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A Regional Guidebook for Conducting Functional Assessments of Wetland and Riparian Forests in the Ouachita Mountains and Crowley's Ridge Regions of Arkansas

Charles V. Klimas, Elizabeth O. Murray, Henry Langston,
Theo Witsell, Thomas Foti, and Rob Holbrook

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Environmental Laboratory

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Final report

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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 Ouachita Mountains and Crowley's Ridge Regions of Arkansas in a planning and ecosystem restoration context.

Corps of Engineers Research Report Summary, December 2006

Assessing Wetland Functions

A Regional Guidebook for Conducting Functional Assessments of Wetland and Riparian Forests in the Ouachita Mountains and Crowley's Ridge Regions of Arkansas (ERDC/EL TR-06-14)

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 wetland and riparian forests in the Ouachita Mountains and Crowley's Ridge regions 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://www.wes.army.mil/el/wetlands/wlpubs.html* or *http://libweb.wes.army.mil/index.htm*. 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, formerly of Charles Klimas and Associates, Seattle, WA, and currently with the U.S. Army Engineer Research and Development Center (ERDC), Vicksburg MS, 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 the production of the document. Thomas Foti and Theo Witsell are with the Arkansas Natural Heritage Commission, and Henry Langston is with the Arkansas State Highway and Transportation Department. Rob Holbrook was formerly with the Arkansas Game and Fish Commission and is currently with the Central Valley Joint Venture, Sacramento, California. 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 (Charles Klimas and Associates) archived and summarized the field data and generated the data summary graphs in this report.

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 Soil and Water Conservation 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. All of the individuals involved are too numerous to list here, but some people contributed a particularly large amount of time and effort: Ken Brazil (Arkansas Soil and Water Conservation Commission), Joe Krystofik (formerly of Arkansas Soil and Water Conservation Commission, currently with U.S. Fish and Wildlife Service), Gary Tucker (FTN Associates, Ltd.), Phillip Moore (Arkansas State Highway and Transportation Department), Jeff Raasch (formerly MAWPT Coordinator, Arkansas Game and Fish Commission, currently with Texas Parks and Wildlife),

and Bill Richardson (formerly with the Arkansas State Highway and Transportation Department). Terry McKay of the U.S. Forest Service, Caddo River District, Ouachita National Forest helped locate many of the reference sites used in this study. Ken Brazil, Tom Foti, Elizabeth Murray, and Jeff Raasch 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 ERDC. In addition, the development of this guidebook was closely coordinated with similar projects undertaken in other regions within Arkansas ("A Regional Guidebook for Conducting Functional Assessments of Forested Wetlands in the Delta Region of Arkansas, Lower Mississippi River Alluvial Valley," by C. V. Klimas, E. O. Murray, J. Pagan, H. Langston, and T. Foti, 2004, ERDC/EL TR-04-16, U.S. Army Engineer Research and Development Center, Environmental Laboratory, Vicksburg, MS; and "A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Wetlands in the West Gulf Coastal Plain Region of Arkansas," by C. V. Klimas, E. O. Murray, J. Pagan, H. Langston, and T. Foti, 2005, ERDC/EL TR-05-12, U.S. Army Engineer Research and Development Center, Environmental Laboratory, Vicksburg, MS), the Yazoo Basin of Mississippi ("A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Selected Regional Wetland Subclasses, Yazoo Basin, Lower Mississippi River Alluvial Valley," by R. D. Smith and C. V. Klimas, 2002, ERDC/EL TR-02-4, U.S. Army Engineer Research and Development Center, Environmental Laboratory, Vicksburg, MS), and western Kentucky ("A Regional Guidebook for Assessing the Functions of Low Gradient, Riverine Wetlands of Western Kentucky," by W. B. Ainslie, R. D. Smith, B. A. Pruitt, T. H. Roberts, E. J. Sparks, L. West, G. L. Godshalk, M. V. and Miller, 1999, Technical Report WRP-DE-17, Wetlands Research Program, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS). Therefore, portions of the text (particularly Chapters 1, 2, and parts of Chapter 3) were taken directly or adapted from those HGM Guidebooks, and we thank the original authors, especially Dan Smith (ERDC) and Tom Roberts (Tennessee Technological University). Topographic and hillshade maps were created using National Geographic's Topo! within ArcView 9.0.

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 developing 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), Natural Resources Conservation Service (NRCS), Federal Highways 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 document is a Regional Guidebook developed for assessing the most common types of wetlands that occur in the Ouachita Mountains and Crowley's Ridge Regions of Arkansas. The guidebook can also be applied to assessing riparian forests that may not be jurisdictional wetlands, but for the purposes of this guidebook, riparian areas are included with riverine wetlands and assessed in the same manner regardless of their jurisdictional status.

Normally, a Regional Guidebook focuses on a single regional wetland subclass (the term for wetland types in HGM terminology), but we have employed a different approach in this Regional Guidebook and other guidebooks prepared for Arkansas wetlands. Because various wetland subclasses are highly interspersed within Arkansas, 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. In this guidebook, a "wetland subclass" may include areas that do not meet the criteria of jurisdictional wetlands, such as some riparian areas. Whether or not an area is jurisdictional requires a site-specific determination. However, this guidebook may be used to assess non-jurisdictional areas for purposes such as monitoring the effects of management practices.

This Regional Guidebook addresses various objectives:

- To characterize selected regional wetland subclasses in the Ouachita Mountains and Crowley's Ridge Regions 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; and
- To describe the protocols for applying the functional indices to the assessment of wetland functions.

This document is organized in the following manner. Chapter 1 provides the background, objectives, and organization of the document. Chapter 2 provides a brief overview of the major components of the HGM Approach, including the procedures recommended for the development and application of Regional Guidebooks. Chapter 3 characterizes the regional wetland subclasses in the Ouachita Mountains and Crowley's Ridge Regions 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 Ouachita Mountains and Crowley's Ridge Regions of Arkansas. The Appendices include all required field forms and spreadsheets, sampling guidance, and a set of spatial data suitable for use in the context of a geographic information system (GIS).

While it is possible to assess the functions of selected regional wetland subclasses in the Ouachita Mountains and Crowley's Ridge Regions of Arkansas using only the information contained in Chapter 6 and the Appendices, we strongly suggest 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 is conducted in two phases: Development and Application. An interdisciplinary Assessment Team of experts carries out the Development Phase, which results in the production of a Regional Guidebook that presents a set of models and protocols to be used in assessing the functional performance of one or more regional wetland subclasses. The Application Phase consists of the use of that Regional Guidebook in any of a variety of regulatory or planning tasks where wetland functions are of interest (Figure 1).

In developing a Regional Guidebook, the Assessment Team completes the tasks outlined in the National Action Plan for Implementation of the HGM Approach (National Interagency Implementation Team 1996). After organization and training, the first task of the team 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 used in the 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.

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; and
- Analyze field data.

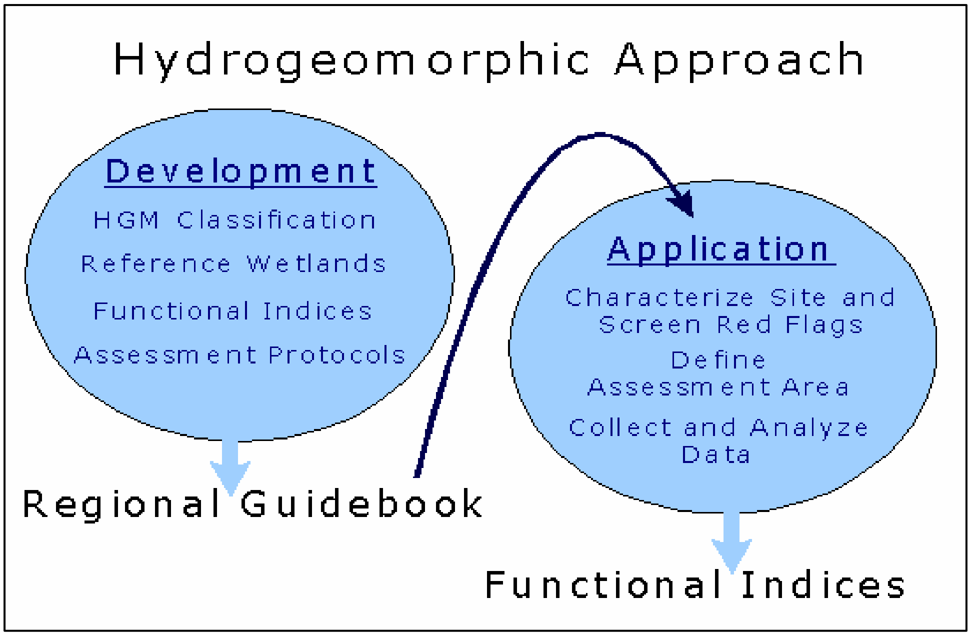


Figure 1. Development and Application Phases of the HGM Approach (from Ainslie et al. 1999)

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 analyses, 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 below. More extensive treatment of these components can be found in Brinson (1993a,b; 1995, 1996), Brinson et al. (1995, 1996, 1998), Smith et al. (1995), and Hauer and Smith (1998).

Hydrogeomorphic Classification

Wetland ecosystems share a number of common attributes, including hydrophytic vegetation, hydric soils, and relatively long periods of inundation or saturation. Despite 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; Semeniuk 1987; 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 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 is to employ a wetland classification system structured specifically to support functional assessment objectives (Smith et al. 1995).

Hydrogeomorphic classification was developed 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,b) identified five hydrogeomorphic wetland classes. These were later expanded to the seven classes described in Table 1 (Smith et al. 1995).

The level of variability encompassed by wetlands at the continental scale is too great to allow the development of assessment indices that can be applied rapidly while retaining the sensitivity necessary to detect changes in function necessary for permit review and other applications. 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 starting points for identifying these regional subclasses (e.g., Stewart and Kantrud 1971; Golet and Larson 1974; Wharton et al. 1982). Regional subclasses 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 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 subclasses in terms of geomorphic setting, water sources, hydrodynamics, vegetation, soil, and other features that were taken into consideration during the classification process.

Table 1
Hydrogeomorphic Wetland Classes

HGM Wetland Class	Definition
Depression	Depression wetlands occur in topographic depressions (i.e., closed elevation contours) that allow the accumulation of surface water. Depression 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. Depression 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 depression 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 river flow 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 and 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 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 slopes, depressions, flats, or uplands as the channel system becomes indistinct. 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 flood-plains 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

* Adapted from Smith et al. 1995, Rheinhardt et al. 1997.

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, and 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 because of 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 re-measured 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 (e.g., Arkansas' Coastal Plain).
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.

Assessment Models and Functional Indices

In the HGM Approach, an assessment model is a simple representation of a function performed by a wetland ecosystem, sometimes called a "crude logic model" (Brinson 1995). 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. The 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:

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

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}), which together represent the 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 the 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. Immature stands with higher densities are assigned a lesser subindex value, although it never approaches zero. Wetlands with lesser densities have usually been harvested or completely cleared. In the latter case the subindex value is zero.

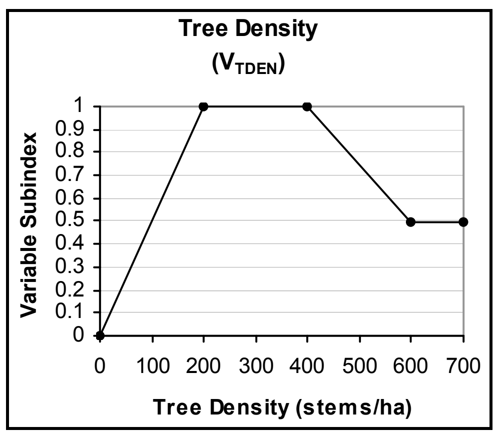


Figure 2. Example subindex graph for the Tree Density (V_{TDEN}) assessment variable for a particular wetland subclass

Assessment Protocol

All of the steps described above concern the 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 applying 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.

3 Characterization of Wetland Subclasses in the Ouachita Mountains and Crowley's Ridge Regions 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) includes the Ouachita Mountains and Crowley's Ridge Regions of Arkansas (Figure 3). The Ouachita Mountains and Crowley's Ridge are widely separated and physiographically distinct but are included together in a single guidebook because their principal wetland types are similar.

The Ouachita Mountains consist primarily of a series of east–west trending ridges and intervening valleys and broad basins that extend from central Arkansas (Little Rock) into southeastern Oklahoma. They span an area up to 100 km wide between the Arkansas River Valley to the north and the West Gulf Coastal Plain to the south and have a maximum elevation range of about 2000 feet. This guidebook encompasses the portion of the Ouachita Mountains that lies within the Red River and Ouachita River watersheds, which is designated as the Ouachita Mountains Wetland Planning Region (Arkansas Multi-Agency Planning Team 1997). The northernmost part of the Ouachita Mountains ecoregion (the ridges and valleys of the Fourche Mountains) drains to the Arkansas River and is considered to be part of the Arkansas River Valley Wetland Planning Region. To the south, the Ouachita Mountains give way to a piedmont zone and then transition fairly abruptly to the Coastal Plain Region. The ridges of the Ouachitas consist largely of folded, fractured, and interbedded sandstones, shales, and cherts, and wetlands occur mostly along the few major streams and numerous small streams and where groundwater discharges from the mountain slopes.

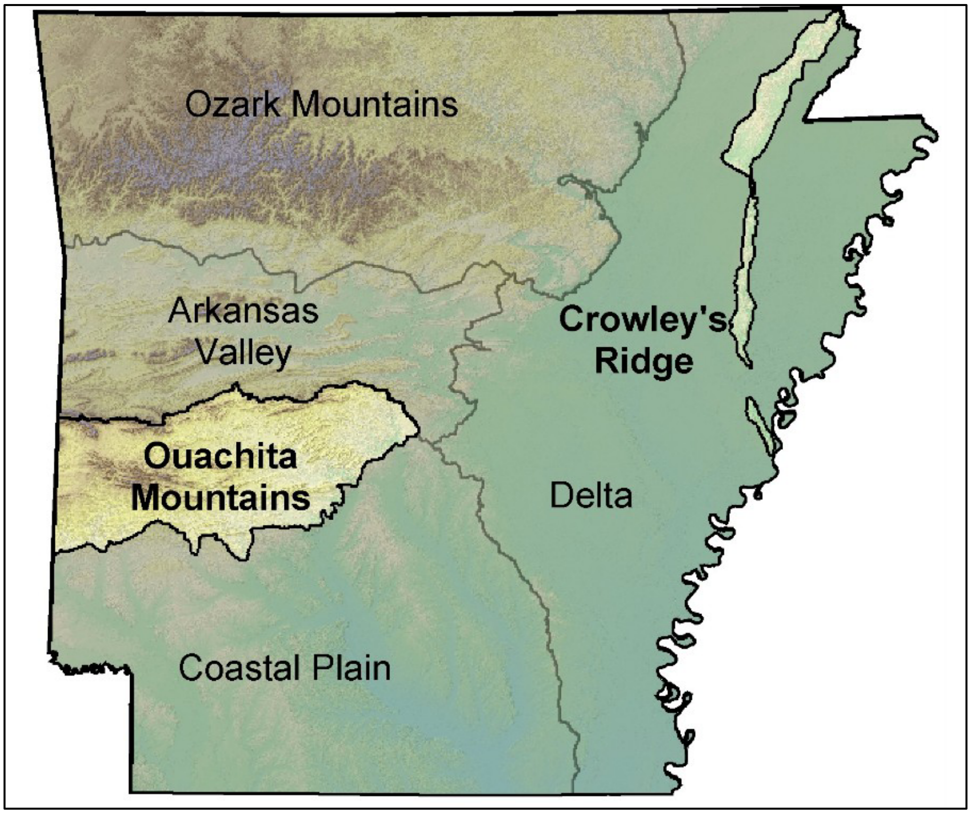


Figure 3. Location of the Ouachita Mountains and Crowley's Ridge Regions of Arkansas

Crowley's Ridge lies about 100 miles east and northeast of Little Rock and is different from the Ouachitas in various ways. Crowley's Ridge is a north–south trending upland that rises as much as 250 ft above the surrounding, relatively flat Delta landscape. It extends from southeastern Missouri through northeastern Arkansas, terminating near the confluence of the St. Francis and Mississippi Rivers in the vicinity of Helena. The Arkansas portion of Crowley's Ridge is about 120 miles long but only 2–12 miles wide. It consists of coastal plain and alluvial sediments capped by thick deposits of wind-blown silt (loess). However, it is similar to the Ouachitas in that the most common types of wetlands are those associated with small streams and hillslope seeps. Similar wetland types occur in the Ozark Mountains Region, but that area also includes extensive karst topography and strongly calcareous substrates and is therefore the subject of a separate guidebook.

The following sections review major concepts that have bearing on the distribution, characteristics, classification, and functions of wetlands and riparian areas in the Ouachita Mountains and Crowley's Ridge Regions of Arkansas. Descriptions of wetland classes and subclasses and guidelines for recognizing them in the field are presented as the final section of this chapter.

Climate

General climatic patterns are similar in both the Ouachita Mountains and Crowley's Ridge Regions. Winters are usually short and mild, while summers are marked by extended hot, humid periods. Rainfall is usually abundant throughout the year, with the wettest period occurring in spring and the driest in summer. Tornadoes and thunderstorms occur commonly. Snowfalls usually are light and do not persist, except in higher elevations and protected areas in the mountains. Ice storms occur infrequently but can be severe and cause widespread damage (Southern Regional Climate Center 2003).

Daily mean temperatures at Mt. Ida, which is centrally located within the Ouachita Mountains, range from a low in January of 37.1°F (2.8°C) to a high of 78.5°F (25.8°C) in July, with an overall annual average of 58.3°F (14.6°C). Daily average maximum temperatures are 89.7°F (32.0°C) in July and August and 48.7°F (9.3°C) in January. Average annual precipitation is 57.95 in. (147.2 cm), with the most precipitation falling in May (6.4 in., or 16.3 cm), and the least in August (2.63 in., or 6.7 cm). Temperature and precipitation patterns elsewhere in the region are similar to these, although local orographic effects can produce significantly wetter conditions in some areas (Southern Regional Climate Center 2003).

Climatic patterns of the Crowley's Ridge Region are somewhat drier and warmer than those in the Ouachita Mountains. Generally, they are similar to patterns in the surrounding Delta landscape. Daily mean temperatures at Wynne, in the central part of Crowley's Ridge, range from a low in January of 36.1°F (2.3°C) to a high of 80.7°F (27.1°C) in July, with an overall annual average of 59.5°F (15.3°C). Daily average maximum temperatures are 90.6°F (32.5°C) in July and 45.1°F (7.3°C) in January. Average annual precipitation is 48.3 in. (122.7 cm), with the most precipitation falling in April (5.75 in., or 14.6 cm) and the least in August (2.23 in., or 5.7 cm) (Southern Regional Climate Center 2003).

Physiography, Geology, and Soils

From a physiographic perspective, the boundaries of the Ouachita Mountains have been defined in various ways, but generally they include as many as eight named mountain ranges, four major basins, and a piedmont zone (Stone and Bush 1986). Integrating biological and physiographic considerations allows the Ouachitas to be subdivided into four ecoregions (Woods et al. 2004). These include the piedmont (the Athens Plateau); a central mountainous zone; a less rugged area of hills, valleys, and low ridges; and a northern mountainous zone (the Fourche Mountains). As noted previously, this guidebook does not address watersheds that drain to the Arkansas River, so the Fourche Mountains are not included here.

The surficial geology of the Ouachita Mountains and Crowley's Ridge Regions is illustrated in Figure 4. The core mountains and the central hill and valley zones of the Ouachitas generally correspond to an area known as the

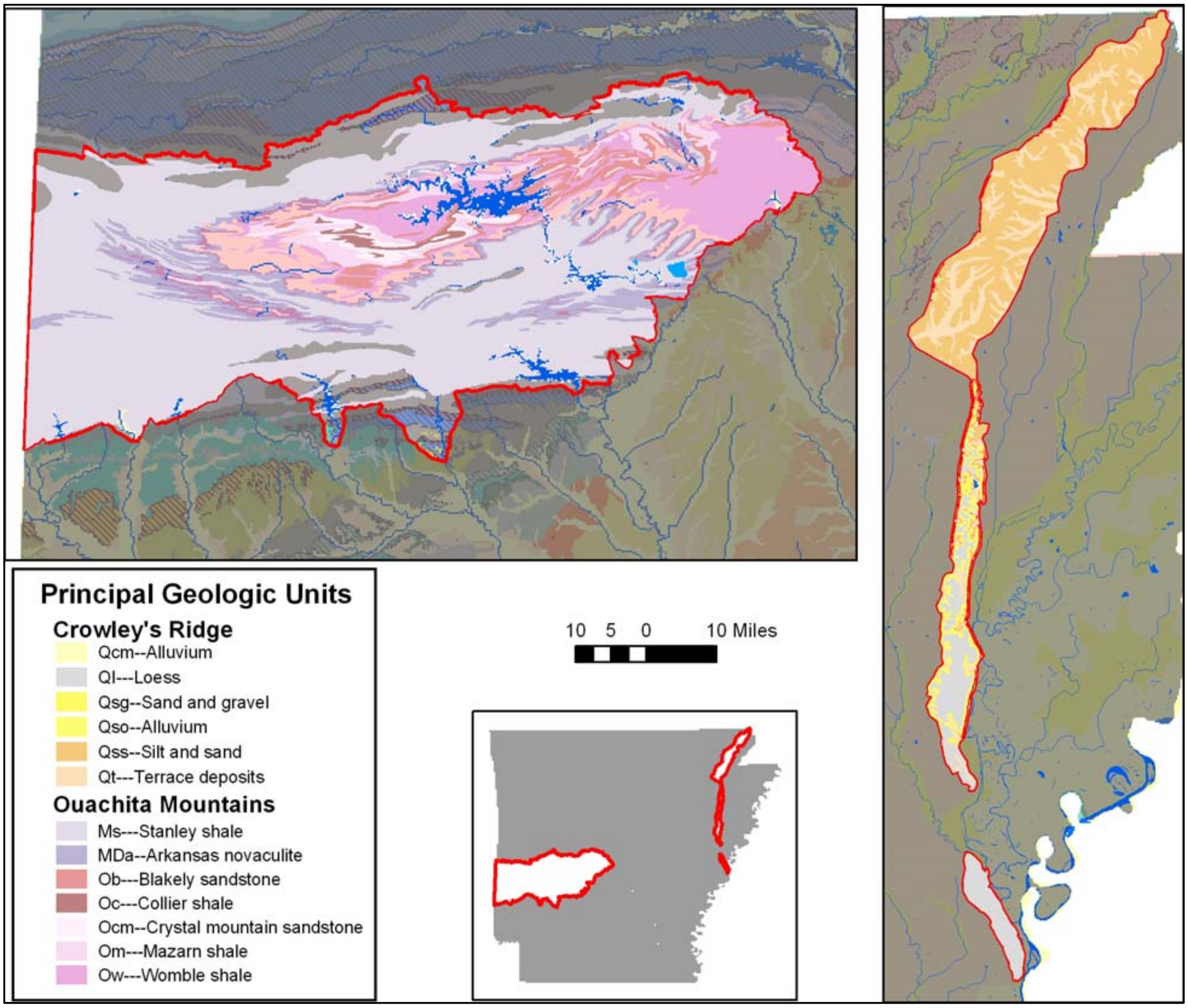


Figure 4. Surficial geology of the Ouachita Mountains and Crowley's Ridge Regions of Arkansas

Novaculite Uplift. With the exception of scattered igneous intrusions, the rocks of the region are thick sedimentary deposits that date from the late Cambrian to the Middle Pennsylvanian periods of the Paleozoic (roughly 300–520 million years ago). They were deposited in a marine basin as alternating layers of mud, sand, gravel, silica, lime, and other materials that were compressed into shale, sandstone, conglomerates, novaculite, chert, and limestone. In the late Paleozoic (approximately 250 million years ago), continental movements laterally compressed the sedimentary deposits, causing folding, fractures, and uplift. Today, the east–west trending mountains, with scattered transverse gaps connecting basins, reflect the folding and faulting process and subsequent differential erosion of the softer rocks. Resistant rocks (novaculite, chert, and hard sandstones) make up or cap the ridges, while valleys have formed where there are exposures of erodible shale, limestone, or impure sandstones. In places, sandstone has been metamorphosed into quartzite, and shales into slate. Some coastal sands and muds were deposited along the southern and eastern perimeter of the mountains after uplift. Most lower slopes are blanketed with colluvium, and alluvial deposits fill the larger valleys (Stone and Bush 1986). The Athens piedmont plateau lies to the south of the Novaculite Uplift and is marked by an undulating surface of relatively low sandstone and shale ridges. A distinct fall line separates the piedmont from the Coastal Plain region to the south and east.

The soils of the Ouachitas formed in the residuum, colluvium, and alluvium derived from the folded and interbedded rocks. Because of the mix of shales and sandstones, quartzite, chert, and other materials, soils may vary considerably over short distances. However, most soils of the mountain slopes are stony or loamy and either well drained or moderately well drained. Soil thickness is highly variable—some ridgetops are bare bedrock, while others have deep soils. On ridges and sideslopes where soils have weathered from shale or and sandstone, most soils are classified as the Carnasaw–Clebit–Sherless Association (Figure 5). Where the parent material is chert or novaculite, slope soils are usually classified as the Yanush–Avant–Bigfork Association. Most alluvial soils (floodplains and terraces) are assigned to the Ceda–Kenn–Avilla Association and are typically

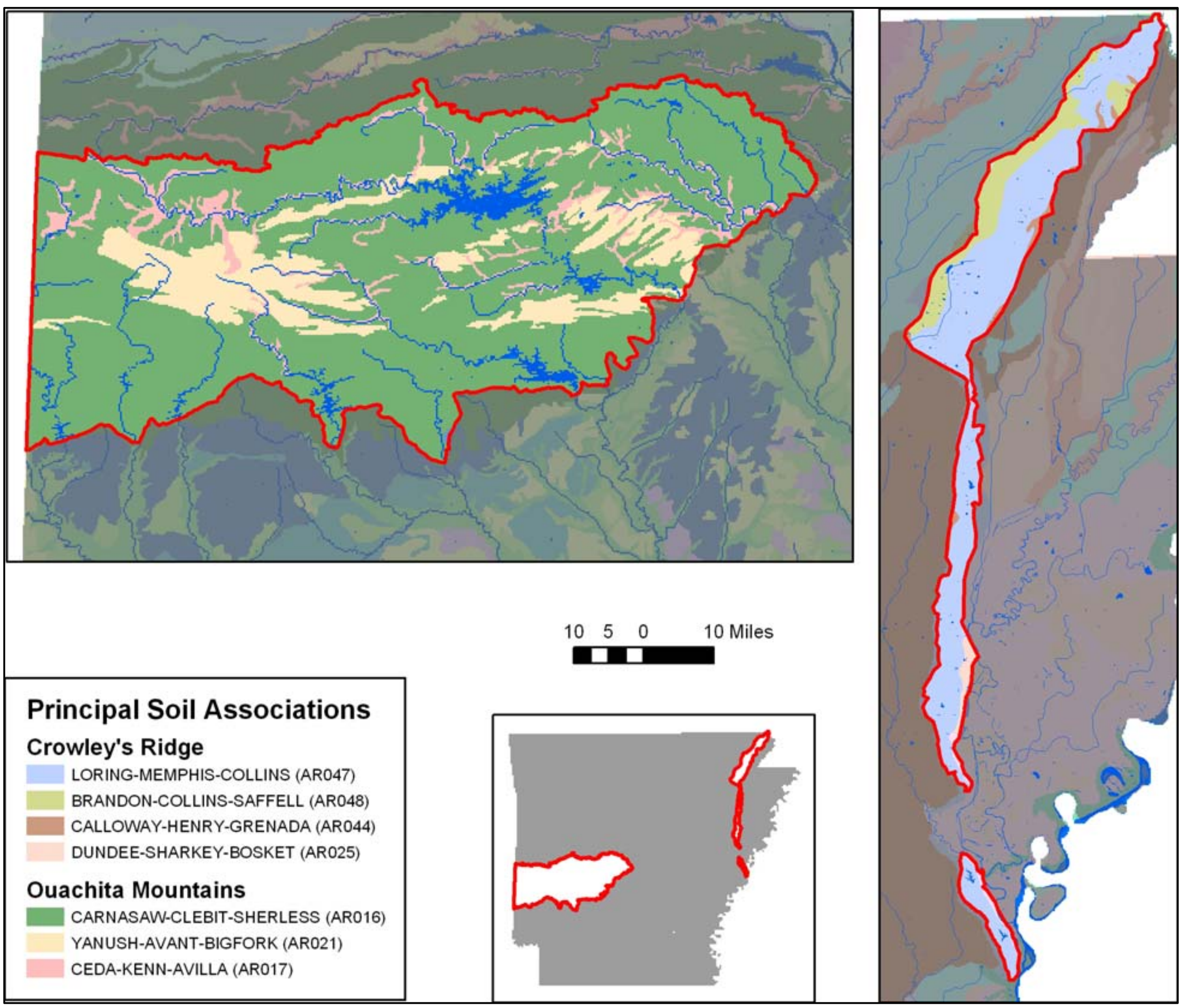


Figure 5. Principal soil associations of the Ouachita Mountains and Crowley's Ridge Regions of Arkansas.

loamy or gravelly. Although soils in the Ouachitas are typically acidic, circumneutral to alkaline soils occur wherever calcareous bedrock material predominates, such as commonly occurs along the Ouachita River. Prehistoric, historic, and modern agriculture has always focused on the alluvial terraces of the larger stream bottoms, though small fields were established wherever feasible (Laurent et al. 1989; USDA Forest Service 2003).

Crowley's Ridge has very different origins than the Ouachitas. The core formations of the Ridge are coastal plain sediments of Tertiary age — the same thick units of sands, clays, and marls that predominate in the Coastal Plain Region of Arkansas, south of the Ouachita Mountains, once were continuous across the area now known as the Delta Region. In the Early Pleistocene, fluvial deposits of gravel and sand, most likely originating in the Appalachians, accumulated on the surface of the coastal plain formations. This graveliferous deposit is often identified as Tertiary in age, but Saucier (1964, 1994) determined that it was more likely an early Pleistocene formation known as the Upland Terrace. As the Pleistocene proceeded, continental glaciers formed, melted, and re-formed multiple times far to the north of the area that is now Crowley's Ridge. During the interglacial periods, vast quantities of meltwater scoured the valley, incrementally lowering the base level but also leaving behind extensive deposits of sand, silt, and gravel outwash (now referred to as "valley train" deposits). Nearly all of the Tertiary coastal plain deposits and the capping fluvial gravels and sands were eroded away, but Crowley's Ridge survived as a long, narrow remnant, with the ancestral Ohio River flowing to the east of the Ridge, and the Mississippi River to the west. After each major outwash episode, winds transported large amounts of silt from the valley train plains to the west, creating multiple distinct loess deposits on Crowley's Ridge as well as on the bluffs on the east side of the Mississippi River (Gray and Ferguson 1977; Autin et al. 1991; Saucier 1994).

The processes and materials that formed Crowley's Ridge have produced a unique landscape that consists of narrow, winding ridge crests and narrow valleys. Side slopes are fairly gentle on the extensive alluvial fans that occur along the flanks of the Ridge, but most valley side slopes are very steep, particularly where the highly erodible loess deposits are thick. The thickness of each major deposit (coastal plain, fluvial terrace, or loess) and their positions relative to the elevation of the surrounding Delta are highly variable along the length of the Ridge. For example, a geologic cross section for an area near the northern limit of the Ridge within Arkansas (Saucier 1964) shows the coastal plain deposits rising more than 200 ft above the elevation of the Delta. On top of that material is a fluvial deposit (of pre-Pleistocene or early Pleistocene age) about 40 ft thick, capped by a discontinuous loess sheet with a maximum thickness of about 25 ft. In contrast, a cross section representing a location at the southern terminus of the Ridge, near Helena, shows a very different situation. The coastal plain deposits do not rise above the existing landscape; in fact, they are buried about 60 ft below the modern land surface. On top of those older rocks is more than 180 ft of fluvial material, capped by 60 ft of loess (Saucier 1964). Generally, the loess cap is thickest and most continuous over the southern half of Crowley's Ridge and may be entirely eroded away from the ridgetops in parts of the northern section (Clark et al. 1974).

The characteristics of the soils on Crowley's Ridge reflect the influence of loess, both in the uplands and where it has been redeposited on sideslopes and in the valley bottoms. The highly dissected uplands are well drained or moderately well drained, but agriculture (pasture, orchards, and rowcrops) tends to be small scale because of the soil erodibility and steep slopes. In the stream bottoms, soils are loamy but less well drained than at the upland sites (Gray and Ferguson 1977). Colluvial deposits at the base of slopes are usually deep, well drained, and loamy. The large quantities of erodible loess also account for the broad, nearly continuous alluvial fans and alluvial aprons that occur along the flanks of the Ridge, except in the southeastern portion, where Holocene meander activity of the Mississippi River has truncated them (Saucier 1994). The great majority of the soils in the deep loess of the uplands as well as those formed in the redeposited loess in the lowlands are classified as the Loring–Memphis–Collins or the Calloway–Henry–Grenada Associations (Figure 5). The individual soils in these associations differ primarily with regard to thickness and whether or not a fragipan is present. Where the loess thinly overlies gravel deposits or where the gravels are part of the surface soils, the Brandon–Collins–Saffell Association is mapped. The Dundee–Sharkey–Bosket Association is found in places along the flanks of the Ridge, where larger streams of the Delta Region deposited natural levee and backswamp soils that do not reflect the local dominance of loess in the uplands.

Hydrology

The Ouachita Mountains Wetland Planning Region (Figure 1) is divided into three Wetland Planning Areas (WPAs) (Figure 6) that reflect major watershed boundaries and physiographic variation (Arkansas Multi-Agency Wetland Planning Team 1997).

The largest WPA in the Ouachitas is the Upper Ouachita River WPA, which encompasses more than half of the region, including most of the central and northern portions of the mountains. The principal stream is the Ouachita River, which arises near Mena, not far from the Oklahoma border, and flows about 112 km (70 miles) eastward before entering a series of three reservoirs (Lakes Ouachita, Hamilton, and Catherine). The Ouachita River exits the mountains southeast of Hot Springs and continues generally southward across the Coastal Plain Region until it enters the Red River in northern Louisiana. Two other major streams drain the southwestern quadrant of the Upper Ouachita River WPA. The Caddo River arises near Black Springs and flows about 64 km (40 miles) southeastward, where it is impounded as DeGray Lake before joining the Ouachita River near Arkadelphia. Southwest of the Caddo River is the watershed of the Little Missouri River, which is free flowing for 46 km (29 miles) before entering Lake Greeson. The Little Missouri is confluent with the Ouachita River at Tate's Bluff in the upper Coastal Plain Region. Lake Ouachita, Degray Lake, and Lake Greeson are operated by the Vicksburg District of the U.S. Army Corps of Engineers for hydropower, flood control, water supply, recreation, and fish and wildlife management. Lakes Hamilton and Catherine are operated by a utility company for similar purposes.

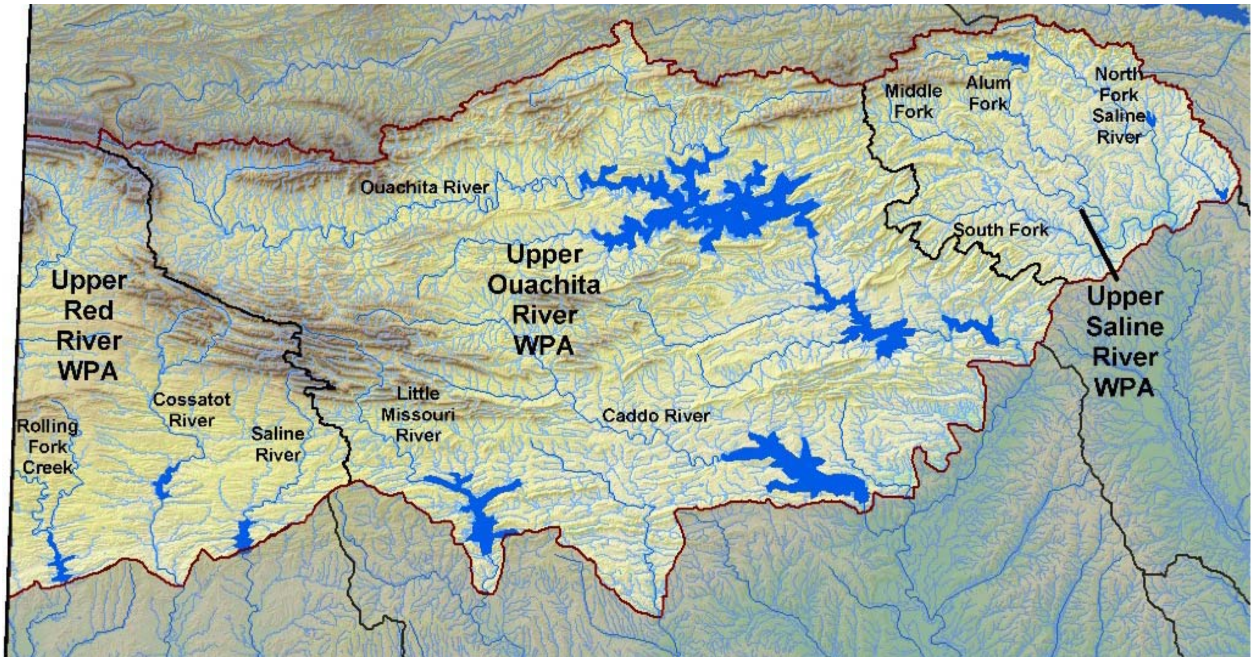


Figure 6. Wetland Planning Areas (WPAs) and major streams of the Ouachita Mountains Wetland Planning Region

The Upper Red River WPA in the western Ouachita Mountains is drained by several small rivers that all are impounded within the mountains before flowing to the Little River (a tributary of the Red River) in the Coastal Plain. The Cossatot River has the largest watershed in the WPA, flowing about 42 km (26 miles) from near Mena to Gilham Lake. East of the Cossatot is the Saline River, which is impounded as Dierk's Lake, and to the west is Rolling Fork Creek, which is impounded as DeQueen Lake. All three of these reservoirs are operated by the Little Rock District of the U.S. Army Corps of Engineers for flood control, water supply, recreation, and fish and wildlife management.

The Upper Saline River WPA occupies the eastern quarter of the Ouachita Mountains Region. (Note: there are two Saline Rivers in the Ouachitas; unless otherwise specified, all subsequent mentions of the Saline River refer to the larger, eastern stream rather than the one in the Upper Red River WPA.) Nearly all drainage in the WPA is via the four forks of the Saline River, which leaves the Ouachitas near Benton and is a major river of the Coastal Plain Region. Small reservoirs exist along some tributary streams, but the Saline is the only large river in the Ouachitas without a major mainstem dam.

Although portions of the principal streams in the Ouachita Mountains region are low-gradient, meandering channels within broad alluvial valleys, the great majority of stream reaches in the Ouachita Mountains region are high- and mid-gradient channels in narrow valleys. The topography of the Ouachita Mountains generates rapid storm runoff and high-velocity flows, resulting in scouring of the bed and bank zones of many headwater streams. This tends to impede plant colonization of the environments adjacent to the channel, and much of the floodplain zone consists of bare cobble bars, particularly on the higher-gradient streams. The resulting lack of shade over many channel segments tends to promote elevated water temperatures, but this often is offset by inputs from numerous cold-water springs and seeps, which also help maintain baseflow (Geise et al. 1987). However, despite groundwater inputs, many streams cannot sustain perennial flow. Streams draining watersheds of less than 260 km^2 (100 square miles) usually go dry every year; those in watersheds between 260 and 520 km^2 (100 and 200 square miles) dry up in one year in ten, on average (Renken 1998).

Crowley's Ridge is considered part of the Delta Wetland Planning Region (Figure 7) and includes parts of four Wetland Planning Areas. The streams of Crowley's Ridge are mostly steep and deeply incised into the loess and underlying sediments. A few streams have carved relatively extensive and broad alluvial valleys (e.g., Big Creek and Prairie Creek), while others open into short stretches of alluvial valley only as they approach the margin of the Ridge. However, most channels remain in narrow valleys until they exit the Ridge to the surrounding Delta landscape. All major streams draining to the east of Crowley's Ridge are tributaries of the St. Francis River, which is confluent with the Mississippi River near Helena. On the western flank, most streams entering the Delta south of Jonesboro drain to the L'Anguille River, which flows to the lower St. Francis River. North of Jonesboro, drainage to the west of the Ridge moves to the White River and on to the Mississippi via either Bayou DeView or the Cache River.

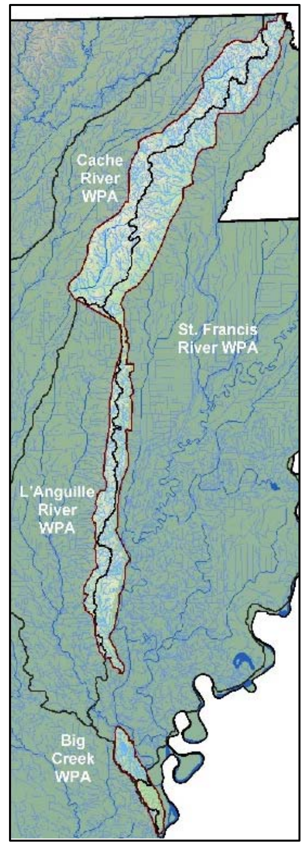


Figure 7. Wetland Planning Areas (WPAs) that include parts of Crowley's Ridge, within the Delta Wetland Planning Region of Arkansas

Groundwater seeps and springs are important wetland sites in both the Ouachita Mountains and Crowley's Ridge. Depending on the characteristics of their source aquifer, they may have perennial or seasonal ("wet-weather") flow. In the Ouachitas, groundwater movement is often limited by confining layers of shale and the low porosity of interbedded sandstones, so seeps and springs are usually associated with fractured rock, contacts between shale and sandstone layers, quartz veins, or local deposits of chert (Renken 1998). Predicting the specific locations of discharge points is complicated, but any significant mass of Big Fork Chert is likely to contain an aquifer, and springs also occur commonly in Crystal Mountain Sandstone and Arkansas Novaculite deposits (Stone and Bush 1986) (Figure 8).

On Crowley's Ridge, seeps and springs discharge at various points along the flanks of the Ridge and on the sideslopes of interior drainages. Because the Tertiary coastal plain deposits do not include gravels and are typically cemented (Saucier 1994), it is likely that most slope wetlands are associated with discharges from the sands and gravels of the higher, younger fluvial terrace deposits (Figure 9).

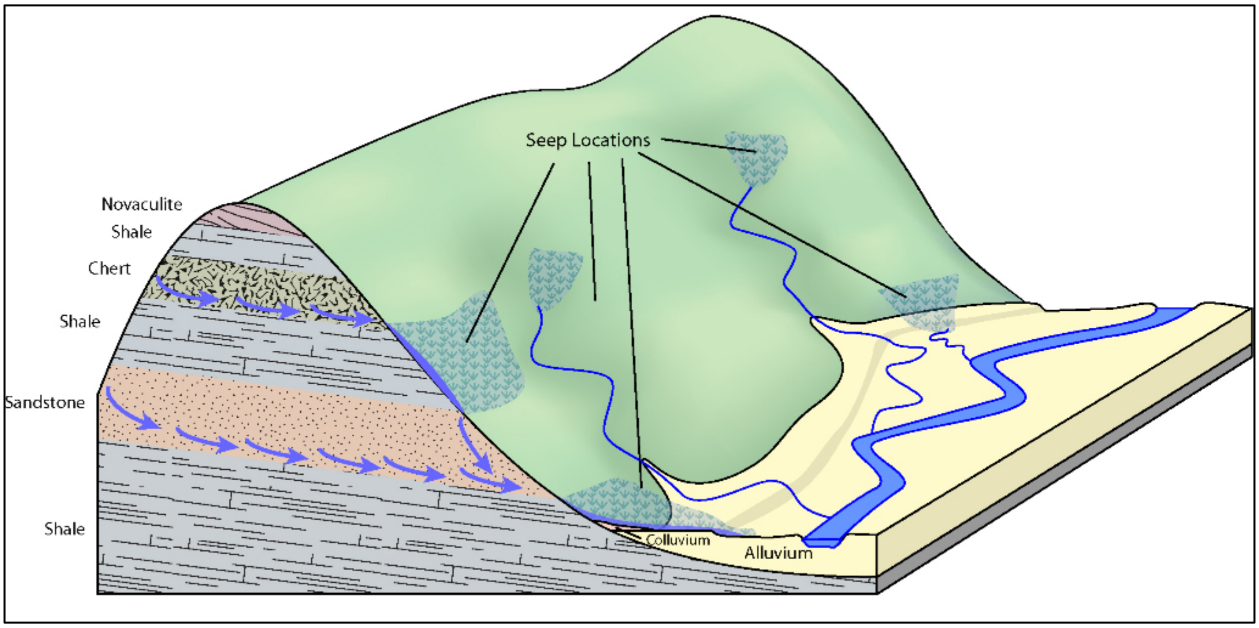


Figure 8. Typical locations of groundwater discharge points (seeps and springs) in the Ouachita Mountains

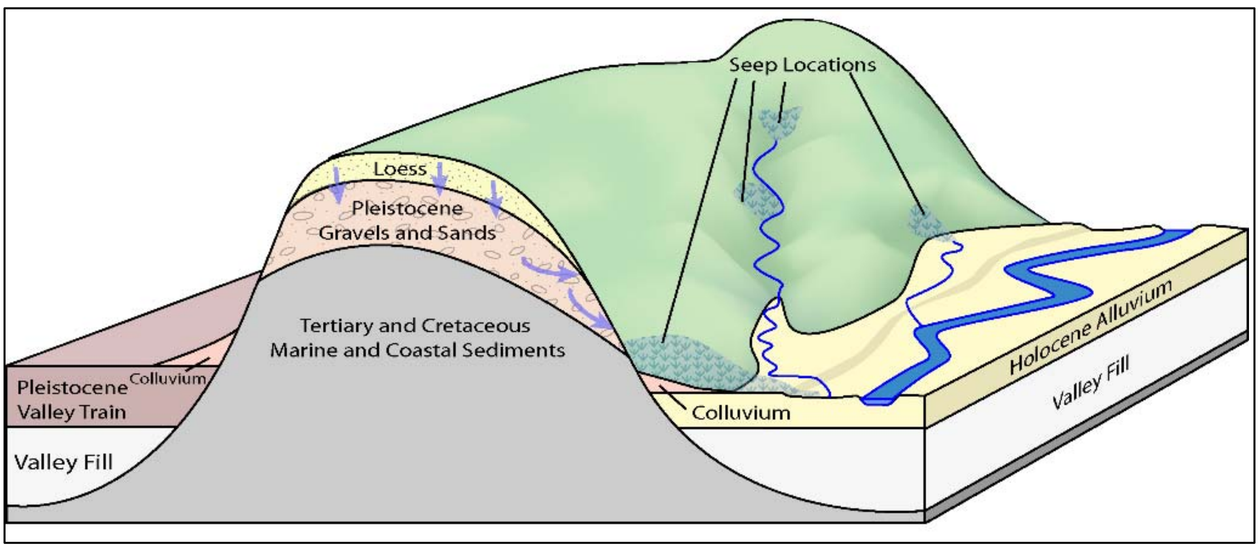


Figure 9. Typical locations of groundwater discharge points (seeps and springs) on Crowley's Ridge

The relatively small size or low permeability of aquifers in both the Ouachitas and Crowley's Ridge means that they usually cannot meet municipal water needs, and most communities must rely on surface water supplies. However, individual domestic wells are common, and many springs on public land have long been used as rural community drinking-water sources. Some springs in the Ouachitas have sufficient discharge to be tapped for the commercial production of bottled water (Arkansas Geological Commission 2000).

Most springs in the Ouachitas are classified as non-thermal, or “cold-water” springs, meaning that their temperature is similar to the mean annual air temperature in the area. Generally, this indicates that the groundwater circulates near the surface. However, in the southeastern Ouachita Mountains, there is a zone where a large number of thermal springs occur. These are classified as either “warm-water” (where temperatures are higher than the average ambient air temperature, up to 36°C, or 98°F) and “hot-water” (with temperatures ranging from 36°C to over 60°C, or 98°F to more than 140°F). The thermal characteristics of these springs are related to deep circulation of groundwater in this area, some of which is estimated to move as deeply as 4000 ft before discharging from zones of fractured and faulted bedrock in Hot Springs National Park and vicinity. The water discharged from the hot springs is high in dissolved solids, particularly silica and calcium, and all 47 of the major hot springs in the area were long ago capped and diverted to bathhouses in the city of Hot Springs (Arkansas Geological Commission 2000; Renken 1998).

Vegetation

The natural vegetation of the Ouachita Mountains is a mixed forest of hardwoods and pine. Dale (1986) mapped the majority of the area as the Pine–Hardwood forest type, with inclusions of Upland Hardwood and Bottomland Hardwood forest vegetation types within the major river valleys. Within the Ouachita Mountains, there is a general tendency for oaks (*Quercus* spp.) to predominate on substrates derived from shale, and pine (*Pinus* spp.) to do better on sandstones (Foti and Glenn 1990), but Dale (1986) noted that, in the Pine–Hardwood forest, the distribution of plant communities is most strongly related to slope and exposure rather than soils. Shortleaf pine (*P. echinata*) is often dominant on dry, south-facing slopes, where blackjack oak (*Q. marilandica*), post oak (*Q. stellata*), and black hickory (*Carya texana*) also occur commonly. North-facing slopes and other mesic sites typically are dominated by white oak (*Q. alba*) or shortleaf pine, with black oak (*Q. velutina*), mockernut hickory (*C. tomentosa*), northern red oak (*Q. rubra*), blackgum (*Nyssa sylvatica*), and southern red oak (*Q. falcata*) as common secondary species (Dale 1986; Foti and Glenn 1990). Ridgetop communities are variable but generally include some combination of post oak, blackjack oak, black oak, mockernut hickory, or white oak. Braun (1950) noted that the vegetation of the Ouachitas generally resembles that of the Ozarks, but certain aspects, particularly the herbaceous flora, show distinct affinities with the Mixed Mesophytic forest region of the Appalachians and Cumberland Plateau far to the east.

Wetlands occur in the Ouachitas in valley bottoms and where groundwater discharges on slopes. Headwater stream channels typically are steep, and wetland communities are limited to small patches that occur on intermittent accumulations of sediment. However, a fairly continuous band of riparian vegetation occupies a narrow streamside zone. As channel systems coalesce and streams flatten and widen, a continuous floodplain zone is usually present, and distinct alluvial terraces are increasingly common. In the largest stream valleys, the terrace systems include two or three distinct levels. Throughout the stream network, frequently flooded wetlands occur on floodplains and the lowest terraces, dominated by species such as red maple (*Acer rubrum*), silver maple (*A. saccharinum*), and river birch (*Betula nigra*). In the larger stream valleys, the high terraces usually do not flood regularly, but in places there are wetlands maintained by rainfall and upslope runoff, and lowland oaks typically dominate. Because alluvial soils of the Ouachitas are sometimes very well drained, many riparian communities have little or no wetland character and are dominated by mesic species typical of the adjacent hillslopes.

The seep wetlands of the Ouachita Mountains usually have a gravelly or somewhat mucky substrate and are forested. Sweetgum (*Liquidambar styraciflua*), red maple, and white oak often dominate the canopy, and American holly (*Ilex opaca*), spicebush (*Lindera benzoin*), and umbrella magnolia (*Magnolia tripetala*) are characteristic understory components. Beech (*Fagus grandifolia*) and various oaks typically occur on the margins of these seeps and may dominate within seeps that are only seasonally wet. Sphagnum moss (*Sphagnum* spp.) is nearly always present and forms a continuous, hummocky mat in many seeps. A variety of fern species also are commonly present.

The forests of Crowley's Ridge include many species commonly seen in the Ouachitas and the Ozarks. However, some tree species, such as bigleaf magnolia (*Magnolia macrophylla)*, butternut (*Juglans cinerea*), and yellow poplar (*Liriodendron tulipifera*), are more characteristic of the loess hills in Tennessee and Mississippi and the southern Appalachians (Braun 1950; Foti 1993; Smith et al. 1984). Clark (1977) recognized three major forest types on Crowley's Ridge: the Oak–Hickory–Pine, Mixed Oak–Hickory, and White Oak–Beech forest types. Soil factors influence the distribution of the major forest types to a greater degree than they do in the Ouachitas (Clark et al. 1974). The Oak–Hickory–Pine forests typically occur on sites that have little or no loess cover, where soils are derived directly from Pleistocene gravels and sands or older coastal plain sediments. This occurs on many ridges and steep upper slopes throughout Crowley's Ridge, and the forest type is easily recognized by the presence (though not necessarily dominance) of shortleaf pine in the overstory. Common associate species include white oak, winged elm (*Ulmus alata*), blackjack oak, post oak, and black hickory. On more gentle slopes and most lowlands, where soils are derived primarily from loess, the Mixed Oak–Hickory type predominates. This forest type is usually diverse, and species that commonly occur as dominants or co-dominants include white oak, northern red oak, southern red oak, black oak, Shumard oak (*Q. shumardii*), black hickory, mockernut hickory, and shagbark hickory (*C. ovata)*. In lowland settings, such as broad stream terraces, additional species occur, including bitternut hickory (*C. cordiformis*), swamp chestnut oak (*Q. michauxii*), pin oak (*Q. palustris*), and willow oak (*Q. nigra*). The White Oak–Beech type is a major forest component only in the southern third of Crowley's Ridge, and even there it is largely restricted to protected coves and lower slopes with deep, loess-derived soils (Clark et al. 1974). White oak and beech are strongly dominant, but other common associates are black oak, northern red oak, yellow poplar, sweetgum, and sugar maple (*A. saccharum*) (Clark 1977).

On Crowley's Ridge, distinct riparian zones occur along all stream channels, but they often are very limited in width. Most stream valleys are steep and narrow until they approach the level of the adjacent Delta, at which point they usually flatten and widen. For the most part, streamside zones on high-gradient channels are similar to the adjacent mesic slope forests, with riparian or lowland species, such as ironwood (*Carpinus caroliniana*) and red maple, occurring only on the streambanks and on in-channel bars. As valleys widen downslope, and floodplain and terrace systems develop, a more distinctive riparian community occurs, typically including sweetgum and lowland oaks. At the very margins of the Ridge, particularly on the east side where stream channels directly enter the Delta, true swamp species such as baldcypress (*Taxodium distichum*) may occur in the lowest reaches of the stream valleys.

Seep wetlands are present on Crowley's Ridge but are limited in distribution, and they occur as two separate clusters with different characteristics. The first set of seep wetlands is near the southern end of the Ridge (Lee and Phillips Counties). The seeps occur in approximately a dozen distinct locations along the eastern flank of the hills, and all are within the St. Francis National Forest. Most are very limited in extent (none is larger than a quarter acre, and most are much smaller) and occur low on the slope, usually directly adjacent to the Delta lowlands. These wetlands sometimes are more like springs than seeps, and at least one is used as a water source by local residents. All of these seeps and springs are assumed to originate from the graveliferous Upland Terrace (fluvial) deposits that blanket the older coastal plain sediments on Crowley's Ridge. As noted previously (Geology), the coastal plain deposits sit at or below the surface of the Delta alluvium at the southern end of the Ridge. Therefore, the gravels are exposed at the bottom of the bluffs, and the seeps occur low on the sideslopes of the Ridge. Where groundwater discharge is sufficient, the seeps and springs are the headwaters of small streams that flow into the adjacent lowlands, usually marked by a strand of baldcypress, and baldcypress may occur as an overstory tree in the seep itself. The common horsetail (*Equisetum hyemale*) dominates the ground cover in at least some of the southern seeps. Soils are usually deep and mucky, but in some cases, springs emanate from strata directly adjacent to stream channels, where no significant soils or wetland plants are present.

A second set of slope wetlands occurs in the northern portion of Crowley's Ridge within Arkansas. At least six large seeps (locally called bogs) are known within Greene and Clay Counties, and five of these have been described floristically (Hawkins and Richards 1995; Vanderpool and Richards 1998). The northern seeps are much larger than those of the southern group—most are between 5 and 10 acres. They also occur higher in the landscape, originating on gentle upper slopes and usually continuing downslope to the valley bottom. The upper slope discharge point reflects the geological characteristics of the area—the gravelly strata capping the coastal plain deposits sit much higher in the landscape than they do in the southern parts of the Ridge, they discharge higher on the slopes, and they cause saturation of a larger downslope area. Most of these larger northern "bogs" have several zones or sub-areas characterized by different soils and vegetation structure. They occur primarily on slopes but may extend into the floodplain or riparian zone of streams, and some have small, intermittent channels within the wetland area. In some places, soils are permanently saturated or slightly ponded, while other sites nearby may show indications of only seasonal saturation. Soils range from deep and highly organic silt loams to nearly pure sand. Where there is little or no canopy present, the ground cover usually is dominated by sedges, but in closed-canopy wetlands, ferns often dominate. Canopy species are typically red maple, sweetgum, green ash (*Fraxinus pennsylvanica*), and other water-tolerant species. Sphagnum is present in all of the seep wetlands but ranges from abundant, forming hummocks, to sparse.

Land Use and Environmental Changes

In the Ouachitas, displacement of native populations by settlers was underway by the early 19th century, and at the beginning of the 20th century, essentially all cultivatable land was being farmed. By that time, railroads were poised to penetrate into the Ouachitas, and interest grew in pursuing commercial exploitation of the shortleaf pine timber. Speculators acquired the rights to large amounts of unappropriated government land by purchasing “warrants” that were awarded to war veterans as bonuses, entitling them to claim free land for homesteads. Instead, most warrants were sold cheaply, and the land and timber became the property of large sawmill operations or groups of investors. These blocks of timber were supplemented with purchases of numerous struggling small farms and government land awarded to the railroads. By these means, large swaths of the Ouachitas became available for harvest. The parallel valleys of the region were particularly suited to efficient logging using spur railroad lines that ran up stream valleys from a main trunk line, which could feed major sawmill operations located at various points throughout the mountains (Smith 1986).

In 1907, most of the remaining public land in the Ouachitas was set aside as the Arkansas National Forest, the first national forest in the south (Faulkner 2001). Commercial timber cutting proceeded rapidly, mostly with a “cut out and get out” approach that left large cutover tracts throughout the mountains by the end of the 1920s. In 1926, the Arkansas National Forest was renamed the Ouachita National Forest, and shortly afterwards it began to expand dramatically as the Forest Service bought cutover timberlands and took possession of abandoned farms. Commercial lumber operations shifted emphasis after the 1920s, often removing only the best timber (high-grading), but the newly acquired (or re-acquired) federal lands began to be managed with an evolving “sustained yield” approach, and fire prevention and suppression became major management objectives (Smith 1986, Faulkner 2001). Today the Ouachita National Forest includes nearly 1.8 million acres (720,000 ha) distributed across 12 counties in Arkansas and 2 in Oklahoma (USDA Forest Service 2005). Approximately 30 percent of forestland in the Ouachita Mountains is owned by the forest industry, and the majority of that is in loblolly pine plantations (Rudis 2001). There are six Arkansas State Parks in the Ouachitas, most of which are adjacent to large lakes. Hot Springs National Park protects an area of about 5,000 acres (2,000 ha) in Hot Springs County.

Crowley’s Ridge attracted settlers in the late 18th century, and small farms, orchards, and cattle operations developed on all reasonably flat terrain over the following century. Lumbering was a major source of income on Crowley’s Ridge prior to 1890 but was evidently pursued on a much smaller scale than in the Ouachitas. Clearing for farms was a primary impetus, and trees were sought for specific purposes, such as yellow poplar logs for cabin construction (Clark et al.

1974). In the early 20th century, many farms on the Ridge were abandoned due to severe erosion, and later, orchards began to disappear as well. Former farmlands reverted to forest, and in 1960, most of Crowley's Ridge south of Marianna was designated as the St. Francis National Forest, which encompasses approximately 22,600 acres (9,000 ha) in Arkansas (Faulkner 2001; USDA Forest Service 2004). Four State Parks are located on the Ridge within Arkansas, all of which are relatively small recreational lake and campground sites. Commercial forests on Crowley's Ridge are primarily small, non-industrial operations (Rudis 2001).

Extensive harvesting, especially of pine, in the early 20th century (Smith 1986) certainly had effects that are still evident in the structure and composition of forests in much of the Ouachita Mountains. However, studies of old-growth forest characteristics and historic data indicate that the current general patterns of species composition and forest type distribution in the Ouachitas are probably similar to pre-settlement conditions (Devall and Rudis 1990; Foti and Glenn 1990, Fryar 1990). In the Ouachitas, early records indicate somewhat wider distributions for some species—for example, post oak was apparently more common on gentle slopes and flats, and shortleaf pine occurred more frequently on northwest exposures than it does currently (Foti and Glenn 1990), but otherwise tree species distributions are consistent with historic accounts and records. However, the forest structure has changed significantly. Tree densities have increased and average tree diameters have decreased, and a woody understory has developed on sites that were formerly open and grassy (Smith 1986; Bukenhofer and Hedrick 2003). These changes are usually attributed to a reduced fire frequency in the modern landscape. Estimates of pre-settlement fire frequencies in the Ouachitas range from once every 10 years to once every few decades, but modern fire suppression practices have dramatically extended the fire return interval on most sites (Bukenhofer and Hedrick 2003; Devall and Rudis 1990; Foti and Glenn 1990, Fryar 1990). Presumably, wetlands and streamside zones would have burned less frequently than the upland forests, but such areas are rarely extensive enough to have completely escaped the effects of large, hot fires in the surrounding landscape.

On Crowley's Ridge, the principal changes in forest composition and structure are more directly attributable to past harvest and land use practices. Settlement focused on the gentler upland slopes, and the subsequent erosion and land abandonment, as well as selective logging, forest grazing, and frequent burning, converted much of the former mixed white oak–red oak forest to a mixed oak–hickory–shortleaf pine type (Clark 1977; Smith et al. 1984). Historical accounts indicate that, prior to the late 1800s, mesic species such as beech and sugar maple were much more common and widely distributed than they are today, and species typical of disturbed sites, such as tulip poplar and sweetgum, were less common (Clark 1977).

Approximately half of the land on Crowley's Ridge, including many of the larger valley bottoms, is agricultural, most of the remaining land being in forest. About 2–5 percent of the land surface is devoted to sand and gravel mining (Smith et al. 1984). The strata containing the sand and gravel resource is the Upland Terrace that sits atop the Tertiary coastal plain sediments, which is assumed to hold the local aquifers that sustain seep wetlands along the flanks of the Ridge.

Responsibility for wetland protection or regulation on non-public lands is shared among a variety of federal and state agencies, including the U.S. Army Corps of Engineers, the USDA Natural Resources Conservation Service (NRCS), and the Arkansas Soil and Water Conservation Commission. Six Arkansas State agencies are members of the Arkansas Multi-Agency Wetland Planning Team (MAWPT), which has an overall goal "to preserve, conserve, enhance, and restore the acreage, quality, biological diversity and ecosystem sustainability of Arkansas' wetlands for citizens present and future." With the assistance of funding provided by the U.S. Environmental Protection Agency, this goal has been pursued through a variety of initiatives, including efforts to characterize the composition, function, and landscape patterns of wetlands in Arkansas (e.g., this document), to provide public information and education, and to improve governmental participation in wetland-related decision-making (Arkansas Multi-Agency Wetland Planning Team 1997).

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 Ouachita Mountains and Crowley's Ridge Regions of Arkansas. Within each class, one or more subclasses are recognized, and individual community types are described within each subclass. Wetlands often intergrade or have unusual characteristics, so a set of specific criteria have been established to assist the user in assigning any particular wetland to the appropriate class (Figure 10). Subclass and community type designations can best be assigned using the descriptions of wetlands and their typical landscape positions presented in the following paragraphs, summarized in Table 4, and illustrated in Figures 11 and 12.

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; the 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; the principal water source is precipitation	Flat
6.	Topography is sloping to flat; the principal water source is groundwater discharge or subsurface flow	Slope

Figure 10. Key to Wetland Classes in the Ouachita Mountains and Crowley's Ridge Regions of Arkansas

Table 4
Hydrogeomorphic Classification of Wetlands in the Ouachita Mountains and Crowley's Ridge Regions of Arkansas, and Typical Geomorphic Settings of Community Types

Wetland Classes, Subclasses, and Communities	Typical Hydrogeomorphic Setting
CLASS: FLAT	
SUBCLASS: NON-ALKALI FLAT	
Hardwood Flat	Poorly drained upland basins and high terraces, not subject to regular flooding (1–5 year return interval), along mid-gradient and low-gradient streams
CLASS: RIVERINE	
SUBCLASS: HIGH-GRADIENT RIVERINE	
High-Gradient Riparian Zone	Narrow floodplains, streambanks, and terraces along headwater and other low-order streams (1–5 year flood return interval).
SUBCLASS: MID-GRADIENT RIVERINE	
Mid-Gradient Floodplain	Point bar and natural levee deposits within regularly flooded (1–5 year flood return interval), active meander belts of streams transitioning from headwaters to broad basins.
SUBCLASS: LOW-GRADIENT RIVERINE	
Low-Gradient Overbank	Point bar and natural levee deposits adjacent to widely meandering streams of large basins (1–5 year flood return interval).
SUBCLASS: IMPOUNDED RIVERINE	
Beaver Complex	All flowing waters.
CLASS: DEPRESSION	
SUBCLASS: UNCONNECTED DEPRESSION	
Unconnected Alluvial Depression	Abandoned channels and large swales in former and current meander belts of larger rivers not subject to regular stream flooding (1–5 year flood return interval).
SUBCLASS: CONNECTED DEPRESSION	
Floodplain Depression	Abandoned channels and large swales in former and current meander belts of larger rivers within the 1–5 year floodplain.
CLASS: FRINGE	
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.
SUBCLASS: CONNECTED LACUSTRINE FRINGE	
Connected Lake Margin	Natural and man-made lakes where water levels are not actively managed and that are within the 1–5 year flood return interval of a larger stream.
SUBCLASS: RESERVOIR FRINGE	
Reservoir Shore	Fluctuation zone of a man-made reservoir manipulated for water supply, power production, and other purposes.
CLASS: SLOPE	
SUBCLASS: NON-CALCAREOUS SLOPE	
Non-Calcareous Perennial Seep	Slopes and adjacent colluvial deposits at perennial aquifer discharge points, usually at the contact between permeable and less-permeable strata or where fractures or quartz veins occur.
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 or quartz veins occur.

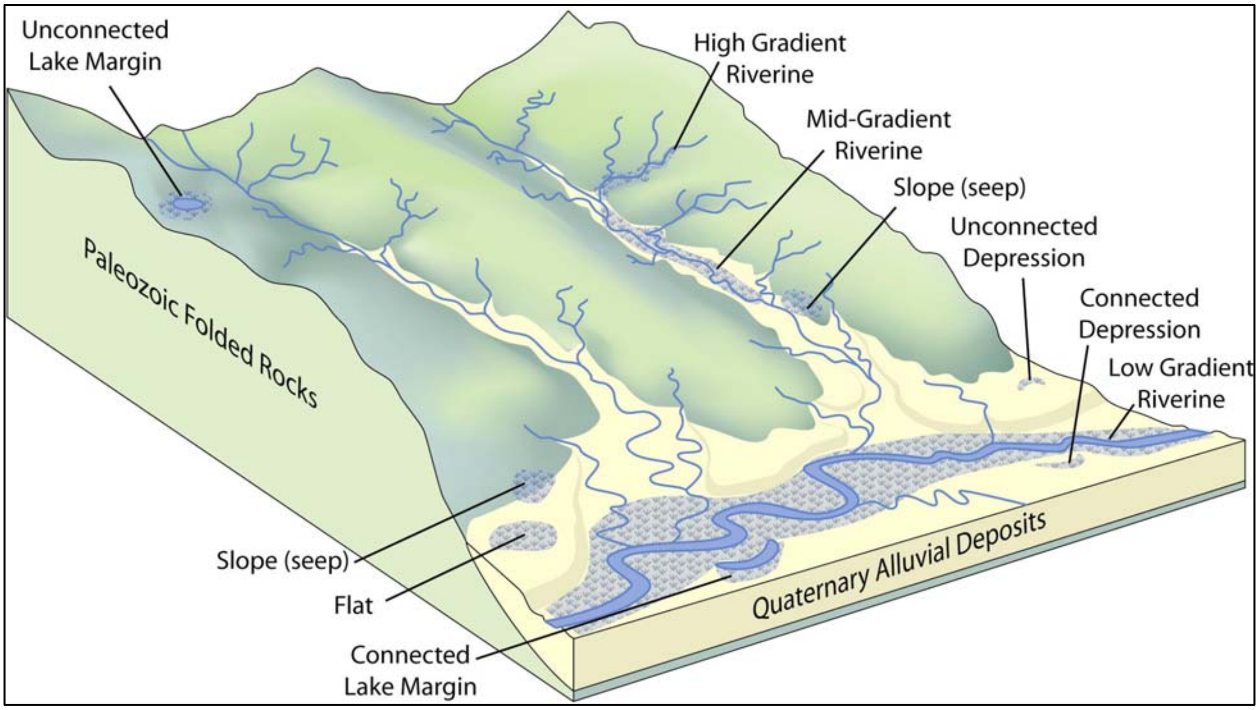


Figure 11. Typical landscape positions of wetland subclasses in the Ouachita Mountains.

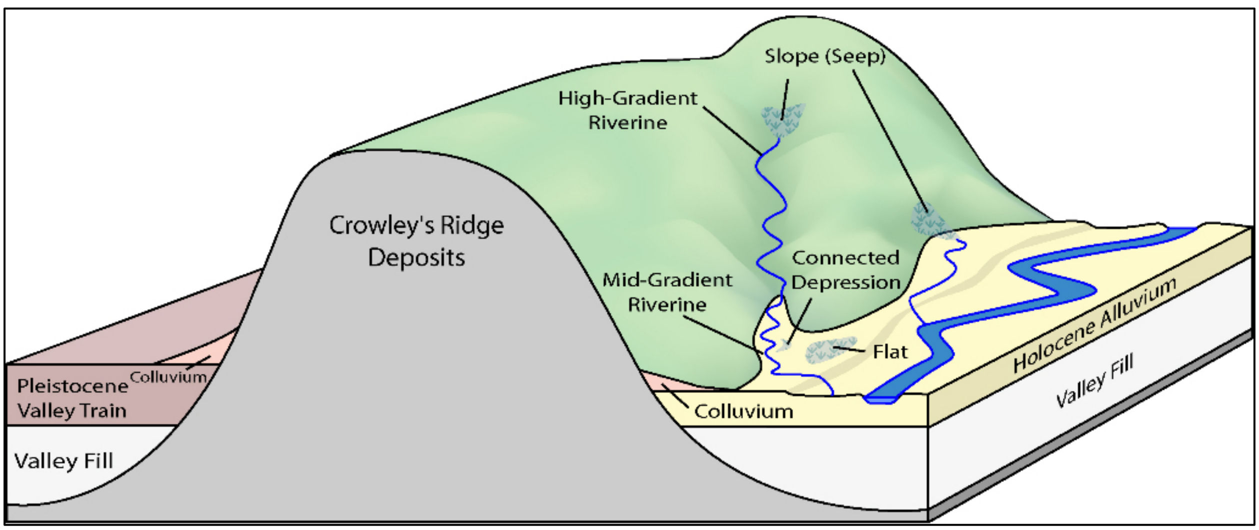


Figure 12. Typical landscape positions of wetland subclasses on Crowley's Ridge.

Note that, in some cases, the classification system and assessment models apply the term "wetland" to sites that may not meet the criteria for jurisdictional wetlands under the Clean Water Act. In particular, the Riverine Class includes riparian areas that may not be jurisdictional, and some Flat sites on alluvial terraces also may not meet regulatory criteria. However, in both of these situations, jurisdictional and non-jurisdictional sites may be highly interspersed, and their regulatory status must be determined in the field, not by using the classification system presented here. Further, even where riparian and terrace sites are determined to not be jurisdictional, the models presented in this guidebook can be applied for non-regulatory applications such as management and restoration.

Some of the criteria that are used in Figure 10 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 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 Ouachita Mountains and Crowley's Ridge Regions of Arkansas. All of the wetland types that occur in the Ouachita Mountains and Crowley's Ridge Regions 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 (*http://www.mawpt.org/*).

Class: Flat

Flats have little or no gradient, and the principal water source is precipitation. There is minimal overland flow into or out of the wetland except as saturated flow. Wetlands on flat areas that are subject to stream flooding during a 5-year event are classified as Riverine. Small ponded areas within flats are considered to be normal components of the Flat Class if they do not meet the criteria for the Depression Class. Sites that have minimal gradient but are maintained as wetlands due to groundwater discharge are considered to be Slope wetlands. Within the Ouachita Mountains and Crowley's Ridge Regions, there is only one subclass in the Flat Class, represented by a single community type (Table 4).

Subclass: Non-Alkali Flat

Community Type:

a. *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 primarily due to rainfall, although runoff from hillslopes may be important in some settings. Within the areas under consideration here, hardwood flats occur mostly on the higher alluvial terraces along large mid- and low-gradient streams and are dominated by various lowland hardwood species such as cherrybark (*Q. pagoda)* and Shumard oaks. In the lower Ouachita River bottoms, loblolly pine (*P. taeda*) is present on some terrace sites and may have been locally abundant in the past. Flat wetlands also may occur in small upland basins or similar areas where drainage is poor, but the soils are not alluvial.

Most alluvial terrace sites, though generally flat, in fact display a great deal of microrelief consisting of small rises and drops in the soil surface that are the result of treefall (which creates holes where roots and soil are pulled free) and depositional processes. The smaller puddles persist for only a few days after a major rain, but large swales and abandoned channels may pond water throughout the winter and spring and are referred to as vernal pools. All of these ponded areas tend to slow runoff and store water on-site and help maintain wetland characteristics and functions on flats. Where very large swales and abandoned channel segments occur, they may hold water well into the growing season and are generally classified as depressions.

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. All other riverine wetlands in the Ouachita Mountains and Crowley's Ridge Regions are classified into one of three subclasses based on stream gradient and landscape position, as illustrated in Figure 13. Table 5 presents typical dimensions of various geomorphic features associated with each riverine subclass to further guide classification. (Note that Table 5 also has potential restoration design applications.)

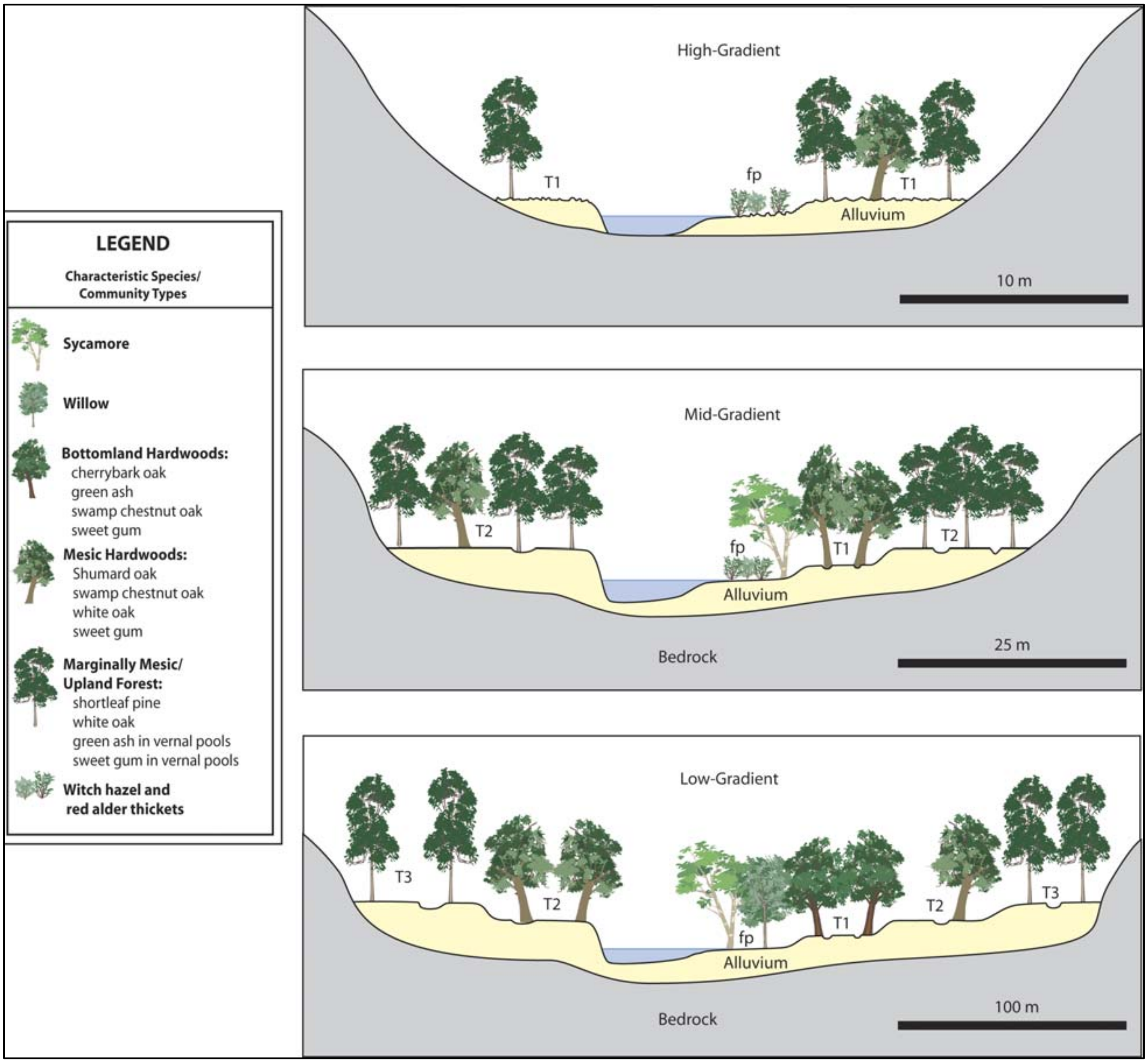


Figure 13. Geomorphic settings and average dimensions of features associated with riverine subclasses in the Ouachita Mountains and Crowley's Ridge Regions. Symbols: fp (floodplain), T1 (terrace 1), T2 (terrace 2), T3 (terrace 3). See Table 5 for additional information

Table 5
Dimensions* of stream channels and alluvial terraces in the Ouachita Mountains and Crowley's Ridge Regions of Arkansas

	High-Gradient Riverine	Mid-Gradient Riverine	Low-Gradient Riverine
STREAM ORDER**	0 – 3	3 – 5	> 4
BANKFULL CHANNEL			
WIDTH (m) Range (mean)	1.6 – 4.7 (3.78)	2.0 – 22.0 (10.73)	5 – 60 (37.86)
MAXIMUM DEPTH (m) Range (mean)	0.05 – 0.5 (0.24)	0.06 – 0.92 (0.32)	0.02 – 2.0 (0.41)
AVERAGE DEPTH (m) Range (mean)	0.03 – 0.4 (0.17)	0.03 – 0.50 (0.17)	0.08 – 1.2 (0.38)
FLOODPLAIN WIDTH (m) Range (mean)	0.2 – 6.0 (1.58)	0.03 – 9.5 (2.0)	2.0 – 40.0 (27.18)
TERRACE 1 (lowest) (% of sites with this terrace present)	82%	94%	100%
HEIGHT (m) Range (mean)	0.2 – 0.75 (0.5)	0.25 – 1.6 (0.92)	0.75 – 3.5 (2.19)
WIDTH (m) Range (mean)	3.0 – 25.0 (10.33)	5.0 – 60.0 (12.25)	5.0 – 100.0 (46.11)
TERRACE 2 (% of sites with this terrace present)	(uncommon)	72%	86%
HEIGHT (m) Range (mean)		1.2 –3.5 (2.0)	2.0 – 5.0 (4.0)
WIDTH (m) Range / (mean)		12.0 – 60.0 (32.38)	20.0 – 150.0 (64.29)
TERRACE 3 (% of sites with this terrace present)	0%	0%	42%
HEIGHT (m) Range (mean)			2.5 – 7.0 (5.79)
WIDTH (m) Range (mean)			25.0 – 200.0 (81.67)

* 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 or extreme headwater reaches. All dimensions are measured with reference to the bankfull channel as defined by Dunne and Leopold (1978).
** 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:

a. *High-Gradient Riparian*. High-gradient riverine wetlands typically occur in association with small stream channels at or near their point of origin (Figures 11 and 12). 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. This might include compound networks of relatively steep channels in larger watersheds of the Ouachitas (stream orders 0–3), but in very small watersheds of Crowley's Ridge, only primary channels (stream orders 0–1) might be included. 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 (Figure 13 and Table 5). Floodplains and low terraces often develop where woody debris (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. Usually, the coarser cobble bars are colonized by pioneer woody species, such as willows (*Salix* spp.), alders (*Alnus* spp.), and sycamore (*Platanus occidentalis*), but the oldest and highest cobble bars usually support pines and oaks typical of droughty sites (Figure 13). The more fine-grained terraces, low cobble bars, and streambanks support riparian species such as red maple, ironwood, and sweetgum, but more mesic species such as northern red oak and beech also are common. The finest materials (usually the low bars that form behind woody debris deposits) characteristically support an herbaceous wetland community of sedges and ferns. The overall character of an intact, functional high-gradient system 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. A typical example reach is illustrated in Figure 13. 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 Type:

a. *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. Streams transitioning from the hills to the major river valleys (which may include channels classified as stream orders 2–6) are included in this category in the Ouachita Mountains and Crowley's Ridge Regions (Figures 11 and 12).

Mid-gradient streams usually have fairly small floodplains and one or two low terrace units (Table 5, Figure 13) that are nearly continuous along the channel, though they often alternate from one side of the channel to the other. Floodplains usually are sparsely vegetated or bare gravel bars. Terrace components may combine elements of upland and lowland forests and can be highly diverse. Riparian species such as red maple, sycamore, and sweetgum dominate some low terraces, but mesic species such as northern red oak, white oak, and basswood (*Tilia americana*) also are common. Where a second, higher terrace occurs, it is usually not flooded frequently enough to be classified as a riverine wetland, but it may have sufficient wetland character to be classified as a flat. It is usually dominated by species such as red maple, water oak, and sweetgum (Figure 13).

Subclass: Low-Gradient Riverine

Community Type:

a. *Low-Gradient Overbank.* Low-gradient riverine wetlands occur within the 5-year floodplain of streams that occupy wide meander belts and typically have a broad floodplain and extensive, continuous terraces. In the Ouachita Mountains, such large bottoms occur mostly in the major river basins (Figure 11), but some of the most extensive terrace systems were inundated by the large reservoirs constructed in the mid-20th century. In the valleys of Crowley's Ridge, widely meandering low-gradient riverine wetlands are not common.

All of the low-gradient riverine wetlands in the Ouachitas and Crowley's Ridge are classified as "overbank" (as opposed to "backwater") because floodwaters tend to move through them quickly and at high velocities. This can cause scour or deep deposition of coarse sediments, and litter and other detritus may be completely swept from a site or accumulate in large debris piles. In-channel bars and riverfront areas usually are dominated by willows, sycamore, river birch, and similar pioneer species, while older and less exposed substrates support more diverse communities. Usually there are two terraces present and sometimes a third, and each of these can be extensive (Table 5 and Figure 13). Characteristic species of the floodplain and first (lowest) terrace include red maple, silver maple, sugarberry (*Celtis laevigata)*, American elm (*Ulmus americana*), and persimmon (*Diospyros virginiana*). Wetlands of higher terraces typically are not flooded frequently and are classified as flats. As in flat wetlands, microrelief and vernal pools are important components of most riverine wetlands, other than those on coarse substrates such as active point bars.

Subclass: Impounded Riverine

Community Type:

a. *Beaver Complex.* Beaver complexes once were nearly ubiquitous here and elsewhere in the continental United States, but they 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 creates 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.

Class: Depression

Depression wetlands occur in topographic low points where water accumulates and remains for extended periods. Sources of water include precipitation, runoff, groundwater, and stream flooding.

Depressions (both connected and unconnected) are distinguished from the vernal pools that occur within the flat and riverine subclasses in several ways. Depressions tend to occur in abandoned channels, abandoned courses, and large swales, while vernal pools within flat and riverine wetlands occur in minor swales or in areas bounded by slight rises and hummocks. Depressions hold water for extended periods because of 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. Vernal pools in flat and riverine settings, in contrast, fill primarily because of direct precipitation inputs, and they dry out within days or weeks.

In the Ouachita Mountains and Crowley's Ridge Regions of Arkansas, there are two subclasses in the Depression Class, each represented by a single community type (Table 4). Figures 11 and 12 illustrate the landscape positions where wetlands in the Depression Class typically are found.

Subclass: Unconnected Depression

Community Type:

a. *Unconnected Alluvial Depression.* Unconnected alluvial depressions are not affected by river flooding during common flood events (1- to 5-year flood frequency zone). They typically occur in abandoned river channels and large swales on the higher terraces flanking large streams and are not common in the Ouachitas or Crowley's Ridge. The lack of connection to the river, which distinguishes this wetland type from floodplain depressions, implies various functional differences. For example, unconnected depressions may lack predatory fish populations and thereby provide vital habitat for certain invertebrate and amphibian species. However, structurally and compositionally the two types are very similar. The deepest parts of unconnected depression wetlands usually are occupied by buttonbush (*Cephalanthus occidentalis*), fringed with species such as green ash, sycamore, silver maple, and river birch. The transition to the surrounding upland, flat, or riverine wetland is usually abrupt.

Subclass: Connected Depression

Community Type:

a. *Floodplain Depression.* Floodplain depression wetlands are most commonly found in the remnants of abandoned stream channels or in broad swales left behind by migrating channels. They are usually near the stream and are inundated during the more common (1- to 5-year) flood events. Connected depressions are structurally and compositionally similar to unconnected depressions in most cases, but there are some variations. In the Ouachitas, some connected depressions occur in high-flow channels across major bars, where extremely coarse substrates predominate, but subsurface connections to the river channel maintain ponded conditions. Sycamore is the common dominant in these situations. In Crowley's Ridge, depressions of any type are uncommon, but floodplain depressions may include species typical of the nearby Delta lowlands, such as overcup oak (*Q. lyrata)* and baldcypress.

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.

In Arkansas, natural lakes occur mostly in the abandoned channels of large rivers (oxbows), but numerous man-made impoundments also support fringe wetlands. The most extensive fringe systems are associated with the upper reaches of the large reservoirs of the Ouachitas, which are shown on Figure 6. There are three subclasses and three community types in the Fringe Class (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.

Subclass: Reservoir Fringe

Community Type:

a. *Reservoir Shore.* Man-made reservoirs include a wide array of features, such as large farm ponds; state, federal, and utility company lakes; and municipal water storage reservoirs. In almost all cases, these lakes are managed specifically to modify natural patterns of water flow, so 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 black willow (*Salix nigra*) or buttonbush, but even these areas are vulnerable to extended drawdowns, ice accumulation, erosion due to boat wakes, and similar impacts.

Subclass: Connected Lacustrine Fringe

Community Type:

a. *Connected Lake Margin.* Connected lake margin wetlands are uncommon in the Ouachitas and Crowley's Ridge, but they may occur where stock ponds, borrow pits, and small oxbow lakes exist near large rivers, where they are frequently inundated during floods (that is, they are within the 1- to 5-year flood frequency zone). Connected lake margins differ from unconnected systems in that they routinely exchange nutrients, sediments, and aquatic organisms with the river system. Shoreline willow stands and fringe marshes are the typical vegetation.

Subclass: Unconnected Lacustrine Fringe

Community Type:

a. *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- to 5-year floodplain). They are similar in appearance to connected lake margins but are classified separately because they do not regularly exchange nutrients, sediments, or fish with river systems. Most are associated with farm ponds and small lakes.

Class: Slope

Slope wetlands occur on sloping land surfaces where groundwater discharge or shallow subsurface flow creates saturated conditions (Figures 8 and 9). There is one subclass comprising two community types in the Ouachita Mountains and Crowley's Ridge Regions (Table 4). The community types are separated by water regime (perennial versus wet-weather) but otherwise are similar in many respects, and they may be difficult to separate in the field without a long period of observation. Therefore, they are assessed using a single set of models applicable to both types. Both community types are highly variable, but they typically are forested, though the overstory may be sparse or dominated by relatively small trees, because the saturated substrate makes them susceptible to windthrow. Numerous uncommon herbaceous and shrub 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. Seeps may occur as isolated, small wetlands, or they may occur as complexes that extend for long distances along valley walls and their adjacent stream bottoms.

Although these wetlands are classified as "non-calcareous" and are sometimes referred to as "acid seeps," it is important to recognize that they occur on a wide variety of substrates and vary widely in mineral content and soil and water reaction. Some may in fact be mildly calcareous. However, they are classified here as non-calcareous seeps in order to stress their differences from the strongly calcareous slope wetlands that occur in the Ozark Mountains Region. Figures 11 and 12 illustrate 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 Ouachita Mountains and Crowley's Ridge Regions.

Community Types:

a. *Non-Calcareous Perennial Seep*. Perennial seeps in the Ouachitas and Crowley's Ridge occur at the discharge point of aquifers large enough to maintain constant flow in all but the driest years. Those with particularly reliable and abundant flow often have been developed as local drinking-water sources and may be referred to as springs rather than seeps. In the Ouachitas, seeps usually have thick organic substrates overlying gravels, but on steeper slopes or where soils have been disturbed, substrates may be primarily bare gravels. Sphagnum moss is nearly always present, and it may form a continuous mat in some sites. Overstory species usually include some combination of sweetgum, beech, blackgum, red maple, green ash, ironwood, and umbrella magnolia. Understory and shrub species may include alder, American holly, spicebush, 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 rare or uncommon elsewhere in the region. Ferns are particularly characteristic, especially cinnamon fern

(*Osmunda cinnamomea*), royal fern (*O. regalis*), and netted chain fern (*Woodwardia areolata*).

On Crowley's Ridge, all of these patterns occur, but there are some differences. Perennial seeps along the southeastern base of the Ridge, adjacent to the Delta, sometimes include baldcypress in the overstory. On the northern part of the Ridge, some seeps have little or no canopy, and the shrub and groundcover diversity is particularly striking. In these seeps, a wide variety of graminoids, usually including three-way sedge (*Dulichium arundinaceum*), share dominance with the same fern species usually found in closed-canopy settings.

b. *Wet-Weather Seep*. Wet-weather seeps are slope wetlands with ground water sources that cease flowing during dry periods. Plant communities of wet-weather seeps resemble perennial seeps in many respects. However, because they may experience extended dry periods, the canopy layer may not include any of the wetter-site species that dominate most perennial seeps, such as sweetgum, and instead may be dominated by mesic species, such as beech and various oaks. However, the shrub and understory layer usually includes characteristic seep species, such as umbrella magnolia, American holly, and spicebush, and the groundcover includes the same ferns, sphagnum, and many of the same forbs and graminoids found in perennial seeps.

4 Wetland Functions and Assessment Models

This Regional Guidebook contains seven sets of assessment models applicable to wetlands in the Ouachita Mountains and Crowley's Ridge Regions of Arkansas. Not all of the wetland subclasses and community types described in Chapter 3 can be assessed using the models presented here. Only forested wetlands (or sites that could support forested wetlands) are intended to be assessed using these models. In addition, none of the Fringe Class or Impounded Riverine subclass wetlands are addressed in this document, even if they are forested. Impacts to these wetlands are likely to involve subtle changes in water level management, which are beyond the scope of a rapid field assessment technique.

The wetlands that can be assessed with the models presented here include all of the subclasses and community types not specifically excluded above and represent most of the common forested wetland types in the region. For simplicity, the Non-Alkali Flat and Non-Calcareous Slope subclasses will be referred to simply as the Flat and Slope subclasses, respectively, for the remainder of this document.

Based on the above discussion, the seven wetland subclasses for which assessment models are presented in this chapter are the following:

- Flat;
- High-Gradient Riverine;
- Mid-Gradient Riverine;
- Low-Gradient Riverine;
- Unconnected Depression;
- Connected Depression; and
- Slope.

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 the national "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 Ouachita Mountains and Crowley's Ridge Regions do the following:

- Detain floodwater;
- Detain precipitation;
- Cycle nutrients;
- Export organic carbon;
- Maintain plant communities; and
- Provide habitat for fish and wildlife.

It should be noted that not all functions are performed by every 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.

In this chapter each of the functions identified above 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 that 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. The final chapter (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 Ouachita Mountains and Crowley's Ridge Regions of Arkansas:

- High-Gradient Riverine;
- Mid-Gradient Riverine;
- Low-Gradient Riverine; and
- Connected Depression.

The recommended procedure for assessing this function involves estimating "roughness" within the wetland, in addition to flood frequency. 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; Dybvig and Hart 1977; 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 that 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 Ouachita Mountains and Crowley's Ridge Regions 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 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 flood frequency can be estimated more specifically, 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 the following assessment variables, which are discussed in greater detail in Chapter 6:

- V_{FREQ} : 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:

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

The assessment model has two components: 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.

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_{TDEN}) interact with a full range of flood depths. 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. Depression and slope wetlands also store precipitation but are not assessed for that function within the Ouachita Mountains and Crowley's Ridge Regions of Arkansas. The hydrology of depression and slope wetlands is dependent on highly variable source areas, groundwater movement, and (in the case of depressions) available storage volumes, all of which are beyond the limits of a rapid field assessment. Four wetland subclasses are assessed for the precipitation detention function in the Ouachita Mountains and Crowley's Ridge Regions of Arkansas:

- Flat;
- High-Gradient Riverine;
- Mid-Gradient Riverine; and
- 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 microdepressions and vernal pools. Microdepressions 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 cut-offs or oxbows. In the Ouachita Mountains and Crowley's Ridge, most microdepressional precipitation storage occurs in the floodplains and terraces of low-gradient streams. The presence of surface organic accumulations also reduces runoff and promotes infiltration. Therefore, sites with large amounts of microdepression and vernal pool storage and a thick, continuous litter or duff layer will most 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 the base flow in nearby streams. Clearing natural vegetation cover will remove the source of litter and the mechanism for developing new microdepressions. 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 the following 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:

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

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. 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:

- Flat;
- High-Gradient Riverine;
- Mid-Gradient Riverine;
- Low-Gradient Riverine;
- Unconnected Depression;
- Connected Depression; and
- Slope.

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; Ricklefs 1990). 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 a 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 re-enter 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, such as primary production and decomposition, 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; Elder and Cairns 1982; Brown and Peterson 1983; Harmon et al. 1986; Symbula and Day 1988; Raich and Nadelhoffer 1989; Brinson 1990; Nadelhoffer and Raich 1992).

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, estimating consumer biomass (animals, etc.) is too complex for a rapid assessment approach, so 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 nutrient cycling 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. That is because it is a relatively transient component of the on-site nutrient capital and may in fact be readily exported. Therefore, it is used as a nutrient-related assessment variable only in the carbon export function, below.

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 river-connected wetlands and slope wetlands, which include the following subclasses in the Ouachita Mountains and Crowley's Ridge Regions of Arkansas:

- High-Gradient Riverine;
- Mid-Gradient Riverine;
- Low-Gradient Riverine;
- Connected Depression; and
- Slope.

Rationale for Selecting the Function

The high productivity of river-connected and slope 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 and Meyers 1986; Edwards 1987). Slope wetlands lack the physical mobilization of detritus that occurs in floodplains and therefore may contribute less total carbon to the aquatic system than riverine wetlands. However, the typical landscape position of slope wetlands—directly adjacent to headwater streams—results in delivery of dissolved carbon to the uppermost reaches of the aquatic system. Dissolved carbon is the basis of the aquatic food web (Schlosser 1991; Wohl 2000), so slope wetlands that discharge to headwater streams may have the effect of initiating ecosystem processes farther upstream than would occur in the absence of those wetlands.

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 (Mulholland and Kuenzler 1979; Brinson et al. 1981; Elder and Mattraw 1982; Johnston et al. 1990). 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) the 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 (Brinson et al. 1981); 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.

General Form of the Assessment Model

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

- V_{FREQ} : Frequency of flooding
- V_{OUT}: Outflow from the wetland
- 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:

$$FCI = \begin{pmatrix} \text{Hydrologic} \\ \text{Variables} \end{pmatrix} \times \frac{\left[\frac{\left(V_{LITTER} + V_{OHOR} + V_{WD} + V_{SNAG}\right)}{4}\right] + \left[\frac{V_{TBA} + V_{SSD} + V_{GVC}}{3}\right]}{2} \qquad (5)$$

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 because of their relative immobility, and an export mechanism is a required component of this model. The export mechanism, represented in the general equation above as "*Hydrologic Variables*," consists of either flooding (V_{FREQ}), which is used for riverine and connected depression subclasses, or outflow (usually discharge of groundwater) (V_{OUT}) in slope wetlands. 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. However, it is included in this model because it represents the most mobile dead organic fraction in the wetland and because it may be the only component of that fraction 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 a more complex analysis that requires familiarity with the regional vegetation and collection of appropriate sample data.

This function is assessed in all subclasses in the Ouachita Mountains and Crowley's Ridge Regions of Arkansas:

- Flat;
- High-Gradient Riverine;
- Mid-Gradient Riverine;
- Low-Gradient Riverine;
- Unconnected Depression;
- Connected Depression; and
- Slope.

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, the nutrient status, and the 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, fires, 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 the tallest woody stratum
- V_{GCOMP}: Composition of the ground-cover stratum
- V_{SOIL} : Soil integrity
- V_{POND} : Micro-depressional ponding.

The model can be expressed in a general form:

$$FCI = \left\langle \left\{ \frac{\left[\frac{(V_{TBA} + V_{TDEN})}{2} + \begin{pmatrix} \text{Composition} \\ \text{Variables} \end{pmatrix} \right]}{2} \right\} \times \left[\frac{(V_{SOIL} + V_{POND})}{2} \right] \right\rangle^{1/2} \quad (6)$$

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 (*Composition Variables*) considers plant species composition. Usually, composition is assessed only for 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). In slope wetlands, the composition of the ground cover layer (V_{GCOMP}) receives special consideration because certain fern species are particularly characteristic of those systems.

The second expression of the model considers two specific site 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 sediments inappropriate to the site or where the native soils have been damaged significantly, as by compaction. 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 the character of many wetlands in the Ouachita Mountains and Crowley's Ridge Regions of Arkansas. 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 utilize 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 (Sorenson 1948; Odum 1950).

This function is assessed in all subclasses in the Ouachita Mountains and Crowley's Ridge Regions of Arkansas:

- Flat;
- High-Gradient Riverine;
- Mid-Gradient Riverine;
- Low-Gradient Riverine;
- Unconnected Depression;
- Connected Depression; and
- Slope.

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 Ouachita Mountains and Crowley's Ridge Regions 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 the wetlands of the Ouachita Mountains and Crowley's Ridge Regions of Arkansas depend 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 from 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 because of 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 (Schoener 1986; Allen 1987).

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 food sources (Harmon et al. 1986; Loeb 1993). Standing dead trees (snags) are used by numerous bird species, and several species depend 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 raccoons also depend 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 the wetlands of the Ouachita Mountains and Crowley's Ridge Regions 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 they 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). Amphibians and reptiles also differentially use headwater stream and slope wetlands that remain saturated through much of the year (Meyer et al. 2003).

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), in an overview of fish use of bottomland hardwood wetlands in the Piedmont and eastern Coastal Plain, 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, the surrounding land uses, any 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 ivory-billed woodpecker, the black bear, and the 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; Howe 1984; Lynch and Whigham 1984; Askins et al. 1987; Sallabanks et al. 1998; Keller et al. 1993; Kilgo et al. 1997). However, the negative effects of forest fragmentation on some species of birds 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, to sustain source breeding populations of individual species within the three groups, 44 patches of 4,000–8,000 ha, 18 patches of 8,000–40,000 ha, and 12 patches larger than 40,000 ha are needed. 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.

The 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), which is the case in the Ouachita Mountains Region of Arkansas (Rudis 2001).

In the case of slope and depression wetlands that typically occur as small patches within a matrix of drier sites, and where wetlands occur as narrow zones along headwater and 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 Buhlmann 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 recognized sites adjacent to wetlands as part of the habitat base and distinguished 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 that width 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 the forest wetlands of Missouri (Semlitsch 1998) and 250 m in the 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 slopes 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 (Rothermel 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} : Frequency of flooding
- 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-meter buffer zone
- V_{BUF250} : Percent of wetland perimeter contiguous with a 250-meter buffer zone.

The model can be expressed in a general form:

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

The expressions within the model reflect the major habitat components described above. The first expression concerns hydrology and includes indicators of both extensive seasonal inundation, which allows river access by aquatic organisms (V_{FREQ}), and the periodic occurrence of temporary, isolated aquatic conditions (V_{POND}). 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 all slope, depression, high-gradient riverine, and mid-gradient riverine subclasses, the assessment of landscape characteristics focuses on the adequacy of buffer zones adjacent to the 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 Export Organic Carbon function is assessed only for wetlands in the Riverine and Slope classes and the Connected Depression subclass, where flooding or distinct downslope flows provide a mechanism for export to aquatic systems. It is not assessed in subclasses that have no export mechanism (i.e. Isolated Depressions and Flats). Similarly, some variables can be deleted from assessment models for subclasses where they cannot be consistently evaluated. For example, ground vegetation cover (V_{GVC}), litter cover (V_{LITTER}), woody debris and logs (V_{WD} and V_{LOG}), and thickness of the O and A horizons (V_{OHOR} and V_{AHOR}) may be difficult to assess in depressions that are inundated, and modified versions of the models applicable to the depression subclasses are provided for use in those situations. The modified models are likely to be less sensitive than the full versions, but they are complete enough to be used when necessary.

Assessment models also differ among subclasses with regard to their associated reference data. Each subclass was the focus of detailed sampling during the 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 presented as described in Chapter 4 if it is applicable in its general and complete form; it is presented in a modified form if certain variables cannot be consistently assessed in certain subclasses; and the function 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; Greenberg et al. 1997; Kennedy and Nowacki 1997; Tyrrell et al. 1998) were used to resolve occasional ambiguities in the data set.

Subclass: Non-Alkali Flat

Four functions are assessed for this subclass. Most of the applicable assessment models have not been changed from the general model form presented in Chapter 4. Figure 14 illustrates the relationship between the variable metrics and the subindex for each of the assessment models based on the reference data.

a. Function 1: Detain Floodwater. Not assessed

b. Function 2: Detain Precipitation.

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

c. Function 3: 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. Function 4: Export Organic Carbon. Not assessed.

e. Function 5: Maintain Plant Communities.

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

f. Function 6: Provide Wildlife Habitat. Applicable in the following modified format:

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

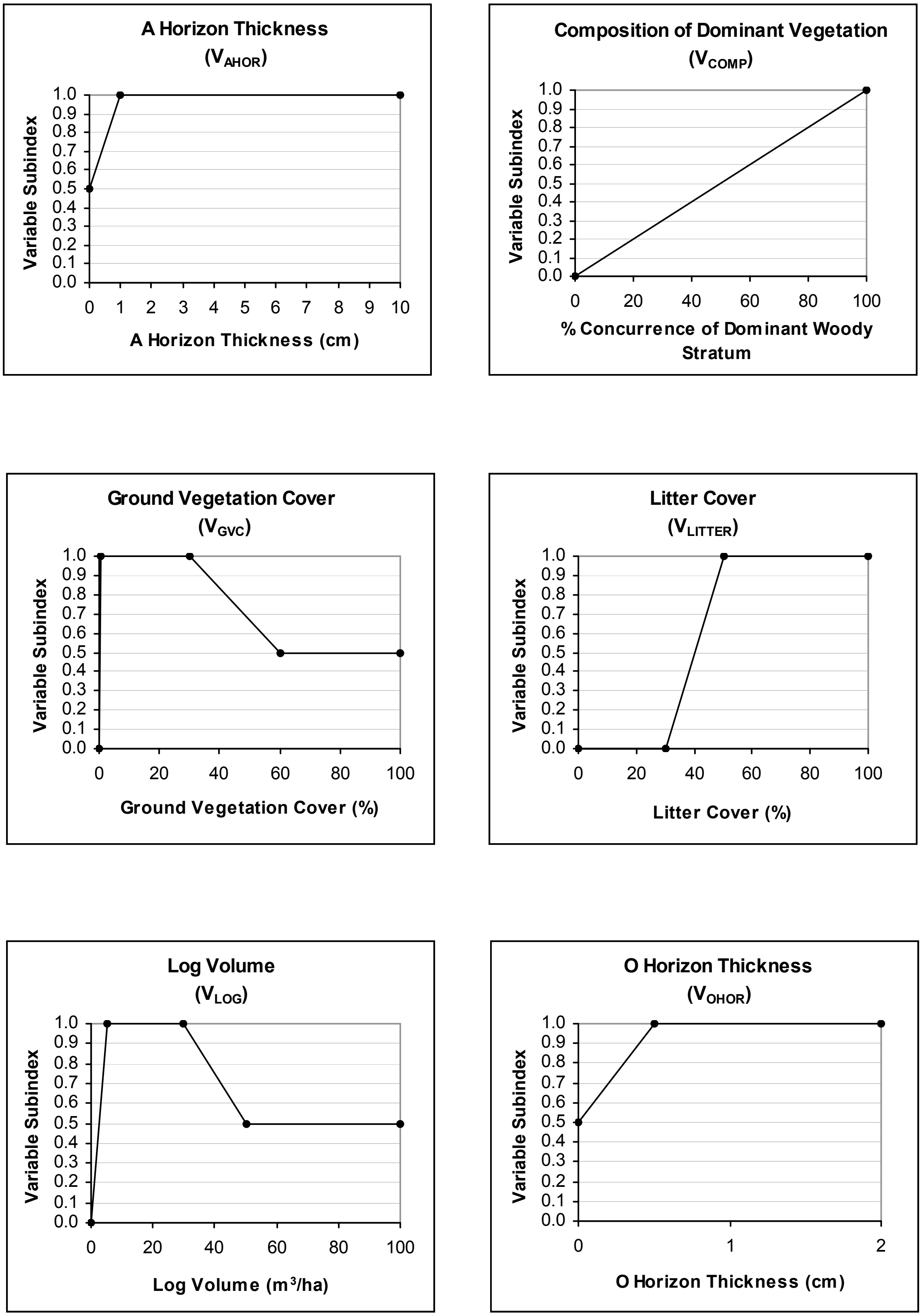


Figure 14. Subindex graphs for flat wetlands (continued)

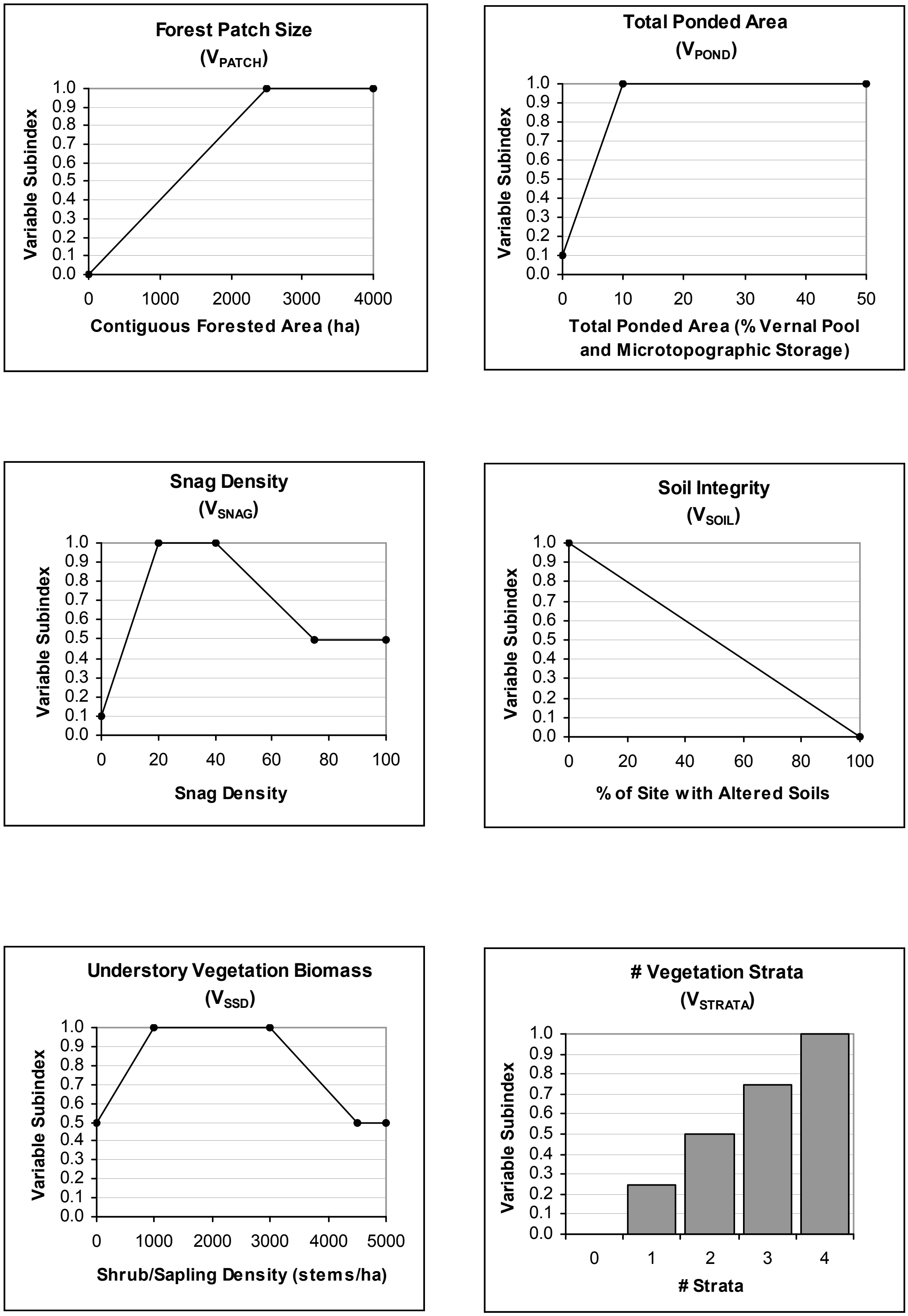


Figure 14. Subindex graphs for flat wetlands (continued)

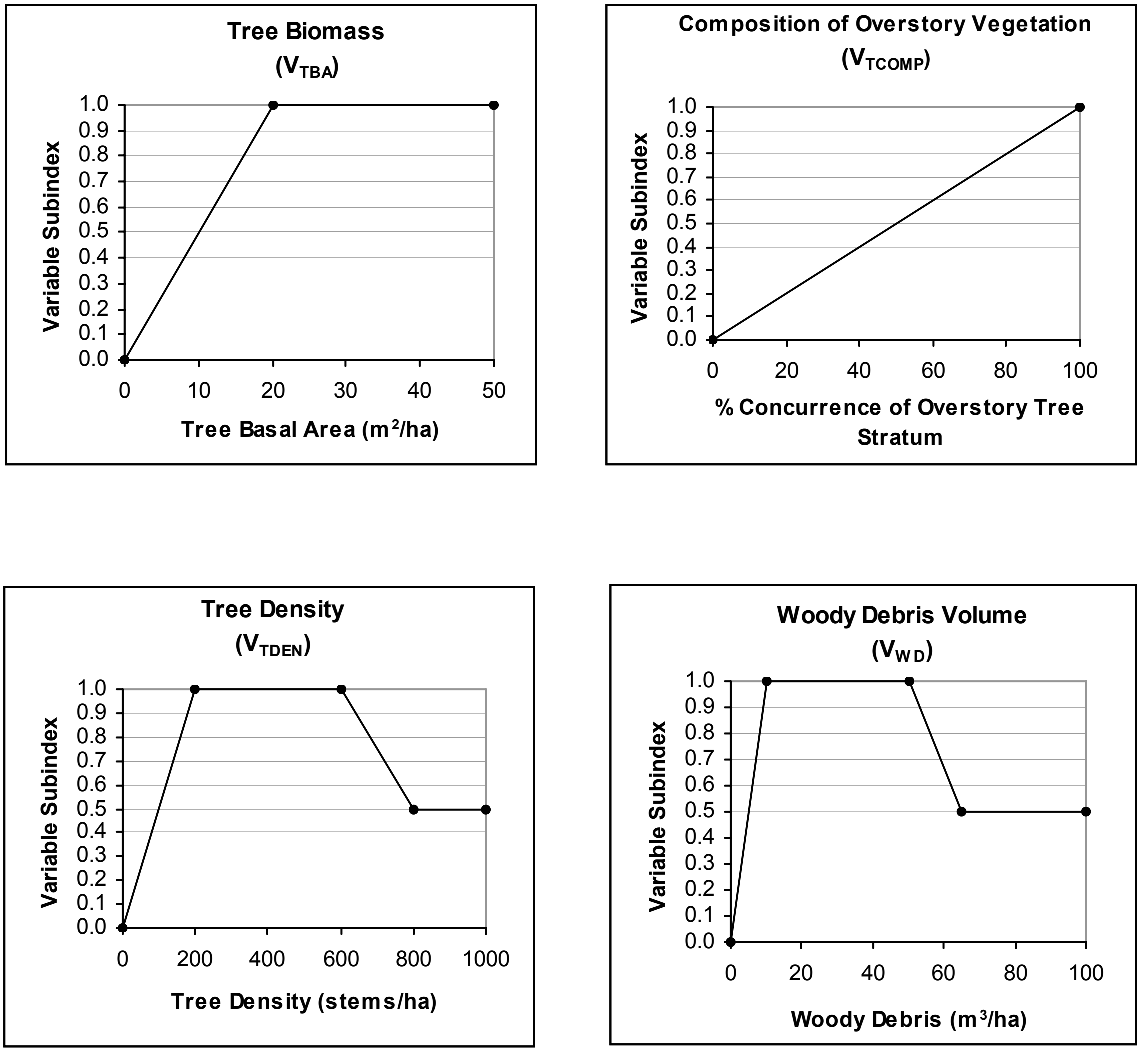


Figure 14. Subindex graphs for flat wetlands (concluded)

Subclass: High-Gradient Riverine

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

a. Function 1: Detain Floodwater.

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

b. Function 2: Detain Precipitation.

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

c. Function 3: 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. Function 4: 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. Function 5: Maintain Plant Communities.

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

f. Function 6: Provide Wildlife Habitat.

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

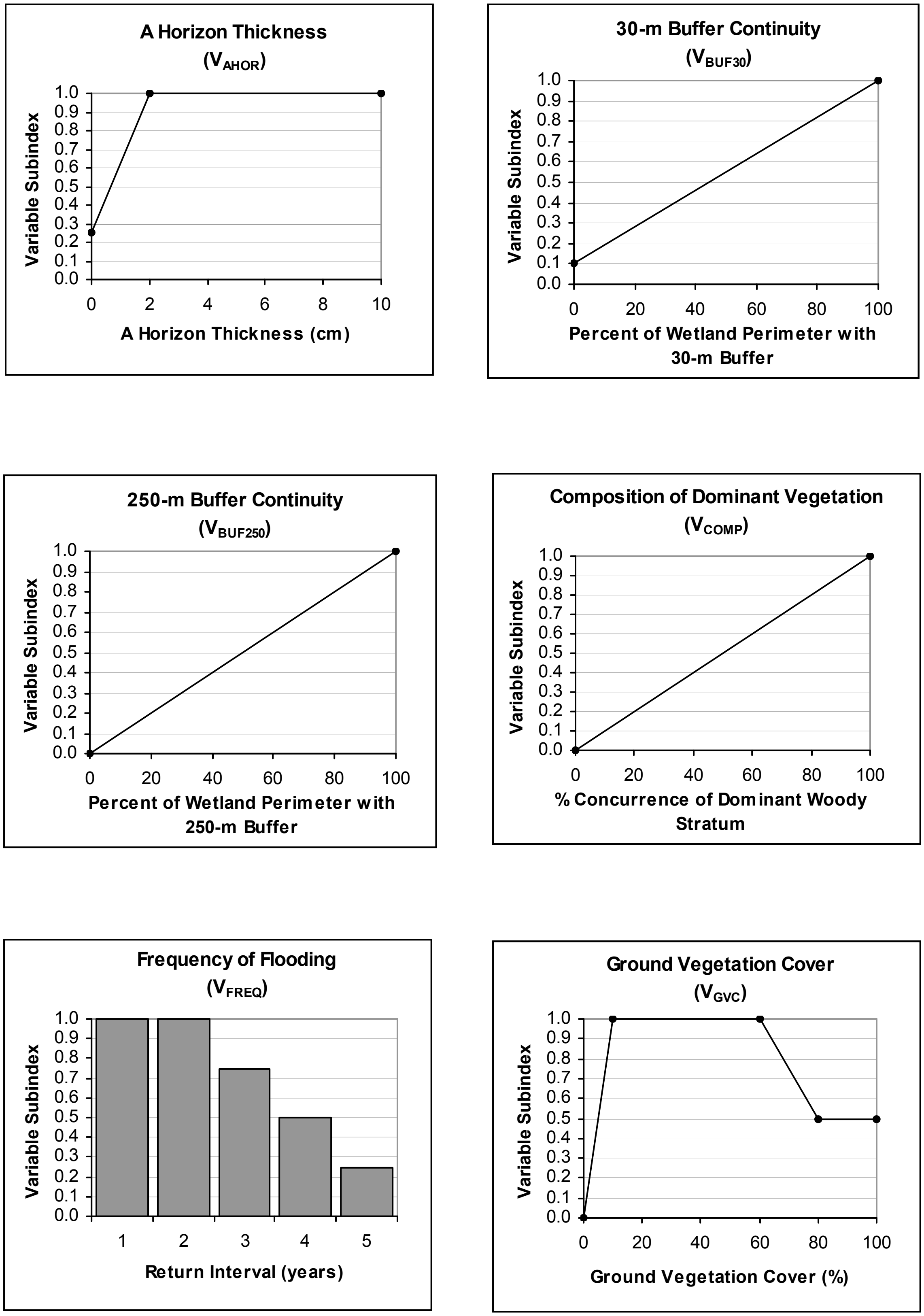


Figure 15. Subindex graphs for high-gradient riverine wetlands (continued)

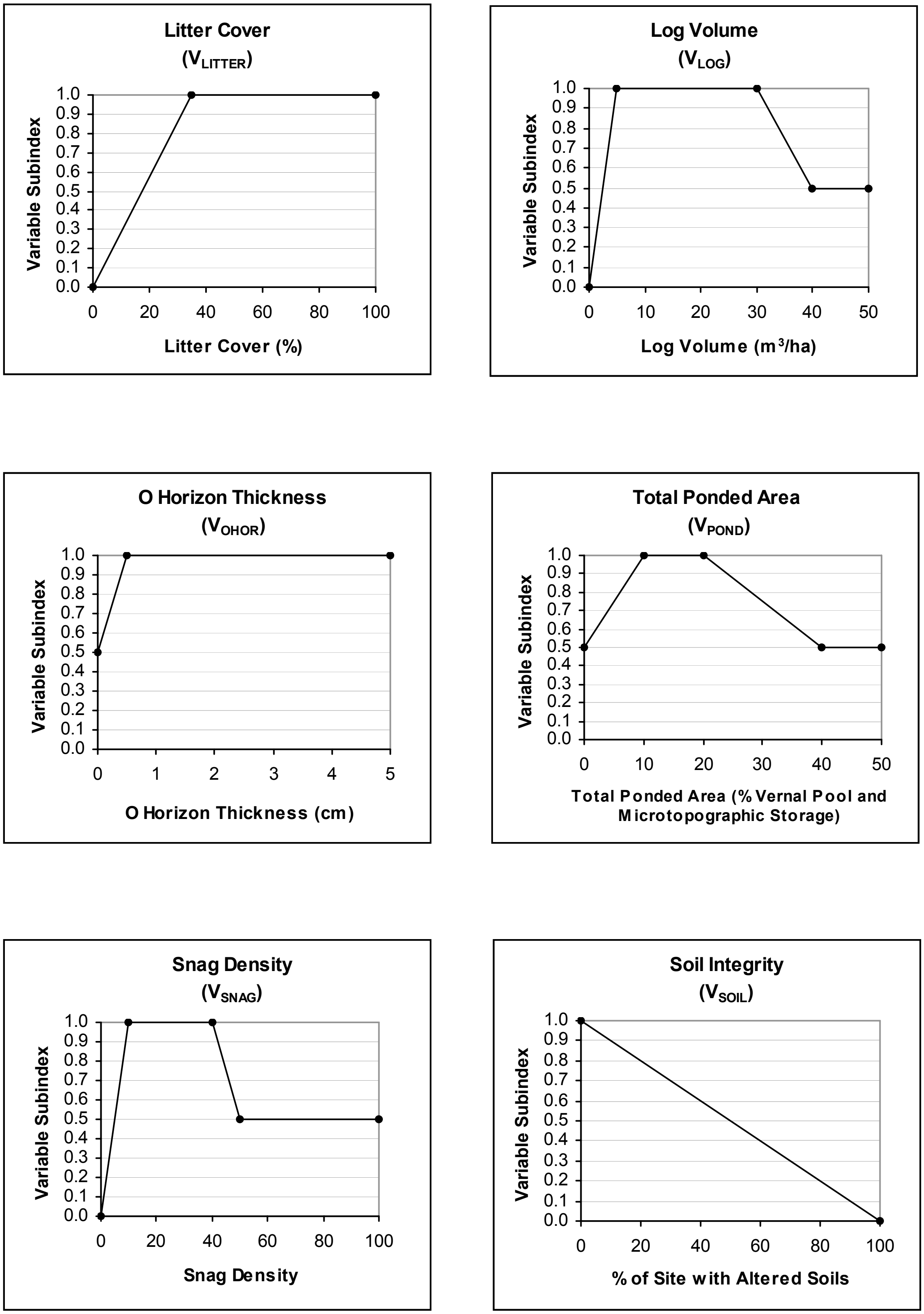


Figure 15. Subindex graphs for high-gradient riverine wetlands (continued)

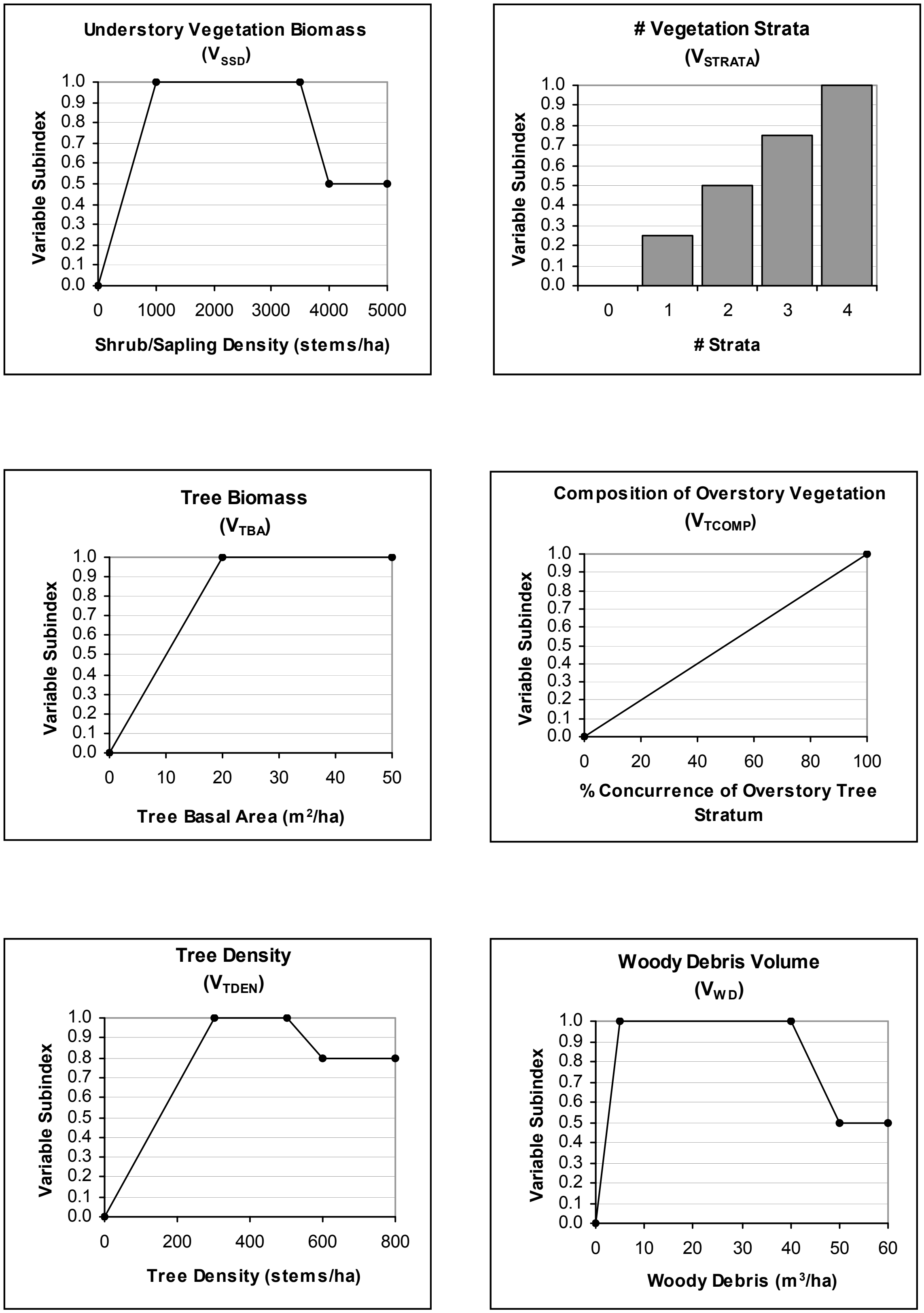


Figure 15. Subindex graphs for high-gradient riverine wetlands (concluded)

Subclass: Mid-Gradient Riverine

All functions are assessed for this subclass using the general form of each assessment model presented in Chapter 4. Figure 16 provides the relationship between the variable metrics and the subindex for each of the assessment variables based on the mid-gradient riverine reference data.

a. Function 1: Detain Floodwater.

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

b. Function 2: Detain Precipitation.

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

c. Function 3: Cycle Nutrients.

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

d. Function 4: Export Organic Carbon.

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

e. Function 5: Maintain Plant Communities.

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

f. Function 6: Provide Wildlife Habitat.

$$FCI = \left\{ \begin{array}{c} \left[\frac{(V_{FREQ} + V_{POND})}{2} \right] \times \left[\frac{(V_{TCOMP} + V_{STRATA} + V_{SNAG} + V_{TBA})}{4} \right] \\ \times \left[\frac{(V_{LOG} + V_{OHOR})}{2} \right] \times \left[\frac{(V_{BUF30} + V_{BUF250})}{2} \right] \end{array} \right\}^{1/4} \tag{23}$$

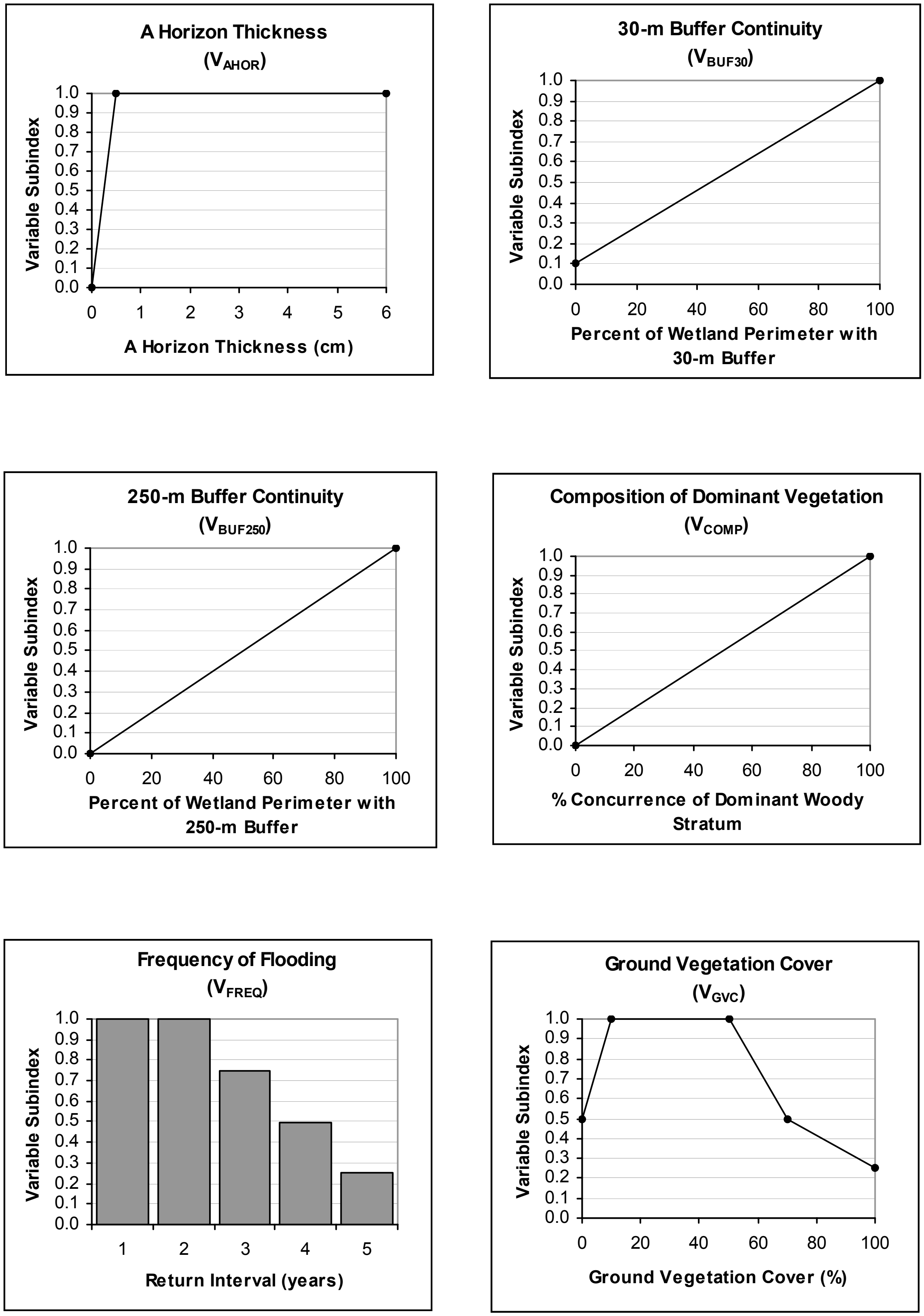


Figure 16. Subindex graphs for mid-gradient riverine wetlands

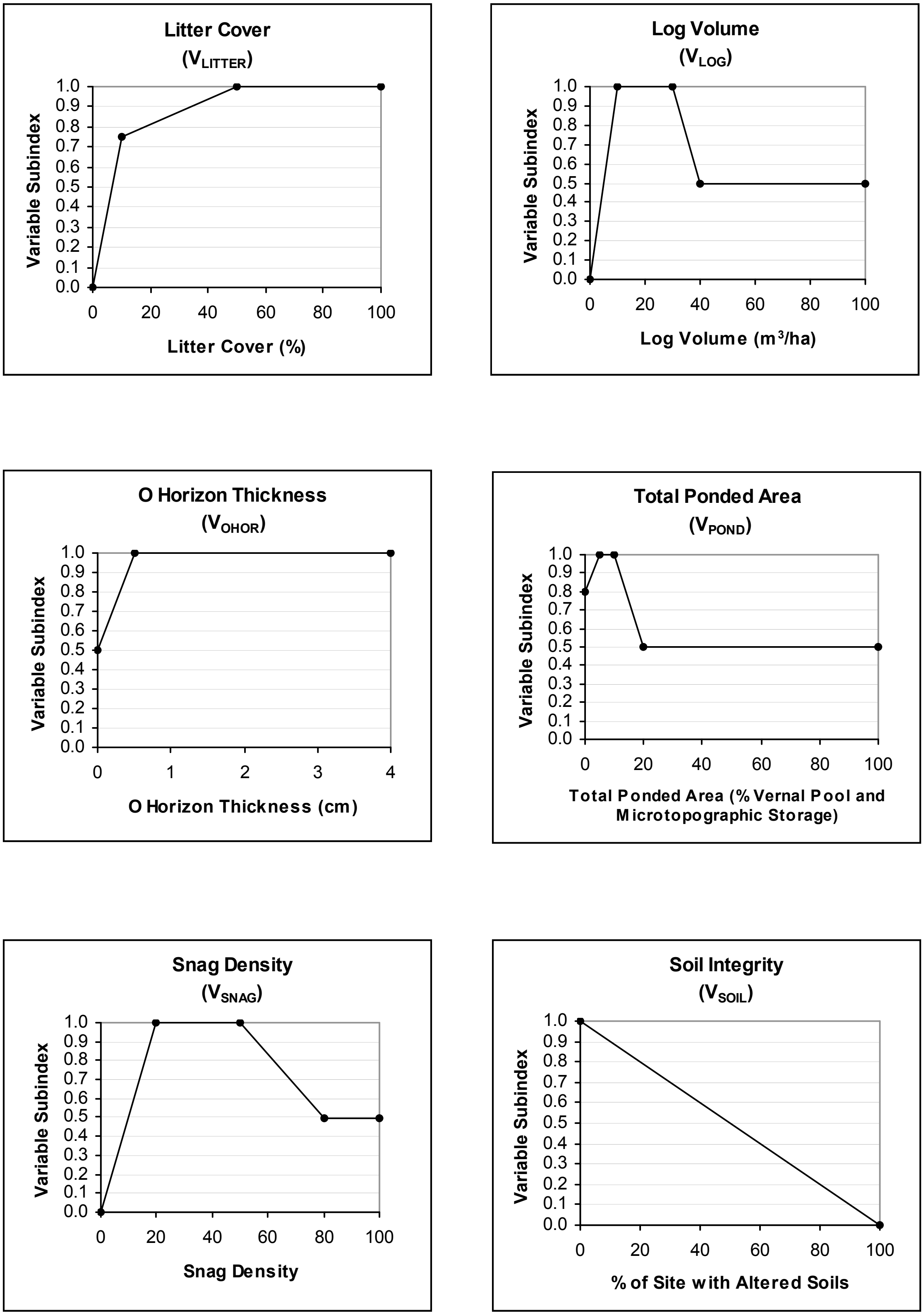


Figure 16. Subindex graphs for mid-gradient riverine wetlands (continued)

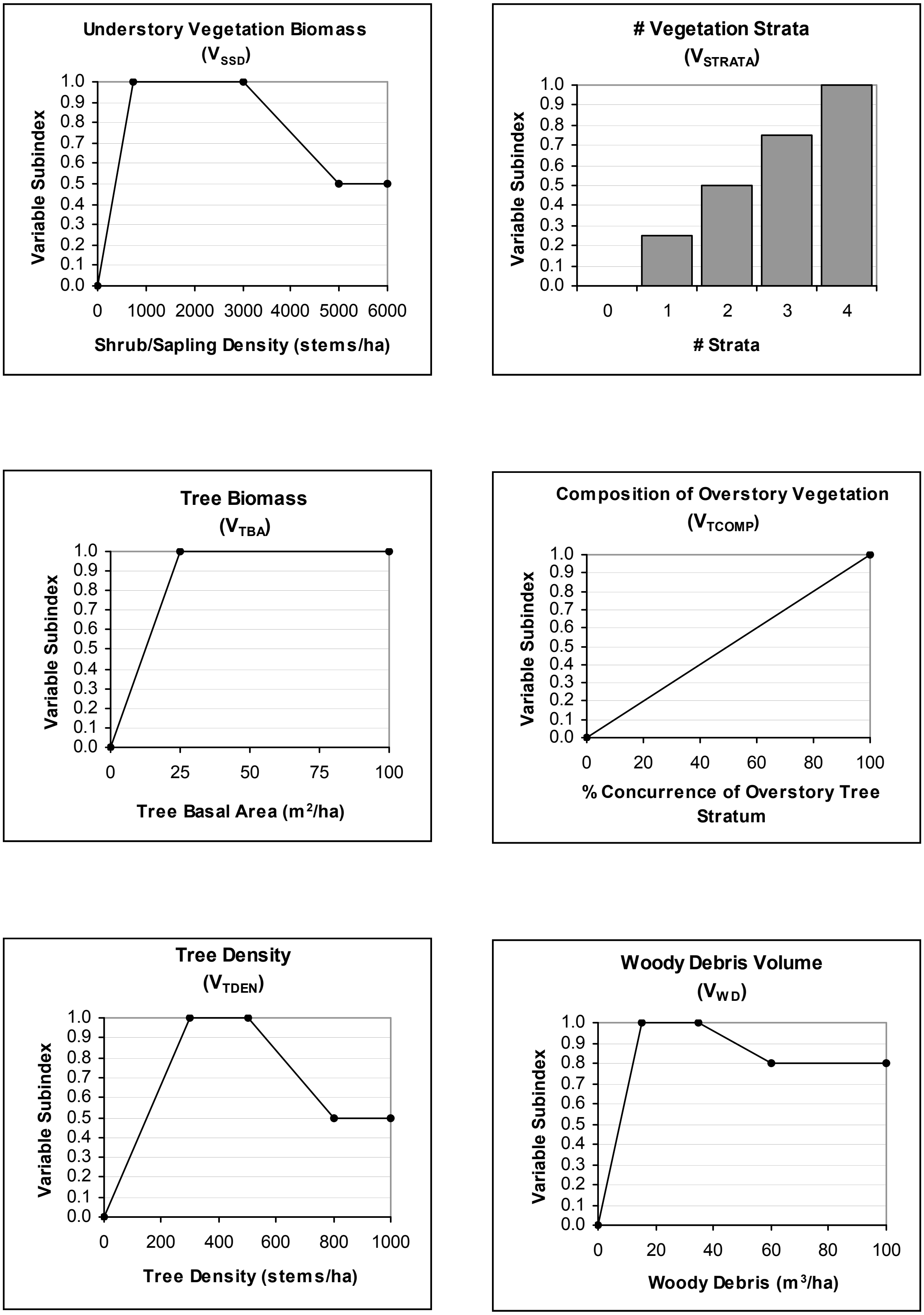


Figure 16. Subindex graphs for mid-gradient riverine wetlands (concluded)

Subclass: Low-Gradient Riverine

All functions are assessed for this subclass using the general form of each assessment model presented in Chapter 4. Figure 17 provides the relationship between the variable metrics and the subindex for each of the assessment variables based on the low-gradient riverine reference data.

a. Function 1: Detain Floodwater.

$$FCI = V_{FREQ} \times \left[\frac{\left(V_{LOG} + V_{GVC} + V_{SSD} + V_{TDEN} \right)}{4} \right] \tag{24}$$

b. Function 2: Detain Precipitation.

$$FCI = \frac{\left[V_{POND} + \frac{\left(V_{OHOR} + V_{LITTER} \right)}{2} \right]}{2} \tag{25}$$

c. Function 3: Cycle Nutrients.

$$FCI = \frac{\left[\frac{\left(V_{TBA} + V_{SSD} + V_{GVC} \right)}{3} + \frac{\left(V_{OHOR} + V_{AHOR} + V_{WD} + V_{SNAG} \right)}{4} \right]}{2} \tag{26}$$

d. Function 4: Export Organic Carbon.

$$FCI = V_{FREQ} \times \frac{\left[\frac{\left(V_{LITTER} + V_{OHOR} + V_{WD} + V_{SNAG} \right)}{4} \right] + \left[\frac{V_{TBA} + V_{SSD} + V_{GVC}}{3} \right]}{2} \tag{27}$$

e. Function 5: Maintain Plant Communities.

$$FCI = \left\langle \left\{ \frac{\left[\frac{\left(V_{TBA} + V_{TDEN} \right)}{2} + V_{COMP} \right]}{2} \right\} \times \left[\frac{\left(V_{SOIL} + V_{POND} \right)}{2} \right] \right\rangle^{1/2} \tag{28}$$

f. Function 6: Provide Wildlife Habitat.

$$FCI = \left\{ \begin{array}{c} \left[\frac{(V_{FREQ} + V_{POND})}{2} \right] \times \left[\frac{(V_{TCOMP} + V_{STRATA} + V_{SNAG} + V_{TBA})}{4} \right] \\ \times \left[\frac{(V_{LOG} + V_{OHOR})}{2} \right] \times V_{PATCH} \end{array} \right\}^{1/4} \qquad (29)$$

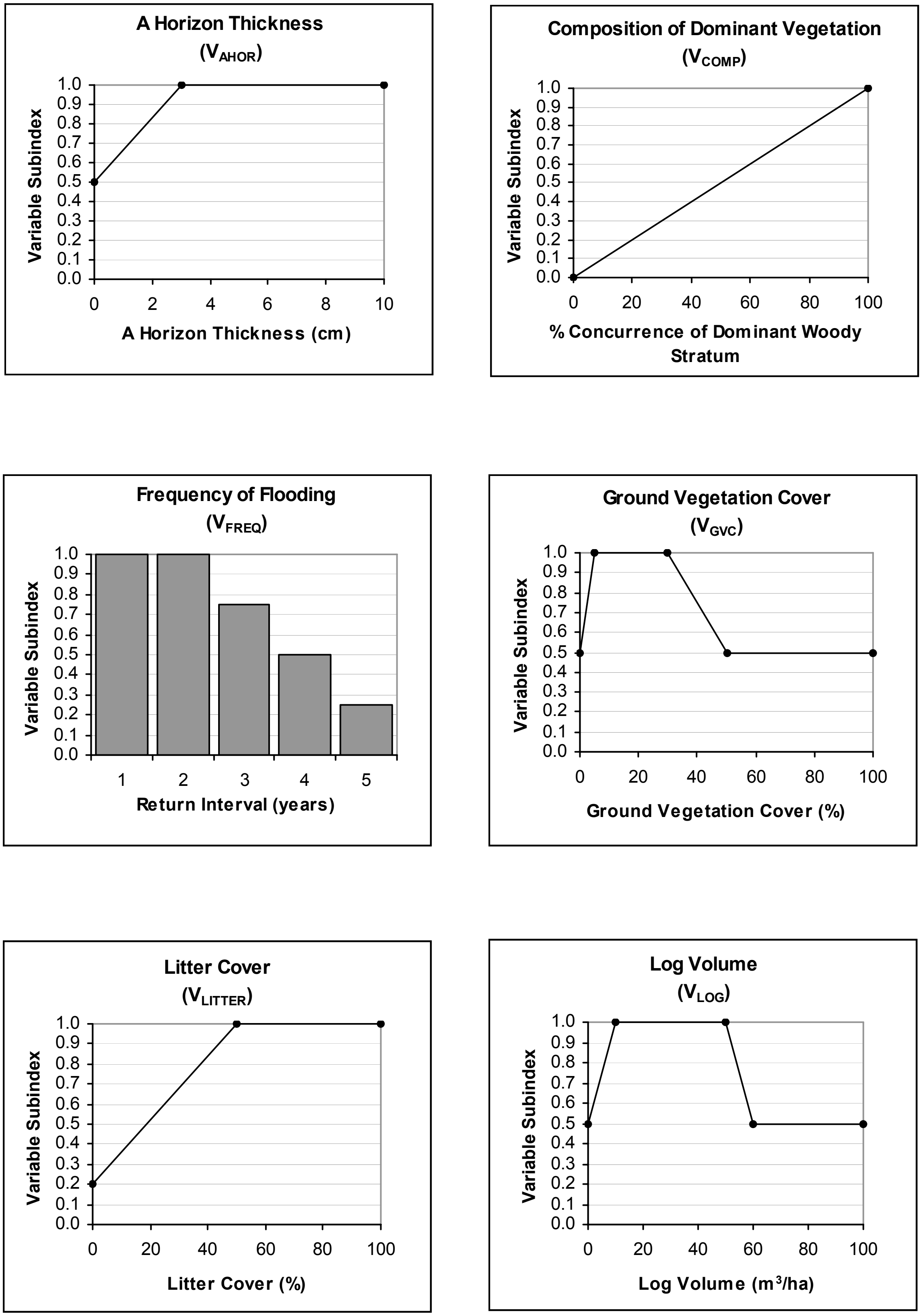


Figure 17. Subindex graphs for low-gradient riverine wetlands

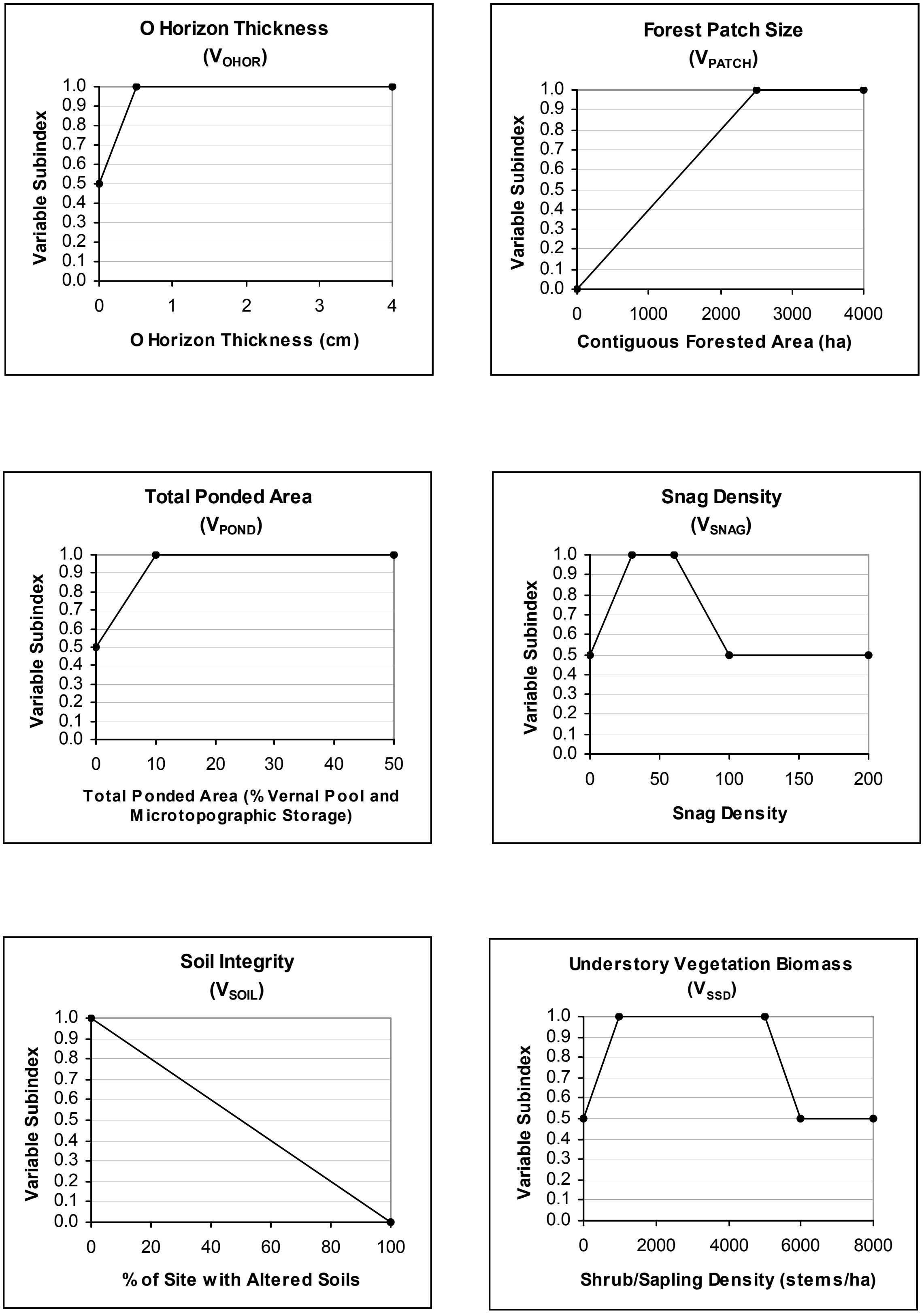


Figure 17. Subindex graphs for low-gradient riverine wetlands (continued)

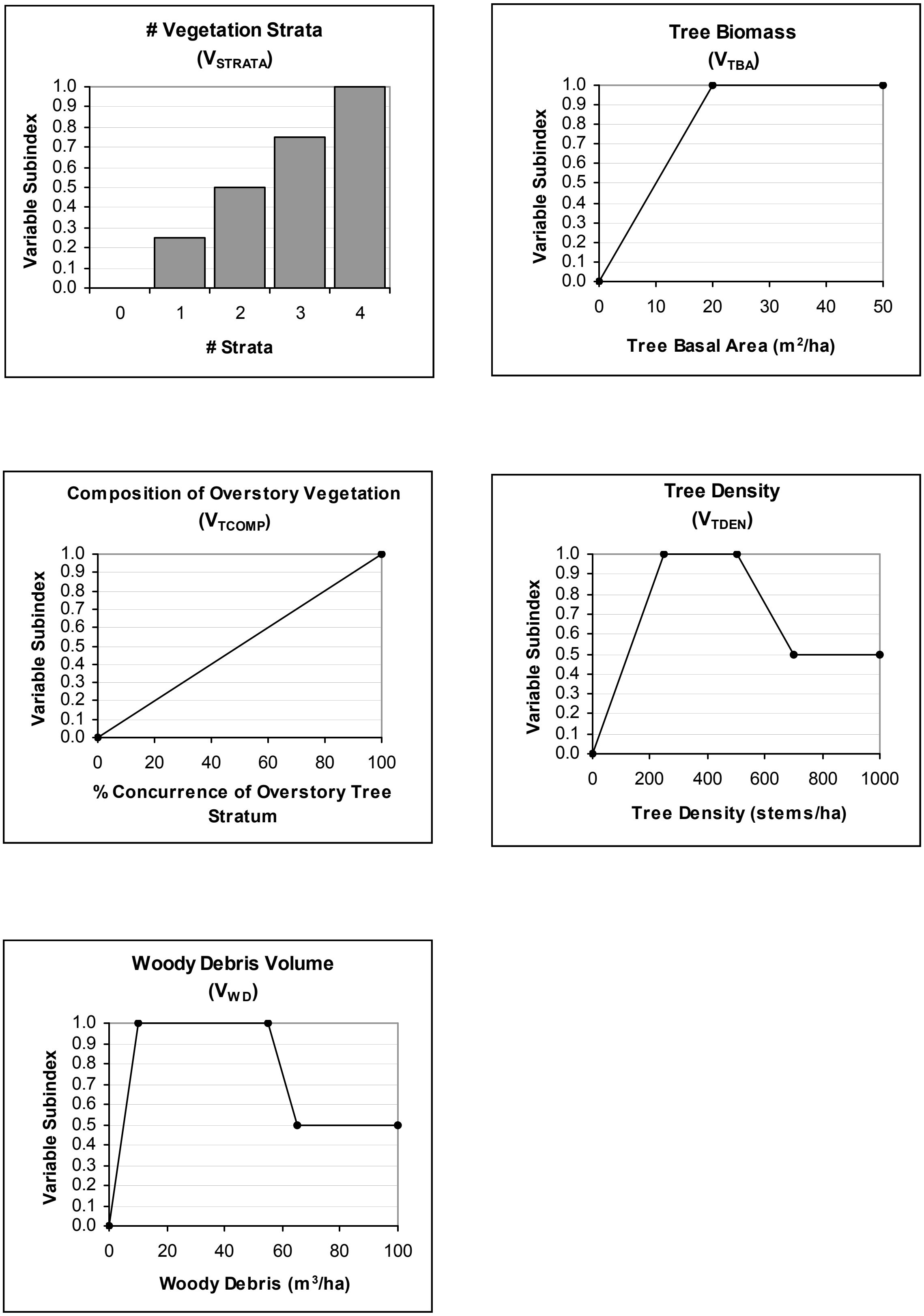


Figure 17. Subindex graphs for low-gradient riverine wetlands (concluded)

Subclass: Unconnected Depression

Three functions are assessed for this subclass. Some of the applicable models are modified from the general form presented in Chapter 4. Alternate versions also are provided that can be used in the event that ground-level observations cannot be made because of inundation. Figure 18 provides the relationship between the variable metrics and the subindex for each of the assessment variables based on the reference data from all depression wetlands combined.

a. Function 1: Detain Floodwater. Not assessed.

b. Function 2: Detain Precipitation. Not assessed.

c. Function 3: Cycle Nutrients.

$$FCI = \frac{\left[\frac{\left(V_{TBA} + V_{SSD} + V_{GVC}\right)}{3} + \frac{\left(V_{OHOR} + V_{AHOR} + V_{WD} + V_{SNAG}\right)}{4}\right]}{2} \qquad (30)$$

Applicable in the following alternate form when inundation prevents observation of ground-level features:

$$FCI = \frac{\left(V_{TBA} + V_{SSD} + V_{SNAG}\right)}{3} \qquad (31)$$

d. Function 4: Export Organic Carbon. Not assessed.

e. Function 5: Maintain Plant Communities. Applicable in the following modified form:

$$FCI = \left\langle \left\{ \frac{\left[\frac{\left(V_{TBA} + V_{TDEN}\right)}{2} + V_{COMP}\right]}{2} \right\} \times V_{SOIL} \right\rangle^{1/2} \qquad (32)$$

Applicable in the following alternate form when inundation prevents observation of ground-level features:

$$FCI = \frac{\left[\frac{\left(V_{TBA} + V_{TDEN}\right)}{2} + V_{COMP}\right]}{2} \qquad (33)$$

f. Function 6: Provide Wildlife Habitat. Applicable in the following modified form:

$$FCI = \left\{ \begin{array}{l} \left[\frac{\left(V_{TCOMP} + V_{STRATA} + V_{SNAG} + V_{TBA} \right)}{4} \right] \\ \times \left[\frac{\left(V_{LOG} + V_{OHOR} \right)}{2} \right] \times \left[\frac{\left(V_{BUF30} + V_{BUF250} \right)}{2} \right] \end{array} \right\}^{1/3} \tag{34}$$

Applicable in the following alternate form when inundation prevents observation of ground-level features:

$$FCI = \left\{ \left[\frac{\left(V_{TCOMP} + V_{STRATA} + V_{SNAG} + V_{TBA} \right)}{4} \right] \times \left[\frac{\left(V_{BUF30} + V_{BUF250} \right)}{2} \right] \right\}^{1/2} \tag{35}$$

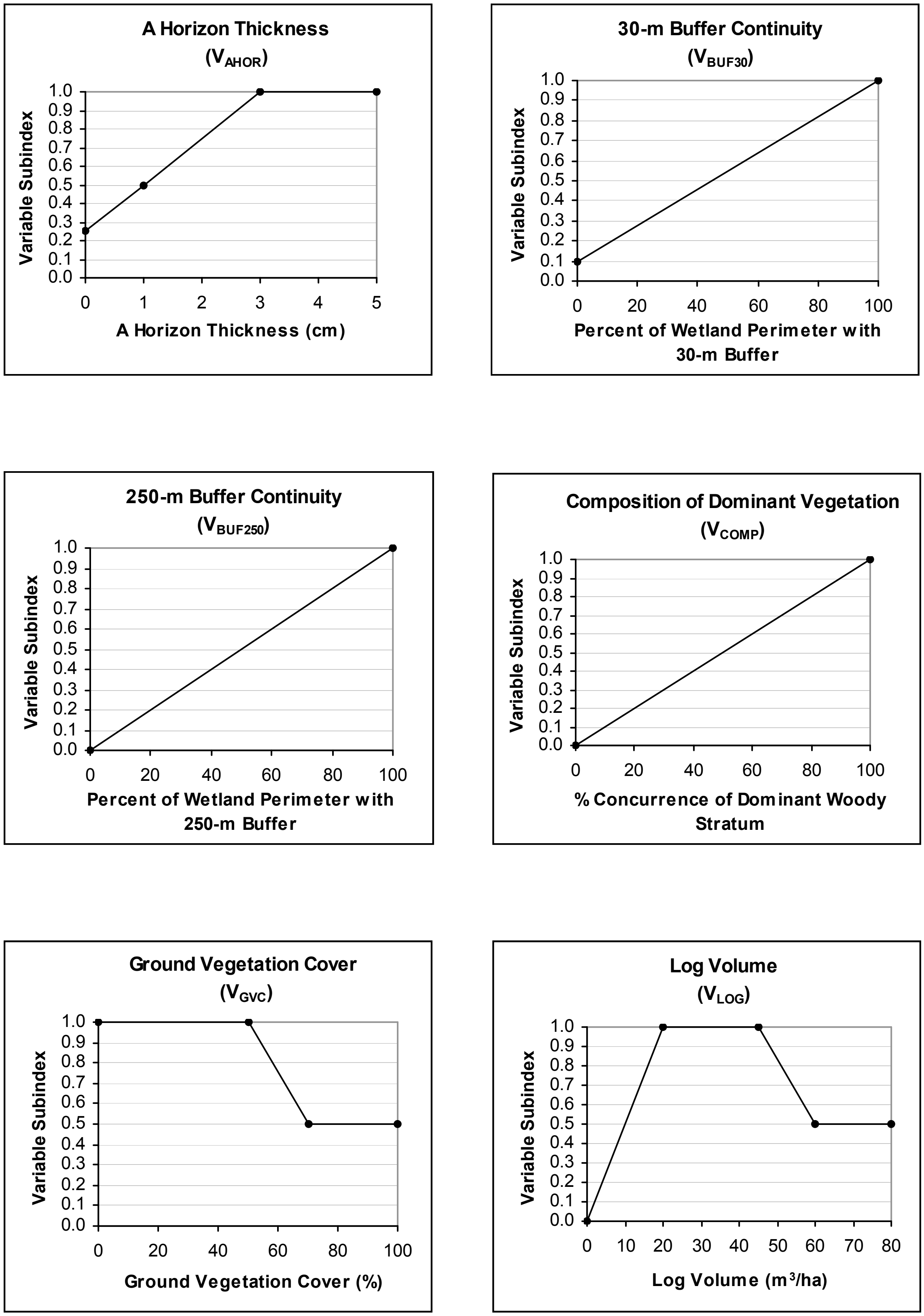


Figure 18. Subindex graphs for unconnected depression wetlands

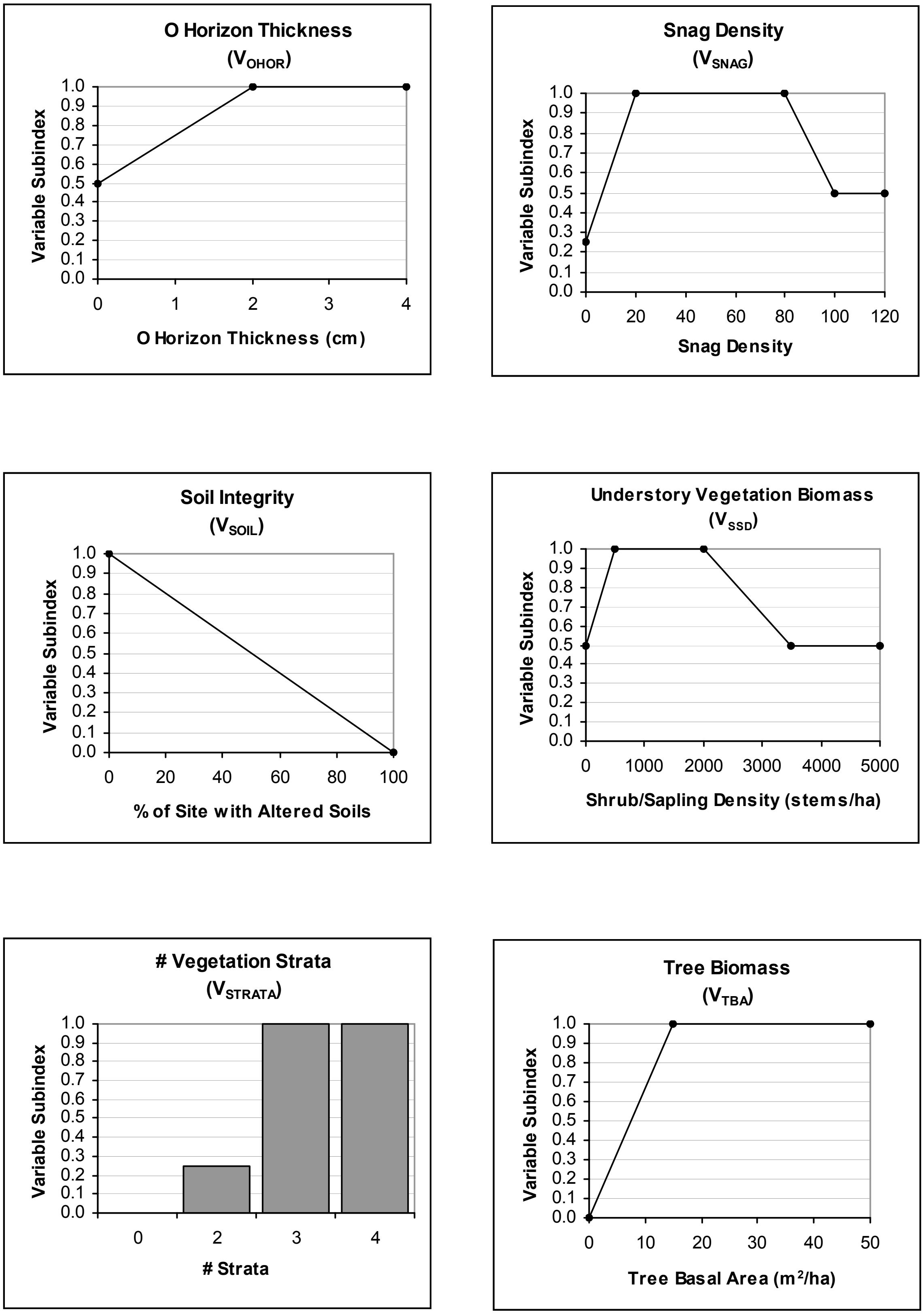
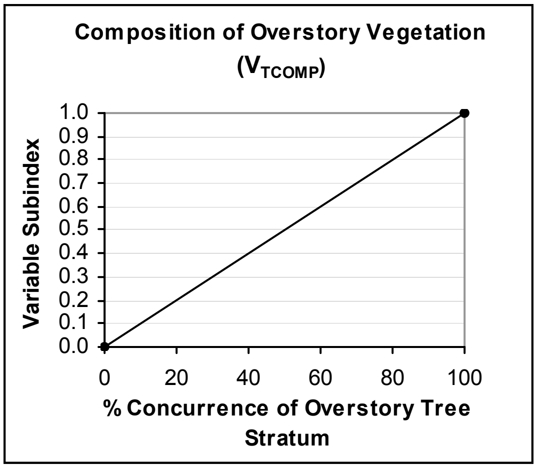
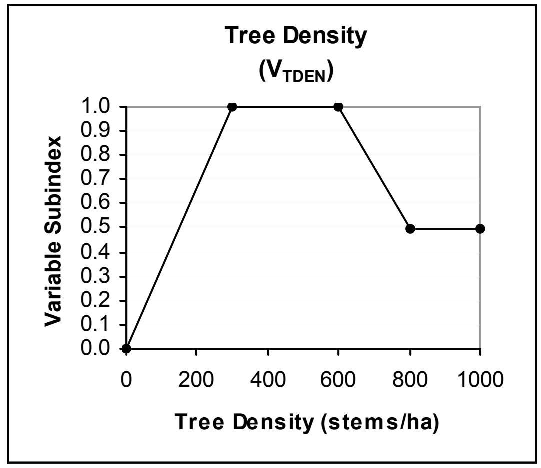


Figure 18. Subindex graphs for unconnected depression wetlands (continued)





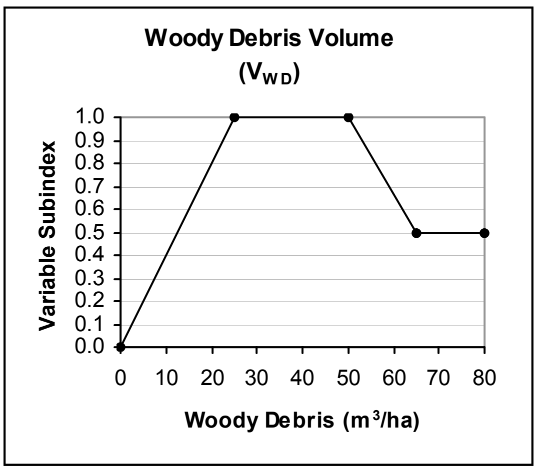


Figure 18. Subindex graphs for unconnected depression wetlands (concluded)

Subclass: Connected Depression

Five functions are assessed for this subclass. Some of the models have been modified from the general model form presented in Chapter 4. Figure 19 provides the relationship between the variable metrics and the subindex for each of the assessment variables based on the reference data from all depression wetlands combined.

a. Function 1: Detain Floodwater.

$$FCI = V_{FREQ} \times \left[\frac{\left(V_{LOG} + V_{GVC} + V_{SSD} + V_{TDEN}\right)}{4} \right] \tag{36}$$

Applicable in the following alternate form when inundation prevents observation of ground-level features:

$$FCI = V_{FREQ} \times \left[\frac{\left(V_{SSD} + V_{TDEN} \right)}{2} \right] \tag{37}$$

b. *Function 2: Detain Precipitation*. Not assessed.

c. *Function 3: Cycle Nutrients.* Applicable in the following modified form:

$$FCI = \frac{\left[\frac{\left(V_{TBA} + V_{SSD} + V_{GVC} \right)}{3} + \frac{\left(V_{OHOR} + V_{AHOR} + V_{WD} + V_{SNAG} \right)}{4} \right]}{2} \tag{38}$$

Applicable in the following alternate form when inundation prevents observation of ground-level features:

$$FCI = \frac{\left(V_{TBA} + V_{SSD} + V_{SNAG} \right)}{3} \tag{39}$$

d. *Function 4: Export Organic Carbon.* Applicable in the following modified form:

$$FCI = V_{FREQ} \times \frac{\left[\frac{\left(V_{LITTER} + V_{OHOR} + V_{WD} + V_{SNAG} \right)}{4} \right] + \left[\frac{V_{TBA} + V_{SSD} + V_{GVC}}{3} \right]}{2} \tag{40}$$

Applicable in the following alternate form when inundation prevents observation of ground-level features:

$$FCI = V_{FREQ} \times \left[\frac{\left(V_{TBA} + V_{SSD} + V_{SNAG} \right)}{3} \right] \tag{41}$$

e. *Function 5: Maintain Plant Communities.* Applicable in the following modified form:

$$FCI = \left\langle \left\{ \frac{\left[\frac{\left(V_{TBA} + V_{TDEN} \right)}{2} + V_{COMP} \right]}{2} \right\} \times V_{SOIL} \right\rangle^{1/2} \tag{42}$$

Applicable in the following alternate form when inundation prevents observation of ground-level features:

$$FCI = \frac{\left[\frac{\left(V_{TBA} + V_{TDEN}\right)}{2} + V_{COMP}\right]}{2} \qquad (43)$$

f. *Function 6: Provide Wildlife Habitat*. Applicable in the following modified form:

$$FCI = \left\{ \begin{array}{l} V_{FREQ} \times \left[\frac{\left(V_{TCOMP} + V_{STRATA} + V_{SNAG} + V_{TBA}\right)}{4}\right] \\ \times \left[\frac{\left(V_{LOG} + V_{OHOR}\right)}{2}\right] \times \left[\frac{\left(V_{BUF30} + V_{BUF250}\right)}{2}\right] \end{array} \right\}^{1/4} \qquad (44)$$

Applicable in the following alternate form when inundation prevents observation of ground-level features:

$$FCI = \left\{ V_{FREQ} \times \left[\frac{\left(V_{TCOMP} + V_{STRATA} + V_{SNAG} + V_{TBA}\right)}{4}\right] \times \left[\frac{\left(V_{BUF30} + V_{BUF250}\right)}{2}\right] \right\}^{1/3} \qquad (45)$$

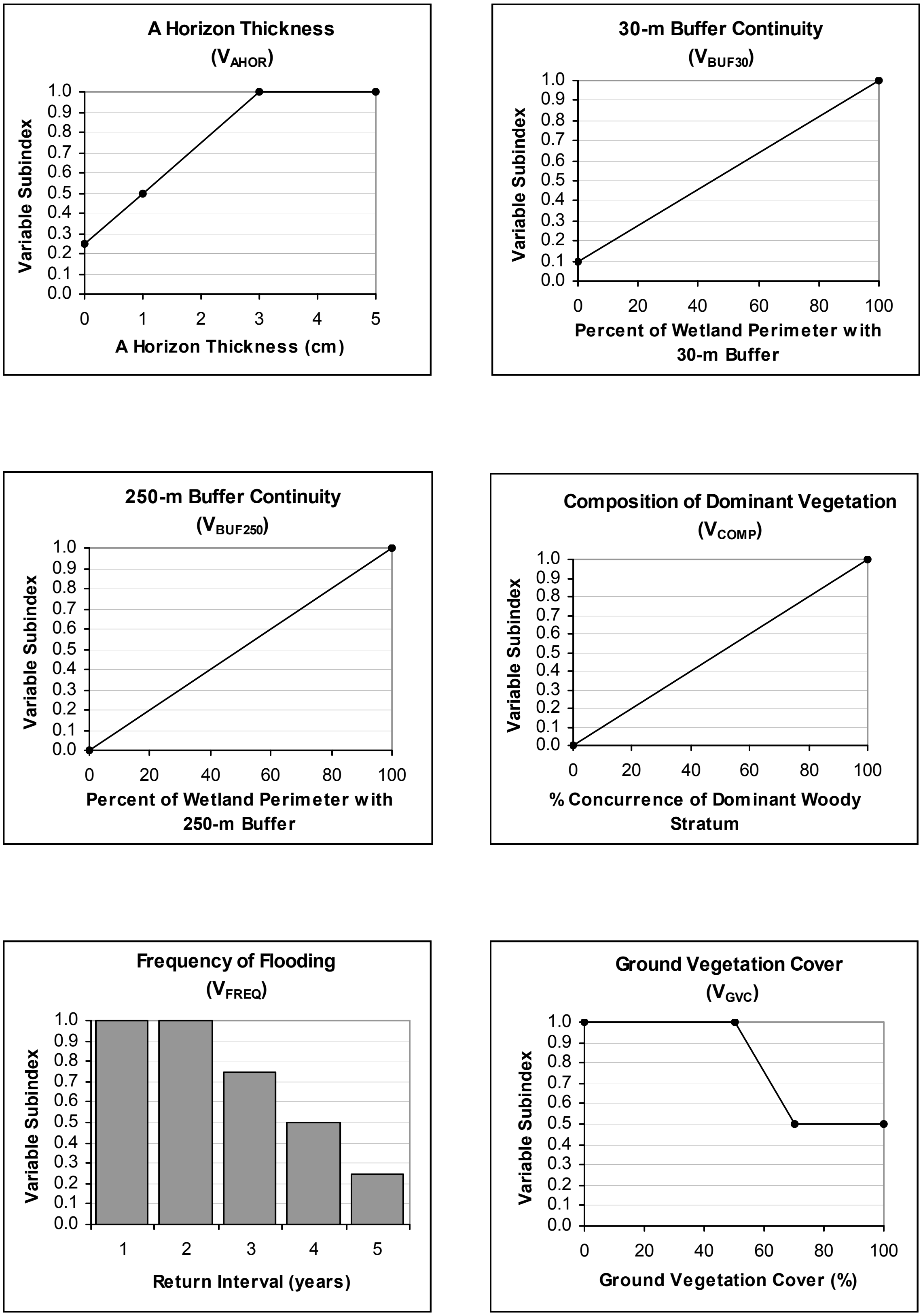
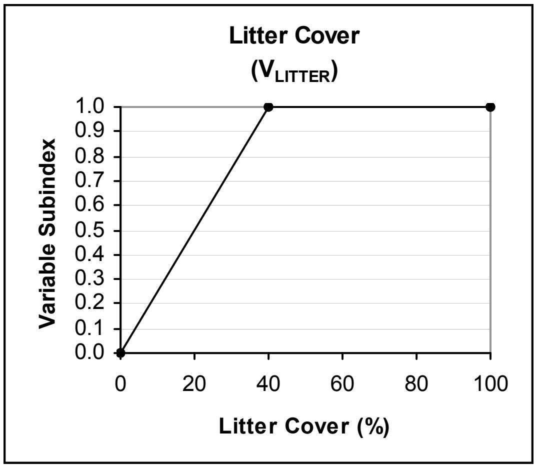
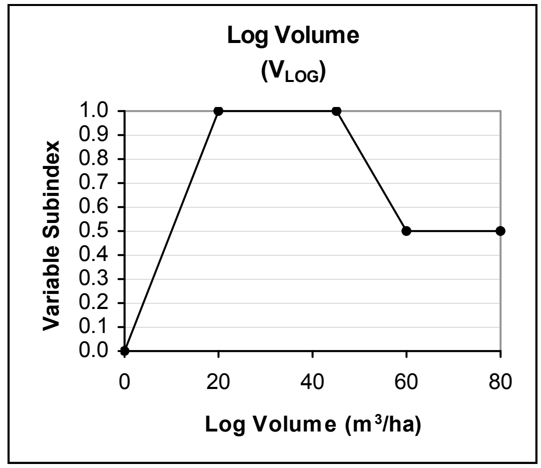
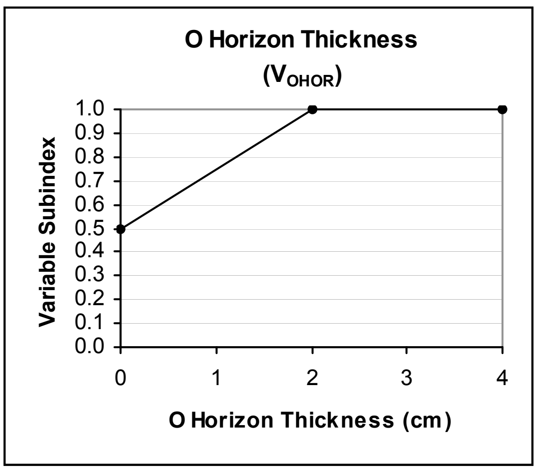
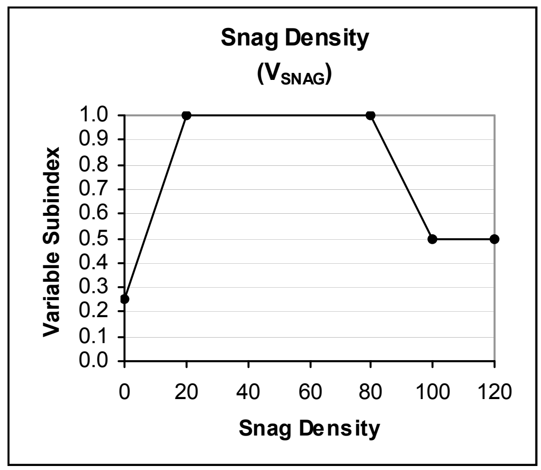


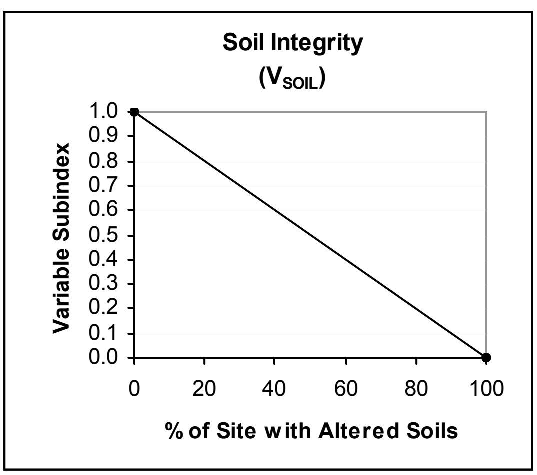
Figure 19. Subindex graphs for connected depression wetlands











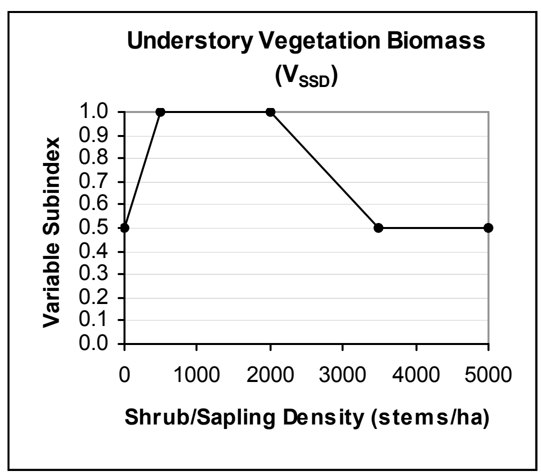


Figure 19. Subindex graphs for connected depression wetlands (continued)

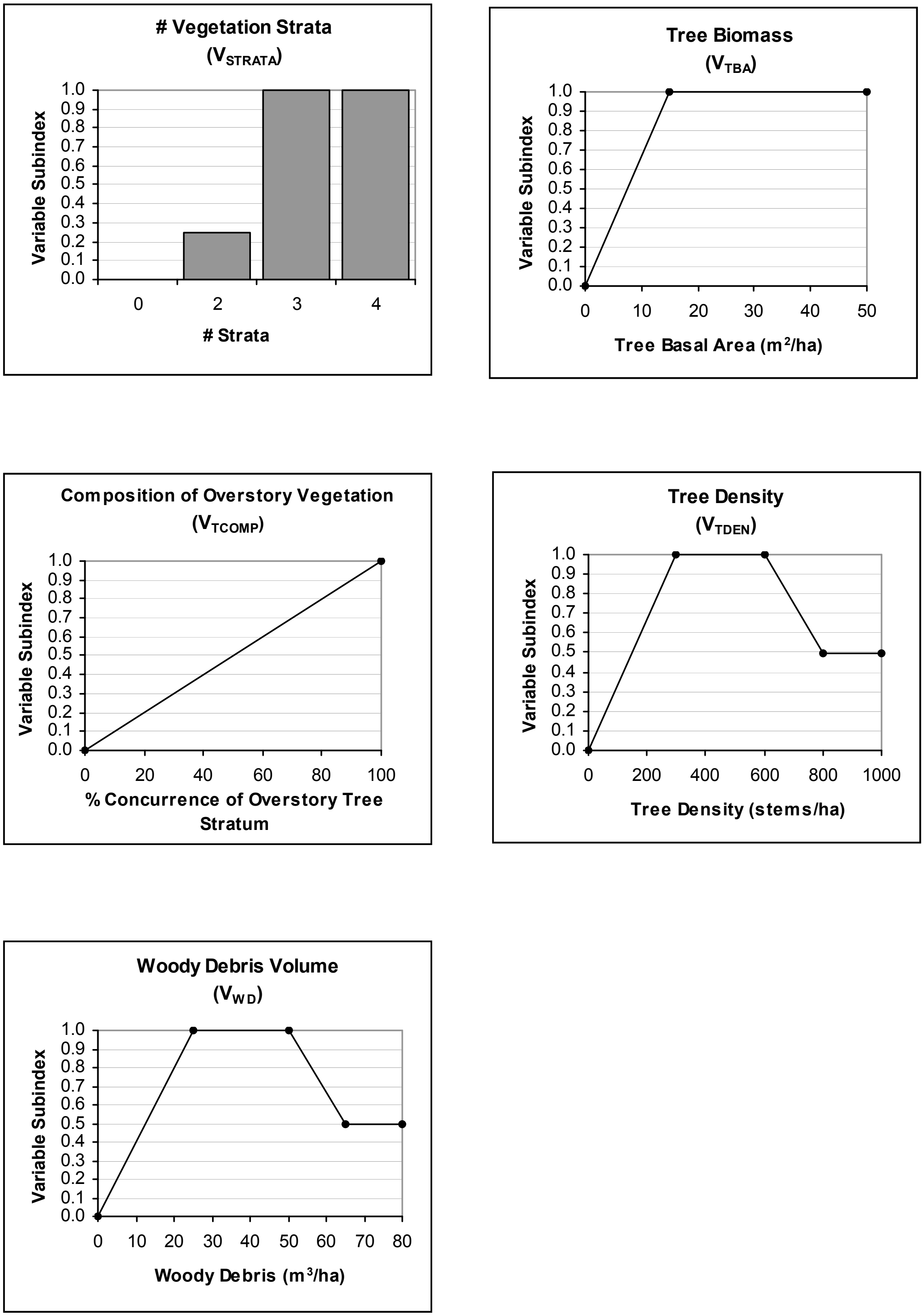


Figure 19. Subindex graphs for connected depression wetlands (concluded)

Subclass: Non-Calcareous Slope

Two functions are assessed for this subclass using the general form of each assessment model presented in Chapter 4, and two functions are assessed using modified models. Figure 20 illustrates the relationship between the variable metrics and the subindex for each of the assessment variables for slope wetlands, based on the combined reference data for both perennial and *wet-weather seeps*.

a. Function 1: Detain Floodwater. Not assessed.

b. Function 2: Detain Precipitation. Not assessed.

c. Function 3: Cycle Nutrients.

$$FCI = \frac{\left[\frac{\left(V_{TBA} + V_{SSD} + V_{GVC}\right)}{3} + \frac{\left(V_{OHOR} + V_{AHOR} + V_{WD} + V_{SNAG}\right)}{4}\right]}{2} \qquad (46)$$

d. Function 4: Export Organic Carbon.

$$FCI = V_{OUT} \times \frac{\left[\frac{\left(V_{LITTER} + V_{OHOR} + V_{WD} + V_{SNAG}\right)}{4}\right] + \left[\frac{V_{TBA} + V_{SSD} + V_{GVC}}{3}\right]}{2} \qquad (47)$$

e. Function 5: Maintain Plant Communities. Applicable in the following modified form:

$$FCI = \left\langle \left[\frac{V_{TBA} + V_{TDEN} + V_{COMP} + V_{GCOMP}}{4}\right] \times V_{SOIL} \right\rangle^{1/2} \qquad (48)$$

f. Function 6: Provide Wildlife Habitat. Applicable in the following modified form:

$$FCI = \left\{ \begin{array}{c} \left[\frac{\left(V_{T\,COMP} + V_{STRATA} + V_{SNAG} + V_{TBA}\right)}{4}\right] \times \\ \left[\left[\frac{\left(V_{LOG} + V_{OHOR}\right)}{2}\right] \times \left[\frac{\left(V_{BUF30} + V_{BUF250}\right)}{2}\right]\right] \end{array} \right\}^{1/3} \qquad (49)$$

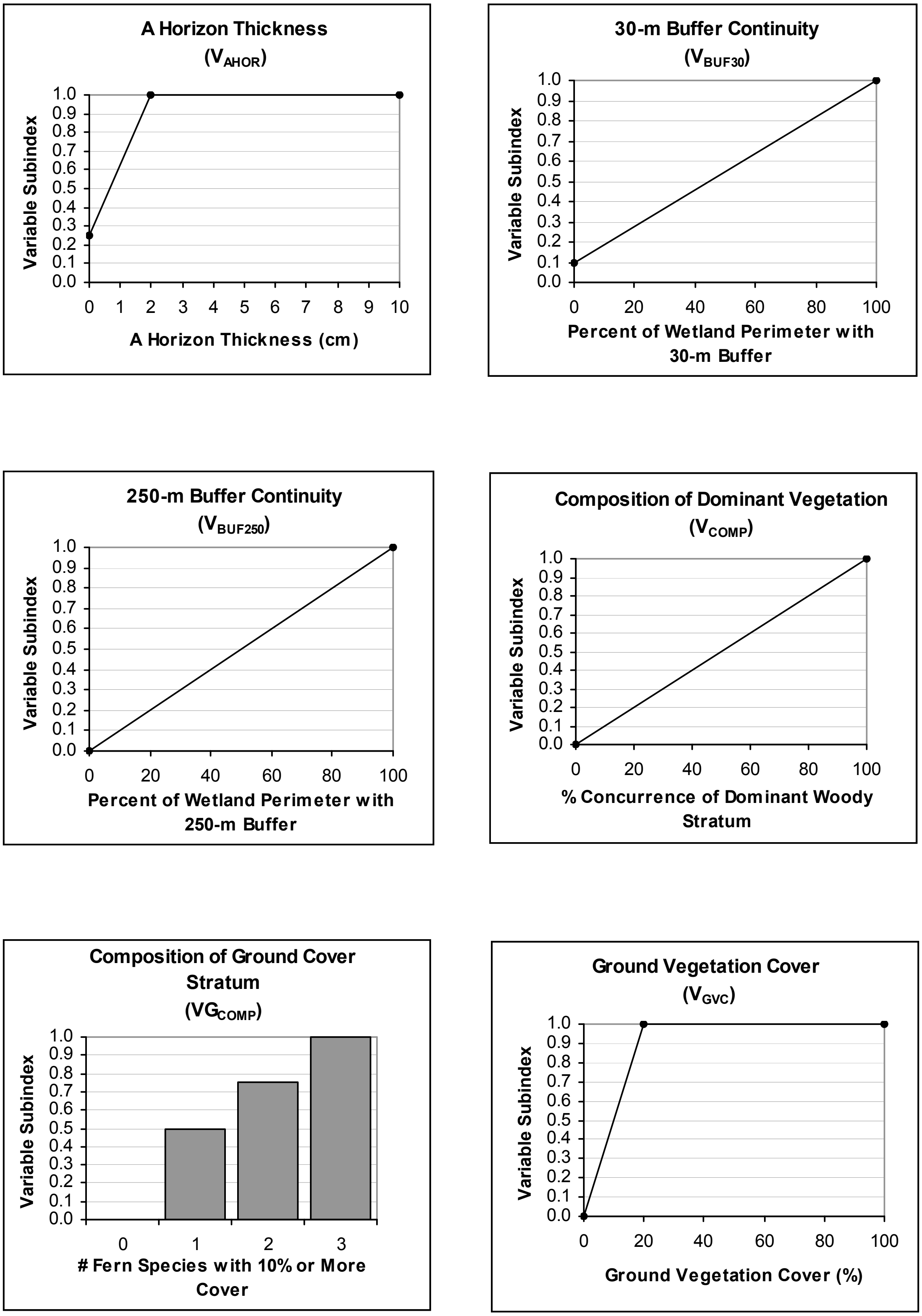


Figure 20. Subindex graphs for slope wetlands

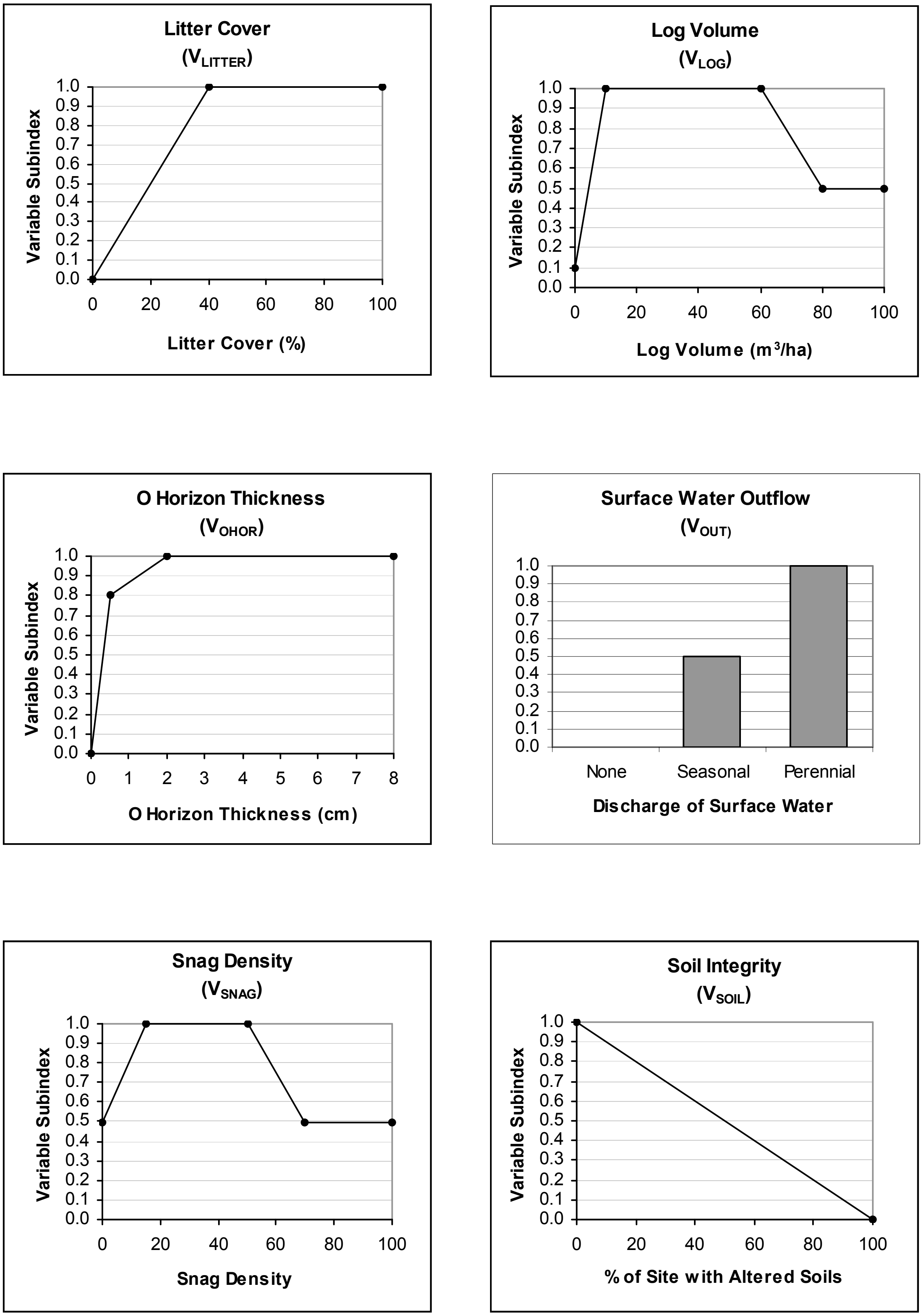


Figure 20. Subindex graphs for slope wetlands (continued)

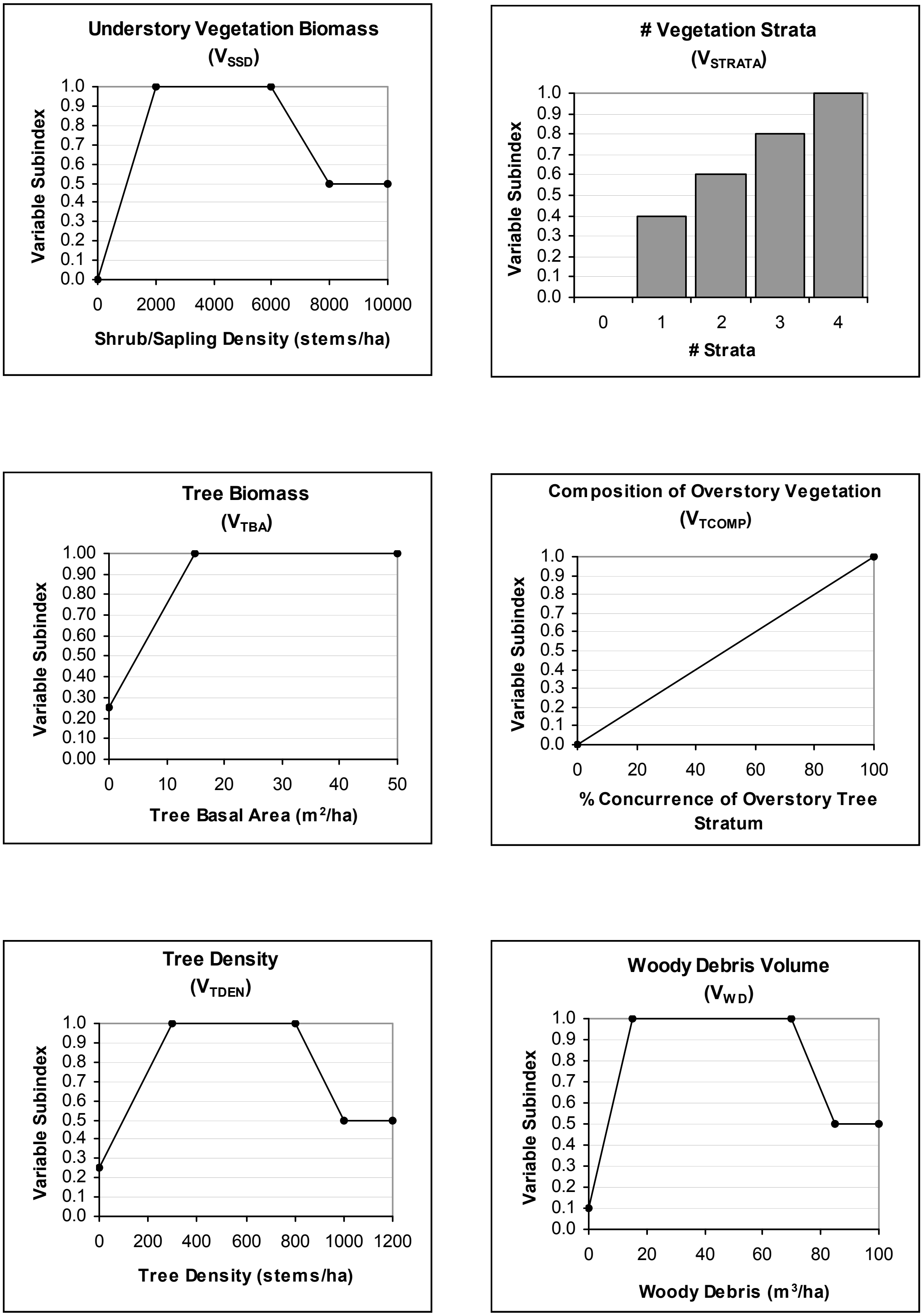


Figure 20. Subindex graphs for slope wetlands (concluded)

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 wetland subclasses in the Ouachita Mountains and Crowley's Ridge Regions 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 a comparison be made between pre- and post-project conditions of wetlands at the project site 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 represent existing conditions at the project site, while data for the post-project assessment are 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 Ouachita Mountains and Crowley's Ridge Regions 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; and
- 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 it serves as a cover sheet for all compiled assessment maps, drawing, data forms, and other information. It requires that you assign a project name and identify personnel involved in the assessment. It then prompts you 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 or geologic maps;
- County soil survey;
- National Wetland Inventory maps;
- Flood frequency maps; and
- 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 21 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.

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.

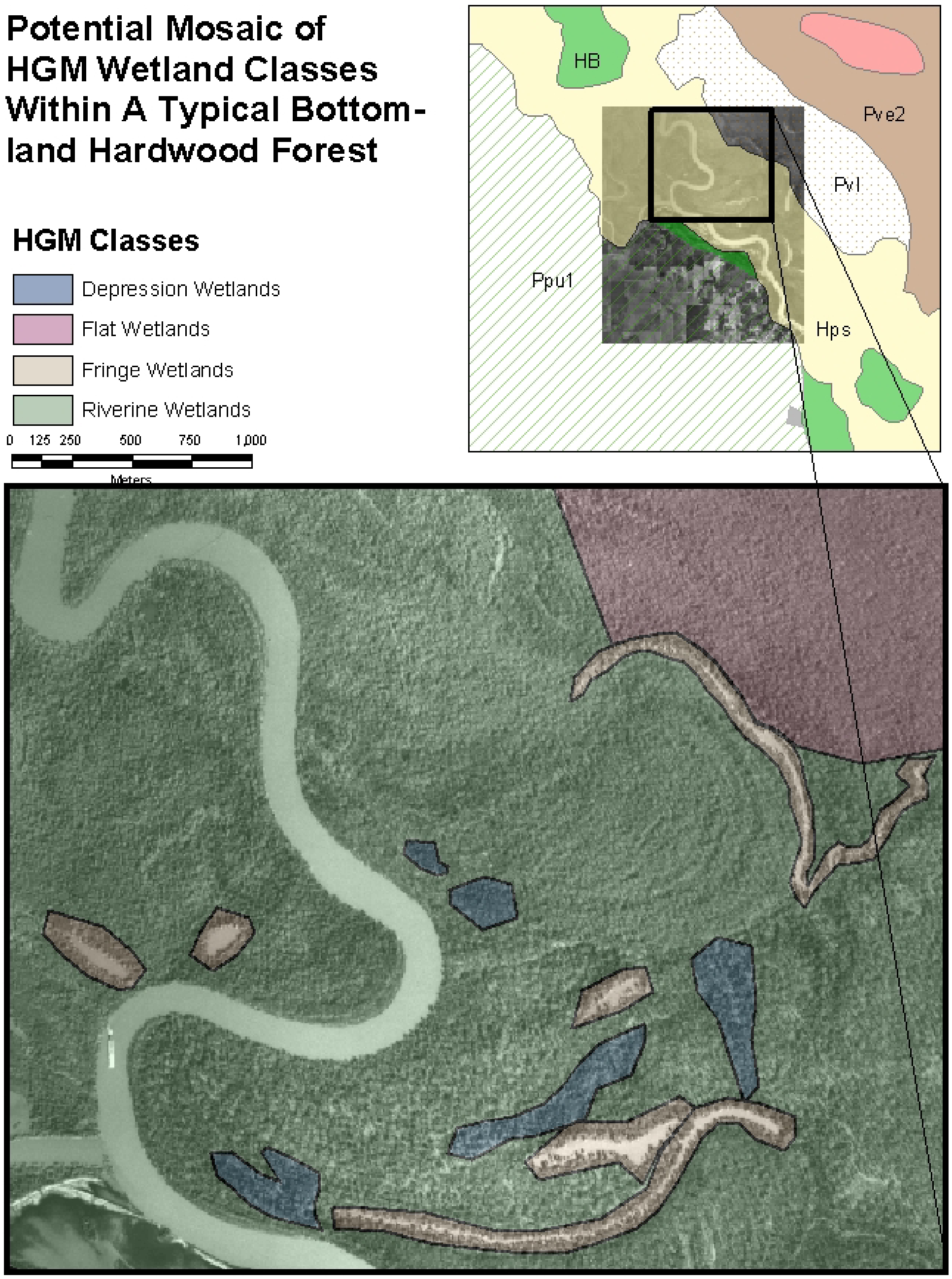


Figure 21. Example application of geomorphic mapping and aerial photography to develop a preliminary wetland classification for a proposed project area

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 Soil and Water Conservation 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 be simply to 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; or
- 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 22–25 present a simplified project scenario to illustrate the steps used to designate the boundaries of Wetland Assessment Areas (WAAs), each of which will require a separate HGM assessment. Figure 22 illustrates a land cover map for a hypothetical project area. Figure 23 shows the project area (in yellow) superimposed on the land cover map. To determine the boundaries of the WAA, first use the Key to Wetland Classes (Figure 10) and the descriptions of community types in Table 4 to identify the wetland subclasses within and contiguous to the project area (Figure 24). Overlay the project area boundary and the wetland subclass boundaries to identify the WAAs for which data will be collected (Figure 25). 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 WAA, specifying the subclass it belongs to, and calculating the area (ha).

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, and successional stage). However, as the size and heterogeneity of the project area increases, 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 WAAs, because the assessment process includes consideration of the size and isolation of individual wetland units. The second situation occurs when more than one regional wetland subclass occurs within a project area, as illustrated in Figure 23, where both Flat and Low-gradient Riverine wetlands are present within the project area. These must be separated because they are assessed using different models and reference data systems. The third situation occurs when 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 25, where the area designated as (low-gradient) Riverine Overbank Wetlands in Figure 24 is further subdivided into two WAAs based on land use and vegetation cover. The farmed area clearly will have different characteristics than the forested wetland, and it will be assessed separately (though using the same models and reference data).

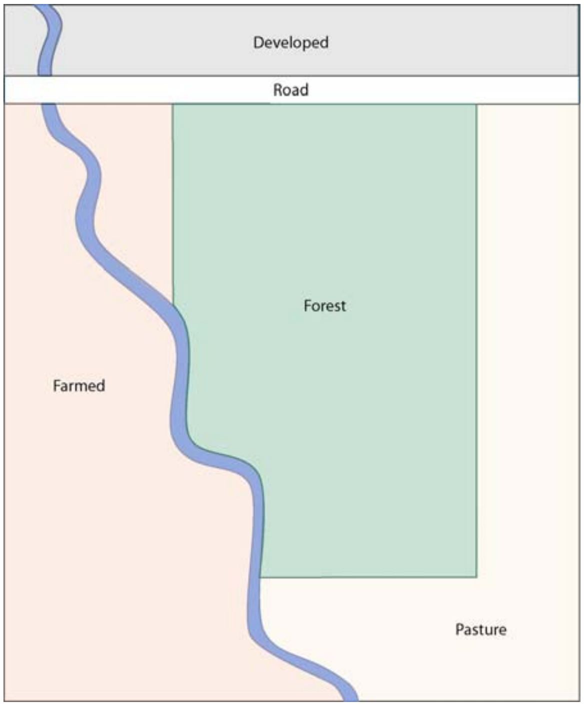


Figure 22. Land cover

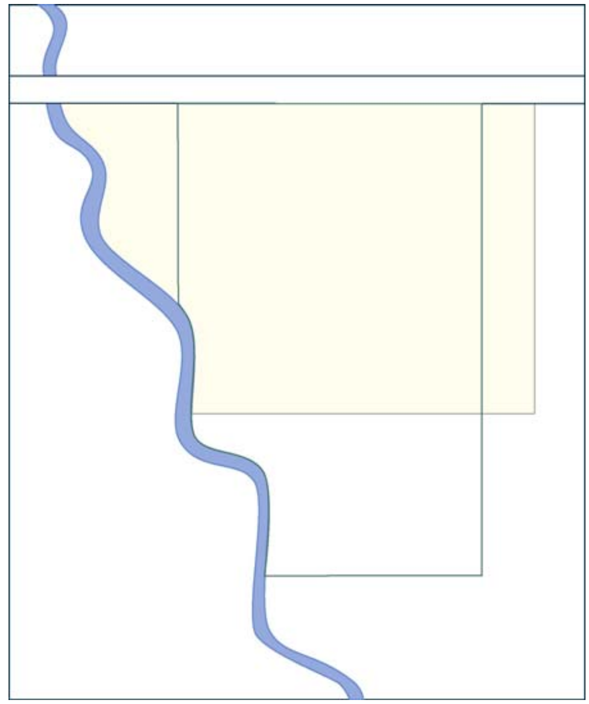


Figure 23. Project area (in yellow)

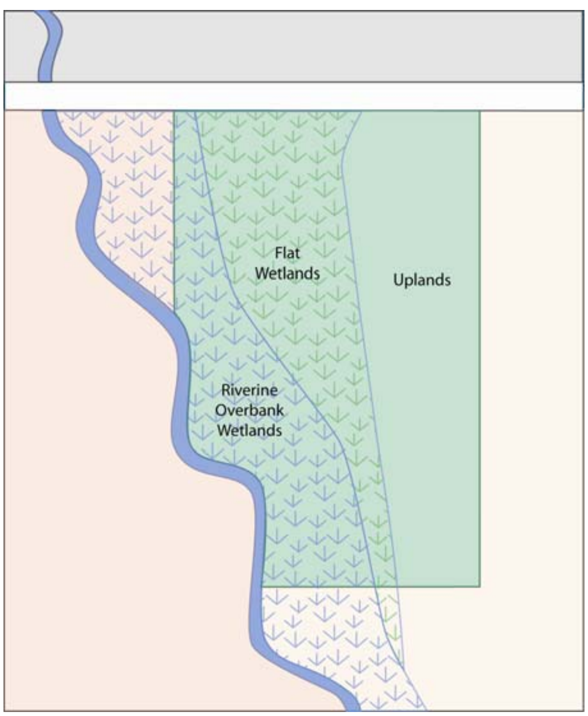


Figure 24. Wetland subclasses

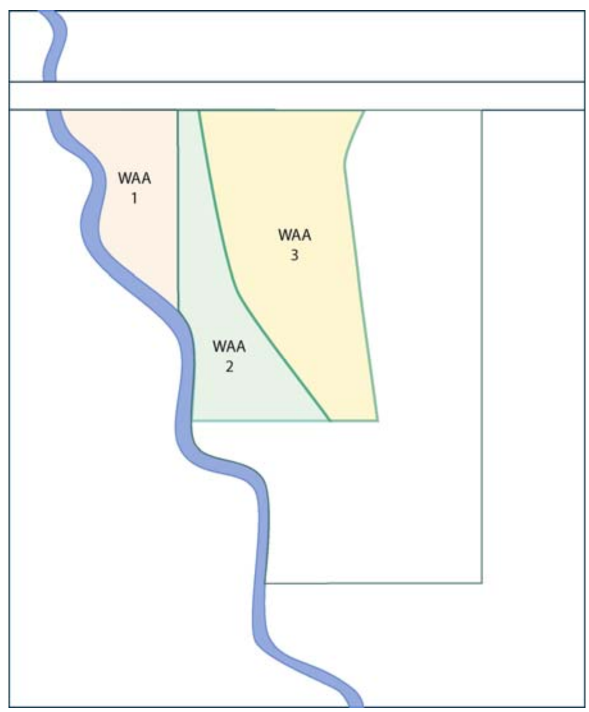


Figure 25. Wetland Assessment Areas

In the Ouachita Mountains and Crowley's Ridge Regions of Arkansas, the most common scenarios requiring designation of multiple WAAs involve tracts of land with interspersed regional subclasses or tracts composed of a single regional subclass that includes areas with distinctly different land use influences that produce different land cover. For example, within a large riverine backwater unit, you may define separate WAAs that are cleared land, early successional sites, and mature forests. However, be cautious about splitting a project area into many WAAs 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 WAAs 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 Ouachita Mountains and Crowley's Ridge Regions 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.

Table 7
Applicability of Variables by Regional Wetland Subclass

Variable Code	Flat	High-Gradient Riverine	Mid-Gradient Riverine	Low-Gradient Riverine	Unconnected Depression	Connected Depression	Slope
V_{AHOR}	+	+	+	+	*	*	+
V_{BUF30}	N/A	+	+	N/A	+	+	+
V_{BUF250}	N/A	+	+	N/A	+	+	+
V_{COMP}	+	+	+	+	+	+	+
V_{FREQ}	N/A	+	+	+	N/A	+	N/A
V_{GCOMP}	N/A	N/A	N/A	N/A	N/A	N/A	+
V_{GVC}	+	+	+	+	*	*	+
V_{LITTER}	+	+	+	+	N/A	*	+
V_{LOG}	+	+	+	+	*	*	+
V_{OHOR}	+	+	+	+	*	*	+
V_{OUT}	N/A	N/A	N/A	N/A	N/A	N/A	+
V_{PATCH}	+	N/A	N/A	+	N/A	N/A	N/A
V_{POND}	+	+	+	+	N/A	N/A	N/A
V_{SNAG}	+	+	+	+	+	+	+
V_{SOIL}	+	+	+	+	*	*	+
V_{SSD}	+	+	+	+	+	+	+
V_{STRATA}	+	+	+	+	+	+	+
V_{TBA}	+	+	+	+	+	+	+
V_{TCOMP}	+	+	+	+	+	+	+
V_{TDEN}	+	+	+	+	+	+	+
V_{WD}	+	+	+	+	*	*	+

N/A = Not used in assessment of this subclass.
+ = Variable always used in assessment of this subclass.
* = Variable used unless conditions preclude observation.

The data forms provided in Appendix B are organized to facilitate data collection at each of the 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 data sheets. Additional copies of Data Form 2 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 Ouachita Mountains and Crowley's Ridge Regions. 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.

A typical layout for the establishment of sample plots and transects in the hypothetical WAAs is shown in Figure 26. 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 WAA. Experience has shown that the time required to complete an assessment of an area that size is 2–4 hours, depending primarily on the experience of the assessment team. However, as the size and heterogeneity of the WAA increases, 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 by differentially emphasizing or excluding any of these local conditions but should 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. Using the WAA designations shown on Figure 25, WAA 2 in Figure 26 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

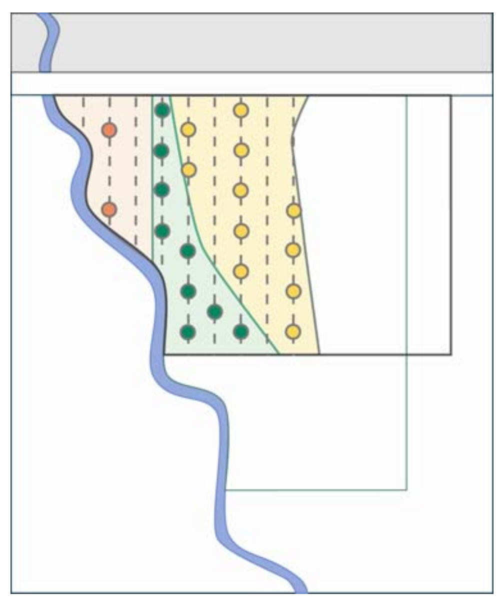


Figure 26. Example sample distribution. Refer to Figure 25 for WAA designations

Figure 26). 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 has increased, are you no longer encountering new dominant species, 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 remains 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 that correspond well to the overall suite of characteristics of interest within a particular WAA. In some cases, such as sites where trees have been planted or where the 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 26, 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 some 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 27. 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.

V_{AHOR} — “A” Horizon Organic Accumulation

This variable represents the 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.

The 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 in the Ouachita Mountains and Crowley’s Ridge Regions) and measure the thickness of the “A” horizon. Record measurements 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 it in the right-hand column.

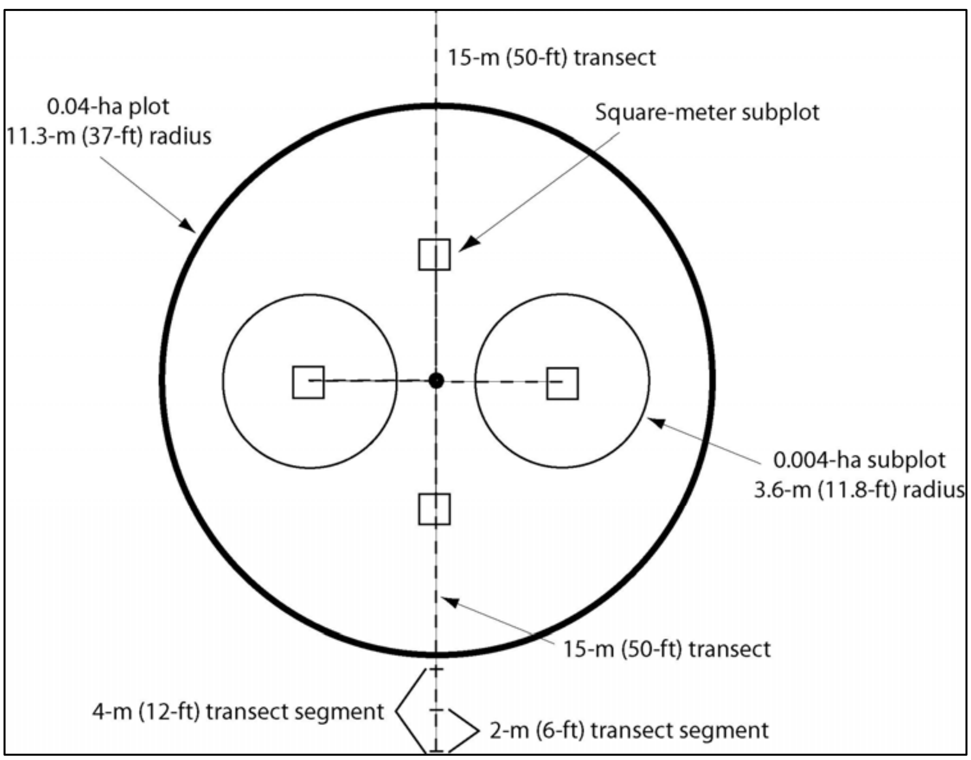


Figure 27. Layout of plots and transects for field sampling.

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, and limited nesting and hibernation) of many reptiles and amphibians. Note that the buffer can consist of any community type that is usually "drier" than the depression, slope, or riverine wetland; this can include 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 the 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 in depressions, on slopes, and 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 28 as needed.

1. For slope, depression, and high-gradient riverine wetlands, draw a continuous line on a map or photo separating the WAA 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 28a, b, and c).
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 28a and b).
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 28a, 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%. 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 3.

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 28c). In the example shown in Figure 28c, the continuity of the 30-m buffer is 100%.

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. Note that the buffer can consist of any community type that is usually "drier" than the depression or slope wetland; this can include flats and riverine wetlands as well as uplands. 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 in depressions, on slopes, and 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 28 as needed.

1. On a map or photo, draw a continuous line separating the depression, slope, or 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 (Figures 28a, b, and c).
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 (Figures 28a, b, and c).

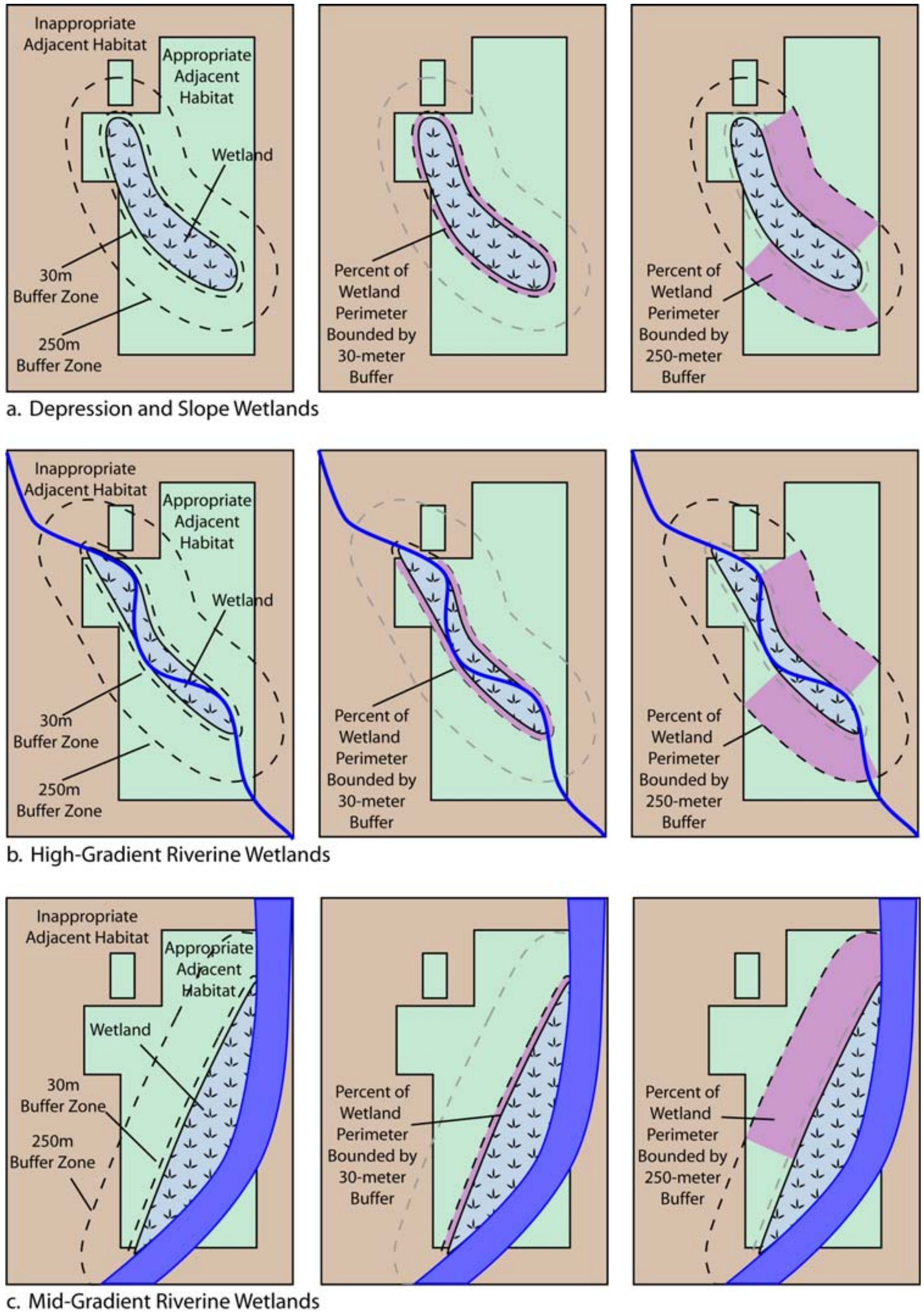


Figure 28. Measurement of buffer characteristics

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 Figures 28a and b, 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%. Record that percentage on Data Form 1 in the box at the right-hand side of the V_{BUF250} row, and transfer the same number to the right-hand side of the V_{BUF250} row on Data Form 3.

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 28c). In the example shown in Figure 28c, the continuity of the 250-m buffer is approximately 70%.

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 the 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%, go to Step 2. If the percent cover of the tree stratum is estimated to be less than 20%, skip Step 2 and go directly to Step 3.
2. If the tree stratum has at least 20% 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 the 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 it in the right-hand column.
3. If the tree stratum does not have at least 20% cover, determine the tallest woody stratum with at least 10% total cover. Within this stratum, identify the dominant species based on percent cover using the 50/20 rule (Federal Interagency Committee for Wetland Delineation 1989): rank species in descending order of percent cover and identify the dominants by summing relative dominance in descending order until 50% is exceeded; additional species with 20% 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 the 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. Transfer the V_{COMP} plot values to Data Form 3. Calculate an overall WAA average on that form and enter it in the right-hand column.

V_{FREQ} — Frequency of Flooding

Frequency of flooding refers to the frequency with which overbank or backwater flooding from a stream inundates the WAA. Ideally, characterization of hydrologic regimes would also consider flood depth and duration. However, obtaining these data for a particular assessment area typically requires considerably more time and effort than is normally available under a rapid assessment scenario. Consequently, recurrence interval in years is used to quantify this variable. Determine this value using the following procedure.

Determine the recurrence interval using one of the following methods:

1. Recurrence interval map;
2. Data from a nearby stream gage;
3. 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);
4. Hydrologic models such as HEC-2 (USACE 1981, 1982), HEC-RAS (USACE 1997), or HSPF (Bicknell et al. 1993);
5. Local knowledge; or
6. A regional dimensionless rating curve.

Record the recurrence interval on the Data Form 1 in the box at the right-hand side of the V_{FREQ} row, and transfer the same number to the box on the right-hand side of the V_{FREQ} row on Data Form 3.

V_{GCOMP} — Ground Vegetation Composition

This variable is assessed only in slope wetlands and focuses on the occurrence and abundance of specific fern species. Cinnamon fern, royal fern, and sensitive fern are particularly characteristic of slope wetlands in the Ouachita Mountains and Crowley's Ridge Regions, and a variety of other species also occur commonly. Where soils and hydrology are sufficient to sustain slope wetlands, at least one of these species would be expected to be common, and where two or more fern species are common, microsite diversity is usually high, which provides habitat for more plant species (including uncommon species) than uniform land surfaces or grazed sites. A simple assessment of fern abundance and diversity is all that is required, as outlined below. Because most of the fern species of interest are relatively robust, they usually leave enough evidence off their abundance to allow evaluation during the dormant season as well as the growing season.

1. Count the number of fern species characteristic of slope wetlands that account for at least 10% cover within the assessment area.
2. Record the number on Data Form 1 in the box at the right-hand side of the V_{GCOMP} rows on Data Forms 1 and 3.

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 27. 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 values 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 the V_{WD} discussion, below)]. It also excludes organic material sufficiently decayed to be included in the estimate of "O" horizon thickness (see the V_{OHOR} discussion below). Generally, litter cover is easily recognized and estimated except in 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 27). Record the 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 values 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 the 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 less than 0.6 cm in diameter, flowers, fruits, insect frass, dead moss, or detached lichens on or near the surface of the ground (USDA SCS 1993). 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 values to the V_{OHOR} row on Data Form 3. Average all plot values on that form and record the result in the box at the right-hand side of the V_{OHOR} row.

V_{OUT} — Surface Water Outflow

This variable is intended to represent the frequency at which water is discharged as surface flow from a slope wetland to downslope streams or wetlands. The variable is scored on the basis of field indicators that surface water discharge occurs and whether the discharge is seasonal or perennial.

The field procedure is as follows:

1. Inspect the lower perimeter of the slope wetland and determine if there are indicators of surface water discharge present. These may include actual surface flow occurring at the time of the observation or the presence of small surface channels present within the wetland; these usually give the wetland a hummocky surface.
2. If discharge appears to occur, inspect the setting of the wetland and the adjacent downslope landscape to determine if water containing dissolved organic material has the opportunity to enter a stream or another wetland system (e.g. the floodplain along the stream). If the discharge is isolated from any aquatic or wetland system (which is a rare occurrence), enter “0” (zero) in the V_{OUT} row on Data Forms 1 and 3.
3. If discharge to a wetland or stream does occur, determine if it is perennial or seasonal in nature. Perennial seepage will be visible at the time of the observation, except during severe droughts. Other indicators are the presence of organic material accumulation and perennial hydrophytic vegetation in the outflow channels. If perennial outflow occurs, enter “1” in the V_{OUT} row on Data Forms 1 and 3. If the outflow is determined to occur seasonally or intermittently (“wet-weather seeps”), enter “0.5” in the V_{OUT} row on Data Forms 1 and 3.

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% canopy tree cover. This variable is used in assessing flat and low-gradient riverine wetlands.

Determine the size of the forested tract 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 2,500 ha, you can simply record 2,500) 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 small microdepressions and larger vernal pools.

Estimate the 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 the 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 is a variety of soil properties contributing to integrity that should be considered (i.e., structure, horizon development, texture, and 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 the 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 27). 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% cover, on average, throughout the site:
2. Canopy (trees greater than or equal to 10 cm dbh that are in the canopy layer);
3. 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);
4. Understory (shrubs and saplings less than 10 cm dbh but at least 4.5 ft tall); and
5. Ground cover (woody plants less than 4.5 ft tall, and herbaceous vegetation)
6. Enter the number of vegetation strata (0–4) 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 with 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 for our purposes, and it is readily available.

2. Calculate the plot basal area in m^2/ha 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 3. Average all the 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 should you choose 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, if you 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 to you. Or you may wish to use the direct measurement approach to facilitate more rigorous data collection, particularly if you are interested in the relative contribution of each tree species to the total basal area of the WAA. Therefore, 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 you can sum the individual tree values for each species if you wish to know 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 your 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 (cm) diameter tape or tree calipers, 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.
2. A spreadsheet is available (Appendix D1) to complete the calculations in Steps 2–5 below, or you can do them by hand as follows:
3. Square the dbh measurement for each woody stem and enter that number in Column 3.
4. Convert the squared diameters to square meters per hectare by multiplying by 0.00196. Enter this number in Column 4.

5. 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.
6. Average the plot values on the Data Form 3 and record the result in the box on the right-hand side of the V_{TBA} 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 greater than or equal to 10 cm or 4 in. at breast height) within the plot is 20% 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% cover, identify the dominant species (based on cover, or on basal area if dbh measurements are taken) and circle them on Data Form 2 of the appropriate wetland subclass. To identify dominants, apply the 50/20 rule (Federal Interagency Committee for Wetland Delineation 1989). This requires that you rank species in descending order of percent cover, summing relative dominance in descending order until 50% is exceeded. Additional species with 20% 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 the 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% tree cover.
4. Transfer the V_{TCOMP} plot values 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 are the metrics 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 27).
2. Count the number of nonliving stems in Size Class 1 (small; greater than or equal to 0.6 cm and less than 2.5 cm, or greater than or equal to 0.25 in. 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 27 illustrates it as placed at the end farthest 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 27 illustrates it as placed at the end farthest 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, or greater than or equal to 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 Functional Capacity Index (FCI) for each assessed function. Finally, the FCI is multiplied by the area of the WAA (ha) to calculate Functional Capacity Units (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 (ha) 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). Also note that the depression subclasses offer the choice of two spreadsheets: one for non-inundated conditions and a simpler version for situations where ground-level variables are not assessed because of standing water. Use the spreadsheet for inundated conditions if any of the plots are under water. Alternatively, separate WAAs can be established for inundated and non-inundated subsections of the depression.

When using the spreadsheets in Appendix D3, be sure to first clear any values in the "Metric Values" column (shaded green) completely fill out the green-shaded boxes to identify the project and the WAA, and specify the size (ha) of the WAA. 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 WAA at different points in time, compare different WAAs at the same point in time, or compare different alternatives to a project. The basic unit of comparison is the FCU, but it is often helpful to examine specific impacts and mitigation actions by examining their effects on the 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 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 us 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 or isolated depressions. Conversely, isolated depressions are more likely to support endemic species than are river-connected systems. 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.

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, some depression sites with near-permanent flooding are dominated by buttonbush. Where this occurs because of water control structures or impeded drainage due to roads, it should be recognized as having arrested functional status, at least for some functions. However, where the same situation occurs because of beaver activity or 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 beavers 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 beavers 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 WAA 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 the functional status will improve as a result of restoration actions intended to offset impacts to jurisdictional wetlands. The graphs in Figure 29 represent general recovery trajectories for forested hardwood wetlands within the Ouachita Mountains and Crowley’s Ridge Regions 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, so 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 depend on the extent of site contouring work done prior to planting, in most cases. In the

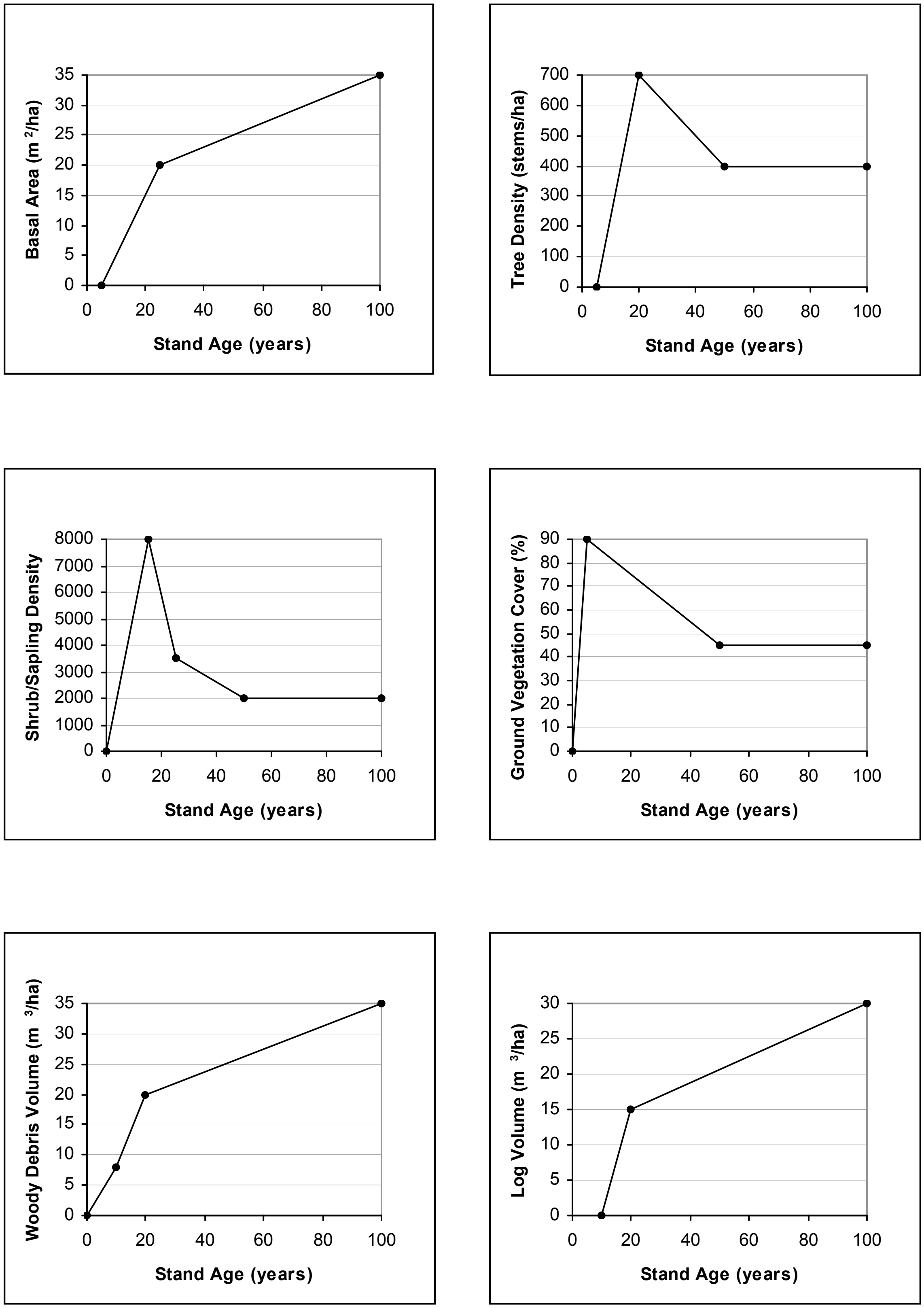


Figure 29. Projected recovery trajectories for selected assessment variables

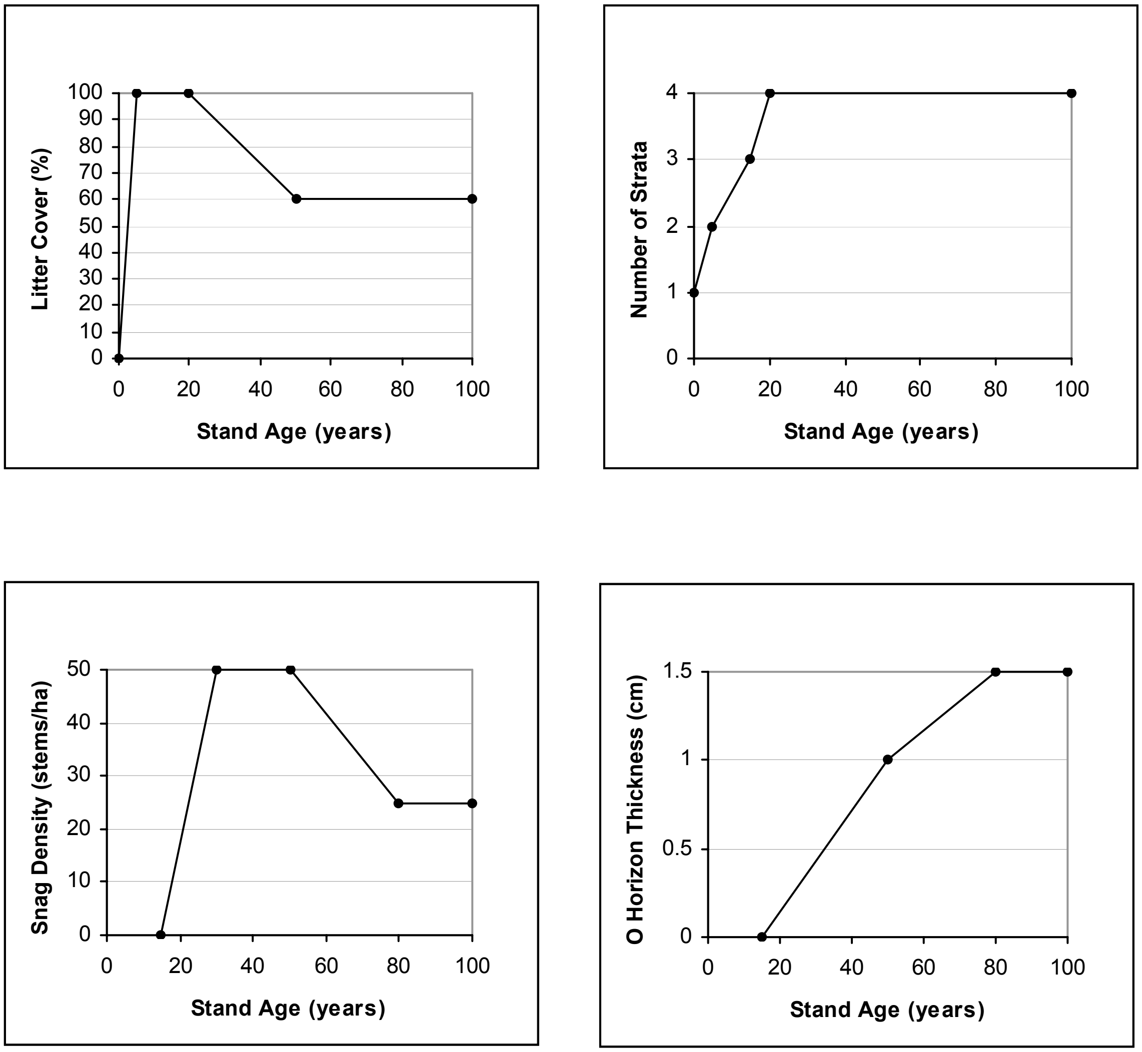


Figure 29. Projected recovery trajectories for selected assessment variables (concluded)

case of riverine wetlands, restoration design should also take into account the relative positions and dimensions of terraces; general guidance may be found in Figure 13 and Table 5. Similarly, the rates of compositional change (V_{COMP} and V_{TCOMP}) depend 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. Estimation of future composition for unplanted areas will require a site-specific evaluation of seed sources and probable colonization patterns. Note also that the graphs in Figure 30 are amalgams of data from all wetland subclasses. In situations where a site is expected to be unusual in one or more respects, more specific data may exist and should be substituted for these general curves as appropriate.

References

Ainslie, W. B., R. D. Smith, B. A. Pruitt, T. H. Roberts, E. J. Sparks, L. West, G. L. Godshalk, and M. V. Miller. 1999. *A regional guidebook for assessing the functions of low gradient, riverine wetlands of western Kentucky*. Technical Report WRP-DE-17, Wetlands Research Program, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Allen, A. W. 1987. *Habitat suitability index models: Gray squirrel, revised*. Biological Report 82(10.135), U.S. Fish and Wildlife Service.

Ambuel, B., and S. A. Temple. 1983. Area-dependent changes in the bird communities and vegetation of southern Wisconsin forests. Ecology 64, 1057–1068.

Arkansas Geological Commission. 2000. Water—A discussion. http://www.state.ar.us/agc/water.htm

Arkansas Multi-Agency Wetland Planning Team. 1997. *Arkansas wetland strategy.* MAWPT Coordination Office, Arkansas Game and Fish Commission, Little Rock.

Askins, R. A., M. J. Philbrick, and D. S. Sugeno. 1987. Relationship between the regional abundance of forest and the composition of forest bird communities. Biological Conservation 39, 129–152.

Autin, W. J., S. F. Burns, B. J. Miller, R. T. Saucier, and J. I. Snead. 1991. *Quaternary geology of the Lower Mississippi Valley*. Quaternary nonglacial geology: Conterminous U.S. Vol. K-2, The Geology of North America. R. B. Morrison, ed. Geological Society of America, Boulder, CO, 547–582.

Bailey, M. A., and K. A. Bailey. 2000. *Wetland fauna and drainage basin studies: Amphibian and reptile habitat utilization*. Arnold Engineering Development Center, Arnold Air Force Base, TN.

Baker, J. A., and K. J. Killgore. 1994. *Use of a flooded bottomland hardwood wetland by fishes in the Cache River System, Arkansas*. Technical Report WRP-CP-3, Wetlands Research Program, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Batista, W. B., W. J. and Platt. 1997. *An old-growth definition for southern mixed hardwood forests*. General Technical Report SRS-9, U.S. Department of Agriculture, Forest Service, Southern Research Station, Asheville, NC.

Bicknell, B. R., J. C. Imhoff, J. L. Kittle, A. S. Donigan, and R. C. Johanson. 1993. *Hydrologic Simulation Program—Fortran (HSPF): User's manual for release 10.0*. EPA 600/3-84-066, Environmental Research Laboratory, Athens, GA.

Blake, J. G., and J. R. Karr. 1984. Species composition of bird communities and the conservation benefit of large versus small forests. Biological Conservation 30, 173–187.

Bormann, F. H., and G. E. Likens. 1970. *The nutrient cycles of an ecosystem*. *Scientific American* 223, 92–101.

Bovee, K. D. 1982. *A guide to stream habitat analysis using the in stream flow incremental methodology*. Instream Flow Information Paper No. 12, OBS-82/26, U.S. Fish and Wildlife Service.

Boyd, L. 2001. Wildlife use of wetland buffer zones and their protection under the Massachusetts Wetland Protection Act. Department of Natural Resources Conservation, University of Massachusetts.

Braun, E. L. 1950. *Deciduous forests of eastern North America*. Hafner Press, New York.

Brinson, M. M. 1990. *Riverine forests*. Forested wetlands. A. E. Lugo, M. M. Brinson, and S. Brown, ed., Elsevier Scientific Publishers, Amsterdam, 87–141.

_____. 1993a. *A hydrogeomorphic classification for wetlands*. Technical Report WRP-DE-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

_____. 1993b. Changes in the functioning of wetlands along environmental gradients. Wetlands 13, 65–74.

_____. 1995. *The hydrogeomorphic approach explained*. National Wetlands Newsletter, November/December, Environmental Law Institute, Washington, DC.

_____. 1996. *Assessing wetland functions using HGM*. National Wetlands Newsletter, January/February, Environmental Law Institute, Washington, DC.

Brinson, M. M., H. D. Bradshaw, and E. S. Kane. 1984. *Nutrient assimilative capacity of an alluvial floodplain swamp*. Journal of Applied Ecology. 21, 1041–1057.

Brinson, M. M., F. R. Hauer, L. C. Lee, W. L. Nutter, R. D. Rheinhardt, R. D. Smith, and D. Whigham. 1995. *A guidebook for application of hydrogeomorphic assessments to riverine wetlands*. Wetlands Research Program. Technical Report WRP-DE-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Brinson, M. M., A. E. Lugo, and S. Brown. 1981. *Primary productivity, decomposition and consumer activity in freshwater wetlands*. Annual Review of Ecology and Systematics 12, 123–161.

Brinson, M. M., W. L. Nutter, R. Rheinhardt, and B. A. Pruitt. 1996. *Background and recommendations for establishing reference wetlands in the Piedmont of the Carolinas and Georgia*. EPA/600/R-96/057, U.S. Environmental Protection Agency National Health and Environmental Effects Laboratory, Western Division, Corvallis, OR.

Brinson, M. M., R. D. Smith, D. F. Whigham, L. C. Lee, R. D. Rheinhardt, and W. L. Nutter. 1998. Progress in development of the hydrogeomorphic approach for assessing the functioning of wetlands. Proceedings, INTECOL International Wetland Conference, Perth, Australia.

Brooks, K. N., P. F. Ffolliott, H. M. Gregerson, and J. L. Thames. 1991. *Hydrology and the management of watersheds*. Iowa State University Press, Ames, IA.

Brown, J. K. 1974. *Handbook for inventorying downed woody material*. General Technical Report INT-16, U.S. Department of Agriculture, Forest Service.

Brown, J. K., R. D. Oberheu, and C. M. Johnston. 1982. *Handbook for inventorying surface fuels and biomass in the interior west*. General Technical Report INT-129, U.S. Department of Agriculture, Forest Service, Inter-mountain Forest and Range Experiment Station, Ogden, UT.

Brown, S., and D. L. Peterson. 1983. Structural characteristics and biomass production of two Illinois bottomland forests. American Midland Naturalist 110, 107–117.

Bukenhofer, G. A., and L. D. Hedrick. 2003. Shortleaf pine/bluestem grass ecosystem renewal in the Ouachita Mountains. *http://www.fs.fed.us/oonf/rcw/slp_bs_renewal.htm*.

Burke, V. J., and J. W. Gibbons. 1995. Terrestrial buffer zones and wetland conservation: a case study of freshwater turtles in a Carolina bay. *Conservation Biology* 9, 1365–1369.

Campbell, K. L., and H. P. Johnson. 1975. Hydrologic simulation of watersheds with artificial drainage. *Water Resources Research* 11, 120–126.

CAST. 1996. *Land Cover of Arkansas: GAP Analysis*. Center for Advanced Spatial Technologies, University of Arkansas, Fayetteville.

Clark, G. T. 1977. Forest communities of Crowley's Ridge. *Arkansas Academy of Science Proceedings.* 31, 34–37.

Clark, G. T., J. A. Akers, S. W. Bailey, W. H. Freeman, M. H. Hill, L. P. Lowman, S. O. Loyd, W. R. Randel, R. B. Rosen, and J. S. Workman. 1974. *A preliminary ecological study of Crowley's Ridge*. Arkansas natural area plan. Arkansas Department of Planning, Little Rock, 213–241.

Conner, W. H., and J. W. Day, Jr. 1976. Productivity and composition of a baldcypress-water tupelo site and bottomland hardwood site in a Louisiana swamp. *American Journal of Botany.* 63, 1354–1364.

Cowardin, L. M, V. Carter, F. C. Golet, and E. T. LaRoe. 1979. *Classification of wetlands and deep-water habitats of the United States*. FWS/OBS-79/31, Office of Biological Services, U.S. Fish and Wildlife Service, Washington, DC.

Dahm, C. M. 1981. Pathways and mechanisms for removal of dissolved organic carbon from leaf leachates in streams. *Canadian Journal of Fish and Aquatic Science* 38, 68–76.

Dale, E. E. 1986. The vegetation of Arkansas. *The Arkansas Naturalist* 4 (5), 7–28.

Day, F. P. 1979. Litter accumulation in four plant communities in the Dismal Swamp, Virginia. *American Midland Naturalist* 102, 281–289.

Demissie, M., and A. Kahn. 1993. *Influence of wetlands on streamflow in Illinois*. Illinois State Water Survey.

Devall, M. S., and V. A. Rudis. 1990. Older stands characterized and estimated from sample-based surveys. *Proceedings from the Conference on Restoring Old Growth Forests in the Interior Highlands of Arkansas and Oklahoma*, Winrock International, Morrilton, AR, 121–137.

Dewey and Kropper Engineers. 1964. *Effect of loss of valley storage due to encroachment— Connecticut River*. Report to the Water Resources Commission, Hartford, CT.

Dickinson, C. H., and G. Pugh. 1974. *Biology of plant litter decomposition*. Volume I. Academic Press, London, England.

Dunne, T., and L. B. Leopold. 1978. *Water in environmental planning*. W. H. Freeman and Company, San Francisco, CA.

Dybvig, W. L., and J. R. Hart. 1977. The effects of agricultural drainage on flood flows at Moose Jaw. *Proceedings, 1977 Canadian hydrology symposium*, National Resources Council, 311–321.

Edwards, R. T. 1987. Sestonic bacteria as a food source for filtering invertebrates in two southeastern blackwater streams. *Limnology and Oceanography* 32, 221–234.

Edwards, R. T., and J. L. Meyers. 1986. Production and turnover of plantonic bacteria in two sub-tropical blackwater rivers. *Applied Environmental Microbiology* 52, 1317–1323.

Elder, J. F., and D. J. Cairns. 1982. *Production and decomposition of forest litter fall on the Appalachicola River flood plain, Florida*. Water Supply Paper 2196-B, U.S. Geological Survey, Washington, DC.

Elder, J. F., and H. Mattraw. 1982. Riverine transport of nutrients and detritus to the Apalachicola Bay Estuary, Florida. *Water Resources Bulletin* 18, 849–856.

Elwood, J. W., J. D. Newbold, R. V. O'Neill, and W. Van Winkle. 1983. *Resource spiraling: An operational paradigm for analyzing lotic ecosystems*. Dynamics of lotic ecosystems. T. D. Fontaine and S. M. Bartell, ed., Ann Arbor Science, Ann Arbor, MI.

Estes, C. C., and J. F. Orsborn. 1986. Review and analysis of methods for quantifying instream flow requirements. *Water Resources Bulletin* 22, 389–398.

Faulkner, J. L. 2001. Arkansas forests, 1600–1988. *Proceedings of the symposium on Arkansas forests: A conference on the results of the recent forest survey of Arkansas*. J.M. Guldin, comp., USDA Forest Service Gen.Tech. Rep. SRS–41, Southern Research Station, Asheville, NC, 7–10.

Federal Interagency Committee for Wetland Delineation. 1989. *Federal manual for identifying and delineation of jurisdictional wetlands*. Cooperative Technical Publication, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and USDA Soil Conservation Service, Washington, DC.

Finch, D. M. 1991. *Population ecology, habitat requirements, and conservation of neotropical migratory birds*. General Technical Report RM-205, U.S. Department of Agriculture, Forest Service.

Foti, T. 1993. *The river's gifts and curses*. The Arkansas delta: Land of paradox. J. Whayne and W. B. Gatewood, ed., University of Arkansas Press, Fayetteville, 30–57.

Foti, T. L., and S. M. Glenn. 1990. The Ouachita Mountain landscape at the time of settlement. *Proceedings from the conference on restoring old growth forests in the interior highlands of Arkansas and Oklahoma*, Winrock International, Morrilton, AR, 49–64.

Fowler, W. P. 1994. Woody debris dynamics in zero order streams of the Ouachita National Forest: preliminary findings. Proceedings from the symposium on ecosystem management research in the Ouachita Mountains: Pretreatment conditions and preliminary findings. J. B. Baker, comp., General Technical Report. SO-112, USDA Forest Service, Southern Forest Experiment Station, New Orleans, LA, 182–185.

Fredrickson, L. H. 1978. *Lowland hardwood wetlands: Current status and habitat values for wildlife*. Wetland functions and values: The state of our understanding. P. E. Greeson, J. R. Clark, and J. E. Clark, ed., American Water Resources Association, Minneapolis, MN, 207–306.

Fryar, R. D. 1990. Old growth stands of the Ouachita National Forest. *Proceedings from the conference on restoring old growth forests in the interior highlands of Arkansas and Oklahoma*, Winrock International, Morrilton, AR, 105–113.

Geise, J., B. Kieth, M. Maner, R. McDaniel, and B. Singleton. 1987. Physical, chemical, and biological characteristics of least-disturbed reference streams in Arkansas' ecoregions. Volume II: Data analysis. Arkansas Department of Pollution Control and Ecology.

Gibbons, J. W., and K. A. Buhlmann. 2001. *Reptiles and amphibians*. Wildlife of southern forests, habitat and management. J. G. Dickson, ed., Hancock House Publishers, Blaine, WA, 372–390.

Gibbons, J. W. 2003. Terrestrial habitat: A vital component for herpetofauna of isolated wetlands. *Wetlands* 23: 630–635.

Golet, F. C., and J. S. Larson. 1974. *Classification of freshwater wetlands in the glaciated Northeast*. Resource Publication 116, U.S. Fish and Wildlife Service.

Gray, J. L., and D. V. Ferguson. 1977. *Soil Survey of Poinsett County, Arkansas*. U.S. Department of Agriculture, Soil Conservation Service, Little Rock, AR.

Greenberg, C. H., D. E. Mcleod, and D. L. Loftis. 1997. *An old-growth definition for western and mixed mesophytic forests*. General Technical Report SRS-16, U.S. Department of Agriculture, Forest Service, Southern Research Station, Asheville, NC.

Haley, B. R. 1993. *Geologic map of Arkansas*. Arkansas Geological Commission and U.S. Geological Survey.

Harmon, M. E., J. F. Franklin, and F. J. Swanson. 1986. Ecology of coarse woody debris in temperate ecosystems. *Advances in Ecological Research* 15, 133–302.

Harris, L. D., and J. G. Gosselink. 1990. *Cumulative impacts of bottomland hardwood forest conversion on hydrology, water quality, and terrestrial wildlife*. Ecological processes and cumulative impacts illustrated by bottomland hardwood wetland ecosystems. J. G. Gosselink, L. C. Lee, and T. A. Muir, ed., Lewis Publishers, Chelsea, MI, 259–322.

Hauer, F. R., and R. D. Smith. 1998. The hydrogeomorphic approach to functional assessment of riparian wetlands: Evaluating impacts and mitigation on river floodplains in the USA. *Freshwater Biology* 40, 517–530.

Hawkins, T. K., and E. L. Richards. 1995. A floristic study of two bogs on Crowley's Ridge in Greene County, Arkansas. *Castanea* 60, 233–244.

Hayes, A. J. 1979. The microbiology of plant litter decomposition. *Scientific Progress* 66, 25–42.

Hodges, J. D. 1997. Development and ecology of bottomland hardwood sites. *Forest Ecology and Management* 90, 117–125.

Howard, R. J., and J. A. Allen. 1989. Streamside habitats in southern forested wetlands: Their role and implications for management. *Proceedings of the symposium: The forested wetlands of the southern United States*. General Technical Report SE-50. D. D. Hook and R. Lea, ed., U.S. Department of Agriculture Forest Service.

Howe, R. W. 1984. Local dynamics of bird assemblages in small forest habitat islands in Australia and North America. *Ecology* 65, 1585–1601.

Hunter, M. L. 1990. Wildlife, forests, and forestry: Principles of managing forests for biological diversity. Prentice Hall, Englewood Cliffs, NJ.

Hunter, W. C., J. G. Dickson, D. N. Pashley, and P. B. Hamel. 2001. *Bird communities of southern forests*. Wildlife of southern forests, habitat and management. J. G. Dickson, ed. W. Hancock House Publishers, Blaine, WA, 322–349.

Jennings, M. E., W. O. Thomas, Jr., and H. C. Riggs. 1994. Nationwide summary of U.S. Geological Survey regional regression equations for estimating magnitude and frequency of floods for ungaged sites, 1993. Water Resources Investigations Report 94-4002, U.S. Geological Survey.

Johnson, T. R. 1987. *The amphibians and reptiles of Missouri*. Missouri Department of Conservation, Jefferson City, MO.

Johnston, C. A., N. E. Detenbeck, and G. J. Niemi. 1990. The cumulative effect of wetlands on stream water-quality and quantity: A landscape approach. *Biogeochemistry* 10, 105–141.

Keller, C. M. E., C. S. Robbins, and J. S. Hatfield. 1993. Avian communities in riparian forests of different widths in Maryland and Delaware. *Wetlands* 13, 137–144.

Kennedy, H. E., and G. J. Nowacki. 1997. *An old-growth definition for seasonally wet oak-hardwood woodlands*. General Technical Report SRS-8, U.S. Department of Agriculture, Forest Service, Southern Research Station, Asheville, NC.

Kilgo, J. C., R. A. Sargent, K. V. Miller, and B. R. Chapman. 1997. Landscape influences on breeding bird communities in hardwood fragments in South Carolina. *Wildlife Society Bulletin* 25, 878–885.

Klimas, C. V., E. O. Murray, J. Pagan, H. Langston, and T. Foti. 2004. A regional guidebook for conducting functional assessments of forested wetlands in the delta region of Arkansas, lower Mississippi River alluvial valley. ERDC/EL TR-04-16, Arkansas Multi-Agency Wetland Planning Team, U.S. Army Engineer Research and Development Center, Environmental Laboratory, Vicksburg, MS.

_____. 2005. A regional guidebook for applying the hydrogeomorphic approach to assessing wetland functions of forested wetlands in the west gulf coastal plain region of Arkansas. ERDC/EL TR-05-12, Arkansas Multi-Agency Wetland Planning Team, U.S. Army Engineer Research and Development Center, Environmental Laboratory, Vicksburg, MS.

Kuenzler, E. J., P. J. Mulholland, L. A. Yarbro, and L. A. Smock. 1980. *Distributions and budgets of carbon, phosphorus, iron, and manganese in a floodplain swamp ecosystem*. Report No. 157, Water Resources Institute of the University of North Carolina, Raleigh, NC.

Laurent, G. D., J. D. Chism, R. K. Rhodes, C. R. Wilson, and W. R. Townsend. 1989. *Soil survey of Garland County, Arkansas*. USDA. Soil Conservation Service, Little Rock, AR.

Leopold, L. B. 1994. *A view of the river*. Harvard University Press, Cambridge, MA.

Loeb, S. C. 1993. *The role of coarse woody debris in the ecology of southeastern mammals*. Biodiversity and coarse woody debris in southern forests. GTR-SE-94, J. W. McMinn and D. A. Crossley, ed., U.S. Department of Agriculture, Forest Service, Southern Research Station, 108–118.

Lynch, J. F., and D. F. Whigham. 1984. Effects of forest fragmentation on breeding bird communities in Maryland, USA. *Biological Conservation* 28, 287–324.

McWilliams, S. R., and M. D. Bachman. 1988. Using life history and ecology as tools to manage a threatened salamander species. *Journal of the Iowa Academy of Science* 95, 66–71.

Meadows, J. S., and G. J. Nowacki. 1996. *An old-growth definition for eastern riverfront forests*. General Technical Report SRS-4, U.S. Department of Agriculture, Forest Service, Southern Research Station, Asheville, NC.

Messina, M. G., and W. H. Conner. 1997. *Southern forested wetlands: Ecology and management*. Lewis Publishers, Boca Raton, FL.

Meyer, J. L., L. A. Kaplan, D. Newbold, D. L. Strayer, C. J. Woltemade, J. B. Zedler, R. Beilfus, Q. Carpenter, R. Semlitsch, M. C. Watzin, and P. H. Zedler. 2003. *Where rivers are born*. American Rivers and the Sierra Club.

Miller, B. T. 1995. An investigation of rare, threatened, and endangered fauna and their habitats on Arnold Air Force Base, Coffee and Franklin Counties, Tennessee: Amphibian and reptile survey. Middle Tennessee State University, Murfreesboro, TN.

Mitch, P. P., and J. G. Gosselink. 1993. *Wetlands*. Van Nostrand Reinhold, New York, NY.

Morrison, M. L., B. C. Marcot, and R. W. Mannan. 1992. *Wildlife-habitat relationships: Concepts and applications*. University of Wisconsin Press, Madison, WI.

Mueller, A. J., C. R. Loesch, and D. J. Twedt. 1995. Development of management objectives for breeding birds. *Proceedings, Partners in Flight international workshop*, Cape May, NJ.

Mulholland, P. J. 1981. Organic carbon flow in a swamp-stream ecosystem. *Ecological Monographs* 51, 307–332.

Mulholland, P. J., and E. J. Kuenzler. 1979. Organic-carbon export from upland and forested wetland watersheds. *Limnology and Oceanography* 24, 960–966.

Nadelhoffer, K. J., and J. W. Raich. 1992. Fine root production estimates and belowground carbon allocation in forest ecosystems. *Ecology* 73, 1139–1147.

National Interagency Implementation Team. 1996. *National action plan to implement the hydrogeomorphic approach (NAP)*. Federal Register 61(160), 42, 593–42, 603.

Novitski, R. P. 1978. *Hydrogeological characteristics of Wisconsin's wetlands and their influences on floods, stream flow, and sediment*. Wetland functions and values: The state of our understanding. P. E. Greeson, J. R. C. Clark, and J. E. Clark, ed., American Water Resources Association, Minneapolis, MN, 377–388.

Odum, E. P. 1950. Bird populations of the Highlands (North Carolina) Plateau in relation to plant succession and avian invasion. *Ecology* 31, 587–605.

Ogawa, H., and J. W. Male. 1983. *The flood mitigation potential of inland wetlands*. Publication Number 138, Water Resources Center, Amherst, MA.

_____. 1986. Simulating the flood mitigation role of wetlands. *Journal of Water Resources Planning and Management, ASCE* 112, 114–128.

Ovington, J. D. 1965. Organic production, turnover and mineral cycling in woodlands. *Biological Review* 40, 772–785.

Patton, P. C. 1988. Drainage basin morphometry and floods. *Flood geomorphology*. V. R. Baker, R. C. Kochel, and P. C. Patton, ed., John Wiley and Sons, New York, NY, 51–64.

Perry, D. A. 1994. *Forest ecosystems*. Johns Hopkins University Press, Baltimore, MD.

Pomeroy, L. R. 1970. The strategy of mineral cycling. *Annual Review of Ecology and Systematics* 1, 171–190.

Pugh, G., and C. H. Dickinson. 1974. *Biology of plant litter decomposition, Volume II*. Academic Press, London.

Raich, J. W., and K. J. Nadelhoffer. 1989. Belowground carbon allocation in forest ecosystems: Global trends. *Ecology* 70, 1346–1354.

Reiners, W. A. 1972. Terrestrial detritus and the carbon cycle. *Carbon and the biosphere*. G. M. Woodwell and E. V. Pecan, ed., Conference Proceedings 720510, U.S. Atomic Energy Commission.

Renken, R. A. 1998. Groundwater atlas of the United States: Arkansas, Louisiana, Mississippi. U.S. Geological Survey HA 730-F. http://capp.water.usgs.gov?gwa/ch_f 2/28/03.

Rheinhardt, R. D., M. M. Brinson, and P. M. Farley. 1997. Applying wetland reference data to functional assessment, mitigation, and restoration. *Wetlands* 17: 195–215.

Ricklefs, R. E. 1990. *Ecology. 3rd ed*., W. H. Freeman and Company, New York, NY.

Ritter, D. F., R. C. Kochel, and J. R. Miller. 1995. *Process geomorphology. 3rd ed*., William C. Brown Publishers, Chicago, IL.

Robertson, P. A. 1992. Environmental factors affecting tree growth on three wetland sites in southern Illinois. *American Midland Naturalist* 128, 218–326.

Robertson, P. A., M. D. MacKenzie, and L. F. Elliot. 1984. Gradient analysis and classification of the woody vegetation for four sites in southern Illinois and adjacent Missouri. *Vegetatio* 58, 87–104.

Robertson, P. A., G. T. Weaver, and J. A. Cavanaugh. 1978. Vegetation and tree species patterns near the northern terminus of the southern floodplain forest. *Ecological Monographs* 48, 249–267.

Robinson, S. K. 1996. Setting objectives in forested habitats. Presentation, Partners in Flight, midwest and southern Great Plains workshop, April 8, St. Louis, MO.

Robinson, S. K., F. R. Thompson III, T. M. Donovan, D. R. Whitehead, and J. Faaborg. 1995. Regional forest fragmentation and the nesting success of migratory birds. *Science* 267, 1987–1990.

Rothermel, B. B., and R. D. Semlitsch. 2002. An experimental investigation of landscape resistance of forest versus old-field habitats to emigrating juvenile amphibians. *Conservation Biology* 16, 1324–1332.

Rudis, V. A. 2001. Landscape context and regional patterns in Arkansas' forests. *Proceedings of the symposium on Arkansas forests: A conference on the results of the recent forest survey of Arkansas*. J.M. Guldin, comp., USDA Forest Service General Technical Report SRS-41, Southern Research Station, Asheville, NC, 24-45.

Sallabanks, R., J. R. Walters, and J. A. Collazo. 1998. Breeding bird abundance in bottomland forests: Habitat, edge, and patch size effects. *Condor* 102, 748–758.

Saucier, R. T. 1964. *Geological investigation of the St. Francis Basin*. Technical Report 3-659, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

_____. 1994. *Geomorphology and quaternary geologic history of the Lower Mississippi Valley*. Vol I (report), Vol II (map folio), U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Schlesinger, W. H. 1977. Carbon balance in terrestrial detritus. Annual Review of Ecology and Systematics 8, 51–81.

Schlosser, I. J. 1991. Stream fish ecology: A landscape perspective. *Bioscience* 41, 704-712.

Schoener, T. W. 1986. *Resource partitioning*. Community ecology: Patterns and processes. J. Kikkawa and D. J. Anderson, ed., Blackwell, Melbourne, 91-126.

Scott, V. E., K. E. Evans, D. R. Patton, and C. P. Stone. 1977. *Cavity nesting birds of North American forests*. Handbook 553, U.S. Department of Agriculture Forest Service.

Sedell, J. R., J. E. Richey, and F. J. Swanson. 1989. The river continuum concept: A basis for the expected ecosystem behavior of very large rivers. *Canadian Journal of Fisheries and Aquatic Science* 46, 49–55.

Semeniuk, C. A. 1987. Wetlands of the Darling System: A geomorphic approach to habitat classification. *Journal of the Royal Society of Western Australia* 69, 95–112.

Semlitsch, R. D. 1998. Biological delineation of terrestrial buffer zones for pond-breeding salamanders. *Conservation Biology* 12, 1113–1119.

Semlitsch, R. D., and J. R. Bodie. 1998. Are small, isolated wetlands expendable? *Conservation Biology* 12, 1129–1133.

_____. 2003. Biological criteria for buffer zones around wetlands and riparian habitats for amphibians and reptiles. *Conservation Biology* 17, 1219–1228.

Semlitsch, R. D., and J. B. Jensen. 2001. Core habitat, not buffer zone. *National Wetlands Newsletter* 23:5–11.

Shafer, D. J., and D. J. Yozzo. 1998. *National guidebook for application of hydrogeomorphic assessment to tidal fringe wetlands*. Technical Report WRP-DE-16, Wetlands Research Program, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Singh, J. S., and S. R. Gupta. 1977. Plant decomposition and soil respiration in terrestrial ecosystems. *Botanical Review* 43, 449–528.

Smith, K. L. 1986. Sawmill: The story of cutting the last great virgin forest east of the Rockies. University of Arkansas Press, Fayetteville, AR.

Smith, K. L., W. F. Pell, J. H. Rettig, R. H. Davis, and H. W. Robison. 1984. *Arkansas's natural heritage*. B. Shepherd, ed., August House, Little Rock, AR.

Smith, R. D. 1996. Composition, structure, and distribution of woody vegetation on the Cache River floodplain, Arkansas. *Wetlands* 16, 264–278.

_____. 2001. Hydrogeomorphic approach to assessing wetland functions: Guidelines for developing regional guidebooks. Chapter 3: Developing the reference wetland system. ERDC/EL TR-01-29, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Smith, R. D., A. A. Ammann, C. Bartoldus, and M. M. Brinson. 1995. *An approach for assessing wetland functions using hydrogeomorphic classification, reference wetlands, and functional indices*. Wetlands Research Program Technical Report WRP-DE-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Smith, R. D., and C. V. Klimas. 2002. A regional guidebook for applying the hydrogeomorphic approach to assessing wetland functions of selected regional wetland subclasses, Yazoo Basin, lower Mississippi River alluvial valley. ERDC/EL TR-02-4, U.S. Army Engineer Research and Development Center, Environmental Laboratory, Vicksburg, MS.

Sorenson, T. A. 1948. A method of establishing groups of equal amplitude in plant sociology based on similarity of species content, and its application to analyses of the vegetation on Danish commons. *Kongelige Danske Videnskabernes Selskab Biologiske Skrifter* 56, 1–34.

Southern Regional Climate Center. 2003. Electronic climate atlas. *http://www.srcc.lsu.edu/atlas.html*.

Stanford, J. A., J. V. Ward, W. J. Liss, C. A. Frissell, R. N. Williams, J. A. Lichatowich, and C. C. Coutant. 1996. A general protocol for restoration of regulated rivers. *Regulated Rivers Research and Management* 12, 391–413.

Stauffer, D. F., and L. B. Best. 1980. Habitat selection by birds of riparian communities evaluating effects of habitat alterations. *Journal of Wildlife Management* 44, 11-15.

Stewart, R. E., and H. A. Kantrud. 1971. *Classification of natural ponds and lakes in the glaciated prairie region*. Resource Publication 92, U.S. Fish and Wildlife Service, Washington, DC.

Stone, C. G., and W. V. Bush. 1986. General geology and mineral resources of the Ouachita Mountains, Arkansas. *Proceedings of the 22nd forum on the geology of industrial minerals*. G.W. Colton, ed., Arkansas Geological Commission, Little Rock, 87–106.

Symbula, M., and F. W. Day. 1988. Evaluation of two methods for estimating belowground production in a fresh-water swamp forest. *American Midland Naturalist* 120, 405–415.

Temple, S. A. 1986. Predicting impacts of habitat fragmentation on forest birds: A comparison of two models. *Wildlife 2000: Modeling habitat relationships of terrestrial vertebrates*. J. Verner, M. L. Morrison and C. J. Ralph, ed., University of Wisconsin Press, Madison, WI, 301–304.

Terry, J. E., R. L. Hosman, and C. T. Bryant. 1979. *Summary appraisals of the nation's ground-water resources—Lower Mississippi Region*. U.S. Geological Survey Professional Paper 813-N.

Thomas, D. M., and M. A. Hanson. 1981. *Generalization of streamflow characteristics from drainage-basin characteristics*. Water Supply Paper 1-55, U. S. Geological Survey, Washington, DC.

Thompson, F. R., III, W. D. Dijak, T. G. Kulowiec, and D. A. Hamilton. 1992. Breeding bird populations in Missouri Ozark forests with and without clearcutting. *Journal of Wildlife Management* 56, 23–30.

Tinkle, D. W. 1959. Observations of reptiles and amphibians in a Louisiana swamp. *American Midland Naturalist* 62, 189–205.

Tyrrell, L. E., G. J. Nowacki, T. R. Crow, D. S. Buckley, E. A. Nauertz, J. N. Niese, J. L. Rollinger, and J. C. Zasada. 1998. *Information about old growth for selected forest type groups in the eastern United States*. General Technical Report NC-197, U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station, St. Paul, MN.

U.S. Army Corps of Engineers. 1981. *HEC-1 flood hydrograph package. Users manual*. Hydrologic Engineering Center, Davis, CA.

_____. 1982. *HEC-2 water surface profiles. Users manual*. Hydrologic Engineering Center, Davis, CA.

_____. 1997. *HEC-RAS river analysis system. User manual*. Hydrologic Engineering Center, Davis, CA.

U.S. Department of Agriculture, Soil Conservation Service. 1993. *Soil survey manual*. U.S. Department of Agriculture Handbook 18, U.S. Government Printing Office, Washington, DC.

U.S. Department of Agriculture, Natural Resources Conservation Service. 1995. State Soil Geographic (STATSGO) Data Base for the Conterminous United States. *http://water.usgs.gov*.

U.S. Department of Agriculture, Forest Service. 2003. Ecological Subregions of the United States, Chapter 23: Ouachita Mixed Forest-Meadow. *http://www.fs.fed.us/land/pubs/ecoregions/toc.html*

_____. 2004. St. Francis National Forest. *http://www.fs.fed.us/oonf/ozark/index.html*.

_____. 2005. Ouachita National Forest. *http://www.fs.fed.us/r8/ouachita/*.

Vanderpool, S. S., and E. L. Richards. 1998. A floristic inventory of three bogs on Crowley's Ridge in northeast Arkansas. *Journal of the Arkansas Academy of Science* 52, 99–109.

Vannote, R. L., G. W. Minshall, K. W. Cummins, J. R. Sedell, and C. E. Cushing. 1980. The river continuum concept. *Canadian Journal of Fisheries and Aquatic Sciences* 37, 130–137.

Vogt, K. A., C. C. Grier, and D. J. Vogt. 1986. Production, turnover, and nutrient dynamics of above and belowground detritus of world forests. *Advances in Ecological Research* 15, 303–377.

Wakeley, J. S., and T. H. Roberts. 1996. Bird distribution and forest zonation in a bottomland hardwood wetland. *Wetlands* 16, 296–308.

Welsh, C. J. E., and W. M. Healy. 1993. Effect of even-aged timber management on bird species diversity and composition in northern hardwoods of New Hampshire. *Wildlife Society Bulletin* 21, 143–154.

Wharton, C. H., W. M. Kitchens, E. C. Pendleton, and T. W. Sipe. 1982. *The ecology of bottomland hardwood swamps of the Southeast: A community profile*. Report FWS/OBS-81/37, Office of Biological Services, U.S. Fish and Wildlife Service, Washington, DC.

Whittaker, R. H. 1975. *Communities and ecosystems*. MacMillan Publishing Company, New York, NY.

Wohl, E. 2000. *Mountain rivers*. Water Resources Monograph 14, American Geophysical Union, Washington DC.

Woods, A. J., T. L. Foti, S. S. Chapman, J. M. Omernik, J. A. Wise, E. O. Murray, W. L. Prior, J. B. Pagan, J. A. Comstock, and M. Radford. 2004. *Ecoregions of Arkansas*. color poster with map, descriptive text, summary tables, and photographs (map scale 1:1,000,000), U.S. Geologic Survey, Reston, Virginia. *http://www.epa.gov/wed/pages/ecoregions/level_iv.htm*

Appendix A
Preliminary Project Documentation and Field Sampling Guidance

Contents

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)

Field Assessment Preparation Checklist

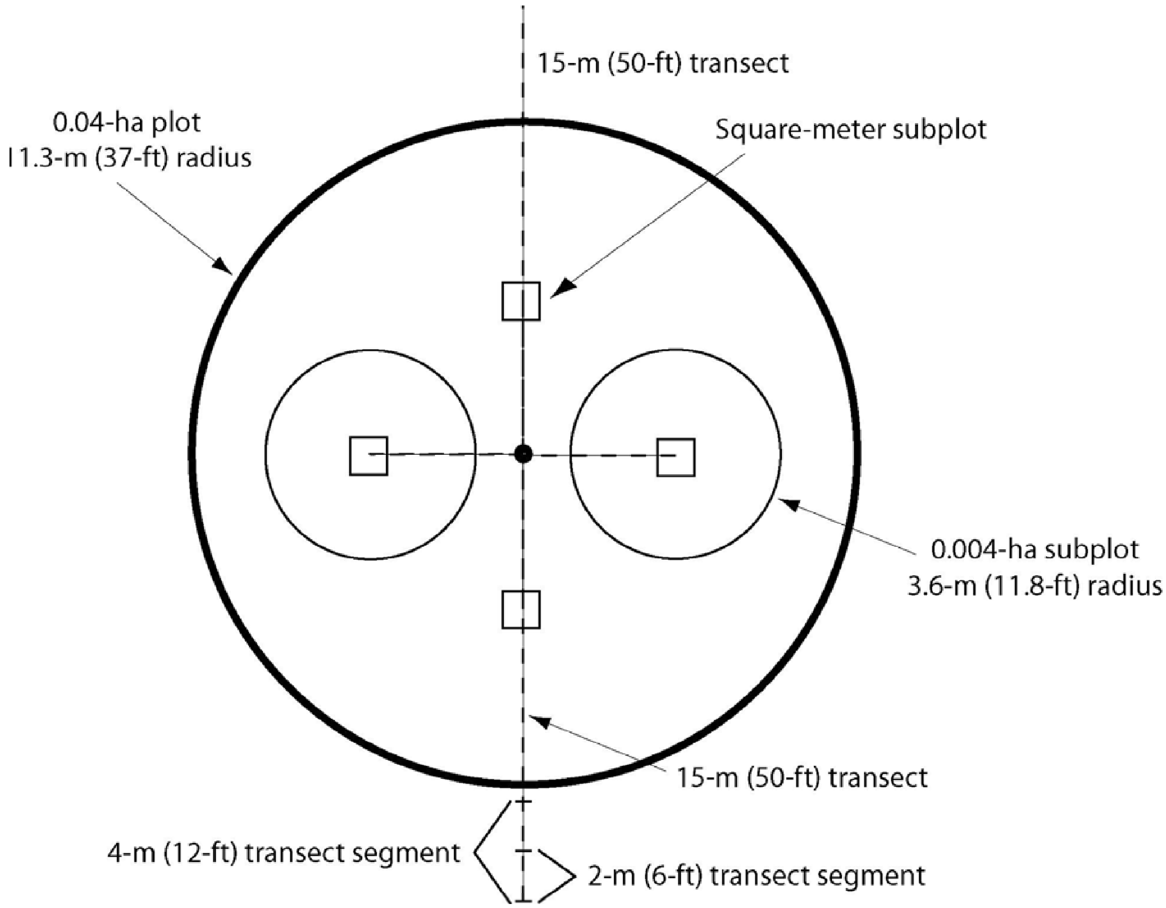
Prior to conducting field studies, review the checklist below to determine what field gear will be required and how many copies of each data form will be needed. It may be helpful to complete as much of the Project or Site Description Form (Appendix A1) as possible prior to going to the field, and for 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 handy to mark the plot center and anchor the tape for woody debris transects and for determining 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 or 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, note that you will need the supplemental field data form for recording 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	You'll need clipboards and 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.

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)	1
Data Form 1 - Tract and WAA-Level Variables (1 page). (Complete using maps, photos, hydrologic data, field reconnaissance, etc.)	1 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.)	1 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)



Layout of plots and transects for field sampling.

Appendix B
Field Data Forms

Contents

Appendix B1
Field Data Forms for Flat Wetlands

Data Form	Number of Pages	Title
1	1	Tract and Wetland Assessment Area – Level Data Collection
2	3	Plot-Level Data Collection
3	1	Wetland Assessment Area - Data Summary
Please reproduce forms for local use as needed.		

DATA FORM 1 (1 page) — TRACT AND WAA-LEVEL DATA COLLECTION
SUBCLASS: FLAT WETLANDS
WAA # __________
PLOT # __________

Complete one copy of this form for each Wetland Assessment Area.

Use aerial photos, project descriptions, and topographic 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 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: 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 #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: 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 suppression, high-grading, or other disturbances	**C:** Uncommon, minor, or shrub species in reference standard sites, but may dominate in degraded systems
Carya cordiformis	*Carya tomentosa*	*Carpinus caroliniana*
Fagus grandifolia	*Fraxinus pennsylvanica*	*Celtis occidentalis*
Pinus echinata	*Liquidambar styraciflua*	*Gleditsia triacanthos*
Quercus alba	*Pinus taeda*	*Juniperus virginiana*
Quercus pagoda	*Quercus nigra*	*Prunus serotina*
Quercus phellos		*Quercus falcata*
		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: 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 4 SUBPLOTS 1-M X 1-M SQUARE

From the centerpoint, measure 5 m in each cardinal direction and establish a 1-m × 1-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 feet 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 inch) and 2.54 cm (1 inch) 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 inch) and 7.6 cm (3 inches) 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 inches) 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: 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 8 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	_______ %
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 B2
Field Data Forms for Low-Gradient Riverine Wetlands

Data Form	Number of Pages	Title
1	1	Tract and Wetland Assessment Area – Level Data Collection
2	3	Plot-Level Data Collection
3	1	Wetland Assessment Area - Data Summary
Please reproduce forms for local use as needed.		

DATA FORM 1 (1 PAGE) — TRACT AND 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, and topographic 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} Flood frequency	Determine (or estimate) the frequency of flooding due to backwater or overbank flows from streams for sites within the 5-year floodplain.	Flood return interval = _____ (1 = annual flooding, 5 = once in 5 years)

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: 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 suppression, high-grading, or other disturbances	**C:** Uncommon, minor, or shrub species in reference standard sites, but may dominate in degraded systems
Betula nigra	*Acer saccharinum*	*Carpinus caroliniana*
Carya cordiformis	*Fraxinus pennsylvanica*	*Celtis laevigata*
Liquidambar styraciflua	*Platanus occidentalis*	*Gleditsia triacanthos*
Pinus taeda	*Quercus nigra*	*Prunus serotina*
Quercus nuttallii	*Ulmus americana*	
Quercus pagoda		
Quercus shumardii		
Taxodium distichum		
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 4 SUBPLOTS 1-M × 1-M SQUARE

From the centerpoint, measure 5 m in each cardinal direction and establish a 1-m × 1-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 feet 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 inch) and 2.54 cm (1 inch) 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 inch) and 7.6 cm (3 inches) 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 inches) 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}	Flood recurrence interval in the WAA (1 = annual, 5 = 1 year in 5)	________
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 B3
Field Data Forms for Mid-Gradient Riverine Wetlands

Data Form	Number of Pages	Title
1	1	Tract and Wetland Assessment Area – Level Data Collection
2	3	Plot-Level Data Collection
3	1	Wetland Assessment Area - Data Summary
Please reproduce forms for local use as needed.		

DATA FORM 1 (1 PAGE) — TRACT AND 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, and topographic maps (Appendix E) to complete the following section.

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
V_{FREQ} Flood frequency	Determine (or estimate) the frequency of flooding due to backwater or overbank flows from streams for sites within the 5-year floodplain.	Flood return interval = _____ (1 = annual flooding, 5 = once in 5 years)
V_{BUF30} Percent contiguous 30-m buffer	On a map or photo, outline a 30-m–wide buffer area around the wetland, but only on the side of the channel where the wetland occurs. Estimate the percentage of this area that is occupied by native vegetation or other appropriate habitat that is contiguous with the depression. 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 around the wetland, but only on the side of the channel where the wetland occurs. Estimate the percentage of this area that is occupied by native vegetation or other appropriate habitat that is contiguous with the depression. Enter the percentage at right.	Percent contiguous 250-m buffer = _______ %

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 suppression, high-grading, or other disturbances	**C:** Uncommon, minor, or shrub species in reference standard sites, but may dominate in degraded systems
Liriodendron tulipifera	*Carya cordiformis*	*Carpinus caroliniana*
Nyssa sylvatica	*Carya tomentosa*	*Cercis canadensis*
Pinus echinata	*Celtis laevigata*	*Crataegus spp.*
Quercus alba	*Fraxinus pennsylvanica*	*Ostrya virginiana*
Quercus shumardii	*Ilex opaca*	
Quercus rubra	*Liquidambar styraciflua*	
	Pinus taeda	
	Ulmus americana	

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 4 SUBPLOTS 1-M X 1-M SQUARE

From the centerpoint, measure 5 m in each cardinal direction and establish a 1-m × 1-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 feet 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 inch) and 2.54 cm (1 inch) 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 inch) and 7.6 cm (3 inches) 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 inches) 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_{FREQ}	Flood recurrence interval in the WAA (1= annual, 5 = 1 year in 5)									________
V_{BUF30}	Percent contiguous 30-m buffer									________%
V_{BUF250}	Percent contiguous 250-m buffer									________%
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 High-Gradient Riverine Wetlands

Data Form	Number of Pages	Title
1	1	Tract and Wetland Assessment Area – Level Data Collection
2	3	Plot-Level Data Collection
3	1	Wetland Assessment Area - Data Summary
Please reproduce forms for local use as needed.		

DATA FORM 1 (1 PAGE) — TRACT AND 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, and topographic maps (Appendix E) to complete the following section.

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
V_{FREQ} Flood frequency	Determine (or estimate) the frequency of flooding due to backwater or overbank flows from streams for sites within the 5-year floodplain.	Flood return interval = _____ (1 = annual flooding, 5 = once in 5 years)
V_{BUF30} Percent contiguous 30-m buffer	On a map or photo, outline a 30-m–wide buffer area around the wetland. Estimate the percentage of this area that is occupied by native vegetation or other appropriate habitat that is contiguous with the depression. 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 around the wetland. Estimate the percentage of this area that is occupied by native vegetation or other appropriate habitat that is contiguous with the depression. Enter the percentage at right.	Percent contiguous 250-m buffer = _______ %

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: 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

<table>
<tr><th colspan="3">Field Procedure</th></tr>
<tr><td colspan="3">(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.</td></tr>
<tr><td colspan="3">(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.</td></tr>
<tr><td>A: Common dominants in reference standard sites</td><td>B: Species commonly present in reference standard sites, but dominance generally indicates fire suppression, high-grading, or other disturbances</td><td>C: Uncommon, minor, or shrub species in reference standard sites, but may dominate in degraded systems</td></tr>
<tr><td>Fraxinus americana</td><td>Acer rubrum</td><td>Carpinus caroliniana</td></tr>
<tr><td>Pinus echinata</td><td>Carya texana</td><td>Ilex opaca</td></tr>
<tr><td>Pinus taeda</td><td>Carya tomentosa</td><td>Morus rubra</td></tr>
<tr><td>Quercus alba</td><td>Liquidambar styraciflua</td><td>Ostrya virginiana</td></tr>
<tr><td>Quercus rubra</td><td>Platanus occidentalis</td><td>Ulmus alata</td></tr>
<tr><td></td><td>Quercus alba</td><td></td></tr>
<tr><td></td><td>Quercus phellos</td><td></td></tr>
<tr><td></td><td>Quercus shumardii</td><td></td></tr>
<tr><td></td><td>Ulmus americana</td><td></td></tr>
<tr><th colspan="3">Calculations</th></tr>
<tr><td colspan="3">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 = _____ %</td></tr>
<tr><th>HGM Variable Addressed</th><th>Procedure (see Chapter 6 for details)</th><th>Indicator Value</th></tr>
<tr><td>V_{TCOMP}
V_{COMP}
Composition of woody vegetation strata</td><td>If tree cover is ≥ 20%, record % concurrence in the V_{TCOMP} and V_{COMP} rows as a plot value.
<u>OR</u>
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.</td><td>Percent concurrence:
V_{TCOMP} = _________%
V_{COMP} = __________%</td></tr>
</table>

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 4 SUBPLOTS 1-M X 1-M SQUARE

From the centerpoint, measure 5 m in each cardinal direction and establish a 1-m × 1-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 feet 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 inch) and 2.54 cm (1 inch) 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 inch) and 7.6 cm (3 inches) 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 inches) 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: 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_{FREQ}	Flood recurrence interval in the WAA (1= annual, 5 = 1 year in 5)									________
V_{BUF30}	Percent contiguous 30-m buffer									________%
V_{BUF250}	Percent contiguous 250-m buffer									________%
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 B5
Field Data Forms for Unconnected Depression Wetlands

Data Form	Number of Pages	Title
1	1	Tract and Wetland Assessment Area – Level Data Collection
2	3	Plot-Level Data Collection
3	1	Wetland Assessment Area - Data Summary
Please reproduce forms for local use as needed.		

DATA FORM 1 (1 PAGE) — TRACT AND WAA-LEVEL DATA COLLECTION
SUBCLASS: UNCONNECTED DEPRESSION WETLANDS
WAA # __________
PLOT # __________

Complete one copy of this form for each Wetland Assessment Area
Use field surveys, aerial photos, project descriptions, and topographic 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 around the depression. Estimate the percentage of this area that is occupied by native vegetation or other appropriate habitat that is contiguous with the depression. 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 around the depression. Estimate the percentage of this area that is occupied by native vegetation or other appropriate habitat that is contiguous with the depression. Enter the percentage at right.	Percent contiguous 250-m buffer = _______ %

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. (NOTE: shaded variables are not used if they cannot be accurately assessed due to inundation).

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: UNCONNECTED DEPRESSION 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. (NOTE: shaded variables are not used if they cannot be accurately assessed due to inundation).

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: UNCONNECTED DEPRESSION WETLANDS
WAA # __________
PLOT # __________

OBSERVATIONS WITHIN A 0.04-HA PLOT

<table>
<tr><th colspan="3">Field Procedure</th></tr>
<tr><td colspan="3">(1) If tree cover is ≥ 20%, use the 50/20 rule and circle the dominant trees in Columns A and B 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.</td></tr>
<tr><td colspan="3">(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 and B 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.</td></tr>
<tr><td colspan="2">A: Common dominants in reference standard sites</td><td>B: Species commonly present in reference standard sites, but dominance generally indicates heavy selective harvest, land abandonment, or other disturbances</td></tr>
<tr><td colspan="2">Acer saccharinum</td><td>Celtis laevigata</td></tr>
<tr><td colspan="2">Betula nigra</td><td>Liquidambar styraciflua</td></tr>
<tr><td colspan="2">Fraxinus pennsylvanica</td><td>Salix nigra</td></tr>
<tr><th colspan="3">Calculations</th></tr>
<tr><td colspan="3">Using the dominant species circled in Columns A and B 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) / total number of circled dominants in all columns} × 100 = _____ %</td></tr>
<tr><th>HGM Variable Addressed</th><th>Procedure (see Chapter 6 for details)</th><th>Indicator Value</th></tr>
<tr><td>V_{TCOMP}
V_{COMP}
Composition of woody vegetation strata</td><td>If tree cover is ≥ 20%, record % concurrence in the V_{TCOMP} and V_{COMP} rows as a plot value.
<u>OR</u>
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.</td><td>Percent concurrence:

V_{TCOMP} = _________%
V_{COMP} = __________%</td></tr>
</table>

DATA FORM 2 (3 PAGES) — PLOT-LEVEL DATA COLLECTION
SUBCLASS: UNCONNECTED DEPRESSION 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 4 SUBPLOTS 1-M × 1-M SQUARE

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

V_{GVC} Ground vegetation cover	Estimate the percent cover of all herbaceous plants and woody plants < 4.5 feet 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 inch) and 2.54 cm (1 inch) 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 inch) and 7.6 cm (3 inches) 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 inches) 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: UNCONNECTED DEPRESSION 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_{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_{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 B6
Field Data Forms for Connected Depression Wetlands

Data Form	Number of Pages	Title
1	1	Tract and Wetland Assessment Area – Level Data Collection
2	3	Plot-Level Data Collection
3	1	Wetland Assessment Area - Data Summary
Please reproduce forms for local use as needed.		

DATA FORM 1 (1 PAGE) — TRACT AND WAA-LEVEL DATA COLLECTION
SUBCLASS: CONNECTED DEPRESSION WETLANDS
WAA # __________
PLOT # __________

Complete one copy of this form for each Wetland Assessment Area
Use field surveys, aerial photos, project descriptions, and topographic maps (Appendix E) to complete the following section.

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
V_{FREQ} Flood frequency	Determine (or estimate) the frequency of flooding due to backwater or overbank flows from streams for sites within the 5-year floodplain.	Flood return interval = _____ (1 = annual flooding, 5 = once in 5 years)
V_{BUF30} Percent contiguous 30-m buffer	On a map or photo, outline a 30-m–wide buffer area around the depression. Estimate the percentage of this area that is occupied by native vegetation or other appropriate habitat that is contiguous with the depression. 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 around the depression. Estimate the percentage of this area that is occupied by native vegetation or other appropriate habitat that is contiguous with the depression. Enter the percentage at right.	Percent contiguous 250-m buffer = _______ %

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.
(NOTE: shaded variables are not used if they cannot be accurately assessed due to inundation).

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: CONNECTED DEPRESSION 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. (NOTE: shaded variables are not used if they cannot be accurately assessed due to inundation).

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: CONNECTED DEPRESSION 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 and B 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 and B 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 heavy selective harvest, land abandonment, or other disturbances
Acer saccharinum	*Celtis laevigata*
Betula nigra	*Liquidambar styraciflua*
Fraxinus pennsylvanica	*Salix nigra*
Platanus occidentalis	
Calculations	
Using the dominant species circled in Columns A and B 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) / 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: CONNECTED DEPRESSION 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 4 SUBPLOTS 1-m × 1-m SQUARE

From the centerpoint, measure 5 m in each cardinal direction and establish a 1-m × 1-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 feet 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 inch) and 2.54 cm (1 inch) 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 inch) and 7.6 cm (3 inches) 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 inches) 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: CONNECTED DEPRESSION 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}	Flood recurrence interval in the WAA (1= annual, 5 = 1 year in 5)								________
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 B7
Field Data Forms for Slope Wetlands

Data Form	Number of Pages	Title
1	1	Tract and Wetland Assessment Area – Level Data Collection
2	3	Plot-Level Data Collection
3	1	Wetland Assessment Area - Data Summary
Please reproduce forms for local use as needed.		

DATA FORM 1 (1 PAGE) — TRACT AND WAA-LEVEL DATA COLLECTION
SUBCLASS: SLOPE WETLANDS
WAA # __________
PLOT # __________

Complete one copy of this form for each Wetland Assessment Area
Use field surveys, aerial photos, project descriptions, and topographic 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 around the depression. Estimate the percentage of this area that is occupied by native vegetation or other appropriate habitat that is contiguous with the depression. 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 around the depression. Estimate the percentage of this area that is occupied by native vegetation or other appropriate habitat that is contiguous with the depression. Enter the percentage at right.	Percent contiguous 250-m buffer = _______ %

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_{GCOMP} Ground vegetation composition	Count the number of indicator fern species present that account for at least 10% ground cover. Indicator species include cinnamon fern, royal fern, and sensitive fern.	Number of fern species = ______
V_{OUT} Surface water outflow	Inspect the downslope edge of the wetland for evidence of water discharge to other wetlands or streams (small surface channels, hydrophytic vegetation, etc.). Enter “0” if no evidence of outflow exists; enter “0.5” if seasonal or intermittent outflow occurs; enter “1” if evidence of perennial outflow is present.	Ouflow 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: SLOPE 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. (NOTE: shaded variables are not used if they cannot be accurately assessed due to inundation.)

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 m²/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 = ______m²/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: SLOPE 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 and B 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 and B 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 heavy selective harvest, land abandonment, or other disturbances
Acer rubrum	*Carpinus caroliniana*
Liquidambar styraciflua	*Diospyros virginiana*
Magnolia tripetala	*Ilex opaca*
Nyssa sylvatica	*Juniperus virginiana*
Quercus alba	*Planera aquatica*
Quercus rubra	*Platanus occidentalis*
Taxodium distichum	*Sassafras albidum*
	Ulmus serotina

Calculations
Using the dominant species circled in Columns A and B 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) / 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. <u>OR</u> 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: SLOPE 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 4 SUBPLOTS 1-M × 1-M SQUARE

From the centerpoint, measure 5 m in each cardinal direction and establish a 1-m × 1-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 feet 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 inch) and 2.54 cm (1 inch) 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 inch) and 7.6 cm (3 inches) 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 inches) 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: SLOPE 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_{GCOMP}	Ground vegetation composition	____# fern spp
V_{OUT}	Surface water outflow	_____outflow index
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

Please reproduce these forms locally as needed.

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

SUBCLASS: ______________________

WAA # ___________

PLOT # ___________

If you are not using a basal area prism or similar tool to estimate tree basal area for the V_{TBA} variable, but instead are measuring individual tree diameters, 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 in case you wish to sum individual basal areas of each species to develop a more accurate estimate of V_{TCOMP} than the reconnaissance-level sample provides. You can also count the trees in 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 C1 (1 PAGE) — BASAL AREA DETERMINATION USING DIAMETER MEASUREMENTS

SUBCLASS: _______________

WAA # __________

PLOT # __________

If you 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, you can calculate the same summary data 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 inches) 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 =**	

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 *http://el.erdc.usace.army.mil/wetlands/datanal.html*

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} calculations, 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**

Figure D1. 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 Total Stem Count	Size Class 1 tons/acre	Size Class 2 No. of Stems/ 3.65 m Transect		Size Class 2 Total Stem Count	Size Class 2 tons/acre
	Transect 1	Transect 2			Transect 1	Transect 2		
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 Diameter² (in)		Size Class 3 Stem Diameters (cm) 15.25 m Transect		Size Class 3 Stem Diameter² (in)		Size Class 3 Stem Diameters (cm) 15.25 m Transect		Size Class 3 Stem Diameter² (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 Diameter² (in)		Size Class 3 Stem Diameters (cm) 15.25 m Transect		Size Class 3 Stem Diameter² (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

Figure D2. Example of the input form used in the woody debris calculation spreadsheet

	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

Figure D2. Example of the input form used in the woody debris calculation spreadsheet (concluded)

FCI and FCU Calculations for the Flats Regional Subclass in the Arkansas Ouachita Mountains and Crowley's Ridge Regions
(Version of 10/2005)

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	%	N/A
V_{BUF250}	N/A	%	N/A
V_{COMP}		%	
V_{FREQ}	N/A	years	N/A
V_{GCOMP}	N/A	# species	N/A
V_{GVC}		%	
V_{LITTER}		%	
V_{LOG}		m^3 / ha	
V_{OHOR}		cm	
V_{OUT}	N/A	discharge frequency	N/A
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	N/A	N/A
Maintain Plant Communities		
Provide Wildlife Habitat		

Figure D3. Example input form used in the FCI/FCU calculator spreadsheet

Appendix E
Spatial Data

The following digital spatial data pertinent to the Ouachita Mountains and Crowley's Ridge Regions 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

All of this information can be downloaded from the ERDC website at *http://el.erdc.usace.army.mil/publications.cfm?Topic=techreport&Code=emrrp*

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

Common Name	**Scientific Name**
Red maple	*Acer rubrum*
Silver maple	*Acer saccharinum*
Sugar maple	*Acer saccharum*
Alder	*Alnus* spp.
River birch	*Betula nigra*
Ironwood	*Carpinus caroliniana*
Bitternut hickory	*Carya cordiformis*
Shagbark hickory	*Carya ovata*
Black hickory	*Carya texana*
Mockernut hickory	*Carya tomentosa*
Sugarberry	*Celtis laevigata*
Hackberry	*Celtis occidentalis*
Buttonbush	*Cephalanthus occidentalis*
Redbud	*Cercis canadensis*
Hawthorn	*Crataegus* spp.
Persimmon	*Diospyros virginiana*
Three-way sedge	*Dulichium arundinaceum*
Common horsetail	*Equisetum hyemale*
Beech	*Fagus grandifolia*
White ash	*Fraxinus americana*
Green ash	*Fraxinus pennsylvanica*
Honey locust	*Gleditsia triacanthos*
Witch hazel	*Hamamelis virginiana*
Witch hazel	*Hamamelis vernalis*
American holly	*Ilex opaca*
Butternut	*Juglans cinerea*
Eastern red cedar	*Juniperus virginiana*
Spicebush	*Lindera benzoin*
Sweetgum	*Liquidambar styraciflua*
Yellow poplar	*Liriodendron tulipifera*

Common Name	Scientific Name
Bigleaf magnolia	*Magnolia macrophylla*
Umbrella magnolia	*Magnolia tripetela*
Red mulberry	*Morus rubra*
Blackgum	*Nyssa sylvatica*
Cinnamon fern	*Osmunda cinnamomea*
Royal fern	*Osmunda regalis*
Hop hornbeam	*Ostrya virginiana*
Shortleaf pine	*Pinus echinata*
Loblolly pine	*Pinus taeda*
Water elm	*Planera aquatica*
Sycamore	*Platanus occidentalis*
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*
Nuttall oak	*Quercus nuttallii*
Cherrybark oak	*Quercus pagoda*
Pin oak	*Quercus palustris*
Willow oak	*Quercus phellos*
Northern red oak	*Quercus rubra*
Shumard oak	*Quercus shumardii*
Post oak	*Quercus stellata*
Black oak	*Quercus velutina*
Black willow	*Salix nigra*
Sassafras	*Sassafras albidum*
Saltmarsh cordgrass	*Spartina alterniflora*
Sphagnum moss	*Sphagnum* spp.
Baldcypress	*Taxodium distichum*
Basswood	*Tilia americana*
Winged elm	*Ulmus alata*
American elm	*Ulmus americana*
Highbush blueberry	*Vaccinium arboreum*
Netted chain fern	*Woodwardia aereolata*

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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 depressional wetlands in the Ouachita Mountains the Crowley's Ridge Regions of Arkansas in a planning and ecosystem restoration context.

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Functional assessment	National Action Plan	Wetland function
Geomorphology	Ouachita Mountains	Wetland restoration
Hydrogeomorphic (HGM) approach	Reference wetlands	