wetland Subclass(es) Present, and Identify Assessment Area Boundaries

Begin the assessment process by unambiguously stating the objective of conducting the assessment. Most commonly, this will simply determine how a proposed project will impact wetland functions; however, there are other potential objectives:

- compare several wetlands as part of an alternatives analysis
- identify specific actions that can be taken to minimize project impacts
- document baseline conditions at a wetland site
- determine mitigation requirements
- determine mitigation success
- evaluate the likely effects of a wetland management technique

Frequently, there will be multiple objectives, and defining these objectives in a clear and concise manner will facilitate communication and understanding among those involved in conducting the assessment, as well as other interested parties. In addition, it will help to define the specific approach and level of effort that will be required to conduct assessments. For example, the specific approach and level of effort will vary depending on whether the project is a 404 individual permit review, an Advanced Identification (ADID) project, a Special Area Management Plan (SAMP), or some other assessment scenario.

Figures 17 through 20 present a simplified project scenario to illustrate the steps used to designate the boundaries of Wetland Assessment Areas, each of which will require a separate HGM assessment. Figure 17 illustrates a land cover map for a hypothetical project area. Figure 18 shows the project area (in yellow) superimposed on the land cover map. To determine the boundaries of the Wetland Assessment Areas, first use the Key to Wetland Classes (Figure 8) and the wetland subclass descriptions (Table 4) to identify the wetland subclasses within and contiguous to the project area (Figure 19). Overlay the project area boundary and the wetland subclass boundaries to identify the Wetland Assessment Areas for which data will be collected (Figure 20). Attach these maps, photos, and drawings to Data Form A1 and complete the first three columns of the table on Data Form A1 by assigning an identifying number to each Wetland Assessment Area (WAA), specifying the subclass it belongs to, and calculating the area (hectares).

Each WAA is a portion of the project area that belongs to a single regional wetland subclass and is relatively homogeneous with respect to the criteria used to assess wetland functions (i.e., hydrologic regime, vegetation structure, topography, soils, successional stage). However, as the size and heterogeneity of the project area increase, it is more likely that it will be necessary to define and assess multiple WAAs within a project area.

At least three situations can be identified that necessitate defining and assessing multiple WAAs within a project area. The first situation occurs when widely separated areas of wetlands, belonging to the same regional subclass, occur in the project area. Such non-contiguous wetlands must be designated as separate Wetland Assessment Areas, because the assessment process includes consideration of the size and isolation of individual wetland units. The second situation occurs where more than one regional wetland subclass occurs within a project area, as illustrated in Figure 19, where both Flat and Riverine wetlands are present within the project area. These must be separated because they are

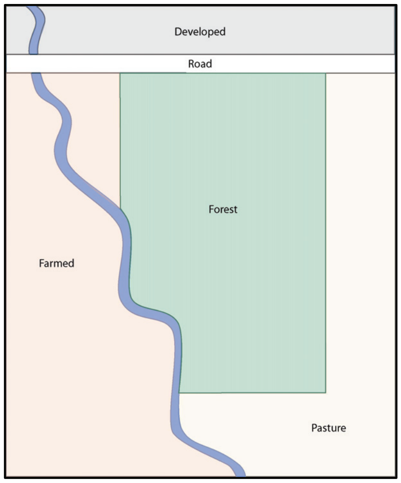

Figure 17. Land cover

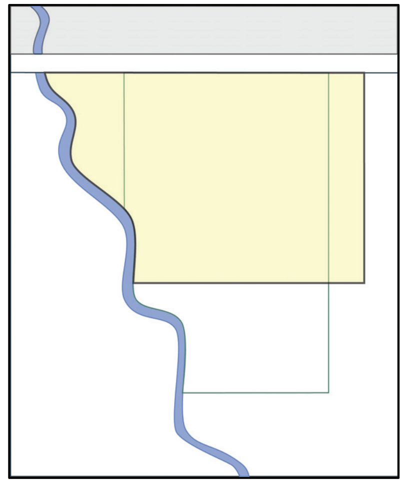

Figure 18. Project area (in yellow)

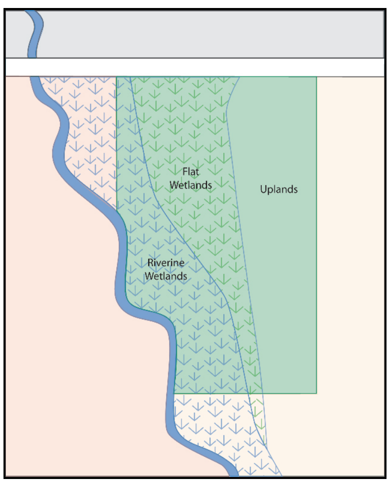

Figure 19. Wetland subclasses. Birds-foot symbols indicate extent of wetlands

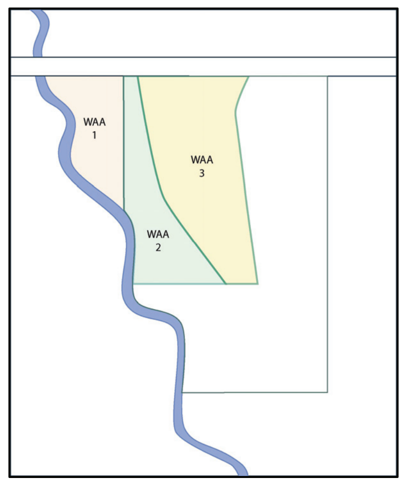

Figure 20. Wetland Assessment Areas

assessed using different models and reference data systems. The third situation occurs where a contiguous wetland area of the same regional subclass exhibits spatial heterogeneity in terms of hydrology, vegetation, soils, or other assessment criteria. This is illustrated in Figure 20, where the area designated as Riverine Wetlands in Figure 19 is further subdivided into two Wetland Assessment Areas based on land use and vegetation cover. The farmed area clearly will have different characteristics than the forested wetland, and they will be assessed separately (though using the same models and reference data).

In the Ozark Mountains Region of Arkansas, wetlands tend to be small and do not often occur as extensive tracts of land with interspersed regional subclasses (such as depressions scattered within a matrix of flats or riverine wetlands). However, even in relatively small wetlands composed of a single wetlands). However, even in relatively small wetlands composed of a single regional subclass there may be distinctly different land use influences that produce different land cover. These may be significant enough to warrant the designation of more than one Wetland Assessment Area. However, caution should be taken in splitting a project area into many Wetland Assessment Areas based on relatively minor differences, such as local variation due to canopy gaps and edge effects. The reference curves used in this document (Chapter 5) incorporate such variation, and splitting areas into numerous Wetland Assessment Areas based on subtle differences will not materially change the outcome of the assessment. It will, however, greatly increase the sampling and analysis requirements. Field experience in the region should provide a sense of the range of variability that typically occurs, and is sufficient to make reasonable decisions in defining multiple WAAs.

Collect Field Data

Information on the variables used to assess the functions of regional wetland subclasses in the Ozark Mountains Region of Arkansas is collected at several different spatial scales, and requires several summarization steps. The checklists and data forms in the Appendices are designed to assist the assessment team in assembling the required materials and proceeding in an organized fashion. As noted above, the Project Description and Assessment Documentation Form (Appendix A1) is intended to be used as a cover sheet and for an overview of all documents and data forms used in the assessment. Assembling the background information listed on this form should guide the assessment team in determining the number, types, and sizes of the separate Wetland Assessment Areas likely to be designated within the project area (see above). Based on that information, the field gear and data form checklists in Appendix A2 should be used to assemble the needed materials before heading to the field to conduct the assessment.

Note that different wetland subclasses require different field data forms, because the assessment variables differ among subclasses (Table 7). Use the Data Form checklist in Appendix A2 to determine how many of each form are needed, then make copies of the required forms, which are provided in Appendix B.

The Data Forms provided in Appendix B are organized to facilitate data collection at each of the several spatial scales of interest. For example, the first group of variables on Data Form 1 contains information about landscape scale characteristics collected using aerial photographs, maps, and hydrologic information regarding each WAA and vicinity. Information on the second group of variables on Data Form 1 is collected during a walking reconnaissance of the WAA. Data collected for these two groups of variables are entered directly on the data forms, and do not require plot-based sampling. Information on the next group of variables is collected in sample plots placed in representative locations throughout the WAA. Data from a single plot are recorded on Data Form 2, which is made up of three separate data sheets. Additional copies of Data Form 2

Table 7 Applicability of Assessment Variables by Regional Wetland Subclass				
Variable Code	**Flat**	**High-Gradient Riverine**	**Mid-Gradient Riverine**	**Low-Gradient Riverine**
V_{AHOR}	+	+	+	+
V_{BUF30}	not used	+	+	not used
V_{BUF250}	not used	+	+	not used
V_{COMP}	+	+	+	+
V_{DUR}	not used	+	+	+
V_{FREQ}	not used	+	+	+
V_{GVC}	+	+	+	+
V_{LITTER}	+	+	+	+
V_{LOG}	+	+	+	+
V_{OHOR}	+	+	+	+
V_{PATCH}	+	not used	not used	+
V_{POND}	+	not used	+	+
V_{SNAG}	+	+	+	+
V_{SOIL}	+	+	+	+
V_{SSD}	+	+	+	+
V_{STRATA}	+	+	+	+
V_{TBA}	+	+	+	+
V_{TCOMP}	+	+	+	+
V_{TDEN}	+	+	+	+
V_{WD}	+	+	+	+
Note: Variables not used in assessment of a particular subclass are identified as such. Variables always used in assessment of the subclass are indicated by +.				

are completed for each plot sampled within the WAA. All summary data from each of the data forms are compiled on Data Form 3 prior to entry into the spreadsheets that calculate the functional capacity of the wetland being assessed.

The sampling procedures for conducting an assessment require few tools, but you will need certain tapes, a shovel, specialized basal area estimation or measurement tools, reference materials, and an assortment of other items (Appendix A2). Generally, all measurements should be taken in metric units (although English equivalents are indicated for most sampling criteria such as plot sizes). Collecting data in English units will require conversion of sample data to metric before completing the necessary calculations of entering data into spreadsheets for summarization. There are two exceptions to this general rule: the recommended basal area prism is an English 10-factor prism, which is an appropriate size for use in the forests of the Ozark Mountains Region. A conversion factor is built into the data form to make the needed adjustments to the recorded field data. The second instance involves use of a diameter tape for basal area measurement, which is an alternative approach to the prism method. Because English dbh tapes are more widely available than metric tapes, the summarization spreadsheets provided in Appendix D are able to accept either English or metric units as input data.

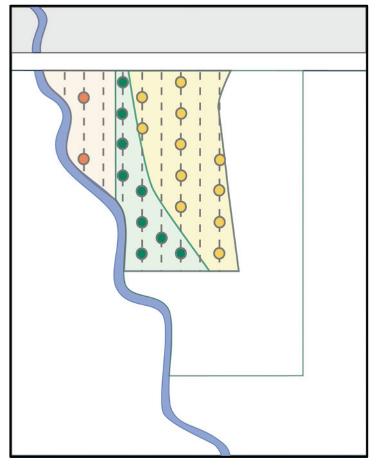

Figure 21. Example sample distribution. Refer to Figure 20 for WAA designations.

A typical layout for the establishment of sample plots and transects in the hypothetical Wetland Assessment Areas is shown in Figure 21. As in defining the WAA, there are elements of subjectivity and practicality in determining the number of sample locations for collecting plot-based and transect-based site-specific data. The exact numbers and locations of the plots and transects are dictated by the size and heterogeneity of the WAA. If the WAA is relatively small (i.e., less than 2-3 acres, or about a hectare) and homogeneous with respect to the characteristics and processes that influence wetland function, then three or four 0.04-ha plots, with associated nested transects and subplots in representative locations, are probably adequate to characterize the Wetland Assessment Area. Experience has shown that the time required to complete an assessment of an area that size is 2-4 hr, depending primarily on the experience of the assessment team. However, as the size and heterogeneity of the wetland assessment area increase, more sample plots are required to accurately represent the site. Large forested wetland tracts usually include a mix of tree age classes, scattered small openings in the canopy that cause locally dense understory or ground cover conditions, and perhaps some very large individual trees or groups of old-growth trees. The sampling approach should not bias data collection to differentially emphasize or exclude any of these local conditions, but to represent the site as a whole. Therefore, on large sites the best approach often is a simple systematic plot layout, where evenly spaced parallel transects are established (using a compass and pacing) and sample plots are distributed at regular paced intervals along those transects. For example, a 12-ha tract, measuring about 345 m on each side, might be sampled using two transects spaced 100 m apart (and 50 m from the tract edge), with plots at 75-m intervals along each transect (starting 25 m from the tract edge). This would result in eight sampled plot locations, which should be adequate for a relatively diverse 12-ha forested wetland area. On Figure 21, WAA 2 illustrates this approach for establishing fairly high-density, uniformly distributed samples. Larger or more uniform sites can usually be sampled at a lower plot density. One approach is to establish a series of transects, as described above, and sample at intervals along alternate transects (see WAA 3 on Figure 21). Continue until the entire site has been sampled at a low plot density, then review the data and determine if the variability in overstory composition and basal area has been largely accounted for. That is, as the number of plots sampled increases, are new dominant species no longer encountered, and has the average basal area for the site changed markedly with the addition of recent samples? If not, there is probably no need to add further samples to the set. If overstory structure and composition variability remain high, then return to the alternate, unsampled transects and continue sampling until the data set is representative of the site as a whole, as indicated by a "leveling off" of the dominant species list and basal area values. Other variables may "level off " more quickly or slowly than tree composition and basal area, but these two factors are generally good indicators, and correspond well to the overall suite of characteristics of interest within a particular Wetland Assessment Area. In some cases, such as sites where trees have been planted or composition and structure are highly uniform (e.g. sites dominated by a single tree species), it may be apparent that relatively few samples are adequate to reasonably characterize the wetland. In Figure 21, this is illustrated by the sample distribution in WAA 1, which is a farmed area where few variables are likely to be measurable, or at least will vary little from plot to plot. In this case, every other plot location is sampled along every other transect.

The information on Data Form 1 and on the multiple copies of Data Form 2 is transferred to Data Form 3, where it is summarized and used as input to the spreadsheet that calculates Functional Capacity Index values and Functional Capacity Units for each WAA. All of the field and summary data forms, as well as the printed output from the final spreadsheet calculations, should be attached to the Project Information and Assessment Documentation Form provided in Appendix A. Appendix C provides alternate data forms that may be needed in cases where alternative field methods are used, or where the user wishes to calculate summary data by hand, rather than using the spreadsheets. The use of these forms is explained on the forms themselves, and in the pertinent variable descriptions below. Appendix D contains the spreadsheets (in Excel format) that are recommended for completing the data summary calculations. Appendix F is a listing of common and scientific names of tree and shrub species that are referenced on the field data forms.

Detailed instructions on collecting the data for entry on Data Forms 1 and 2 are provided below. Where plot and point samples are required, refer to the plot layout diagram in Figure 22. Variables are listed in alphabetical order by variable codes to facilitate locating them. Each set of directions results in an overall WAA value for the variable entered on Data Form 3. Those numbers are then used in the final spreadsheet (Appendix D) to complete the assessment calculations. Not all variables are used to assess all subclasses, as described in Chapter 5 and Table 7, but the data forms in Appendix B indicate which variables are pertinent to each subclass. The data forms also provide brief summaries of the methods used to assess each variable, but the user should read through these more detailed descriptions and have them available in the field for reference as necessary.

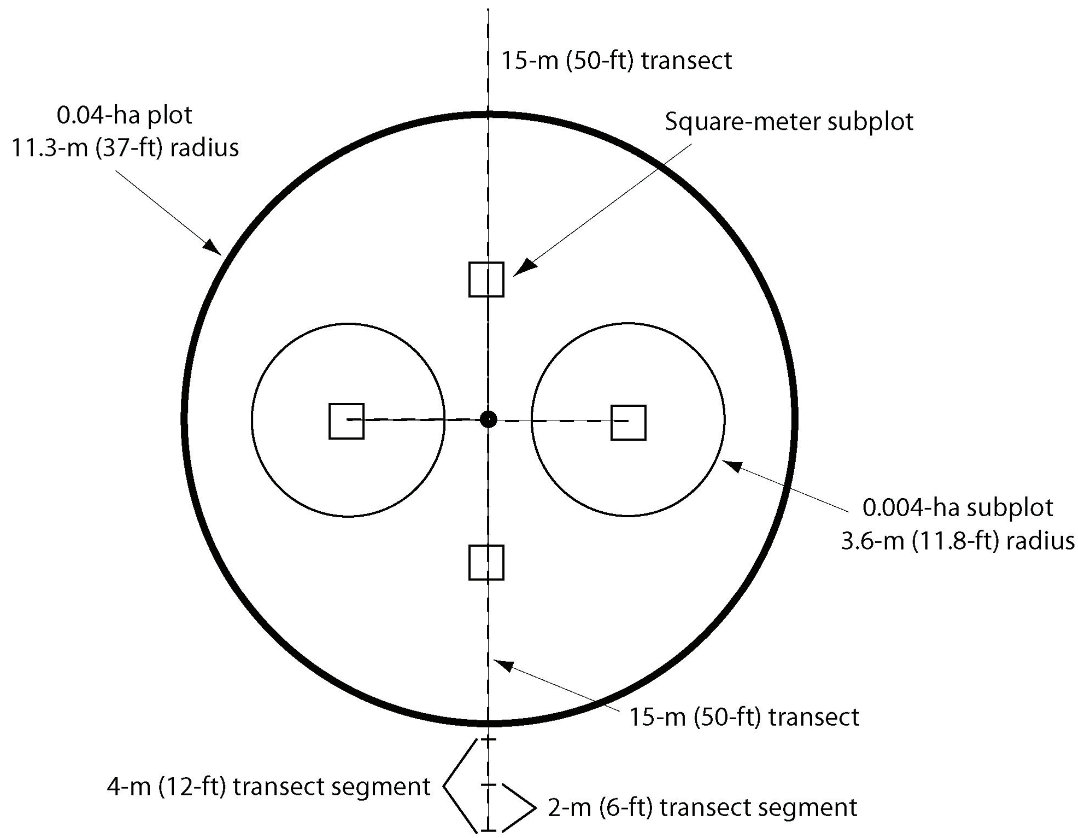

Figure 22. Layout of plots and transects for field sampling

V_{AHOR} - "A" horizon organic accumulation

This variable represents total mass of organic matter in the "A" soil horizon. The "A" soil horizon is defined as a mineral soil horizon that occurs at the ground surface, below the "O" soil horizon, consisting of an accumulation of unrecognizable decomposed organic matter mixed with mineral soil (USDA SCS 1993). In practice, the HGM models using this variable are concerned with the storage of organic matter, so for our purposes the "A" horizon is identified in the field simply as a zone of darkened soil.

Thickness of the "A" horizon is the metric used to quantify this variable. Measure it using the procedure outlined below.

(1) Establish sample points by selecting two or more locations within the 0.04-ha circular plot that are representative of the range of microtopographic conditions in the plot, or select two or more of the four 1-m^2 subplots established for litter and ground cover estimation (see below). Dig a hole (25 cm or 10 in. deep is usually adequate) and measure the thickness of the "A" horizon. Record measurements in

centimeters on Data Form 2, and calculate the average value for the plot as indicated on that form.

(2) Transfer the average plot value to Data Form 3. Calculate an overall WAA average on that form and enter in the right-hand column.

V_{BUF30} — Percent of perimeter bounded by 30-m buffer

This variable describes the percentage of the wetland perimeter bounded by a 30-m buffer that provides contiguous habitat with appropriate characteristics to meet the "general use" habitat needs (basking, feeding, limited nesting and hibernation) of many reptiles and amphibians. It is applied in assessing wildlife functions on high- and mid-gradient riverine systems. The buffer can consist of flats and other wetlands as well as uplands. Acceptable buffer community types include native forest, prairie, and shrub/scrub habitats, but not areas dominated by non-native species such as pasture grasses, or densely vegetated old-field habitats. Managed pine forest is acceptable if soils, litter, and ground-layer vegetation have not been extensively disturbed (e.g. bedded) such that there is no cover or animal movement is impeded.

In the discussion below, the potential buffer area is assumed to completely surround wetlands along high-gradient streams. However, for wetlands along mid-gradient streams the variable is approached differently. The average channel width and depth data presented in Table 5 indicate that average mid-gradient channels are likely to represent a barrier to movement or exposure to predators for many of the species of greatest interest with regard to this variable. Therefore, for mid-gradient riverine wetlands, buffer widths are calculated for only that side of the stream where the wetland is present. Note also that the application of this approach requires a field assessment of channel conditions — in some instances, high-gradient riverine wetlands may be more appropriately assessed using the mid-gradient approach, and vice-versa.

Determine the value of this metric using the procedure below, and refer to Figure 23 as needed.

(1) For high-gradient riverine wetlands, draw a continuous line on a map or photo separating the wetland assessment area from adjacent uplands or other wetland subclasses. This line defines the inner edge of the 30-m buffer zone.

(2) Draw a second line 30 m outside the wetland boundary line. This defines the outer limit of the 30-m buffer zone (Figures 23a and 23b).

(3) Identify and mark the boundaries of the appropriate habitats within the buffer zone. If the boundary of appropriate habitat intersects the boundary of the 30-m buffer, draw a line perpendicular to the wetland boundary to determine where along the perimeter the full 30-m buffer ends. Areas of appropriate habitat that are not contiguous with the wetland boundary will not be considered in this metric (Figures 23a and 23b).

(4) Visually estimate the percentage of the wetland perimeter bounded by a full 30-m buffer. This is actually measured as a lineal percentage. Consider the wetland outline to be a clock face. In Figure 23a, the full 30-m buffer runs from roughly 12:15 to 9:30, and then again from 10:00 to 11:45 or 11/12= 92 percent. Record that percentage on Data Form 1 in the box at the right-hand side of the V_{BUF30} row, and transfer the same number to the right-hand side of the V_{BUF30} row on Data Form 4.

(5) For mid-gradient riverine wetlands, use the same approach described above, but restrict the procedure to the same side of the stream where the wetland occurs (Figure 23b). In the example shown in Figure 23b, the continuity of the 30-m buffer is 100 percent.

V_{BUF250} — Percent of perimeter bounded by 250-m buffer

This variable describes the percentage of the wetland perimeter bounded by a 250-m buffer that provides contiguous habitat with appropriate characteristics to meet nesting, hibernation, and other habitat needs of a broad suite of reptiles and amphibians. Acceptable buffer community types include native forest, prairie, and shrub/scrub habitats, but not dense emergent communities or areas dominated by non-native species such as pasture grasses. Managed pine forest is acceptable if soils, litter, and ground-layer vegetation have not been extensively disturbed (e.g. bedded) such that there is no cover or animal movement is impeded.

In the discussion below, the potential buffer area is assumed to completely surround wetlands along high-gradient streams. However, for wetlands along mid-gradient streams the variable is approached differently. The average channel width and depth data presented in Table 5 indicate that average mid-gradient channels are likely to represent a barrier to movement or exposure to predators for many of the species of greatest interest with regard to this variable. Therefore, for mid-gradient riverine wetlands, buffer widths are calculated for only that side of the stream where the wetland is present. Note also that the application of this approach requires a field assessment of channel conditions — in some instances, high-gradient riverine wetlands may be more appropriately assessed using the mid-gradient approach, and vice-versa.

Determine the value of this metric using the procedure below, and refer to Figure 23 as needed.

(1) On a map or photo, draw a continuous line separating the high-gradient riverine wetland assessment area from adjacent uplands or other wetland subclasses. This line defines the inner edge of the 250-m buffer zone.

(2) Draw a second line 250 m outside the wetland boundary line. This defines the outer limit of the 250-m buffer zone (Figure 23a).

(3) Identify and mark the boundaries of the appropriate habitats within the buffer zone. If the boundary of appropriate habitat intersects the

boundary of the 250-m buffer, draw a line perpendicular to the wetland boundary to determine where along the perimeter the full 250-m buffer ends. Areas of appropriate habitat that are not contiguous with the wetland boundary will not be considered in this metric (Figure 23a).

(4) Visually estimate the percentage of the wetland perimeter bounded by a full 250-m buffer. This is actually measured as a lineal percentage. Consider the wetland outline to be a clock face. In Figure 23a, the full 250-m buffer runs from roughly 1:15 to 5:00 and then again from 6:00 to 8:30, or 6.25/12= 52 percent. Record that percentage on Data Form 1 in the box at the right-hand side of the V_{B250} row, and transfer the same number to the right-hand side of the V_{B250} row on Data Form 4.

(5) For mid-gradient riverine wetlands, use the same approach described above, but restrict the procedure to the same side of the stream where the wetland occurs (Figure 23b). In the example shown in Figure 23b, the continuity of the 250-m buffer is approximately 70 percent.

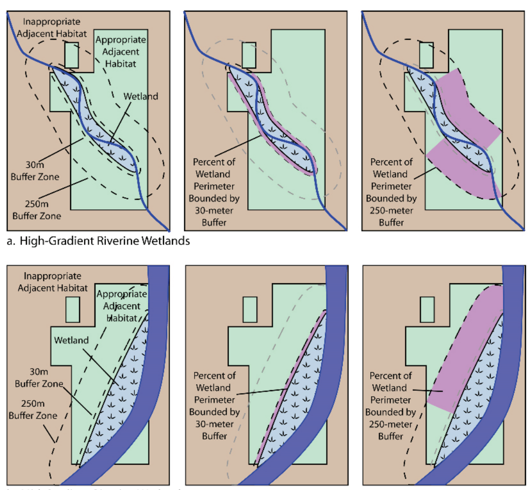

Figure 23. Measurement of buffer characteristics

V_{COMP} - Composition of tallest woody vegetation stratum

This variable represents the species composition of the tallest woody stratum present in the assessment area. This could be the tree, shrub-sapling, or seedling stratum. Percent concurrence with reference wetlands of the dominant species in the dominant vegetation stratum is used to quantify this variable. Measure it using the procedure outlined below.

(1) Determine percent cover of the tree stratum by visually estimating what percentage of the sky is blocked by leaves and stems of the tree stratum, or vertically projecting the leaves and stems to the forest floor. If the percent cover of the tree stratum is estimated to be at least 20 percent,

go to Step 2. If the percent cover of the tree stratum is estimated to be <20 percent, skip Step 2 and go directly to Step 3.

(2) If the tree stratum has at least 20 percent cover, then the value for V_{COMP} will be the same as the value for V_{TCOMP}. In this case, skip the remaining steps and simply enter the V_{TCOMP} value (see V_{TCOMP} discussion, below) in the box at the right-hand side of the V_{COMP} row on Data Form 2, then transfer the V_{COMP} plot value to Data Form 3. Calculate an overall WAA average on that form and enter in the right-hand column.

(3) If the tree stratum does not have at least 20 percent cover, determine the tallest woody stratum with at least 10 percent total cover. Within this stratum, identify the dominant species based on percent cover using the 50/20 rule (U. S. Army Corps of Engineers 1992): rank species in descending order of percent cover and identify dominants by summing relative dominance in descending order until 50 percent is exceeded; additional species with 20 percent relative dominance should also be included as dominants. Circle these species on Data Form 2 of the appropriate wetland subclass. Accurate identification of woody species is critical for determining the dominant species in each plot. Sampling during the dormant season may require proficiency in recognizing plant form, bark, and dead or dormant plant parts. Users who do not feel confident in identifying trees and shrubs should get help.

(4) Calculate percent concurrence using the formula provided on Data Form 2, which weights dominant species based on their likelihood of being dominant in reference stands of varying condition. The result is intended to indicate the character of the developing forest.

(5) Record the percent concurrence value in the box at the right-hand side of the V_{COMP} row on Data Form 3.

(6) Transfer the V_{COMP} plot value to Data Form 3. Calculate an overall Wetland Assessment Area average on that form and enter in the right-hand column.

V_{DUR} – Change in growing season flood duration

Growing season flood duration refers to the maximum number of continuous days in the growing season that overbank or backwater flooding from a stream inundates the Wetland Assessment Area. Riverine wetlands may flood as infrequently as one year in five (see the discussion of the V_{FREQ} variable in the following section), but when flooding does occur, it usually extends for some days or weeks into the growing season, and strongly influences plant and animal communities. In some cases, where impoundments are constructed around existing wetlands (e.g. greentree reservoirs), or where stream engineering projects are constructed, such as flood control projects, additional growing season flooding may occur in the spring or fall. The V_{DUR} variable is intended to reflect changes in function that result where changes in growing season hydrology have occurred or are expected to occur as a result of leveeing, drainage, impoundment, or other engineering projects. Either increases or decreases in growing season flood durations are assumed to cause reduced function relative to the pre-impact condition for both the Maintain Plant Communities and Provide Wildlife Habitat functions.

In order to account for this type of change, the V_{DUR} variable is incorporated in the relevant models. The V_{DUR} variable was developed for use primarily in the context of proposed Corps of Engineers water projects in the Delta Region, and is therefore structured specifically to accommodate the type of hydrologic information generated in the Corps project planning process. It was developed based on field studies on greentree reservoirs in the Bayou Meto basin (Heitmeyer and Ederington 2004), where changes in flood duration were expressed in terms of continuous days of flooding in the growing season. Changes in flood duration are presented as "zone changes," where a single zone change corresponds to approximately one week of additional or reduced continuous flooding during the growing season. Because these data are usually generated to evaluate likely project-induced changes in the acreage of jurisdictional wetlands, the "period of continuous flooding" may not correspond to the total days of flooding. At this time, no specific correlation has been established between this means of presenting flood duration data and the more common method of discussing flood durations that are based on total days of flooding in the entire annual cycle.

Estimates of growing-season flood durations are not typically readily available for any particular site, and in most cases the change in duration will be assumed to be zero unless specific information to the contrary is available from project planning or permit application documents. Whatever the case, the percent change should be calculated consistently for the before-project and after-project conditions.

(1) Determine the change in growing season flood duration by comparing the pre-project and post-project flood durations.

(2) Record the pre-project and post-project growing season flood durations on Data Form 1 in the indicated boxes in the V_{DUR} row, calculate the number of zone changes represented (where one-week change in continuous growing-season flooding constitutes a zone change), and transfer that number to the box on the right-hand side of the V_{DUR} row on Data Form 3. Changes greater than five zone changes should be recorded as 5.

V_{FREQ} – Change in frequency of flooding

Frequency of flooding refers to the frequency (return interval in years) with which overbank or backwater flooding from a stream inundates the Wetland Assessment Area. In the classification employed here, where the 5-year return interval distinguishes connected from unconnected wetlands, the frequencies of interest are the 1, 2, 3, 4, and 5-year return intervals. However, in the context of the assessment models where the V_{FREQ} variable is used, there is no implication that more frequent flooding translates to higher functionality. Rather, all connected wetlands are assumed to be fully functional with regard to the V_{FREQ} variable unless there has been a change in flood frequency, and any such change, whether more or less frequent, is assumed to have adverse effects on the wetland communities and processes currently in place. (Note: as with the classification system, flood frequencies established as a result of the major river engineering projects in the mid-20th century are considered to be the baseline condition in most assessment scenarios). In practice, the change in flood frequency will be a consideration most often where the hydrology of a site has been recently modified, as through a levee, drainage, or pumping project, or where such a change is proposed. In such situations the change in flood frequency can be used to indicate the magnitude of deviation from the pre-project condition.

(1) Determine the change in recurrence interval by comparing the pre-project and post-project flood frequencies. For the pre-project condition, the recurrence interval can be determined or estimated using one of the following information sources:

- Recurrence interval map
- Data from a nearby stream gage
- Regional flood frequency curves developed by local and State offices of USACE, USGS-Water Resources Division, State Geologic Surveys, or NRCS (Jennings et al. 1994)
- Hydrologic models such as HEC-2 (USACE 1981, 1982), HEC-RAS (USACE 1997), or HSPF (Bicknell et al. 1993)
- Local knowledge
- A regional dimensionless rating curve

The same sources may be used to determine the post-project recurrence interval, or it may be specified in planning documents and applications.

(2) Record the pre-project and post-project recurrence intervals on Data Form 1 in the indicated boxes in the V_{FREQ} row, calculate the difference, and transfer that number to the box on the right-hand side of the V_{FREQ} row on Data Form 3. Note that the final number can be a fraction (e.g. 1.5 years) if the available information supports such a specific estimate, and that only the change is of concern, not whether it is positive or negative.

Example: A Riverine site that normally floods every year (5 years out of 5) will be affected by a nearby channel-deepening project that reduces flood frequency to 2 years out of 5. The change in return interval is 3 years.

Note that the number of possible changes in return interval varies depending on the starting flood frequency. This is in part due to the classification of the flood frequencies: any area flooded more frequently than once a year is grouped with the 1-year return interval group, and everything flooded less frequently than every 5 years is no longer classified as riverine; therefore the frequency variable no longer applies. As Figure 24 illustrates, the maximum of four zone changes are possible only for wetlands starting in the 1- or 5-year return interval categories (blue and red, below). This maximum change leads to a 0.2 variable subindex. In contrast, if the starting return interval is 3 years, a maximum of two zone changes is possible in either direction (green line below), leading to a potential subindex of 0.6. A Subindex of 0.0 only occurs if the change in frequency extends beyond the 5-year return interval required in the definition of riverine wetlands.

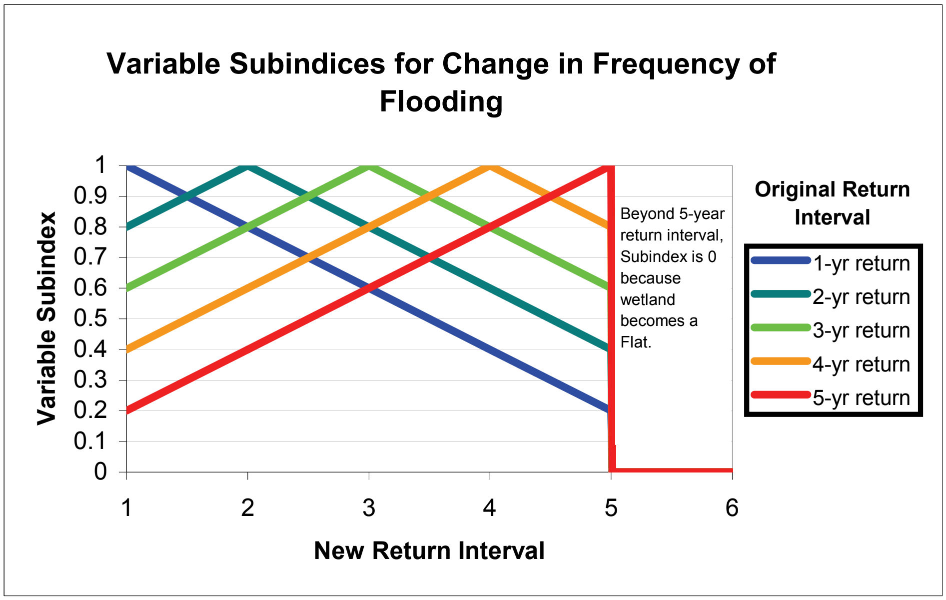

Figure 24. Potential flood frequency variable subindices for various initial return intervals

V_{GVC} - Ground vegetation cover

Ground vegetation cover is defined as herbaceous and woody vegetation less than or equal to 1.4 m (4.5 ft) in height. The percent cover of ground vegetation is used to quantify this variable. Determine the value of this metric using the procedure outlined below.

(1) Visually estimate the proportion of the ground surface that is covered by ground vegetation by mentally projecting the leaves and stems of ground vegetation to the ground surface. Do this in each of four 1-m^2 subplots placed 5 m (15 ft) from the plot center, one in each cardinal direction as illustrated in Figure 22. Record measurements for each subplot on Data Form 2, and enter the average value for the entire plot in the right-hand column of the V_{GVC} row on Data Form 2.

(2) Transfer the average plot value to the V_{GVC} row on Data Form 3, and average all plot values in the block in the right-hand column.

V_{LITTER} - Litter cover

Litter cover is estimated as the average percent of the ground surface covered by recognizable dead plant materials (primarily decomposing leaves and twigs). This estimate excludes undecomposed woody material large enough to be tallied in the woody debris transects (i.e., twigs larger than 0.6 cm (0.25 in.) in diameter — see V_{WD} discussion, below). It also excludes organic material sufficiently decayed to be included in the estimate of "O" horizon thickness (see V_{OHOR} discussion, below). Generally, litter cover is easily recognized and estimated except during autumn, during active leaf fall, when freshly fallen materials should be disregarded in making the estimate, because the volume of freshly fallen material will inflate cover estimates.

The percent cover of litter is used to quantify this variable. Determine the value of this metric using the procedure outlined below.

(1) Visually estimate the proportion of the ground surface that is covered by litter. Do this in each of the four 1-m^2 subplots (the same subplots established for estimating ground vegetation cover, Figure 22). Record measurements for each subplot on Data Form 2, and enter the average value for the entire plot in the right-hand column of the V_{LITTER} row on Data Form 2.

(2) Transfer the average plot value to the V_{LITTER} row on Data Form 3, and average all plot values in the block in the right-hand column.

V_{LOG} - Log biomass

See discussion in the Woody Debris (V_{WD}) and Log Biomass (V_{LOG}) section below.

V_{OHOR} - "O" horizon organic accumulation

The "O" horizon is defined as the soil layer dominated by organic material that consists of partially decomposed organic matter such as leaves, needles, sticks or twigs <0.6 cm in diameter, flowers, fruits, insect frass, dead moss, or detached lichens on or near the surface of the ground. The "O" horizon does not include recently fallen material, or material that has been incorporated into the mineral soil.

Thickness of the "O" soil horizon is the metric used to quantify this variable. Measure it using the procedure outlined below.

(1) Measure the thickness of the "O" horizon in the same holes dug to determine the thickness of the A horizon (above). That will result in two or more measurements per plot, which are recorded as subplot values in the V_{OHOR} section of Data Form 2.

(2) Average the "O" horizon thickness measurements from each of the subplots, and record the average on Data Form 2 in the V_{OHOR} row as a plot value.

(3) Transfer the average plot value to the V_{OHOR} row on Data Form 3. Average all plot values on that form and record in the box at the right-hand side of the V_{OHOR} row.

V_{PATCH} - Forest patch size

This variable is defined as the area of contiguous forest that includes the WAA. This may include non-wetland forests adjacent to the WAA, but all areas considered "forest" should have more than 70 percent canopy tree cover.

Determine the size of the forested patch using the procedure outlined below.

(1) Determine the size of the forested area (ha) that is contiguous and directly accessible to wildlife utilizing the WAA (including the WAA itself, if it is forested). Use topographic maps, aerial photography, GIS, field reconnaissance, or another appropriate method.

(2) Record the area in hectares (if the area exceeds 2500 ha, simply record 2500) on Data Form 1 in the box at the right-hand side of the V_{PATCH} row. Transfer this number to the V_{PATCH} box on Data Form 3.

V_{POND} - Total ponded area

Total ponded area refers to the percent of the WAA ground surface likely to collect and hold precipitation for periods of days or weeks at a time. (Note: This is distinct from the area that is prone to flooding, where the surface of the WAA is inundated by overbank or backwater connections to stream channels). The smaller (microtopographic) depressions are usually a result of tree "tip ups" and the scouring effects of moving water, and typically they are between 1 and 10 m^2 in area. Larger vernal pools (usually at least 0.04 ha) occur in the broad swales typical of meander scroll topography, or in other areas where impeded drainage produces broad, shallow pools during rainy periods. The wetlands where these features are important typically have a mix of both the small microdepressions and the larger vernal pools.

Estimate total ponded area using the following procedure:

(1) During a reconnaissance walkover of the entire WAA, estimate the percentage of the assessment area surface having microtopographic depressions and vernal pool sites capable of ponding rainwater. Base the estimate on the actual presence of water immediately following an extended rainy period if possible, but during dry periods use indicators such as stained leaves, or changes in ground vegetation cover. Generally, it is not difficult to visualize the approximate percentage of

the area subject to ponding, but it is important to base the estimate on a walkover of the entire assessment area.

(2) Report the percent of the assessment area subject to ponding on Data Form 1 in the box on the right-hand side of the V_{POND} row, and transfer that value to the V_{POND} box on Data Form 3.

V_{SNAG} - Snag density

Snags are standing dead woody stems at least 1.4 m (4.5 ft) tall with a dbh greater than or equal to 10 cm (4 in.). The density of snag stems per hectare is the metric used to quantify this variable. Measure it using the procedure outlined below.

(1) Count the number of snag stems within each 0.04-ha circular plot. Record the number of snag stems in the indicated box on the V_{SNAG} row on Data Form 2. Multiply this number by 25 and enter the result in the right-hand box on V_{SNAG} row on Data Form 2.

(2) Transfer snag density per hectare as a plot value to the V_{SNAG} row on Data Form 3, and enter the average of all of the plot values on that form in the right-hand box of the V_{SNAG} row.

V_{SOIL} - Soil integrity

It is difficult in a rapid assessment context to assess soil integrity for two reasons. First, there are a variety of soil properties contributing to integrity that should be considered (i.e., structure, horizon development, texture, bulk density). Second, the spatial variability of soils within many wetlands makes it difficult to collect the number of samples necessary to adequately characterize a site. Therefore, the approach used here is to assume that soil integrity exists where evidence of alteration is lacking. Stated another way, if the soils in the assessment area do not exhibit any of the characteristics associated with alteration, it is assumed that the soils are similar to those occurring in the reference standard wetlands and have the potential to support a characteristic plant community.

This variable is measured as the proportion of the assessment area with altered soils. Measure it with the following procedure.

(1) As part of the reconnaissance walkover of the entire WAA, determine if any of the soils in the area being assessed have been altered. In particular, look for evidence of excavation or fill, severe compaction, or other types of impact that significantly alter soil properties. For the purposes of this assessment approach, the presence of a plow layer should not be considered a soil alteration.

(2) If no altered soils exist, the percent of the assessment area with altered soils is zero. This indicates that all of the soils in the assessment area are similar to soils in reference standard sites.

(3) If altered soils exist, estimate the percentage of the assessment area that has soils that have been altered.

(4) Report the percent of the assessment area with altered soils on Data Form 1 in the box on the right of the V_{SOIL} row, and transfer that value to the box on the right of the V_{SOIL} row on Data Form 3.

V_{SSD} - Shrub-sapling density

Shrubs and saplings are woody stems less than 10 cm (4 in) dbh and greater than 1.4 m (4.5 ft) in height. Density of shrub-sapling stems per hectare is the metric used to quantify this variable. Measure it using the procedure outlined below.

(1) Count woody stems less than 10 cm (4 in.) and greater than 1.4 m (4.5 ft) in height in two 0.004-ha circular subplots (radius 3.6 m or 11.8 ft) nested within the 0.04-ha plot (Figure 22). Record the number of stems in each 0.004-ha subplot in the spaces provided in the V_{SSD} row on Data Form 2.

(2) Sum the subplot values and multiply by 125. Enter the result in the right-hand block in the V_{SSD} row on Data Form 2. Transfer this value (stems/ha) to the V_{SSD} row on Data Form 3.

(3) Sum the V_{SSD} plot values on Data Form 3 and enter the result in the right-hand block in the V_{SSD} row on Data Form 3.

V_{STRATA} - Number of vegetation strata

The number of vegetation layers (strata) present in a forested wetland reflects the diversity of food, cover, and nest sites available to wildlife, particularly birds, but also to many reptiles, invertebrates, and arboreal mammals. Estimate the vertical complexity of the WAA using the following procedure:

(1) During a reconnaissance walkover of the entire WAA, identify which of the following vegetation layers are present and account for at least 10 percent cover, on average, throughout the site.

- Canopy (trees greater than or equal to 10 cm dbh that are in the canopy layer)
- Subcanopy (trees greater than or equal to 10 cm dbh that are below the canopy layer — recognize this layer if it is distinctly different from a higher, more mature canopy)
- Understory (shrubs and saplings less than 10 cm dbh but at least 4.5 ft tall)

- Ground cover (woody plants less than 4.5 ft tall, and herbaceous vegetation)

(2) Enter the number of vegetation strata (0 – 4) present in the right-hand block on the V_{STRATA} row on Data Form 1, and transfer that number to the V_{STRATA} row on Data Form 3.

V_{TBA} - Tree basal area

Trees are defined as living woody stems greater than or equal to 10 cm (4 in.) dbh. Tree basal area is a common measure of abundance and dominance in forest ecology that has been shown to be proportional to tree biomass (Whittaker 1975). Tree basal area per hectare is the metric used to quantify this variable. Measure it using the procedure outlined below.

(1) Use a basal area wedge prism (or other basal area estimation tool) as directed to tally eligible tree stems, and enter the tally in the indicated space on the V_{TBA} line on Data Form 3. Basal area prisms are available in various Basal Area Factors, and in both metric and English versions. Some are inappropriate for use in collecting the data needed here, because they are intended to be used for large-diameter trees in areas with little understory. The English 10-factor prism works well and it is readily available.

(2) Calculate plot basal area in square meters per hectare by multiplying the tree count by the appropriate conversion factor. For example, when using the English 10-factor prism, multiply the number of stems tallied by 25. Enter the total basal area figure in the right-hand box on the V_{TBA} row on Data Form 2.

(3) Transfer the total basal area as a plot value to the V_{TBA} row on Data Form 4. Average all plot basal area values and enter that number in the right-hand box on the V_{TBA} row on Data Form 3.

An alternative method also is available that allows users to directly measure tree diameters in the 0.04-ha plot, rather than use a plotless (e.g., wedge prism) estimation method. The difference between the two methods is likely to be insignificant at the level of resolution employed in the HGM assessment. However, for users who don't have access to a wedge prism or similar tool, or if undergrowth is too thick to allow a prism to be used accurately, direct diameter measurement (using a dbh tape or tree caliper) may be the only option available. Or, users may wish to use the direct measurement approach to facilitate more rigorous data collection, particularly if they are interested in the relative contribution of each tree species to the total basal area of the WAA. An alternative field form is provided in Appendix C1 that can be used to record the species and diameter of every tree within the 0.04-ha plot. Basal area can be calculated by hand on that Data Form, or on the spreadsheet provided in Appendix D1. The spreadsheet will also indicate the basal area of each tree so that individual tree values for each species can be summed to determine the total basal area by species. This can be used simply to provide more detailed documentation of the assessment process, or to improve the rigor of estimates for the V_{TCOMP} variable. Tree counts directly from the basal area sheets can also be used instead of the field counts that are the recommended method for deriving the V_{TDEN} variable.

In general, the recommended field methods are likely to be much faster than the diameter-measurement approach, but the outcome of the assessment should not differ significantly regardless of which method is used.

The procedure for using the alternative (direct diameter measurement) method is as follows:

(1) Using a metric (centimeters) diameter tape, measure the diameter of all trees (living woody stems greater than or equal to 10 cm (4 in.) at breast height) (dbh) in a circular 0.04-ha plot with a radius of 11.3 m (37 ft). Record each diameter measurement in Column 2 of Data Form C1. Recording the species of each tree (Column 1) is optional, but may be helpful, as described above.

A spreadsheet is available (Appendix D1) to complete the calculations in Steps 2–5 below, or they can be done by hand as follows:

(2) Square the dbh measurement for each woody stem and enter that number in Column 3.

(3) Convert the squared diameters to square meters per hectare by multiplying by 0.00196. Enter this number in Column 4.

(4) Sum all Column 4 numbers to get total basal area (m^2 / ha) for the plot. Enter this number as a plot value in the V_{TBA} row on Data Form 3.

(5) Average the plot values on Data Form 3 and record the result in the box on the right-hand side of the VTBA row.

V_{TCOMP} - Tree composition

The tree composition variable is intended to represent the pattern of dominance among tree species in the forest canopy. V_{TCOMP} is calculated if the total canopy cover of trees (living woody stems ≥10 cm or 4 in. at breast height) within the plot is 20 percent or more. Percent concurrence of the dominant tree species in the assessment area with the species composition of reference wetlands in various conditions is the metric used to quantify this variable. Measure it with the procedure outlined below.

(1) If the tree stratum has at least 20 percent cover, identify the dominant species (based on cover, or on basal area if dbh measurements are taken) and circle them on Data Form 3 of the appropriate wetland subclass. To identify dominants, apply the 50/20 rule (U. S. Army Corps of Engineers 1992). This requires ranking species in descending order of percent cover, summing relative dominance in descending order until 50 percent is exceeded. Additional species with 20 percent relative dominance should also be included as dominants. Accurate

identification of woody species is critical for determining the dominant species in each plot. Sampling during the dormant season may require proficiency in recognizing plant form, bark, and dead or dormant plant parts. Users who do not feel confident in identifying trees and shrubs should get help.

(2) Calculate percent concurrence using the formula provided on Data Form 2, which weights dominant species based on their likelihood of being dominant in reference stands of varying condition.

(3) Record the percent concurrence value in the box at the right-hand side of the V_{TCOMP} row on Data Form 2. Record a zero for any plot having less than 20 percent tree cover.

(4) Transfer the V_{TCOMP} plot value to Data Form 3. Average all plot values and enter that number in the right-hand box of the V_{TCOMP} row.

V_{TDEN} - Tree density

Tree density is the number of trees (i.e., living woody stems greater than or equal to 10 cm or 4 in.) per unit area. The density of tree stems per hectare is the metric used to quantify this variable. Measure it using the procedure outlined below.

(1) Count the number of tree stems within the 0.04-ha plot (note: this is not the same as the stem count taken with the basal area wedge prism to determine V_{TBA}). Care should be taken not to err in determining whether or not a tree should be counted. Measure the plot radius to all marginal trees, and include only trees having at least half the stem within the plot. If tree diameters were recorded to calculate basal area, then the number of stems can be counted directly from the supplemental basal area field sheet (Appendix C1).

(2) Record the stem count on Data Form 2 in the V_{TDEN} row, and multiply by 25 to calculate stems/ha. Transfer stems/ha as a plot value to the V_{TDEN} row on Data Form 3.

(3) Average the plot values on Data Form 3 and record the result in the box on the right-hand side of the V_{TDEN} row.

V_{WD} - Woody debris biomass and V_{LOG} - log biomass

Woody debris is an important habitat and nutrient cycling component of forests. Volume of woody debris and log biomass per hectare is the metric used to quantify these variables. Measure them with the procedure outlined below (Brown 1974, Brown et al. 1982).

(Note: all stem diameter criteria and measurements for all size classes refer to diameter at the point of intersection with the transect line. Leaning dead stems that intersect the sampling plane are sampled. Dead trees and shrubs still supported by their roots are not sampled. Rooted stumps are not sampled, but uprooted stumps are sampled. Down stems that are decomposed to the point where they no longer maintain their shape but spread out on the ground are not sampled).

(1) Lay out two 50-ft (15.24-m) east-west transects, originating at the 0.04-ha plot center point (Figure 22).

(2) Count the number of nonliving stems in Size Class 1 (small) (greater than or equal to 0.6 and less than 2.5 cm / greater than or equal to 0.25 and less than 1 in.) that intersect a vertical plane above a 6-ft segment of each 50-ft transect. This can be any 6-ft segment, as long as it is consistently placed. Figure 22 illustrates it as placed at the end furthest from the plot center point. Record the number of Size Class 1 stems from each transect in the spaces provided on the V_{WD} (Size Class 1) line on Data Form 2.

(3) Count the number of nonliving stems in Size Class 2 (medium) (greater than or equal to 2.5 cm and less than 7.6 cm or greater than or equal to 1 in. and less than 3 in.) that intersect the plane above a 12-ft segment of each 50-ft transect. This can be any 12-ft segment, as long as it is consistently placed. Figure 22 illustrates it as placed at the end furthest from the plot center point, overlapping with the 6-ft transect segment. Record the number of Size Class 2 stems from each transect in the spaces provided on the V_{WD} (Size Class 2) line on Data Form 2.

(4) Measure and record the diameter of nonliving stems in Size Class 3 (large) (greater than or equal to 7.6 cm / ≥3 in) that intersect the plane above the entire length of the 50-ft transect. Record the diameter of individual stems (in centimeters) in Size Class 3 from each transect in the spaces provided on the V_{LOG} and V_{WD} (Size Class 3) line on Data Form 2.

(5) Use the spreadsheet (Appendix D2) to convert the stem tallies and diameter measurements to woody debris and log volume (m^3/ha) and transfer the resulting values as plot values on the V_{LOG} and V_{WD} rows on Data Form 3. Average all plot values, and enter them in the right-hand blocks on the V_{LOG} and V_{WD} rows on Data Form 3.

Alternative:

Appendix C1 is an alternative field and calculation form that allows V_{LOG} and V_{WD} to be calculated by hand if the user does not wish to use the spreadsheet. Transfer the resulting plot values to the V_{LOG} and V_{WD} rows on Data Form 3. Average all plot values, and enter them in the right-hand blocks on the V_{LOG} and V_{WD} rows on Data Form 3.

Analyze Field Data

The analysis of field data requires three steps. The first step is to transform the measure of each assessment variable into a variable subindex. This can be done manually by comparing the summary data (right-hand boxes) from Data Form 3 to the graphs at the end of Chapter 5. The second step is to insert the variable subindices into the appropriate assessment models in Chapter 5 and calculate the FCI for each assessed function. Finally, the FCI is multiplied by the area of the WAA (hectares) to calculate FCUs for each assessed function. However, all of these calculations can be carried out automatically by entering the Data Form 3 summary data (right-hand boxes) and the area (hectares) of the WAA into the spreadsheet workbook provided in Appendix D3. Note that the workbook includes multiple spreadsheets (i.e., pages), so be sure to use the correct spreadsheet for the wetland subclass being assessed (see the tabs at the bottom of the window).

When using the spreadsheets in Appendix D3, be sure to first clear any values in the "Metric Values" column (shaded green) and to completely fill out the green-shaded boxes to identify the project and the Wetland Assessment Area, and to specify the size (hectares) of the Wetland Assessment Area. Do not attempt to clear or enter data into any non-shaded boxes – the spreadsheet will not accept direct changes to those cells.

After all summary data and the area of the WAA are entered into the spreadsheet, the FCI and FCU values for each assessed function are displayed at the bottom of the spreadsheet.

Document Assessment Results

Once all of the data collection, summarization, and analysis steps have been completed, it is important to assemble all pertinent documentation. Appendix A2 is a cover sheet that, when completed, identifies the assembled maps, drawings, project description, Data Forms and summary sheets (including spreadsheet printouts) that are attached to document the assessment. It is highly recommended that this documentation step be completed.

Apply Assessment Results

Once the assessment and analysis phases are complete, the results can be used to compare the same Wetland Assessment Area at different points in time, compare different Wetland Assessment Areas at the same point in time, or compare different alternatives to a project. The basic unit of comparison is the Functional Capacity Unit (FCU), but it is often helpful to examine specific impacts and mitigation actions by examining their effects on the Functional Capacity Index (FCI), independent of the area affected. The FCI/FCU spreadsheets are particularly useful tools for testing various scenarios and proposed actions — they allow experimentation with various alternative actions and areas affected to help isolate the project options with the least impact, or the most effective restoration or mitigation approaches.

Note that the assessment procedure does not produce a single grand index of function — rather each function is separately assessed and scored, resulting in a set of functional index scores and functional units. How these are used in any particular analysis depends on the objectives of the analysis. In the case of an impact assessment, it may be reasonable to focus on the function that is most detrimentally affected. In cases where certain resources are particular regional priorities, the assessment may tend to focus on the functions most directly associated with those resources. For example, wildlife functions may be particularly important in an area that has been extensively converted to agriculture. Hydrologic functions may be of greatest interest if the project being assessed will alter water storage or flooding patterns. Conversely, this type of analysis can help to recognize when a particular function is being maximized to the detriment of other functions, as might occur where a wetland is created as part of a stormwater facility; vegetation composition and structure, detritus accumulation, and other variables in such a setting would likely demonstrate that some functions are maintained at very low levels, while hydrologic functions are maximized.

Generally, comparisons can be made only between wetlands or alternatives that involve the same wetland subclass, although comparisons between subclasses can be made on the basis of functions performed rather than the magnitude of functional performance. For example, riverine subclasses have import and export functions that are not present in flats. These types of comparisons may be particularly important where a proposed action will result in a change of subclass. When a levee, for example, will convert a riverine wetland to a flat, it is helpful to be able to recognize that certain import and export functions will no longer occur.

Special issues in applying the assessment results

Users of this document must recognize that not all situations can be anticipated or accounted for in developing a rapid assessment method. In particular, users must be able to adapt the material presented here to special or unique situations encountered in the field. Most of the reference sites were relatively mature, diverse, and structurally complex hardwood stands, but there are situations where relatively low diversity and different structural characteristics may be entirely appropriate, and these are generally incorporated into the subindex curves. For example, a fairly simple stand of cottonwood or willow dominating on a newly deposited bar is recognized as an appropriate V_{COMP} condition. In other instances, however, professional judgment in the field is essential to proper application of the models. For example where a buttonbush shrub community dominates a site that normally would support forest, because of beaver activity or natural changes in channel courses, the buttonbush swamp should be recognized as a functional component of a larger wetland complex, and the V_{COMP} weighting system can be adjusted accordingly. Another potential way to deal with beaver in the modern landscape is to adopt the perspective that beaver complexes are fully functional, but transient, components of riverine wetland systems for all functions. At the same time, if beaver are not present (even in an area where they would normally be expected to occur), the resulting riverine wetland can be assessed using the models, but the overall Wetland Assessment Area is not penalized either way. Other situations that require special consideration include areas affected by fire, sites damaged by ice storms, and similar occurrences. Fire, in particular, can cause dramatic short-term changes in many of the indicators measured to assess function, such as ground cover, woody debris, and litter accumulation. Note however that normal, non-catastrophic disturbances to wetlands (i.e., tree mortality causing small openings) are accounted for in the reference data used in this guidebook.

Another potential consideration in the application of the assessment models presented here concerns the projection of future conditions. This may be particularly important in determining the rate at which functional status will improve as a result of restoration actions intended to offset impacts to jurisdictional wetlands. The graphs in Figure 25 represent general recovery trajectories for forested hardwood wetlands within the Ozark Mountains Region of Arkansas based on a subset of the reference data collected to develop this guidebook. In selected stands, individual trees were aged using an increment corer to develop a general relationship between the age of sampled stands and the site-specific variables employed in the assessment models. Thus, a user can estimate the overstory basal area, shrub density, woody debris volume, and other functional indicators for various time intervals, and calculate functional capacity indices for all assessed functions. These curves are specifically constructed to reflect wetland recovery following restoration of agricultural land. Therefore, they assume that the initial site condition includes bare ground that has been tilled. Varying degrees and types of tillage within reference areas confused recovery patterns for soil development, therefore no trajectory curve is presented for V_{AHOR}. Users should base projections for this variable on the initial site condition, or modify the assessment equations so that this variable is not considered in future projections. Note that landscape variables are not included here, because they require site-specific knowledge to project future conditions. Ponding development rates also are not estimated, because ponding is the result of both geomorphic and biotic factors, and the initial site conditions (i.e., extent of land leveling). The degree of microtopographic relief will be dependent on the extent of site contouring done prior to planting, in most cases. Similarly, the rates of compositional change (V_{COMP} and V_{TCOMP}) are dependent on initial site conditions; generally, a site planted with appropriate species should have an FCI score of 1.0 soon after planting for the compositional variable V_{COMP}, and maintain that fully functional status indefinitely as V_{TCOMP} becomes the applicable compositional variable. Estimating future composition for unplanted areas will require site-specific evaluation of seed sources and probable colonization patterns.

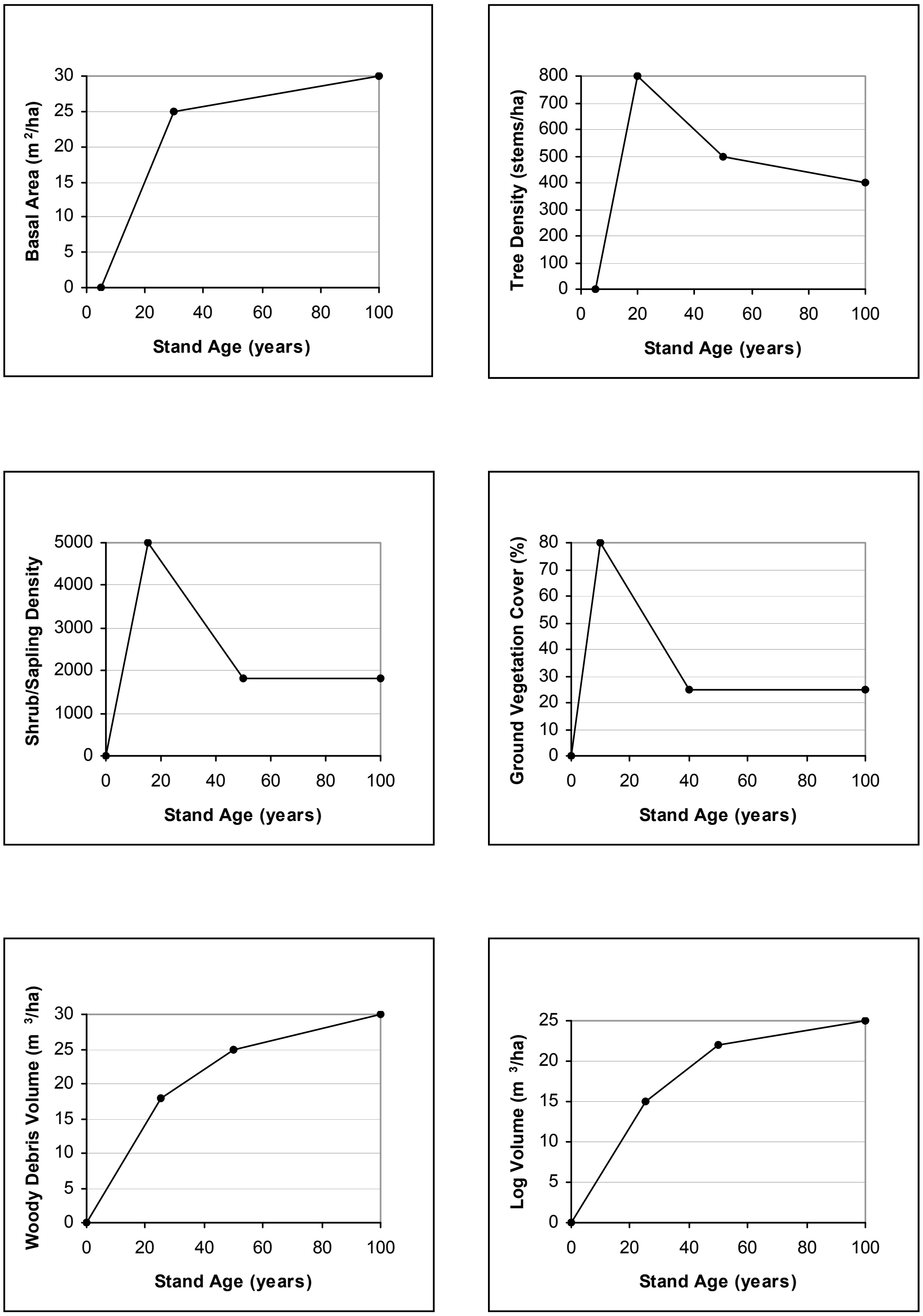

Figure 25. Projected recovery trajectories for selected assessment variables (Sheet 1 of 2)

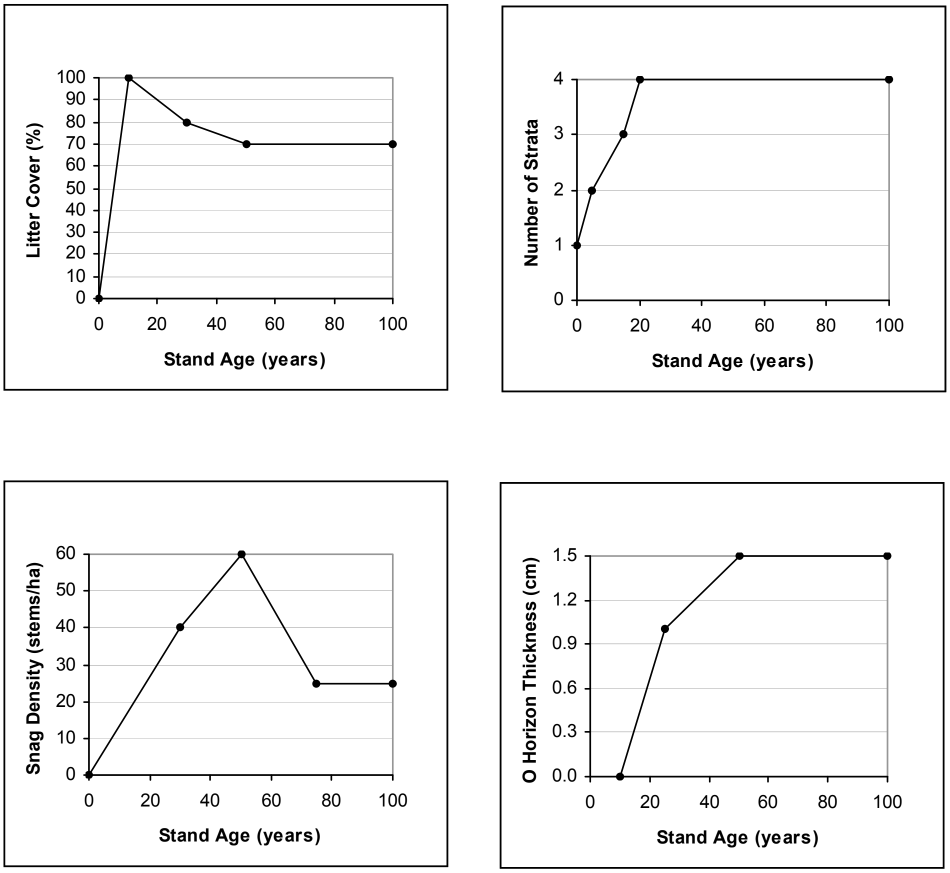

Figure 25. (Sheet 2 of 2)

Note also that the graphs in Figure 25 are amalgams of data from all wetland subclasses. In situations where a site is expected to be unusual in one or more respects (such as a cottonwood stand, where basal areas are likely to increase more quickly than in hardwood forests) more specific data may exist, and should be substituted for these general curves as appropriate. Similarly, the influence of fire is not assumed — changes to system characteristics depicted in the graphs reflect conditions where fire has been suppressed, as it has been in the majority of the reference sites.

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Appendix A
Preliminary Project Documentation and Field Sampling Guidance

CONTENTS

Please reproduce these forms locally as needed.

APPENDIX A1

SITE or PROJECT INFORMATION and ASSESSMENT DOCUMENTATION

(Complete one form for entire site or project area)

Date: ___________________________________

Project/Site Name: _______________________

Person(s) involved in assessment:

Field ____

____

Computations/summarization/quality control____________________________________

____

The following checked items are attached:

_____ A description of the project, including land ownership, baseline conditions, proposed actions, purpose, project proponent, regulatory or other context, and reviewing agencies.

_____ Maps, aerial photos, and /or drawings of the project area, showing boundaries and identifying labels of Wetland Assessment Areas and project features.

_____ Other pertinent documentation (describe): ______________________________

____

_____ Field Data Forms and assessment summaries (listed in table below):

Wetland Assessment Area (WAA) ID Number	**HGM Subclass**	**WAA Size (ha)**	**Number of plots sampled**	**Attached Data Forms and Summary Forms**			
				Data Forms (number attached)			**FCI/FCU Summaries (spreadsheet D3 printouts or hand calculations)**
				Form 1	**Form 2**	**Form 3**	

Alternative Field and Summarization Forms Attached:

_______ Basal Area (DATA FORM C1)

_______ Log and Woody Debris (DATA FORM C2)

APPENDIX A2

FIELD ASSESSMENT PREPARATION CHECKLIST

Prior to conducting field studies, review the checklist below to determine what field gear will be required, and how many copies of each data form will be needed. It may be helpful to complete as much of the Project or Site Description Form (Appendix A1) as possible prior to going to the field, and for large or complex assessment areas, that form should be completed as part of a reconnaissance study to classify and map all of the Wetland Assessment Areas within the project area or site boundary.

FIELD GEAR REQUIRED	COMMENTS
DISTANCE TAPE (preferably metric, at least 50 ft or 20 m) AND ANCHOR PIN	Minimum of one, but two will speed work if enough people are available to independently record different information. A survey pin is helpful to mark the plot center and anchor the tape for woody debris transects and to determine plot boundaries.
FOLDING RULE	A folding rule, small tape, or dbh caliper suitable for measuring the diameter of logs is needed.
PLANT IDENTIFICATION MANUALS	At least one person on the assessment team must be able to readily and reliably identify woody species, but field guides are recommended as part of the assessment tool kit. If species of concern, threatened, or endangered species are potentially present, the assessment team should include a botanist who can recognize them.
PLOT LAYOUT DIAGRAM	A copy is attached to this checklist.
DATA FORMS	See data form requirements table, below.
BASAL AREA PRISM OR DBH TAPE OR SUITABLE SUBSTITUTE	A 10-factor English unit wedge prism (available from forestry equipment supply companies) is the recommended tool for quickly determining tree basal area. Other tools may be substituted if they provide comparable data. Guidelines for the use of the wedge prism are attached to this checklist. If using a dbh tape or caliper, the supplemental field data form will be needed to record diameter measurements (Data Form C1).
SOIL SURVEY	Optional, but may be helpful in evaluating soil-related variables.
HGM GUIDEBOOK (this document)	At minimum, Chapter 6 should be available in the field to consult regarding field methods. All assessment team members should be familiar with the entire document prior to fieldwork.
SHOVEL OR HEAVY-DUTY TROWEL	If heavy or hard soils are anticipated, a shovel will be necessary. You need to be able to dig at least 10 inches deep. A water bottle is recommended if conditions are dry, to help distinguish soil colors (organic-stained soils must be distinguished from mineral soil).
MISCELLANEOUS SUGGESTED GEAR	Clipboards, pencils, and extra data forms are highly recommended. Flagging may be helpful for establishing plot centers and boundaries, at least until the assessment team is comfortable with the field procedures. A camera and GPS unit will improve documentation of the assessment and are highly recommended. Record position and take a representative photo at each plot location. Field copies of aerial photos and topo maps may be important if multiple Wetland Assessment Areas must be established and recognized in the field.

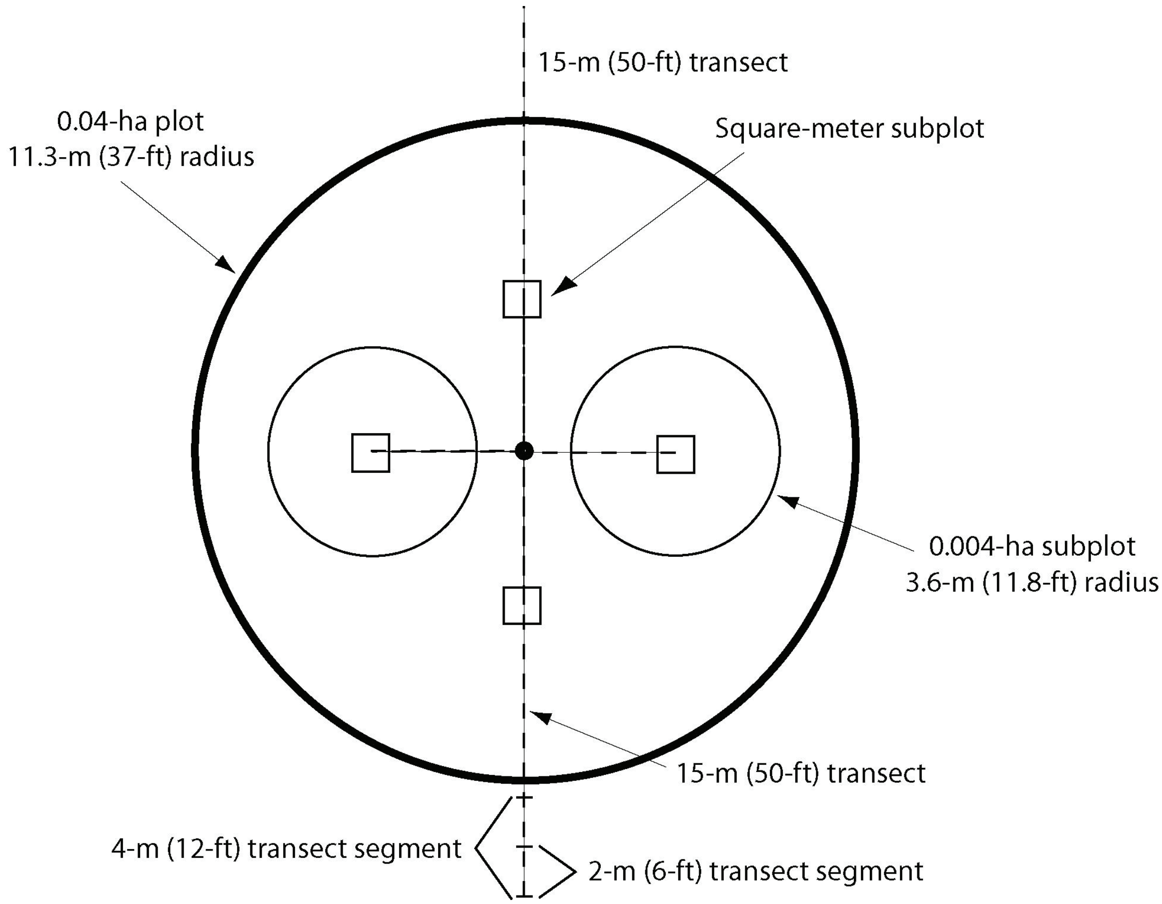
APPENDIX A2

DATA FORMS

Print the following data forms (found in Appendix B) in the numbers indicated. (Extras are always a good idea). Be sure to use the forms developed specifically for the wetland subclass(es) you are assessing.

DATA FORM	Number of Copies Required
Project or Site Description and Assessment Documentation (1 page)	One
Data Form 1 - Tract and WAA-Level Variables (1 page) (Complete using maps, photos, hydrologic data, field reconnaissance, etc.)	One per Wetland Assessment Area
Data Form 2 - Plot-Level Variables (3 pages per set) (Complete by sampling within nested circular plots and along transects)	Multiple sets, depending on size, variability, and number of Wetland Assessment Areas (see Chapter 6)
Data Form 3- Variable Summary Form (1 page) (Use to compile data from Forms 1 and 2 prior to entering in spreadsheet or manually calculating FCI and FCU.)	One per Wetland Assessment Area
OPTIONAL: **Alternate Basal Area Field Form** (2 pages) [Use if sampling with a dbh tape or caliper (rather than prism); you'll also need Form 3d to calculate basal area. Both forms are located in Appendix C)]	Multiple copies (same number as Data Form 2 sets)

APPENDIX A3



Layout of plots and transects for field sampling.

Appendix B
Field Data Forms

CONTENTS

Please reproduce these forms locally as needed.

Appendix B1
Field Data Forms for Hardwood Flat Wetlands

DATA FORM 1 (1 page) – TRACT AND WAA -LEVEL DATA COLLECTION

SUBCLASS: HARDWOOD FLAT WETLANDS
WAA # ___________
PLOT # ___________

Complete one copy of this form for each Wetland Assessment Area

Use aerial photos, project descriptions, topographic maps, and geomorphic maps (Appendix E) to complete the following section.

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
V_{PATCH} Forest patch size	From aerial photos or field reconnaissance, estimate the size of the forested area that is contiguous to the WAA and accessible to wildlife (including the WAA itself, if it is forested). Include both upland and wetland forests. Record the area at right – if it exceeds 2500 ha, enter "2500."	Size of the forested tract = _______ ha

Walk the entire Assessment Area and estimate the following indicators. For large or highly variable Assessment Areas, establish a series of transects across the area and make estimates along each transect, then average them for the area.

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
V_{POND} Percentage of the site capable of ponding water	Estimate the area likely to be ponded following extended rainfall. This includes both large vernal pool sites (swales) and microdepressions such as those left by trees that have blown over and uprooted.	% of site likely to pond = _________
V_{STRATA} Number of vegetation strata present	Vegetation layers are counted as present in the following categories if they account for at least 10% cover over the observed area: **Canopy** (trees ≥ 10 cm dbh that are in the canopy layer) **Subcanopy** (trees ≥ 10 cm dbh that are below the canopy layer) **Understory** (shrubs and saplings < 10 cm dbh but at least 4.5 ft tall) **Ground cover** (woody plants < 4.5 ft tall, and herbaceous vegetation)	Number of strata present = _______
V_{SOIL} Soil Integrity	Estimate the percentage of the site that has significantly altered soils. Normal farm tillage is not considered a significant alteration in this case, but fill, land leveling that removes surface horizons, and compacted areas such as roads are counted.	Percent of site with altered soils = ____

DATA FORM 2 (3 pages) - PLOT-LEVEL DATA COLLECTION

SUBCLASS: HARDWOOD FLAT WETLANDS
WAA # ___________
PLOT # ___________

PROCEDURE
Establish a plot center, assign a plot number (above), and complete the following three data sheets as directed. Repeat with new sets of plot data sheets as needed, assigning a new plot number to each set. See Chapter 6 for sampling details and guidance regarding the number of plots required. Generally, small areas should be represented by at least four plots. For large areas, establish plot centers at paced distances along evenly spaced transects.

OBSERVATIONS FROM THE CENTER POINT

HGM Variable Addressed	Procedure (see Chapter 6 for details)		Indicator Value
V_{TBA} Basal Area	Use a basal area wedge prism (or other basal area estimation tool) as directed, tally eligible tree stems, and calculate basal area in m^2/ha using the appropriate conversion factor for the prism (for example, for standard English 10-factor prism, multiply number of stems tallied by 25). **Alternative method: If measuring individual tree stems with dbh tape or caliper, use worksheet in Appendix C to enter tree diameters and follow directions on that form to calculate basal area per hectare.**	Number of stems tallied = _____ x conversion factor =	Total basal area = ______m^2/ha

OBSERVATIONS WITHIN A 0.04-HA PLOT

Establish a circular plot with a radius of 11.35 m (37.24 ft) from the center point and make the following observations within the plot:

V_{TDEN} Tree density	Count the number of trees (dbh ≥ 10 cm). Multiply by 25 to calculate stems/ha	# trees tallied = ______ x 25 =	tree density per ha _____
V_{SNAG} Snag density	Count the number of snags (standing dead trees at least 4.5 ft tall and dbh ≥ 10 cm). Multiply by 25 to calculate snags/ha	# snags tallied = _______ x 25 =	snag density/ha _______
V_{OHOR} Thickness of the O horizon	Select two or more points within the plot that are representative of the range of microtopography within the plot as a whole. Dig a hole and measure the thickness of the O horizon (organic accumulation on the soil surface, excluding fresh litter, but including surface root mats if present) and the thickness of the A horizon (mineral soil with incorporated organic matter, indicated by distinct darkening relative to lower horizons)	Thickness of O horizon measurements (cm): ____ ____ ____	Average thickness of O horizon =_____ cm
V_{AHOR} Thickness of the A horizon		Thickness of A horizon measurements (cm): ____ ____ ____	Average thickness of A horizon = _____ cm

DATA FORM 2 (3 pages) - PLOT-LEVEL DATA COLLECTION

SUBCLASS: HARDWOOD FLAT WETLANDS
WAA # ___________
PLOT # ___________

OBSERVATIONS WITHIN A 0.04-HA PLOT

Field Procedure		
(1) If tree cover is ≥ 20%, use the 50/20 rule and circle the dominant trees in Columns A, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.		
(2) If tree cover is < 20%, identify the next tallest woody stratum with at least 10% cover. Use the 50/20 rule and circle the dominants in the next tallest woody stratum in Columns A, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.		
A: Common dominants in reference standard sites	**B:** Species commonly present in reference standard sites, but dominance generally indicates fire supression, high-grading, or other disturbances	**C:** Uncommon, minor, or shrub species in reference standard sites, but may dominate in degraded systems
Carya cordiformis	*Acer negundo*	*Cercis canadensis*
Carya ovata	*Acer rubrum*	*Geditsia triacanthos*
Pinus echinata	*Celtis spp.*	*Juniperus virginiana*
Quercus alba	*Diospyros virginiana*	*Maclura pomifera*
Quercus nigra	*Fraxinus spp.*	*Morus rubra*
Quercus shumardii	*Liquidambar styraciflua*	*Ostrya virginiana*
	Pinus taeda	*Platanus occidentalis*
	Ulmus americana	*Prunus serotina*
		Ulmus alata
Calculations		
Using the dominant species circled in Columns A, B, and C above, calculate percent concurrence according to the following formula: {[(1.0 * number of circled dominants in Column A) + (0.66 * number of circled dominants in Column B) + (0.33 * number of circled dominants in Column C)] / total number of circled dominants in all columns} × 100 = _____ %		

HGM Variable Addressed	**Procedure (see Chapter 6 for details)**	**Indicator Value**
V_{TCOMP} V_{COMP} Composition of woody vegetation strata	If tree cover is ≥ 20%, record % concurrence in the V_{TCOMP} and V_{COMP} rows as a plot value. *OR* If tree cover is < 20%, record a "0" in the V_{TCOMP} row, and record % concurrence of the next tallest woody stratum in the V_{COMP} row.	Percent concurrence: V_{TCOMP} = __________% V_{COMP} = ___________%

DATA FORM 2 (3 pages) - PLOT-LEVEL DATA COLLECTION

SUBCLASS: HARDWOOD FLAT WETLANDS
WAA # ___________
PLOT # ___________

OBSERVATIONS WITHIN TWO 0.004-HA PLOTS

From the centerpoint, measure north and south 5 m and establish two circular subplots with a radius of 3.6 m (11.8 ft). Within each subplot, measure the following:

HGM Variable Addressed	Procedure (see Chapter 6 for details)		Indicator Value
V_{SSD} Shrub/Sapling density	Count the number of woody stems that are at least 1.4 m (4.5 ft) tall, but less than 10 cm dbh. Sum the tallies from both plots and multiply by 125 to get understory density per hectare	Subplot 1 tally = __ Subplot 2 tally = __ Sum = _____ × 125 = ______	Understory stems/ha = ________

OBSERVATIONS WITHIN FOUR SUBPLOTS 1-m X 1-m SQUARE

From the centerpoint, measure 5 m in each cardinal direction and establish a 1-m x1-m square subplot. Within each subplot record the following:

V_{LITTER} Litter cover	Estimate the percent of the plot area covered by undecomposed litter. Average the results of the four subplots.	Subplot 1 = ____% Subplot 2 = ____% Subplot 3 = ____% Subplot 4 = ____%	Average litter cover = _____%
V_{GVC} Ground vegetation cover	Estimate the percent cover of all herbaceous plants and woody plants < 4.5 ft tall. Average the results of the four subplots.	Subplot 1 = ____% Subplot 2 = ____% Subplot 3 = ____% Subplot 4 = ____%	Average ground veg cover = ________%

OBSERVATIONS ALONG TRANSECTS

Establish two transects (each one 15.25 m or 50 ft) by stretching a tape from the centerpoint in opposite cardinal directions (east and west). Within each transect, establish subtransects 3.65 m (12 ft) and 1.83 m (6 ft) long. Record the following:

V_{WD} (1.83-m or 6-ft subtransects) Size Class 1 (small woody debris)	Count all intersections of sticks that are between 0.6 cm (0.25 in.) and 2.54 cm (1 in.) in diameter. Don't record diameters-just count.	# Small woody debris stems:
	Transect 1	# stems = ______
	Transect 2	# stems = ______
V_{WD} (3.65-m or 12-ft subtransects) Size Class 2 (medium woody debris)	Count all intersections of sticks that are between 2.54 cm (1 in.) and 7.6 cm (3 in.) in diameter. Don't record diameters-just count.	# Medium woody debris stems:
	Transect 1	# stems = _____
	Transect 2	# stems = _____
V_{LOG} *and* V_{WD} (15.25-m or 50-ft transects) Size Class 3 large woody debris (logs)	At each place where the tape intercepts a piece of dead wood on the ground that is at least 7.6 cm (3 in.) in diameter at the intercept point, measure and record the diameter of the stem in centimeters at the point of interception.	Stem diameters (cm)
	Transect 1	_____, ______, ______, _____, _____
	Transect 2	_____, ______, ______, _____, _____

DATA FORM 3 (1 page) - WETLAND ASSESSMENT AREA-DATA SUMMARY

SUBCLASS: HARDWOOD FLAT WETLANDS
WAA # ___________

Transfer data from Data Form 1 to this form, and also compile and summarize information from all copies of Data Form 2 in the appropriate spaces below. Attach additional copies if more than eight plots are sampled within the Wetland Assessment Area. Enter the data on this form in the FCI Calculator Spreadsheet, or calculate FCI and FCU scores manually using the figures and formulae presented in Chapter 5.

HGM Variable	**Transfer the data below from Data Form 1**	**Enter this number in the FCI calculator spreadsheet**
V_{PATCH}	Forest patch size	______ ha
V_{POND}	Percent of the wetland assessment area that ponds water	_______ %
Geomorphic surface (used to determine appropriate V_{POND} entry on spreadsheet - from Data Form 1)	CHECK ONE:	High terrace or non-alluvial flat ____ Low terrace or recent alluvium ____ Tributary terrace ____
V_{STRATA}	Number of vegetation strata	____ strata
V_{SOIL}	Percent of the wetland assessment area with culturally unaltered soils	_______ %

Transfer the plot data below from Data Form 2 and average all values

	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	**AVERAGES**
V_{TBA}									BA = _____m²/ha
V_{TDEN}									density = ___stems/ha
V_{SNAG}									density = ___stems/ha
V_{TCOMP}									concurrence = _______ %
V_{COMP}									concurrence = _______ %
V_{SSD}									density = ___stems/ha
V_{GVC}									cover = _______ %
V_{LITTER}									cover = _______ %
V_{OHOR}									thickness = ______ cm
V_{AHOR}									thickness = ______ cm

Use the Woody Debris Calculator spreadsheet (or the worksheet in Appendix C) to generate log and woody debris volume based on the transect data on Data Form 2. Enter those values below and average.

V_{LOG}									log volume = _____ m³/ha
V_{WD}									wd volume = _____ m³/ha

Appendix B2
Field Data Forms for High-Gradient Riverine Wetlands

DATA FORM 1 (1 page) – WAA -LEVEL DATA COLLECTION

SUBCLASS: HIGH-GRADIENT RIVERINE WETLANDS
WAA # ___________
PLOT # ___________

Complete one copy of this form for each Wetland Assessment Area

Use aerial photos, project descriptions, topographic maps, and geomorphic maps (Appendix E) to complete the following section.

HGM Variable Addressed	Procedure (see Chapter 6 for details)		Indicator Value
V_{BUF30} Percent contiguous 30-m buffer	On a map or photo, outline a 30-m–wide buffer area adjacent to the riverine wetland. Estimate the percentage of this area that is occupied by native vegetation or other appropriate habitat that is contiguous with the riverine wetland. Enter the percentage at right.		Percent contiguous 30-m buffer = _______ %
V_{BUF250} Percent contiguous 250-m buffer	On a map or photo, outline a 250-m–wide buffer area adjacent to the riverine wetland. Estimate the percentage of this area that is occupied by native vegetation or other appropriate habitat that is contiguous with the riverine wetland. Enter the percentage at right.		Percent contiguous 250-m buffer = _______ %
V_{FREQ} Change in flood frequency	Determine (or estimate) the frequency of flooding from streams for sites within the 5-year floodplain for both pre-project and post-project conditions. Enter 0 if this is not an assessment involving hydrologic alteration.	A. Pre-project flood return interval = _____ (1 = annual flooding, 5 = once in 5 years) B. Post-project flood return interval = _______	A minus B = _______ (absolute value; ignore minus signs) (range = 0 to 5)
V_{DUR} Change in flood duration	Determine (or estimate) the duration of continuous flooding from streams (longest single event) during the growing season for sites within the 5-year floodplain for both pre-project and post-project conditions. Enter 0 if this is not an assessment involving hydrologic alteration.	A. Pre-project growing season flood duration (weeks of continuous growing season flooding, on average) = _____ B. Post-project growing season flood duration (weeks of continuous growing season flooding, on average) = _______	A minus B = ______ (absolute value; ignore minus signs) (range = 0 to 5 –enter 5 if change is 5 or greater)

DATA FORM 1 (1 page) – WAA -LEVEL DATA COLLECTION

SUBCLASS: HIGH-GRADIENT RIVERINE WETLANDS
WAA # ___________
PLOT # ___________

Walk the entire Assessment Area and develop estimates of the following indicators. For large or highly variable Assessment Areas, establish a series of transects across the area and make estimates along each transect, then average them for the area.

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
V_{STRATA} Number of vegetation strata present	Vegetation layers are counted as present in the following categories if they account for at least 10% cover over the observed area. **Canopy** (trees ≥ 10 cm dbh that are in the canopy layer) **Subcanopy** (trees ≥ 10 cm dbh that are below the canopy layer) **Understory** (shrubs and saplings < 10 cm dbh but at least 4.5 ft tall) **Ground cover** (woody plants < 4.5 ft tall, and herbaceous vegetation)	Number of strata present = ______
V_{SOIL} Soil Integrity	Estimate the percentage of the site that has significantly altered soils. Normal farm tillage is not considered a significant alteration in this case, but fill, land leveling that removes surface horizons, and compacted areas such as roads are counted.	Percent of site with altered soils = ____

DATA FORM 2 (3 pages) - PLOT-LEVEL DATA COLLECTION

SUBCLASS: HIGH-GRADIENT RIVERINE WETLANDS
WAA # ___________
PLOT # ___________

PROCEDURE
Establish a plot center, assign a plot number (above), and complete the following three data sheets as directed. Repeat with new sets of plot data sheets as needed, assigning a new plot number to each set. See Chapter 6 for sampling details and guidance regarding the number of plots required. Generally, small areas should be represented by at least four plots. For large areas, establish plot centers at paced distances along evenly spaced transects.

OBSERVATIONS FROM THE CENTER POINT

HGM Variable Addressed	Procedure (see Chapter 6 for details)		Indicator Value
V_{TBA} Basal Area	Use a basal area wedge prism (or other basal area estimation tool) as directed, tally eligible tree stems and calculate basal area in m^2/ha using the appropriate conversion factor for the prism (for example, for standard English 10-factor prism, multiply #stems tallied by 25). **Alternative method: If measuring individual tree stems with dbh tape or caliper, use worksheet in Appendix C to enter tree diameters and follow directions on that form to calculate basal area per hectare.**	Number of stems tallied = _____ x conversion factor =	Total basal area = ______m^2/ha

OBSERVATIONS WITHIN A 0.04-HA PLOT

Establish a circular plot with a radius of 11.35 m (37.24 ft) from the center point and make the following observations within the plot:

V_{TDEN} Tree density	Count the number of trees (dbh ≥ 10 cm). Multiply by 25 to calculate stems/ha	# trees tallied = ______ x 25 =	tree density per ha _____
V_{SNAG} Snag density	Count the number of snags (standing dead trees at least 4.5 ft tall and dbh ≥ 10 cm). Multiply by 25 to calculate snags/ha	# snags tallied = _______ x 25 =	snag density/ha _______
V_{OHOR} Thickness of the O horizon	Select two or more points within the plot that are representative of the range of microtopography within the plot as a whole. Dig a hole and measure the thickness of the O horizon (organic accumulation on the soil surface, excluding fresh litter, but including surface root mats if present) and the thickness of the A horizon (mineral soil with incorporated organic matter, indicated by distinct darkening relative to lower horizons)	Thickness of O horizon measurements (cm): ____ ____ ____	Average thickness of O horizon =_____ cm
V_{AHOR} Thickness of the A horizon		Thickness of A horizon measurements (cm): ____ ____ ____	Average thickness of A horizon = _____ cm

DATA FORM 2 (3 pages) - PLOT-LEVEL DATA COLLECTION

SUBCLASS: HIGH-GRADIENT RIVERINE WETLANDS
WAA # ___________
PLOT # ___________

OBSERVATIONS WITHIN A 0.04-HA PLOT

Field Procedure		
(1) If tree cover is ≥ 20%, use the 50/20 rule and circle the dominant trees in Columns A, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.		
(2) If tree cover is < 20%, identify the next tallest woody stratum with at least 10% cover. Use the 50/20 rule and circle the dominants in the next tallest woody stratum in Columns A, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.		
A: Common dominants in reference standard sites	**B:** Species commonly present in reference standard sites, but dominance generally indicates fire supression, high-grading, or other disturbances	**C:** Uncommon, minor, or shrub species in reference standard sites, but may dominate in degraded systems
Alnus spp.	*Acer rubrum*	*Carpinus caroliniana*
Hamamelis spp.	*Betula nigra*	*Cornus florida*
Pinus echinata	*Carya cordiformis*	*Ilex opaca*
Platanus occidentalis	*Fraxinus spp*	*Juniperus virginiana*
Quercus alba	*Liquidambar styraciflua*	*Ostrya virginiana*
Quercus michauxii	*Ulmus americana*	*Prunus serotina*
Quercus shumardii		*Ulmus alata*
Salix spp		

Calculations
Using the dominant species circled in Columns A, B, and C above, calculate percent concurrence according to the following formula: {[(1.0 * number of circled dominants in Column A) + (0.66 * number of circled dominants in Column B) + (0.33 * number of circled dominants in Column C)] / total number of circled dominants in all columns} × 100 = _____ %

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
V_{TCOMP} V_{COMP} Composition of woody vegetation strata	If tree cover is ≥ 20%, record % concurrence in the V_{TCOMP} and V_{COMP} rows as a plot value. *OR* If tree cover is < 20%, record a "0" in the V_{TCOMP} row, and record % concurrence of the next tallest woody stratum in the V_{COMP} row.	Percent concurrence: V_{TCOMP} = _________% V_{COMP} = __________%

DATA FORM 2 (3 pages) - PLOT-LEVEL DATA COLLECTION

SUBCLASS: HIGH-GRADIENT RIVERINE WETLANDS
WAA # ___________
PLOT # ___________

OBSERVATIONS WITHIN TWO 0.004-HA PLOTS

From the centerpoint, measure north and south 5 m and establish two circular subplots with a radius of 3.6 m (11.8 ft). Within each subplot, measure the following:

HGM Variable Addressed	Procedure (see Chapter 6 for details)		Indicator Value
V_{SSD} Shrub/Sapling density	Count the number of woody stems that are at least 1.4 m (4.5 ft) tall, but less than 10 cm dbh. Sum the tallies from both plots and multiply by 125 to get understory density per hectare	Subplot 1 tally = __ Subplot 2 tally = __ Sum = _____ × 125 = ______	Understory stems/ha = ________

OBSERVATIONS WITHIN FOUR SUBPLOTS 1-m X 1-m SQUARE

From the centerpoint, measure 5 m in each cardinal direction and establish a 1-m x1-m square subplot. Within each subplot record the following:

V_{LITTER} Litter cover	Estimate the percent of the plot area covered by undecomposed litter. Average the results of the four subplots.	Subplot 1 = ____% Subplot 2 = ____% Subplot 3 = ____% Subplot 4 = ____%	Average litter cover = _____%
V_{GVC} Ground vegetation cover	Estimate the percent cover of all herbaceous plants and woody plants < 4.5 ft tall. Average the results of the four subplots.	Subplot 1 = ____% Subplot 2 = ____% Subplot 3 = ____% Subplot 4 = ____%	Average ground veg cover = _______%

OBSERVATIONS ALONG TRANSECTS

Establish two transects (each one 15.25 m or 50 ft) by stretching a tape from the centerpoint in opposite cardinal directions (east and west). Within each transect, establish subtransects 3.65 m (12 ft) and 1.83 m (6 ft) long. Record the following:

V_{WD} (1.83-m or 6-ft subtransects) Size Class 1 (small woody debris)	Count all intersections of sticks that are between 0.6 cm (0.25 in.) and 2.54 cm (1 in.) in diameter. Don't record diameters-just count.	# Small woody debris stems:
	Transect 1	# stems = ______
	Transect 2	# stems = ______
V_{WD} (3.65-m or 12-ft subtransects) Size Class 2 (medium woody debris)	Count all intersections of sticks that are between 2.54 cm (1 in.) and 7.6 cm (3 in.) in diameter. Don't record diameters-just count.	# Medium woody debris stems:
	Transect 1	# stems = _____
	Transect 2	# stems = _____
V_{LOG} *and* V_{WD} (15.25-m or 50-ft transects) Size Class 3 large woody debris (logs)	At each place where the tape intercepts a piece of dead wood on the ground that is at least 7.6 cm (3 in.) in diameter at the intercept point, measure and record the diameter of the stem in centimenters at the point of interception.	Stem diameters (cm)
	Transect 1	_____, ______, ______, _____, _____
	Transect 2	_____, ______, ______, _____, _____

DATA FORM 3 (1 page) - WETLAND ASSESSMENT AREA-DATA SUMMARY

SUBCLASS: HIGH-GRADIENT RIVERINE WETLANDS
WAA # ___________

Transfer data from Data Form 1 to this form, and also compile and summarize information from all copies of Data Form 2 in the appropriate spaces below. Attach additional copies if more than eight plots are sampled within the Wetland Assessment Area. Enter the data on this form in the FCI Calculator Spreadsheet, or calculate FCI and FCU scores manually using the figures and formulae presented in Chapter 5.

HGM Variable	**Transfer the data below from Data Form 1**	**Enter this number in the FCI calculator spreadsheet**
V_{BUF30}	Percent contiguous 30-m buffer	________%
V_{BUF250}	Percent contiguous 250-m buffer	________%
V_{FREQ}	Change in flood recurrence interval (0-5)	________years
V_{DUR}	Change in flood duration (0-5)	_______weeks
V_{STRATA}	Number of vegetation strata	____ strata
V_{SOIL}	Percent of the wetland assessment area with culturally unaltered soils	_______ %

Transfer the plot data below from Data Form 2 and average all values

	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	**AVERAGES**
V_{TBA}									BA = _____m^2/ha
V_{TDEN}									density = ___stems/ha
V_{SNAG}									density = ___stems/ha
V_{TCOMP}									concurrence = _______ %
V_{COMP}									concurrence = _______ %
V_{SSD}									density = ___stems/ha
V_{GVC}									cover = _______ %
V_{LITTER}									cover = _______ %
V_{OHOR}									thickness = ______ cm
V_{AHOR}									thickness = ______ cm

Use the Woody Debris Calculator spreadsheet (or the worksheet in Appendix C) to generate log and woody debris volume based on the transect data on Data Form 2. Enter those values below and average.

V_{LOG}									log volume = _____ m^3/ha
V_{WD}									wd volume = _____ m^3/ha

Appendix B3
Field Data Forms for Mid-Gradient Riverine Wetlands

DATA FORM 1 (1 page) – WAA -LEVEL DATA COLLECTION

SUBCLASS: MID-GRADIENT RIVERINE WETLANDS
WAA # ___________
PLOT # ___________

Complete one copy of this form for each Wetland Assessment Area

Use aerial photos, project descriptions, topographic maps, and geomorphic maps (Appendix E) to complete the following section.

HGM Variable Addressed	**Procedure (see Chapter 6 for details)**	**Indicator Value**
V_{BUF30} Percent contiguous 30-m buffer	On a map or photo, outline a 30-m–wide buffer area adjacent to the riverine wetland. Estimate the percentage of this area that is occupied by native vegetation or other appropriate habitat that is contiguous with the riverine wetland. Enter the percentage at right.	Percent contiguous 30-m buffer = _______ %
V_{BUF250} Percent contiguous 250-m buffer	On a map or photo, outline a 250-m–wide buffer area adjacent to the riverine wetland. Estimate the percentage of this area that is occupied by native vegetation or other appropriate habitat that is contiguous with the riverine wetland. Enter the percentage at right.	Percent contiguous 250-m buffer = _______ %

HGM Variable Addressed	**Procedure (see Chapter 6 for details)**		**Indicator Value**
V_{FREQ} Change in flood frequency	Determine (or estimate) the frequency of flooding from streams for sites within the 5-year floodplain for both pre-project and post-project conditions. Enter 0 if this is not an assessment involving hydrologic alteration.	A. Pre-project flood return interval = _____ (1 = annual flooding, 5 = once in 5 years) B. Post-project flood return interval = _______	A minus B = _______ (absolute value; ignore minus signs) (range = 0 to 5)
V_{DUR} Change in flood duration	Determine (or estimate) the duration of continuous flooding from streams (longest single event) during the growing season for sites within the 5-year floodplain for both pre-project and post-project conditions. Enter 0 if this is not an assessment involving hydrologic alteration.	A. Pre-project growing season flood duration (weeks of continuous growing season flooding, on average) = _____ B. Post-project growing season flood duration (weeks of continuous growing season flooding, on average) = _______	A minus B = ______ (absolute value; ignore minus signs) (range = 0 to 5 –enter 5 if change is 5 or greater)

DATA FORM 1 (1 page) – WAA -LEVEL DATA COLLECTION

SUBCLASS: MID-GRADIENT RIVERINE WETLANDS
WAA # ___________
PLOT # ___________

Walk the entire Assessment Area and develop estimates of the following indicators. For large or highly variable Assessment Areas, establish a series of transects across the area and make estimates along each transect, then average them for the area.

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
V_{POND} Percentage of the site capable of ponding water	Estimate the area likely to be ponded following extended rainfall. This includes both large vernal pool sites (swales) and microdepressions such as those left by trees that have blown over and uprooted.	% of site likely to pond = _________
V_{STRATA} Number of vegetation strata present	Vegetation layers are counted as present in the following categories if they account for at least 10% cover over the observed area. **Canopy** (trees ≥ 10 cm dbh that are in the canopy layer) **Subcanopy** (trees ≥ 10 cm dbh that are below the canopy layer) **Understory** (shrubs and saplings < 10 cm dbh but at least 4.5 ft tall) **Ground cover** (woody plants < 4.5 ft tall, and herbaceous vegetation)	Number of strata present = _______
V_{SOIL} Soil Integrity	Estimate the percentage of the site that has significantly altered soils. Normal farm tillage is not considered a significant alteration in this case, but fill, land leveling that removes surface horizons, and compacted areas such as roads are counted.	Percent of site with altered soils = _____

DATA FORM 2 (3 pages) - PLOT-LEVEL DATA COLLECTION

SUBCLASS: MID-GRADIENT RIVERINE WETLANDS
WAA # ___________
PLOT # ___________

PROCEDURE
Establish a plot center, assign a plot number (above), and complete the following three data sheets as directed. Repeat with new sets of plot data sheets as needed, assigning a new plot number to each set. See Chapter 6 for sampling details and guidance regarding the number of plots required. Generally, small areas should be represented by at least four plots. For large areas, establish plot centers at paced distances along evenly spaced transects.

OBSERVATIONS FROM THE CENTER POINT

HGM Variable Addressed	Procedure (see Chapter 6 for details)		Indicator Value
V_{TBA} Basal Area	Use a basal area wedge prism (or other basal area estimation tool) as directed, tally eligible tree stems and calculate basal area in m^2/ha using the appropriate conversion factor for the prism (for example, for standard English 10-factor prism, multiply #stems tallied by 25). **Alternative method: If measuring individual tree stems with dbh tape or caliper, use worksheet in Appendix C to enter tree diameters and follow directions on that form to calculate basal area per hectare.**	Number of stems tallied = _____ x conversion factor =	Total basal area = ______m^2/ha

OBSERVATIONS WITHIN A 0.04-HA PLOT

Establish a circular plot with a radius of 11.35 m (37.24 ft) from the center point and make the following observations within the plot:

V_{TDEN} Tree density	Count the number of trees (dbh ≥ 10 cm). Multiply by 25 to calculate stems/ha	# trees tallied = ______ x 25 =	tree density per ha _____
V_{SNAG} Snag density	Count the number of snags (standing dead trees at least 4.5 ft tall and dbh ≥ 10 cm). Multiply by 25 to calculate snags/ha	# snags tallied = _______ x 25 =	snag density/ha _______
V_{OHOR} Thickness of the O horizon	Select two or more points within the plot that are representative of the range of microtopography within the plot as a whole. Dig a hole and measure the thickness of the O horizon (organic accumulation on the soil surface, excluding fresh litter, but including surface root mats if present) and the thickness of the A horizon (mineral soil with incorporated organic matter, indicated by distinct darkening relative to lower horizons)	Thickness of O horizon measurements (cm): ____ ____ ____	Average thickness of O horizon =_____ cm
V_{AHOR} Thickness of the A horizon		Thickness of A horizon measurements (cm): ____ ____ ____	Average thickness of A horizon = _____ cm

DATA FORM 2 (3 pages) - PLOT-LEVEL DATA COLLECTION

SUBCLASS: MID-GRADIENT RIVERINE WETLANDS
WAA # ___________
PLOT # ___________

OBSERVATIONS WITHIN A 0.04-HA PLOT

Field Procedure		
(1) If tree cover is ≥ 20%, use the 50/20 rule and circle the dominant trees in Columns A, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.		
(2) If tree cover is < 20%, identify the next tallest woody stratum with at least 10% cover. Use the 50/20 rule and circle the dominants in the next tallest woody stratum in Columns A, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.		
A: Common dominants in reference standard sites	**B:** Species commonly present in reference standard sites, but dominance generally indicates fire supression, high-grading, or other disturbances	**C:** Uncommon, minor, or shrub species in reference standard sites, but may dominate in degraded systems
Acer saccharinum	*Acer rubrum*	*Cornus florida*
Diospyros virginiana	*Betula nigra*	*Ilex opaca*
Liquidambar styraciflua	*Carpinus caroliniana*	*Ostrya virginiana*
Nyssa sylvatica	*Fraxinus spp*	
Platanus occidentalis	*Ulmus americana*	
Quercus michauxii		
Quercus nigra		
Salix spp		
Calculations		
Using the dominant species circled in Columns A, B, and C above, calculate percent concurrence according to the following formula: {[(1.0 * number of circled dominants in Column A) + (0.66 * number of circled dominants in Column B) + (0.33 * number of circled dominants in Column C)] / total number of circled dominants in all columns} × 100 = _____ %		

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
V_{TCOMP} V_{COMP} Composition of woody vegetation strata	If tree cover is ≥ 20%, record % concurrence in the V_{TCOMP} and V_{COMP} rows as a plot value. *OR* If tree cover is < 20%, record a "0" in the V_{TCOMP} row, and record % concurrence of the next tallest woody stratum in the V_{COMP} row.	Percent concurrence: V_{TCOMP} = _________% V_{COMP} = __________%

DATA FORM 2 (3 pages) - PLOT-LEVEL DATA COLLECTION

SUBCLASS: MID-GRADIENT RIVERINE WETLANDS
WAA # ___________
PLOT # ___________

OBSERVATIONS WITHIN TWO 0.004-HA PLOTS

From the centerpoint, measure north and south 5 m and establish two circular subplots with a radius of 3.6 m (11.8 ft). Within each subplot, measure the following:

HGM Variable Addressed	Procedure (see Chapter 6 for details)		Indicator Value
V_{SSD} Shrub/Sapling density	Count the number of woody stems that are at least 1.4 m (4.5 ft) tall, but less than 10 cm dbh. Sum the tallies from both plots and multiply by 125 to get understory density per hectare	Subplot 1 tally = __ Subplot 2 tally = __ Sum = _____ × 125 = ______	Understory stems/ha = ________

OBSERVATIONS WITHIN FOUR SUBPLOTS 1-m X 1-m SQUARE

From the centerpoint, measure 5 m in each cardinal direction and establish a 1-m x1-m square subplot. Within each subplot record the following:

V_{LITTER} Litter cover	Estimate the percent of the plot area covered by undecomposed litter. Average the results of the four subplots.	Subplot 1 = ____% Subplot 2 = ____% Subplot 3 = ____% Subplot 4 = ____%	Average litter cover = _____%
V_{GVC} Ground vegetation cover	Estimate the percent cover of all herbaceous plants and woody plants < 4.5 ft tall. Average the results of the four subplots.	Subplot 1 = ____% Subplot 2 = ____% Subplot 3 = ____% Subplot 4 = ____%	Average ground veg cover = ________%

OBSERVATIONS ALONG TRANSECTS

Establish two transects (each one 15.25 m or 50 ft) by stretching a tape from the centerpoint in opposite cardinal directions (east and west). Within each transect, establish subtransects 3.65 m (12 ft) and 1.83 m (6 ft) long. Record the following:

V_{WD} (1.83-m or 6-ft subtransects) Size Class 1 (small woody debris)	Count all intersections of sticks that are between 0.6 cm (0.25 in.) and 2.54 cm (1 in.) in diameter. Don't record diameters-just count.	# Small woody debris stems:
	Transect 1	# stems = ______
	Transect 2	# stems = ______
V_{WD} (3.65-m or 12-ft subtransects) Size Class 2 (medium woody debris)	Count all intersections of sticks that are between 2.54 cm (1 in.) and 7.6 cm (3 in.) in diameter. Don't record diameters-just count.	# Medium woody debris stems:
	Transect 1	# stems = _____
	Transect 2	# stems = _____
V_{LOG} and V_{WD} (15.25-m or 50-ft transects) Size Class 3 large woody debris (logs)	At each place where the tape intercepts a piece of dead wood on the ground that is at least 7.6 cm (3 in.) in diameter at the intercept point, measure and record the diameter of the stem in centimeters at the point of interception.	Stem diameters (cm)
	Transect 1	_____, ______, ______, _____, _____
	Transect 2	_____, ______, ______, _____, _____

DATA FORM 3 (1 page) - WETLAND ASSESSMENT AREA-DATA SUMMARY

SUBCLASS: MID-GRADIENT RIVERINE WETLANDS
WAA # ___________

Transfer data from Data Form 1 to this form, and also compile and summarize information from all copies of Data Form 2 in the appropriate spaces below. Attach additional copies if more than eight plots are sampled within the Wetland Assessment Area. Enter the data on this form in the FCI Calculator Spreadsheet, or calculate FCI and FCU scores manually using the figures and formulae presented in Chapter 5.

HGM Variable	**Transfer the data below from Data Form 1**	**Enter this number in the FCI calculator spreadsheet**
V_{BUF30}	Percent contiguous 30-m buffer	________%
V_{BUF250}	Percent contiguous 250-m buffer	________%
V_{FREQ}	Change in flood recurrence interval (0-5)	________years
V_{DUR}	Change in flood duration (0-5)	_______weeks
V_{POND}	Percent of the wetland assessment area that ponds water	_______ %
V_{STRATA}	Number of vegetation strata	____ strata
V_{SOIL}	Percent of the wetland assessment area with culturally unaltered soils	_______ %

Transfer the plot data below from Data Form 2 and average all values

	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	**AVERAGES**
V_{TBA}									BA = _____m^2/ha
V_{TDEN}									density = ___stems/ha
V_{SNAG}									density = ___stems/ha
V_{TCOMP}									concurrence = _______ %
V_{COMP}									concurrence = _______ %
V_{SSD}									density = ___stems/ha
V_{GVC}									cover = _______ %
V_{LITTER}									cover = _______ %
V_{OHOR}									thickness = ______ cm
V_{AHOR}									thickness = ______ cm

Use the Woody Debris Calculator spreadsheet (or the worksheet in Appendix C) to generate log and woody debris volume based on the transect data on Data Form 2. Enter those values below and average.

V_{LOG}									log volume = _____ m^3/ha
V_{WD}									wd volume = _____ m^3/ha

Appendix B4
Field Data Forms for Low-Gradient Riverine Wetlands

DATA FORM 1 (1 page) – WAA -LEVEL DATA COLLECTION

SUBCLASS: LOW-GRADIENT RIVERINE WETLANDS
WAA # ___________
PLOT # ___________

Complete one copy of this form for each Wetland Assessment Area

Use aerial photos, project descriptions, topographic maps, and geomorphic maps (Appendix E) to complete the following section.

HGM Variable Addressed	Procedure (see Chapter 6 for details)		Indicator Value
V_{PATCH} Forest patch size	From aerial photos or field reconnaissance, estimate the size of the forested area that is contiguous to the WAA and accessible to wildlife (including the WAA itself, if it is forested). Include both upland and wetland forests. Record the area at right – if it exceeds 2500 ha, enter "2500."		Size of the forested tract = _______ ha
V_{FREQ} Change in flood frequency	Determine (or estimate) the frequency of flooding from streams for sites within the 5-year floodplain for both pre-project and post-project conditions. Enter 0 if this is not an assessment involving hydrologic alteration.	A. Pre-project flood return interval = _____ (1 = annual flooding, 5 = once in 5 years) B. Post-project flood return interval = _______	A minus B = _______ (absolute value; ignore minus signs) (range = 0 to 5)
V_{DUR} Change in flood duration	Determine (or estimate) the duration of continuous flooding from streams (longest single event) during the growing season for sites within the 5-year floodplain for both pre-project and post-project conditions. Enter 0 if this is not an assessment involving hydrologic alteration.	A. Pre-project growing season flood duration (weeks of continuous growing season flooding, on average) = _____ B. Post-project growing season flood duration (weeks of continuous growing season flooding, on average) = _______	A minus B = ______ (absolute value; ignore minus signs) (range = 0 to 5 –enter 5 if change is 5 or greater)

DATA FORM 1 (1 page) – WAA -LEVEL DATA COLLECTION

SUBCLASS: LOW-GRADIENT RIVERINE WETLANDS
WAA # ___________
PLOT # ___________

Walk the entire Assessment Area and estimate the following indicators. For large or highly variable Assessment Areas, establish a series of transects across the area and make estimates along each transect, then average them for the area.

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
V_{POND} Percentage of the site capable of ponding water	Estimate the area likely to be ponded following extended rainfall. This includes both large vernal pool sites (swales) and microdepressions such as those left by trees that have blown over and uprooted.	% of site likely to pond = _________
V_{STRATA} Number of vegetation strata present	Vegetation layers are counted as present in the following categories if they account for at least 10% cover over the observed area. **Canopy** (trees ≥ 10 cm dbh that are in the canopy layer) **Subcanopy** (trees ≥ 10 cm dbh that are below the canopy layer) **Understory** (shrubs and saplings < 10 cm dbh but at least 4.5 ft tall) **Ground cover** (woody plants < 4.5 ft tall, and herbaceous vegetation)	Number of strata present = _______
V_{SOIL} Soil Integrity	Estimate the percentage of the site that has significantly altered soils. Normal farm tillage is not considered a significant alteration in this case, but fill, land leveling that removes surface horizons, and compacted areas such as roads are counted.	Percent of site with altered soils = _____

DATA FORM 2 (3 pages) - PLOT-LEVEL DATA COLLECTION

SUBCLASS: LOW-GRADIENT RIVERINE WETLANDS
WAA # ___________
PLOT # ___________

PROCEDURE
Establish a plot center, assign a plot number (above), and complete the following three data sheets as directed. Repeat with new sets of plot data sheets as needed, assigning a new plot number to each set. See Chapter 6 for sampling details and guidance regarding the number of plots required. Generally, small areas should be represented by at least four plots. For large areas, establish plot centers at paced distances along evenly spaced transects.

OBSERVATIONS FROM THE CENTER POINT

HGM Variable Addressed	Procedure (see Chapter 6 for details)		Indicator Value
V_{TBA} Basal Area	Use a basal area wedge prism (or other basal area estimation tool) as directed, tally eligible tree stems and calculate basal area in m^2/ha using the appropriate conversion factor for the prism (for example, for standard English 10-factor prism, multiply #stems tallied by 25). **Alternative method: If measuring individual tree stems with dbh tape or caliper, use worksheet in Appendix C to enter tree diameters and follow directions on that form to calculate basal area per hectare.**	Number of stems tallied = _____ x conversion factor =	Total basal area = ______m^2/ha

OBSERVATIONS WITHIN A 0.04-HA PLOT

Establish a circular plot with a radius of 11.35 m (37.24 ft) from the center point and make the following observations within the plot:

V_{TDEN} Tree density	Count the number of trees (dbh ≥ 10 cm). Multiply by 25 to calculate stems/ha	# trees tallied = ______ x 25 =	tree density per ha _____
V_{SNAG} Snag density	Count the number of snags (standing dead trees at least 4.5 ft tall and dbh ≥ 10 cm). Multiply by 25 to calculate snags/ha	# snags tallied = _______ x 25 =	snag density/ha _______
V_{OHOR} Thickness of the O horizon	Select two or more points within the plot that are representative of the range of microtopography within the plot as a whole. Dig a hole and measure the thickness of the O horizon (organic accumulation on the soil surface, excluding fresh litter, but including surface root mats if present) and the thickness of the A horizon (mineral soil with incorporated organic matter, indicated by distinct darkening relative to lower horizons)	Thickness of O horizon measurements (cm): ____ ____ ____	Average thickness of O horizon =_____ cm
V_{AHOR} Thickness of the A horizon		Thickness of A horizon measurements (cm): ____ ____ ____	Average thickness of A horizon = _____ cm

DATA FORM 2 (3 pages) - PLOT-LEVEL DATA COLLECTION

SUBCLASS: LOW-GRADIENT RIVERINE WETLANDS
WAA # ___________
PLOT # ___________

OBSERVATIONS WITHIN A 0.04-HA PLOT

Field Procedure		
(1) If tree cover is ≥ 20%, use the 50/20 rule and circle the dominant trees in Columns A, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.		
(2) If tree cover is < 20%, identify the next tallest woody stratum with at least 10% cover. Use the 50/20 rule and circle the dominants in the next tallest woody stratum in Columns A, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.		
A: Common dominants in reference standard sites	**B:** Species commonly present in reference standard sites, but dominance generally indicates fire supression, high-grading, or other disturbances	**C:** Uncommon, minor, or shrub species in reference standard sites, but may dominate in degraded systems
Acer saccharinum	*Celtis laevigata*	*Carpinus caroliniana*
Carya cordiformis	*Fraxinus pennsylvanica*	*Ilex opaca*
Platanus occidentalis	*Liquidambar styraciflua*	*Ulmus alata*
Populus deltoides	*Salix nigra*	
Quercus michauxii	*Ulmus americana*	
Quercus nigra		
Calculations		
Using the dominant species circled in Columns A, B, and C above, calculate percent concurrence according to the following formula: {[(1.0 * number of circled dominants in Column A) + (0.66 * number of circled dominants in Column B) + (0.33 * number of circled dominants in Column C)] / total number of circled dominants in all columns} × 100 = _____ %		

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
V_{TCOMP} V_{COMP} Composition of woody vegetation strata	If tree cover is ≥ 20%, record % concurrence in the V_{TCOMP} and V_{COMP} rows as a plot value. *OR* If tree cover is < 20%, record a "0" in the V_{TCOMP} row, and record % concurrence of the next tallest woody stratum in the V_{COMP} row.	Percent concurrence: V_{TCOMP} = __________% V_{COMP} = ___________%

DATA FORM 2 (3 pages) - PLOT-LEVEL DATA COLLECTION

SUBCLASS: LOW-GRADIENT RIVERINE WETLANDS
WAA # ___________
PLOT # ___________

OBSERVATIONS WITHIN TWO 0.004-HA PLOTS

From the centerpoint, measure north and south 5 m and establish two circular subplots with a radius of 3.6 m (11.8 ft). Within each subplot, measure the following:

HGM Variable Addressed	Procedure (see Chapter 6 for details)		Indicator Value
V_{SSD} Shrub/Sapling density	Count the number of woody stems that are at least 1.4 m (4.5 ft) tall, but less than 10 cm dbh. Sum the tallies from both plots and multiply by 125 to get understory density per hectare	Subplot 1 tally = __ Subplot 2 tally = __ Sum = _____ × 125 = ______	Understory stems/ha = ________

OBSERVATIONS WITHIN FOUR SUBPLOTS 1-m X 1-m SQUARE

From the centerpoint, measure 5 m in each cardinal direction and establish a 1-m x1-m square subplot. Within each subplot record the following:

V_{LITTER} Litter cover	Estimate the percent of the plot area covered by undecomposed litter. Average the results of the four subplots.	Subplot 1 = ____% Subplot 2 = ____% Subplot 3 = ____% Subplot 4 = ____%	Average litter cover = _____%
V_{GVC} Ground vegetation cover	Estimate the percent cover of all herbaceous plants and woody plants < 4.5 ft tall. Average the results of the four subplots.	Subplot 1 = ____% Subplot 2 = ____% Subplot 3 = ____% Subplot 4 = ____%	Average ground veg cover = _______%

OBSERVATIONS ALONG TRANSECTS

Establish two transects (each one 15.25 m or 50 ft) by stretching a tape from the centerpoint in opposite cardinal directions (east and west). Within each transect, establish subtransects 3.65 m (12 ft) and 1.83 m (6 ft) long. Record the following:

V_{WD} (1.83-m or 6-ft subtransects) Size Class 1 (small woody debris)	Count all intersections of sticks that are between 0.6 cm (0.25 in.) and 2.54 cm (1 in.) in diameter. Don't record diameters-just count.	# Small woody debris stems:
	Transect 1	# stems = ______
	Transect 2	# stems = ______
V_{WD} (3.65-m or 12-ft subtransects) Size Class 2 (medium woody debris)	Count all intersections of sticks that are between 2.54 cm (1 in.) and 7.6 cm (3 in.) in diameter. Don't record diameters-just count.	# Medium woody debris stems:
	Transect 1	# stems = _____
	Transect 2	# stems = _____
V_{LOG} and V_{WD} (15.25-m or 50-ft transects) Size Class 3 large woody debris (logs)	At each place where the tape intercepts a piece of dead wood on the ground that is at least 7.6 cm (3 in.) in diameter at the intercept point, measure and record the diameter of the stem in centimeters at the point of interception.	Stem diameters (cm)
	Transect 1	_____, ______, ______, _____, _____
	Transect 2	_____, ______, ______, _____, _____

DATA FORM 3 (1 page) - WETLAND ASSESSMENT AREA-DATA SUMMARY

SUBCLASS: LOW-GRADIENT RIVERINE WETLANDS
WAA # ___________

Transfer data from Data Form 1 to this form, and also compile and summarize information from all copies of Data Form 2 in the appropriate spaces below. Attach additional copies if more than eight plots are sampled within the Wetland Assessment Area. Enter the data on this form in the FCI Calculator Spreadsheet, or calculate FCI and FCU scores manually using the figures and formulae presented in Chapter 5.

HGM Variable	**Transfer the data below from Data Form 1**								**Enter this number in the FCI calculator spreadsheet**
V_{PATCH}	Forest patch size								______ ha
V_{FREQ}	Change in flood recurrence interval (0-5)								________years
V_{DUR}	Change in flood duration (0-5)								_______weeks
V_{POND}	Percent of the wetland assessment area that ponds water								_______ %
V_{STRATA}	Number of vegetation strata								____ strata
V_{SOIL}	Percent of the wetland assessment area with culturally unaltered soils								_______ %
Transfer the plot data below from Data Form 2 and average all values									
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	**AVERAGES**
V_{TBA}									BA = _____m^2/ha
V_{TDEN}									density = ___stems/ha
V_{SNAG}									density = ___stems/ha
V_{TCOMP}									concurrence = _______ %
V_{COMP}									concurrence = _______ %
V_{SSD}									density = ___stems/ha
V_{GVC}									cover = _______ %
V_{LITTER}									cover = _______ %
V_{OHOR}									thickness = ______ cm
V_{AHOR}									thickness = ______ cm
Use the Woody Debris Calculator spreadsheet (or the worksheet in Appendix C) to generate log and woody debris volume based on the transect data on Data Form 2. Enter those values below and average.									
V_{LOG}									log volume = _____ m^3/ha
V_{WD}									wd volume = _____ m^3/ha

Appendix C
Alternate Field Forms

CONTENTS

ALTERNATE DATA FORM C1 (1 page) - BASAL AREA DETERMINATION USING DIAMETER MEASUREMENTS

SUBCLASS: ______________________
WAA # ___________
PLOT # ___________

If a basal area prism or similar tool is not used to estimate tree basal area for the V_{TBA} variable, but individual tree diameters are measured instead, use the form below to record tree diameters within each 0.04-ha plot. Follow the directions to summarize these data in terms of m^2/ha at the plot level, or use the spreadsheet provided in Appendix D, then enter the calculated value for each plot in the appropriate spaces on Data Form 4. Note that species need not be associated with each diameter measure, but that option is included for those users who wish to sum individual basal areas of each species to develop a more accurate estimate of V_{TCOMP} than the reconnaissance-level sample provides. Trees can also be counted with the table below to get tree density (V_{TDEN}) rather than using the plot count specified on Data Form 3.

Record the species (optional) and dbh (cm) of all trees (i.e., woody stems ≥ 10 cm or 4 in dbh) in the 0.04 ha plot in Columns 1 and 2 in the table below. Complete the calculations (or use spreadsheet) to derive basal area per tree, and sum to get total plot basal area (m^2/ha).

1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Species Code (optional)	dbh (cm)	square the value in column 2 (dbh x dbh)	multiply the value in column 3 by 0.00196 to get m^2/ha per tree	Species Code (optional)	dbh (cm)	square the value in column 2 (dbh x dbh)	multiply the value in column 3 by 0.00196 to get m^2/ha per tree

SUM ALL COLUMN 4 VALUES TO GET TOTAL PLOT BASAL AREA = ________ (m^2 / ha)

Record Total Basal Area on Data Form 4 in the V_{TBA} row as a plot value

ALTERNATE DATA FORM C2 (2 pages) - PROCEDURES FOR MANUALLY CALCULATING WOODY DEBRIS AND LOG VOLUME

SUBCLASS: ______________________
WAA # ___________
PLOT # ___________

For users who do not wish to use the spreadsheet provided in Appendix D to calculate woody debris and log volume for use in generating the V_{WD} and V_{LOG} variables, the same summary data can be calculated manually. Transfer the transect data recorded on Data Form 2 (Plot-Level Data Collection, Observations along Transects) to the data sheet below, and make the indicated calculations. Then transfer the results to the appropriate plot summary spaces on Data Form 3.

From Data Form 2, transfer the small woody debris stem counts (Size Class 1 - stems between 0.6 and 2.54 cm in diameter) for Transects 1 and 2, sum them, and multiply by 0.722 to convert to volume per hectare:

Stem Count, Transect 1 ____

Stem Count, Transect 2 ____

total number of stems = _______ × 0.722 = ______ m^3/ha, Size Class 1

From Data Form 2, transfer the medium woody debris stem counts (Size Class 2 - stems between 2.54 and 7.6 cm in diameter) for Transects 1 and 2, sum them, and multiply by 3.449 to convert to volume per hectare:

Stem Count, Transect 1 ____

Stem Count, Transect 2 ____

total number of stems = _______ × 3.449 = ______ m^3/ha, Size Class 2

From Data Form 2, transfer the diameter (cm) of each stem of Size Class 3 (large stems, >7.6 cm, or >3 in.) measured along Transect 1 and Transect 2 into the table below. Multiply each diameter measurement by 0.3937, and then square the result. Sum all results, then multiply that sum by 0.2657 to get large woody debris volume (m^3/ha).

Transect 1			Transect 2		
1	2	3	1	2	3
Stem Diameter (cm)	Multiply stem diameter by 0.3937	Square the result in column 2	Stem Diameter (cm)	Multiply stem diameter by 0.3937	Square the result in column 2
	SUM=			**SUM=**	

ALTERNATE DATA FORM C2 (2 pages) - PROCEDURES FOR MANUALLY CALCULATING WOODY DEBRIS AND LOG VOLUME

SUBCLASS: ______________________
WAA # ___________
PLOT # ___________

V_{LOG} **Sum of Size Class 3 Transect 1 + Sum of Size Class 3 Transect 2 = ______ × 0.2657 =** **__________ m^3/ha, Size Class 3** **(Transfer this number as a plot value to the V_{LOG} row on Data Form 3)**
V_{WD} **Sum of Size Class 1 _____m^3/ha + Size Class 2 _____m^3/ha + Size Class 3 _____m^2/ha =** **______ m^3/ha (total woody debris volume/ha)** **(Transfer this number as a plot value to the V_{WD} row on Data Form 3)**

Appendix D
Spreadsheets

CONTENTS

Note: This appendix contains demonstration printouts of these spreadsheets. Working copies are available for download at www.wes.army.mil/el/wetlands/datanal.html.

APPENDIX D1

Basal Area (V_{TBA}) Calculator (Version of 12/2001)			
Use one of the forms below (depending on whether tree diameters were measured in centimeters or inches) to calculate total basal area (m^2/ha) for a plot. Transfer the Total Plot Basal Area value (located in red cell) to the V_{TBA} line on Data Form 3 (Wetland Assessment Area Data Summary). Delete values from all green input cells and repeat data entry as needed for additional plots. (Note: Recording of species codes is optional. Users may want to include species associated with individual tree diameters to assist in determining dominance for V_{TCOMP} calcuations, but the spreadsheets below will work without entering species codes.)			
Enter individual tree species code in cells A6-A35 (optional)	Enter individual tree diameters (cm) in cells B6-B35	Converts to cm^2/0.04 ha 3.14*(tree diameter/2)^2=cm^2	Converts to m^2/ha - Column C*0.0001*25=m^2/ha
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		0.00	0.00
		Total Plot Basal Area in m^2/ha :	0.00

Example of the input form used in the basal area calculator spreadsheet.

Fill in Size Class 1 (stem count), Size Class 2 (stem count), and Size Class 3 (stem diameters in centimeters) in appropriate light green shaded areas below. Find resulting plot values for V_{LOG} and V_{WD} subindices in yellow shaded areas at the bottom of the sheet.

	Size Class 1 No. of Stems/ 1.83 m Transect		Size Class 1	Size Class 1	Size Class 2 No. of Stems/ 3.65 m Transect		Size Class 2	Size Class 2
	Transect 1	Transect 2	Total Stem Count	tons/acre	Transect 1	Transect 2	Total Stem Count	tons/acre
Plot 1			0	0.0			0	0.0
Plot 2			0	0.0			0	0.0
Plot 3			0	0.0			0	0.0
Plot 4			0	0.0			0	0.0
Plot 5			0	0.0			0	0.0

Size Class 3 Stem Diameters (cm) 15.25 m Transect		Size Class 3 Stem Diameter^2 (in)		Size Class 3 Stem Diameters (cm) 15.25 m Transect		Size Class 3 Stem Diameter^2 (in)		Size Class 3 Stem Diameters (cm) 15.25 m Transect		Size Class 3 Stem Diameter^2 (in)	
Plot 1		Plot 1		Plot 2		Plot 2		Plot 3		Plot 3	
Transect 1	Transect 2	Transect 1	Transect 2	Transect 1	Transect 2	Transect 1	Transect 2	Transect 1	Transect 2	Transect 1	Transect 2
		0.0	0.0			0.0	0.0			0.0	0.0
		0.0	0.0			0.0	0.0			0.0	0.0
		0.0	0.0			0.0	0.0			0.0	0.0
		0.0	0.0			0.0	0.0			0.0	0.0
		0.0	0.0			0.0	0.0			0.0	0.0
		0.0	0.0			0.0	0.0			0.0	0.0
		0.0	0.0			0.0	0.0			0.0	0.0
		0.0	0.0			0.0	0.0			0.0	0.0
		0.0	0.0			0.0	0.0			0.0	0.0
		0.0	0.0			0.0	0.0			0.0	0.0
		0.0	0.0			0.0	0.0			0.0	0.0

Size Class 3 Stem Diameters (cm) 15.25 m Transect		Size Class 3 Stem Diameter^2 (in)		Size Class 3 Stem Diameters (cm) 15.25 m Transect		Size Class 3 Stem Diameter^2 (in)	
Plot 4		Plot 4		Plot 5		Plot 5	
Transect 1	Transect 2	Transect 1	Transect 2	Transect 1	Transect 2	Transect 1	Transect 2
		0.0	0.0			0.0	0.0
		0.0	0.0			0.0	0.0
		0.0	0.0			0.0	0.0
		0.0	0.0			0.0	0.0
		0.0	0.0			0.0	0.0
		0.0	0.0			0.0	0.0
		0.0	0.0			0.0	0.0
		0.0	0.0			0.0	0.0
		0.0	0.0			0.0	0.0
		0.0	0.0			0.0	0.0
		0.0	0.0			0.0	0.0

Example of the input form used in the woody debris calculation spreadsheet (page 1).

	Size Class 3 Sum of Stem Diameter^2 (in)		Size Class 3 Total Diameter^2 (in)	Size Class 3 tons/acre	Size Class 3 ft^3/acre
	Transect 1	Transect 2			
Plot 1	0.0	0.0	0.0	0.0	0.0
Plot 2	0.0	0.0	0.0	0.0	0.0
Plot 3	0.0	0.0	0.0	0.0	0.0
Plot 4	0.0	0.0	0.0	0.0	0.0
Plot 5	0.0	0.0	0.0	0.0	0.0

Size Classes 1, 2, 3 tons/acre	Size Classes 1, 2, 3 ft^3/acre
0.0	0.0
0.0	0.0
0.0	0.0
0.0	0.0
0.0	0.0

V_{LOG} and V_{WD} plot values can be found below:

Plot Number	(V_{LOG}) Size Class 3 m^3/ha
Plot 1	0.0
Plot 2	0.0
Plot 3	0.0
Plot 4	0.0
Plot 5	0.0

Plot Number	(V_{WD}) Size Classes 1, 2, 3 m^3/ha
Plot 1	0.0
Plot 2	0.0
Plot 3	0.0
Plot 4	0.0
Plot 5	0.0

Example of the input form used in the woody debris calculation spreadsheet (page 2).

APPENDIX D3

FCI and FCU Calculations for the Flat Regional Subclass
in the Ozark Mountains Region
(Version of 05/2007)

Project:			
WAA#		**Area of the WAA (ha):**	

In the green shaded cells below delete any existing numeric values and enter the WAA summary values from Data Form 3. Leave no cells blank. Print and attach this sheet to the Project Information and Summary of Assessment Form applicable to the project.

Variable	Metric Value	Units	Subindex
V_{AHOR}		cm	
V_{BUF30}	N/A	%	
V_{BUF250}	N/A	%	
V_{COMP}		%	
V_{DUR}	N/A	%	
V_{FREQ}	N/A	years	
V_{GVC}		%	
V_{LITTER}		%	
V_{LOG}		m^3 / ha	
V_{OHOR}		cm	
V_{PATCH}		ha	
V_{POND}		%	
V_{SNAG}		stems / ha	
V_{SOIL}		%	
V_{SSD}		stems / ha	
V_{STRATA}		# layers	
V_{TBA}		m^2 / ha	
V_{TCOMP}		%	
V_{TDEN}		stems / ha	
V_{WD}		m^3 / ha	

Function	Functional Capacity Index (FCI)	Functional Capacity Units (FCU)
Detain Floodwater	N/A	N/A
Detain Precipitation		
Biogeochemical Cycling		
Export Organic Carbon		
Maintain Plant Communities		
Provide Wildlife Habitat		

Example input form used in the FCI/FCU calculator spreadsheet.

Appendix E
Spatial Data

The following digital spatial data pertinent to the Ozark Mountains Region of Arkansas are available for downloading to assist in orienting field work, assembling project area descriptions, and identifying geomorphic surfaces and soils. Unless otherwise indicated, the files are in ArcView format, and a copy of ArcExplorer is included in the download folder to allow access to the files. Some familiarity with ArcView is required to load and manipulate the digital information.

ArcExplorer (program file: ae2setup – includes user manual)
Roads
Cities and Towns
Counties
Geology (Haley 1993)
Hydrology
STATSGO soils
Wetland Planning Regions and Wetland Planning Areas

Appendix F
Common and Scientific Names of Plant Species Referenced in Text and Data Forms

box elder	*Acer negundo*
red maple	*Acer rubrum*
silver maple	*Acer saccharinum*
sugar maple	*Acer saccharum*
alder	*Alnus serrulata*
alder	*Alnus* spp.
big bluestem	*Andropogon gerardii*
little bluestem	*Andropogon scoparius*
milkweed	*Asclepias* spp.
river birch	*Betula nigra*
sedge	*Carex* spp.
ironwood	*Carpinus caroliniana*
bitternut hickory	*Carya cordiformis*
pignut hickory	*Carya glabra*
shagbark hickory	*Carya ovata*
mockernut hickory	*Carya tomentosa*
Indian paintbrush	*Castilleja coccinea*
sugarberry	*Celtis laevigata*
hackberry	*Celtis occidentalis*
buttonbush	*Cephalanthus occidentalis*
redbud	*Cercis canadensis*
white turtlehead	*Chelone glabra*
flowering dogwood	*Cornus florida*
persimmon	*Diospyros virginiana*
sundew	*Drosera* spp.
beech	*Fagus grandifolia*
white ash	*Fraxinus americana*
green ash	*Fraxinus pennsylvanica*
ash	*Fraxinus* spp.
honey locust	*Gleditsia triacanthos*
witch hazel	*Hamamelis vernalis*
witch hazel	*Hamamelis virginiana*
American holly	*Ilex opaca*
black walnut	*Juglans nigra*
red cedar	*Juniperus virginiana*
water willow	*Justicia americana*
spicebush	*Lindera benzoin*
sweetgum	*Liquidambar styraciflua*
loosestrife	*Lysimachia quadrifolia*
Osage orange	*Maclura pomifera*
cucumber magnolia	*Magnolia accuminata*
umbrella magnolia	*Magnolia tripetala*
monkey flower	*Mimulus ringens*
red mulberry	*Morus rubra*
watercress	*Nasturtium officianale*
blackgum	*Nyssa sylvatica*
hop hornbeam	*Ostrya virginiana*

switchgrass	*Panicum virgatum*
shortleaf pine	*Pinus echinata*
loblolly pine	*Pinus taeda*
sycamore	*Platanus occidentalis*
eastern cottonwood	*Populus deltoides*
black cherry	*Prunus serotina*
white oak	*Quercus alba*
southern red oak	*Quercus falcata*
overcup oak	*Quercus lyrata*
blackjack oak	*Quercus marilandica*
cow oak	*Quercus michauxii*
water oak	*Quercus nigra*
pin oak	*Quercus palustris*
northern red oak	*Quercus rubra*
Shumard oak	*Quercus shumardii*
oak	*Quercus* spp.
post oak	*Quercus stellata*
black oak	*Quercus velutina*
sumac	*Rhus* spp.
beakrush	*Rhynchospora* spp.
orange coneflower	*Rudbeckia fulgida var. umbrosa*
willow	*Salix* spp.
Indiangrass	*Sorghastrum nutans*
sphagnum moss	*Sphagnum* spp.
basswood	*Tilia americana*
winged elm	*Ulmus alata*
American elm	*Ulmus americana*
bladderwort	*Utricularia* spp.
highbush blueberry	*Vaccinium arboreum*

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14. ABSTRACT
Section 404 of the Clean Water Act directs the U.S. Army Corps of Engineers to administer a regulatory program for permitting the discharge of dredged or fill material in "waters of the United States." As part of the permit review process, the impact of discharging dredged or fill material on wetland functions must be assessed. In 1996, a National Action Plan to Implement the Hydrogeomorphic Approach for developing Regional Guidebooks to assess wetland functions was published. The Hydrogeomorphic Approach is a collection of concepts and methods for developing functional indices and subsequently using them to assess the capacity of a wetland to perform functions relative to similar wetlands in a region. This report, one of a series of Regional Guidebooks that will be published in accordance with the National Action Plan, applies the Hydrogeomorphic Approach to forested wetlands and riparian areas in the Ozark Mountains Region of Arkansas in a planning and ecosystem restoration context.

15. SUBJECT TERMS
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