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A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Wetlands in the West Gulf Coastal Plain Region of Arkansas

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

August 2005

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ABSTRACT: The Hydrogeomorphic (HGM) Approach is a method for developing and applying indices for the site-specific assessment of wetland functions. The HGM Approach was initially designed to be used in the context of the Clean Water Act Section 404 Regulatory Program permit review process 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 design of wetland restoration projects and management of wetlands.

This Regional Guidebook presents the HGM Approach for assessing the functions of most of the wetlands that occur in the West Gulf Coastal Plain Region of Arkansas. The report begins with an overview of the HGM Approach and then classifies and characterizes the principal wetlands that have been identified within the Coastal Plain Region of Arkansas. Detailed HGM assessment models and protocols are presented for nine of those wetland types, or subclasses, representing all of the forested wetlands in the region other than those associated with lakes and impoundments. The following wetland subclasses are treated in detail: Pine Flat, Hardwood Flat, Low-gradient Riverine Backwater, Low-gradient Riverine Overbank, Mid-gradient Riverine, Unconnected Depression, Connected Depression, Bayhead, and Seep. For each wetland subclass, the guidebook presents (a) the rationale used to select the wetland functions considered in the assessment process, (b) the rationale used to select assessment model variables, (c) the rationale used to develop assessment models, and (d) the functional index calibration curves developed from reference wetlands that are used in the assessment models. The guidebook outlines an assessment protocol for using the model variables and functional indices to assess each of the wetland subclasses. The appendices provide field data collection forms, spreadsheets for making calculations, and a variety of supporting spatial data intended for use in the context of a Geographic Information System.

Corps of Engineers Research Report Summary, August 2005

Assessing Wetland Functions

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)

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 the "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 assessing the functions of forested wetlands in the West Gulf Coastal Plain Region of Arkansas.

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 U.S. Environmental Protection Agency, which provided funding through the Wetland Grants 104(b)(3) program for States, Tribes, and Local Governments. Charles V. Klimas (Charles Klimas & Associates, Inc.) directed the field studies and prepared the guidebook manuscript, under contract to the Arkansas Game and Fish Commission MAWPT Coordination Office. Elizabeth O. Murray (MAWPT Coordinator, Arkansas Game and Fish Commission) prepared most of the figures. All of the persons listed as authors of this guidebook were involved in every aspect of the project, including classification, field sampling and model testing, and otherwise contributed materially to production of the document. The affiliations of the other authors are as follows: Thomas Foti (Arkansas Natural Heritage Commission), Jody Pagan (Natural Resources Conservation Service), and Henry Langston (Arkansas State Highway and Transportation Department). Other representatives of the MAWPT member agencies provided technical oversight for the project, and together with other organizations, participated in the field studies, and in the workshops that produced the wetland classification system, community characterizations, and assessment models used in this document. Ms. D.J. Klimas 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), Rob Holbrook (Arkansas Game and Fish Commission), Joe Krystofik (formerly of 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), Bill Richardson (Arkansas State Highway and Transportation Department), and Theo Wittsell (Arkansas Natural Heritage Commission). Ken Brazil, Tom Foti, and Elizabeth Murray provided administrative continuity and coordination among participating and funding agencies, in addition to their direct technical participation.

This report was prepared in accordance with guidelines established by the U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, Mississippi. It is published by ERDC as part of the HGM Guidebook series issued under the Ecosystem Management and Restoration Research Program (EMRRP). Mr. Chris V. Noble, Wetlands and Coastal Ecology Branch, Ecosystem Evaluation and Engineering Division, Environmental Laboratory, ERDC, reviewed the report for consistency with HGM guidelines. In addition, the methods and protocols used to prepare this report were closely coordinated with a study undertaken in the Delta Region of Mississippi (the Yazoo Basin). Therefore, portions of the text and some figures are similar or identical to sections of the Yazoo Basin Guidebook ("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, ERDC/EL TR-02-4, U.S. Army Engineer Research and Development Center, Vicksburg, MS). Note also that the Western Kentucky Regional Guidebook ("A Regional Guidebook for Assessing the Functions of Low Gradient, Riverine Wetlands of Western Kentucky," by W. B. Ainslie et al. 1999, Technical Report WRP-DE-17, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS) served as a template for the development of both this and the Yazoo Basin document. The wildlife section in the Western Kentucky document, authored by Tom Roberts (Tennessee Technological University) was particularly helpful, and portions of that document are included here.

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 was initially 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), U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), Federal Highway Administration (FHWA), and U.S. Fish and Wildlife Service (USFWS). The Action Plan, available online at *http://www.epa.gov/OWOW/wetlands/science/hgm.html*, outlines a strategy for developing Regional Guidebooks throughout the United States, provides guidelines and a specific set of tasks required to develop a Regional Guidebook under the HGM Approach, and solicits the cooperation and participation of Federal, State, and local agencies, academia, and the private sector.

This report is a Regional Guidebook developed for assessing the most common types of wetlands that occur in the Coastal Plain region of Arkansas. Normally, a Regional Guidebook focuses on a single regional wetland subclass (the term for wetland types in HGM terminology); however, a different approach has been employed in this Regional Guidebook: multiple regional wetland subclasses are considered. The rationale for this approach is that various wetland subclasses are highly interspersed in the Coastal Plain landscape, and it is most sensible to deal with their classification and assessment in a single integrated Regional Guidebook. This does not mean that wetlands of different hydrogeomorphic classes and regional wetland subclasses are lumped for assessment purposes, but rather that the factors influencing their functions and the indicators employed in their evaluation are best developed and presented in a unified manner.

This Regional Guidebook addresses various objectives:

- To characterize selected regional wetland subclasses in the Coastal Plain region of Arkansas.

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

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

- To present the rationale used to develop assessment models.

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

This report is organized in the following manner. Chapter 1 provides the background, objectives, and organization of the document. Chapter 2 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 Coastal Plain region of Arkansas included in this guidebook. Chapter 4 discusses the wetland functions, assessment variables, and functional indices used in the guidebook from a generic perspective. Chapter 5 applies the assessment models to specific regional wetland subclasses and defines the relationship of assessment variables to reference data. Chapter 6 outlines the assessment protocol for conducting a functional assessment of regional wetland subclasses in the Coastal Plain region of Arkansas. Appendix A presents project documentation and field sampling guidance. Field data forms are presented in Appendix B. Appendix C contains alternate field forms, and Appendix D contains demonstration printouts of spreadsheets used to summarize the field data. Common and scientific names of plant species referenced in the text and data forms are listed in Appendix E.

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

2 Overview of the Hydrogeomorphic Approach

Development and Application Phases

The HGM Approach is conducted in two phases: Development and Application. An interdisciplinary Assessment Team of experts carries out the Development Phase, which results in production of a Regional Guidebook that presents a set of models and protocols to be used in assessing 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).

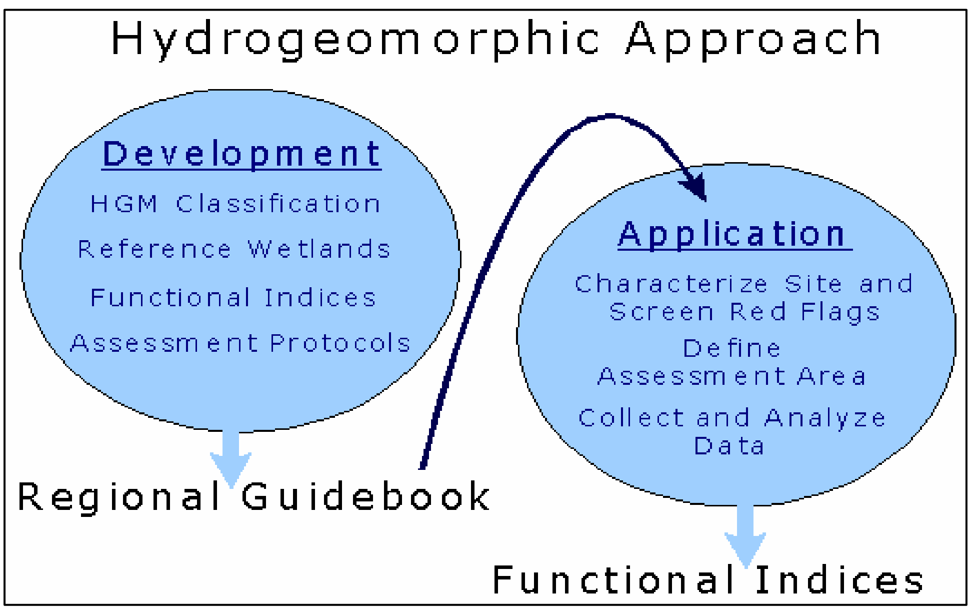


Figure 1. Development and application phases of the HGM approach (from Ainslie et al. 1999)

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 the team is trained, its first task is to classify the wetlands of the region of interest into regional wetland subclasses using the principles and criteria of Hydrogeomorphic Classification (Brinson 1993a; Smith et al. 1995). Next, focusing on a specific regional wetland subclass, the team develops an ecological characterization or functional profile of the subclass. The Assessment Team then identifies the important wetland functions, conceptualizes assessment models, identifies assessment variables to represent the characteristics and processes that influence each function, and defines metrics for quantifying assessment variables. Next, reference wetlands are identified to represent the range of variability exhibited by the regional subclass, and field data are collected and used to calibrate assessment variables and indices 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.
- Analyze field data.

The second step involves applying the results of the assessment at various decision-making points in the planning or permit review sequence, such as alternatives 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 in the following paragraphs. More extensive treatment of these components can be found in Brinson (1993a,b; 1995, 1996), Brinson et al. (1995, 1996, 1998), Hauer and Smith (1998), and Smith et al. (1995).

Hydrogeomorphic Classification

Wetland ecosystems share a number of common attributes, including hydrophytic vegetation, hydric soils, and relatively long periods of inundation or saturation. 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 (Mitch and Gosselink 1993; Semeniuk 1987). The variability of wetlands makes it challenging to develop assessment methods that are both accurate (i.e., sensitive to significant changes in function) and practical (i.e., can be completed in the relatively short time frame normally available for conducting assessments). "Generic" wetland assessment methods have been developed to assess multiple wetland types throughout the United States. In general these methods can be applied quickly, but lack the resolution necessary to detect significant changes in function. One way to achieve an appropriate level of resolution within a limited time frame is to employ a wetland classification system structured 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 development of assessment indices that can be applied rapidly, yet retain the sensitivity necessary to detect changes in function necessary for wetland permit review and other applications. In order to reduce both inter- and intraregional variability, the three classification criteria must be applied at a smaller, regional geographic scale, thus creating regional wetland subclasses. In many parts of the country, existing wetland classifications can serve as a starting point for identifying these regional subclasses (Stewart and Kantrud 1971; Golet and Larson 1974; Wharton et al. 1982). Regional subclasses, like the continental scale wetland classes, are distinguished on the basis of geomorphic setting, water source, and hydrodynamics. Examples of potential regional subclasses are shown in Table 2. In addition, certain ecosystem or landscape characteristics may be useful for distinguishing regional subclasses. For example, depression subclasses might be based on water source (i.e., groundwater versus surface water) or the degree of connection between the wetland and other surface waters (i.e., the flow of surface water in or out of the depression through defined channels). Tidal fringe subclasses might be based on salinity gradients (Shafer and Yozzo 1998). Slope subclasses might be based on the degree of slope or landscape position. Riverine subclasses might be based on position in the watershed, stream order, watershed size, channel gradient, or floodplain width. Regional Guidebooks include a thorough characterization of the regional wetland subclass in terms of geomorphic setting, water sources, hydrodynamics, vegetation, soil, and other features that were taken into consideration during the classification process.

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 riverflow becomes the dominant water source. Additional water sources may be groundwater discharge and precipitation. Because tidal fringe wetlands are frequently flooded and water table elevations are controlled mainly by sea surface elevation, tidal fringe wetlands seldom dry for significant periods. Tidal fringe wetlands lose water by tidal exchange, by overland flow to tidal creek channels, and by evapotranspiration. Organic matter normally accumulates in higher elevation marsh areas where flooding is less frequent and the wetlands are isolated from shoreline wave erosion by intervening areas of low marsh or dunes. *Spartina alterniflora* salt marshes are a common example of tidal fringe wetlands.
Lacustrine Fringe	Lacustrine fringe wetlands are adjacent to lakes where the water elevation of the lake maintains the water table in the wetland. Additional sources of water are precipitation and groundwater discharge, the latter dominating where lacustrine fringe wetlands intergrade with uplands or slope wetlands. Surface water flow is bidirectional. Lacustrine wetlands lose water by evapotranspiration and by flow returning to the lake after flooding. Organic matter may accumulate in areas sufficiently protected from shoreline wave erosion. Unimpounded marshes bordering the Great Lakes are an example of lacustrine fringe wetlands.
Slope	Slope wetlands are found in association with the discharge of groundwater to the land surface or on sites with saturated overland flow 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 by evapotranspiration. They may develop channels, but the channels serve only to convey water away from the slope wetland. Slope wetlands are distinguished from depression wetlands by the lack of a closed topographic depression and the predominance of the groundwater/interflow water source. Fens are a common example of slope wetlands
Mineral Soil Flats	Mineral soil flats are most common on interfluves, extensive relic lake bottoms, or large alluvial terraces where the main source of water is precipitation. They receive virtually no groundwater discharge, which distinguishes them from depressions and slopes. Dominant hydrodynamics are vertical fluctuations. Mineral soil flats lose water by evapotranspiration, overland flow, and seepage to underlying groundwater. They are distinguished from flat non-wetland areas by their poor vertical drainage due to impermeable layers (e.g., hardpans), slow lateral drainage, and low hydraulic gradients. Pine flatwoods with hydric soils are an example of mineral soil flat wetlands.

(Continued)

Table 1 (Concluded)	
HGM Wetland Class	**Definition**
Organic Soil Flats	Organic soil flats, or extensive peatlands, differ from mineral soil flats in part because their elevation and topography are controlled by vertical accretion of organic matter. They occur commonly on flat interfluves, but may also be located where depressions have become filled with peat to form a relatively large flat surface. Water source is dominated by precipitation, while water loss is by overland flow and seepage to underlying groundwater. They occur in relatively humid climates. Raised bogs share many of these characteristics but may be considered a separate class because of their convex upward form and distinct edaphic conditions for plants. Portions of the Everglades and northern Minnesota peatlands are examples of organic soil flat wetlands.
Riverine	Riverine wetlands occur in floodplains and riparian corridors in association with stream channels. Dominant water sources are overbank or backwater flow from the channel. Additional sources may be interflow, overland flow from adjacent uplands, tributary inflow, and precipitation. When overbank flow occurs, surface flows down the floodplain may dominate hydrodynamics. In headwaters, riverine wetlands often intergrade with 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 floodplains are examples of riverine wetlands.

Table 2
Potential Regional Wetland Subclasses in Relation to Classification Criteria

Classification Criteria			Potential Regional Wetland Subclasses	
Geomorphic Setting	**Dominant Water Source**	**Dominant Hydrodynamics**	**Eastern USA**	**Western USA/Alaska**
Depression	Groundwater or interflow	Vertical	Prairie pothole marshes, Carolina bays	California vernal pools
Fringe (tidal)	Ocean	Bidirectional, horizontal	Chesapeake Bay and Gulf of Mexico tidal marshes	San Francisco Bay marshes
Fringe (lacustrine)	Lake	Bidirectional, horizontal	Great Lakes marshes	Flathead Lake marshes
Slope	Groundwater	Unidirectional, horizontal	Fens	Avalanche chutes
Flat (mineral soil)	Precipitation	Vertical	Wet pine flatwoods	Large playas
Flat (organic soil)	Precipitation	Vertical	Peat bogs; portions of Everglades	Peatlands over permafrost
Riverine	Overbank flow from channels	Unidirectional, horizontal	Bottomland hardwood forests	Riparian wetlands
Note: adapted from Smith et al. 1995, Rheinhardt et al. 1997.				

Reference Wetlands

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

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

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

Table 3
Reference Wetland Terms and Definitions

Term	Definition
Reference Domain	The geographic area from which reference wetlands representing the regional wetland subclass are selected (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.

In forested wetland systems of the Coastal Plain region of Arkansas, the concept of "reference standard" varies with the type of community being assessed. In hardwood forests that aren't strongly influenced by fire, the reference standard is a mature stand that has all of the major living and detrital components present, and regeneration is usually by "gap phase" processes. This means that most tree reproduction occurs in small forest openings created by the death of individual large trees, which promotes an uneven-aged forest structure. In fire-controlled systems, the reference standard condition is one where fire frequency and intensity are sufficient to maintain an open-canopy, savanna-like forest that includes characteristic ground-cover species.

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. Application of assessment models results in a Functional Capacity Index (FCI) ranging from 0.0 to 1.0. Wetlands with an FCI of 1.0 perform the assessed function at a level that is characteristic of reference standard wetlands. A lower FCI indicates that the wetland is performing a function at a level below the level that is characteristic of reference standard wetlands.

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

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

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

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

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

1.0 is assigned for assessment models where tree density is a component. 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.

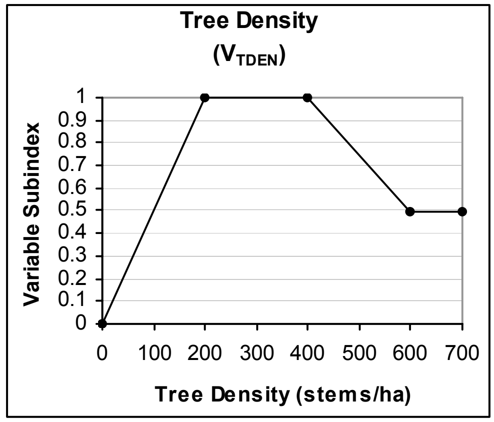


Figure 2. Example subindex graph for the Tree Density (V_{TDEN}) assessment variable for a particular wetland subclass

Assessment Protocol

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

3 Characterization of Wetland Subclasses in the Coastal Plain Region of Arkansas

Reference Domain

The reference domain for this guidebook (i.e., the area from which reference data were collected and to which the guidebook can be applied) is the Coastal Plain region of Arkansas. The Coastal Plain is in the southwestern and southcentral parts of the state, bounded on the north by the Ouachita Mountains and on the east by the alluvial valley of the Mississippi River (the Delta region). For the purposes of this report, the study area generally conforms to the boundaries of the Coastal Plain Wetland Planning Region (Figure 3) established by MAWPT (1997). Because the Wetland Planning Regions reflect hydrologic divides as well as physiography, some minor boundary adjustments were made to emphasize physiographic consistency within the study area.

Most wetlands in the Coastal Plain region occur on stream-deposited sediments, including ancient alluvial terraces that sometimes extend far from modern major river valleys. The relative ages and elevations of recent stream deposits and older terraces are strongly predictive of the types of wetland communities that occur on them. Certain wetland types are associated with non-alluvial surfaces in upland areas, particularly where the dip and composition of subsurface geology causes groundwater discharge at the surface. In addition to these basic controls on wetland distribution, composition, and structure, factors such as soil chemistry and fire can have significant effects on wetlands within the Coastal Plain. The following sections review major concepts that have bearing on the distribution, characteristics, classification, and functions of wetlands in the modern landscape of the Coastal Plain region of Arkansas. Descriptions of the wetland classes and subclasses that occur in the Coastal Plain and guidelines for recognizing them in the field are presented as the final section of this chapter.

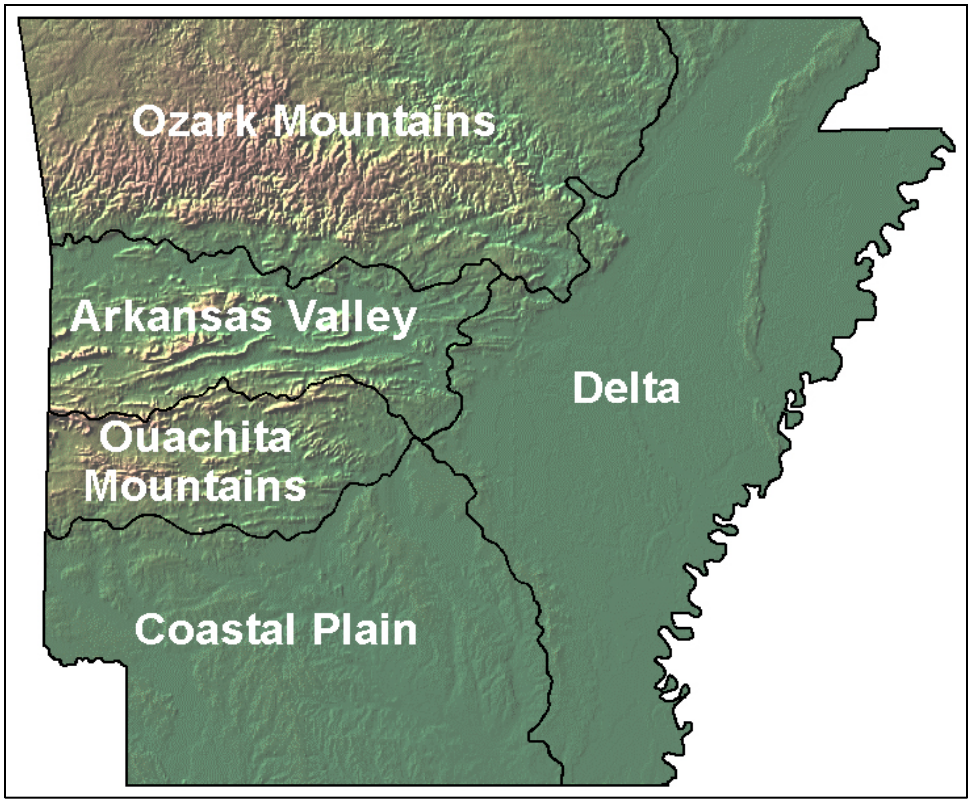


Figure 3. Wetland planning regions of Arkansas (from MAWPT 1997)

Physiography and Climate

The upland landscape of the Coastal Plain region of Arkansas is a gently rolling plain composed primarily of marine and nearshore deposits of various thicknesses, with a general tilt southward. It generally lacks the dramatic uplifted and folded topography of the Ouachita Mountains to the north.

Numerous small and moderate-sized stream systems and several major river valleys dissect the upland landscape. The larger river valleys are composed of alluvial landforms, some of which are similar to the lowlands of the Delta region to the east, while others are unique to the Coastal Plain region. Within Arkansas, transitions from the Coastal Plain to both the Ouachita Mountains and the Delta are typically abrupt.

Climate within the Coastal Plain region of Arkansas is humid subtropical, with temperate winters and long hot summers. Prevailing southerly winds carry moisture from the Gulf Coast, creating high humidity levels and a high incidence of thunderstorms. Tornadoes and ice storms occur commonly in the area; snow falls occasionally, but does not persist. Daily mean temperatures at Camden, which is centrally located within the region, range from a low in January of 41.7 °F (5.3 °C) to a high of 80.3 °F (26.8 °C) in July, with an overall annual average of 62.5 °F (16.9 °C). Daily average maximum temperatures are 92.5 °F (33.6 °C) in July and 52.9 °F (11.6 °C) in January. Average annual precipitation is 53.05 in. (134.7 cm), with the most precipitation falling in November (5.23 in. or 13.9 cm) and the least in August (2.92 inches or 7.4 cm). Temperature and precipitation patterns elsewhere in the region are similar to these (Southern Regional Climate Center 2003).

Drainage System and Hydrology

The Coastal Plain region of Arkansas is dominated by two major drainage systems: the Red River in the southwestern corner of the state (drainages shown in red on Figure 4), and the Ouachita River system, which includes the Saline and Little Missouri Rivers, in the eastern and north-central parts of the region (Drainages shown in blue on Figure 4). Most of the smaller streams in the region eventually drain to one of these major rivers, and most are confluent within the borders of Arkansas. The Ouachita River enters the Red River in southeastern Louisiana, very near the confluence of the Red and the Mississippi Rivers. Streams shown in green on Figure 4 occur on Coastal Plain deposits but drain to the Arkansas River or Bayou Bartholomew in the Delta Wetland Planning Region.

The Red River arises in the High Plains of New Mexico and West Texas and flows eastward forming the boundary between Oklahoma and Texas. Less than 150 miles west of Arkansas, the Red River is impounded as Lake Texoma by Dennison Dam, which modifies flows downstream. Upon reaching Arkansas, the Red River continues generally eastward for about 35 miles until it reaches Fulton, where it abruptly turns and flows southward into Louisiana, about 40 miles distant. The Red River has a fairly limited drainage basin within Arkansas. Most of the local drainage originates in the southwestern Ouachita Mountains, where the Cossatot and Saline[1] Rivers, and a number of smaller streams, carry their flows to the Little River, which is confluent with the Red River near Fulton. The largest reservoir in the Arkansas Coastal Plain, Millwood Lake, is on the Little River not far from Fulton. Below Fulton, the Sulphur River is the principal tributary on the west. Most of the drainage on the east side of the basin is funneled to the Red River in Louisiana via Bodcau and Dorcheat Bayous.

The rest of the Arkansas Coastal Plain region drains to the Red River via the Ouachita River. The Ouachita has its headwaters in the Ouachita Mountains near the Oklahoma border. It flows southeast, passing through two reservoirs (Lake Ouachita and Lake Hamilton) before entering the Coastal Plain at Malvern, where it travels southwest to Arkadelphia before turning again to the southeast. A major mountain tributary, the Caddo River, is also confined within a reservoir (DeGray Lake) before joining the mainstem Ouachita River just upstream of Arkadelphia. The Ouachita River then meanders across the entire Coastal Plain and enters Louisiana near Felsenthal, Arkansas. Below Camden, there are two lock-and-dam pools maintained on the Ouachita River within Arkansas as part of a 322-mile navigation system, the Ouachita-Black Rivers Navigation Project.

[1] Note that there are two Saline Rivers in the Coastal Plain Region of Arkansas. This, the smaller stream, will be identified specifically as a tributary to the Red River whenever it is mentioned in this document. Any other reference to the Saline River concerns the larger stream that is a tributary to the Ouachita River.

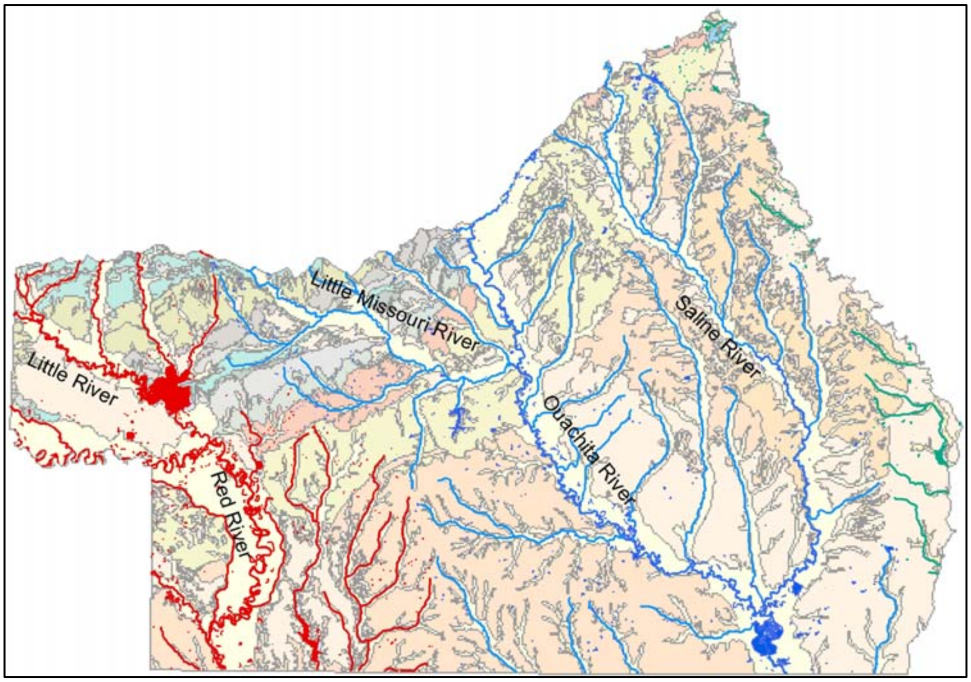


Figure 4. Drainage network of the Arkansas Coastal Plain region

Two major tributaries pick up the flows of smaller streams and are confluent with the Ouachita within the Coastal Plain. The Little Missouri River arises in the western Ouachita Mountains, is impounded as Lake Greeson just before entering the Coastal Plain, and joins the Ouachita River about 15 miles north of Camden. The Saline River has its headwaters in the eastern Ouachita Mountains and flows through the eastern part of the Coastal Plain until it enters the Ouachita River just 10 miles north of the Louisiana border. A small area south of El Dorado is drained by a stream network that flows southward into Louisiana and eventually into the Ouachita River.

The extreme eastern edge of the Coastal Plain is drained by small streams that flow eastward into the Delta region to the Arkansas River near Little Rock and Bayou Bartholomew, which flows south to join the Ouachita in Louisiana.

Ground water is a complex and important component of the hydrologic system in the Arkansas Coastal Plain region. Several types of aquifers are represented in the major outcropping water-yielding geologic units. Most extensive is the Mississippi Embayment aquifer system, which consists of overlapping bands of poorly consolidated to unconsolidated bedded sand, silt, and clay and the alluvial aquifers associated with the major river valleys. Ground water is shallow in many places, discharging as it seeps along valley walls, and artesian flow may occur in river valleys where capping clay layers on terraces create local confinement (Renken 1998).

Surface flows and groundwater conditions in the Arkansas Coastal Plain have been modified by humans in various ways, particularly in 20th century. Navigation and flood-control projects, agriculture, and municipal and industrial water use have all had significant effects on water availability and hydrodynamics, and therefore on wetlands. Some of the major changes to water resources in the region are discussed in the Alterations to Environmental Conditions section.

Geology and Geomorphology

The rolling hills and stream valleys of the Coastal Plain region of Arkansas primarily consist of two types of materials: those deposited in shallow seas of the Mississippi Embayment, or along their margins, during the Late Cretaceous and Early Tertiary periods and those subsequently deposited as alluvium during the Quaternary period. The characteristics and distribution of wetlands in the region are strongly related to the sediment types and origins of the deposits on which they occur.

Most of the Tertiary-age Coastal Plain uplands in southcentral Arkansas are non-calcareous interbedded sands, silts, gravels, and clays, with occasional lignite deposits, some of which were deposited in marginal marine environments, while others are of fluvial origin (Renken 1998). The younger Claiborne and Jackson Groups predominate in the south and east, respectively (Figure 5). The older Wilcox Group is exposed in a relatively narrow band adjacent to the Ouachita Mountains from approximately Little Rock to Arkadelphia (Haley 1993). Ground water is stored in various strata within these groups, ranging from extremely shallow and localized reservoirs that discharge to small stream valleys (sometimes supporting seep wetlands), to vast, regionally important aquifers such as the Sparta Sand unit within the Claiborne Group (Renken 1998).

The Claiborne and Wilcox Groups extend into southwestern Arkansas and remain the predominant pre-Quaternary outcropping deposits south of a line connecting Texarkana, Hope, and the confluence of the Little Missouri and Ouachita Rivers. North of that line, however, the uplands consist of older deposits reflecting much stronger marine origins, with calcareous marls and chalks occurring along with beds of sands, quartzite, and lignite. From south to north, the major groups outcropping as generally parallel, sequentially older bands include the Tertiary Midway Group and a series of Late Cretaceous deposits: the Arkadelphia Marl, Nacatoch Sand, Saratoga Chalk, Marlbrook Marl, Ozan Formation, Brownstone Marl, Tokio Formation, Woodbine Formation, and Trinity Group (Haley 1993). Locally important aquifers are associated with some of these deposits (Renken 1998), however, local hillslope discharge (and associated occurrence of seep wetlands) is not characteristic as it is in the southcentral part of the Coastal Plain. The distribution of the Cretaceous and Tertiary deposits that outcrop within the study area are illustrated in Figure 5 and provided in digital form in Appendix E.

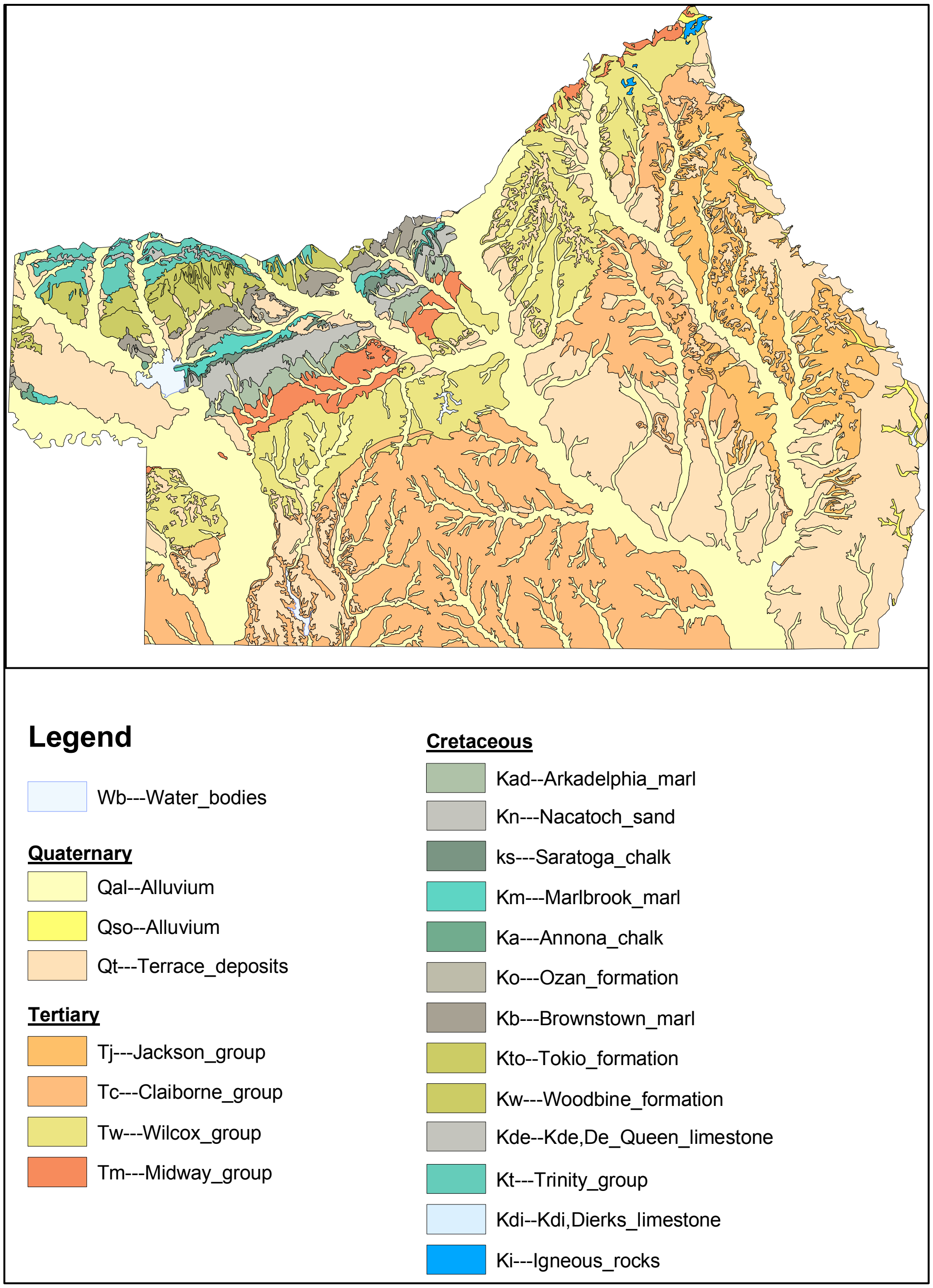


Figure 5. Geology of the Coastal Plain region of Arkansas (adapted from Haley 1993)

The majority of wetlands in the Coastal Plain region occur on active or former floodplains of streams. Because the predominant Tertiary sediments are easily eroded, streams have downcut deeply since the seas retreated from the Mississippi Embayment. The repeated episodes of erosion and deposition have left the larger river valleys in the region flanked by extensive fluvial terraces deposited during the Quaternary period (Saucier 1994). Each terrace was, at one time, active floodplain, and, therefore, is made up of the same depositional features found in the nearby modern floodplain. These features, such as natural levees, point bar deposits, abandoned channel segments, and backswamps, become increasingly muted on progressively older and higher terraces. On active floodplains, certain wetland types are associated with each of these depositional features. On terraces, those relationships become less apparent, but the relative age and elevation of the terraces are often predictive of wetland occurrence and characteristics. Therefore, it is important to understand the origins and distribution of floodplain features and specific terrace levels in order to understand and classify wetlands in the region. The discussion of terrace and floodplain characteristics presented below is based, unless otherwise indicated, on Autin et al. (1991) and Saucier (1994). General representations of the geomorphic surfaces found in the Ouachita River and Red River valleys are presented in Figure 6.

No single map source is adequate to fully understand the distribution of all of the surfaces discussed below and illustrated in Figure 6. An overview of the distribution of all Quaternary deposits in the study area is available as a 1:1,100,000 scale map (Figure7, adapted from Saucier and Snead 1989). This map lacks detail for some types of terraces and Holocene environments but provides coverage of areas not included on other maps. In the 1960s and early 1970s, the Corps of Engineers completed extensive mapping of Quaternary deposits within the lower Mississippi Valley, including the valleys of the Red River and the lower Ouachita River. The maps and detailed cross-sections were issued in folios at a scale of 1:62,500. All are long out of print, but scans of the sheets pertinent to the Arkansas portions of the rivers are included in Appendix E. The Red River maps were completed by Fleetwood (1969) and the Ouachita River was mapped by Smith and Russ (1974). These maps contain very detailed information on Holocene environments as well as Pleistocene terraces, but coverage on the Ouachita River is limited to the lower portion of the river, and there is no coverage of the Saline River valley. Many of these deficiencies are rectified in a map folio by Saucier and Smith (1986). This is a set of 1:24,000 scale maps that depict the Pleistocene terraces of the Ouachita and Saline River valleys in detail. These maps have been scanned and georeferenced and are available for use in a GIS context (Appendix E).

Persons using this document to classify wetlands in the Coastal Plain region of Arkansas will want to refer to the appropriate map sets and will often need to reference more than one of the map resources described above.

Pleistocene terraces

Upland Complex. The Upland Complex is the oldest and highest of the terrace deposits in the Coastal Plain region of Arkansas. It is a graveliferous deposit that occurs as a thin blanket over the older Tertiary sediments and is represented within the study area only as small fragments in the vicinity of Texarkana (Figures 6 and 7). It is believed to consist of remnant alluvial deposits of streams that eroded material from the north and west for a long period during the Early Pleistocene. The few examples of this terrace type within the study area are mostly farmed or developed and are unlikely to have supported extensive wetlands in any case due to their relatively well-drained soils.

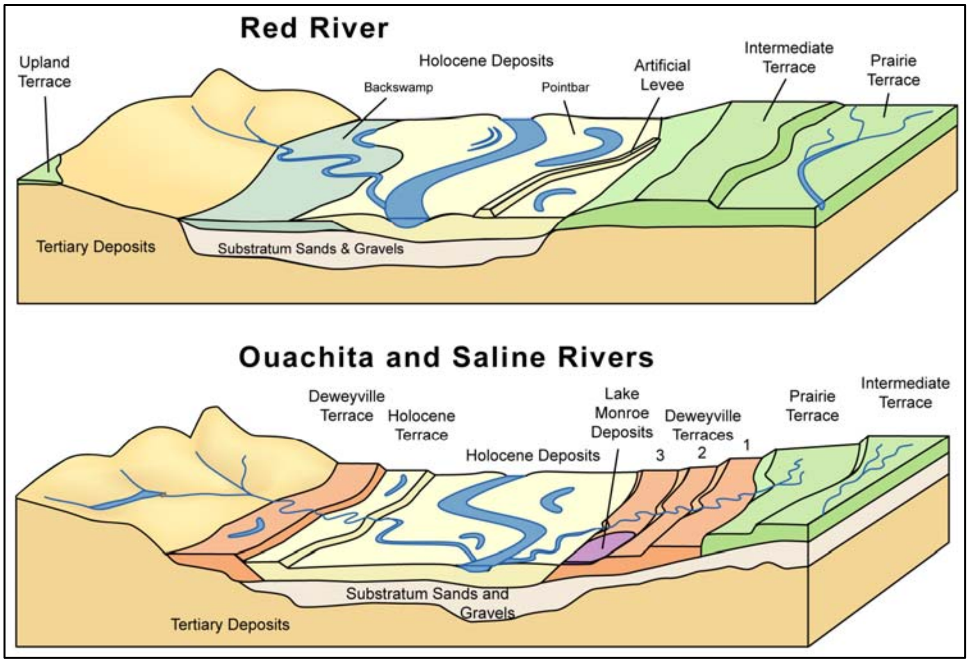


Figure 6. Principal geomorphic settings of the Ouachita and Red River valleys in the Coastal Plain Region of Arkansas

Intermediate Complex. The features mapped as the Intermediate Complex in the Arkansas Coastal Plain region (Figures 6 and 7) are the remnants of floodplains that were deposited in the late Early Pleistocene, more than 800,000 years before present (ybp). They are most abundant along the Ouachita River, but significant areas of Intermediate Terrace also exist near the Saline and Red Rivers. The most detailed mapping of these features can be found on the 1:62,500 folios (Appendix E; Fleetwood 1969; Smith and Russ 1974), where they are identified as the Montgomery Terrace (a local variation of the Intermediate Complex). Intermediate Complex features are not specifically broken out on Saucier and Smith (1986) — they are treated as uplands on those maps. Wetlands are not abundant on these ancient terraces, due to dissection and drainage by stream networks, but they do occur, usually as hardwood flats.

Prairie Complex. Prairie Complex remnants are common along the lower Ouachita River, the Dorcheat Bayou/Bodcau Bayou area, and along the eastern margin of the Coastal Plain region, adjacent to the Delta (Figures 6 and 7). The Prairie Complex occurs widely on major and minor streams throughout the Lower Mississippi Valley and Gulf Coastal Plain, where it reflects several episodes of high sea levels and related valley filling followed by downcutting and the establishment of terraces. It is the time frame of deposition (approximately 120,000 to 100,000 ybp) and consistency in elevation relative to valley base levels that identifies features as part of the complex (Saucier and Smith 1986). There is no single source stream, so features may vary among Prairie Terrace map units. For example, the remnant known as the Grand Prairie, in the Delta region of Arkansas, still has discernible channel features left behind by the Arkansas River, which now flows to the south, and tens of meters below the surface of the Grand Prairie. However, fluvial landforms such as abandoned channels are not generally discernible on Prairie Terrace remnants in the Coastal Plain region of Arkansas, and widespread dissection by small streams limits wetland development to the broader flats.

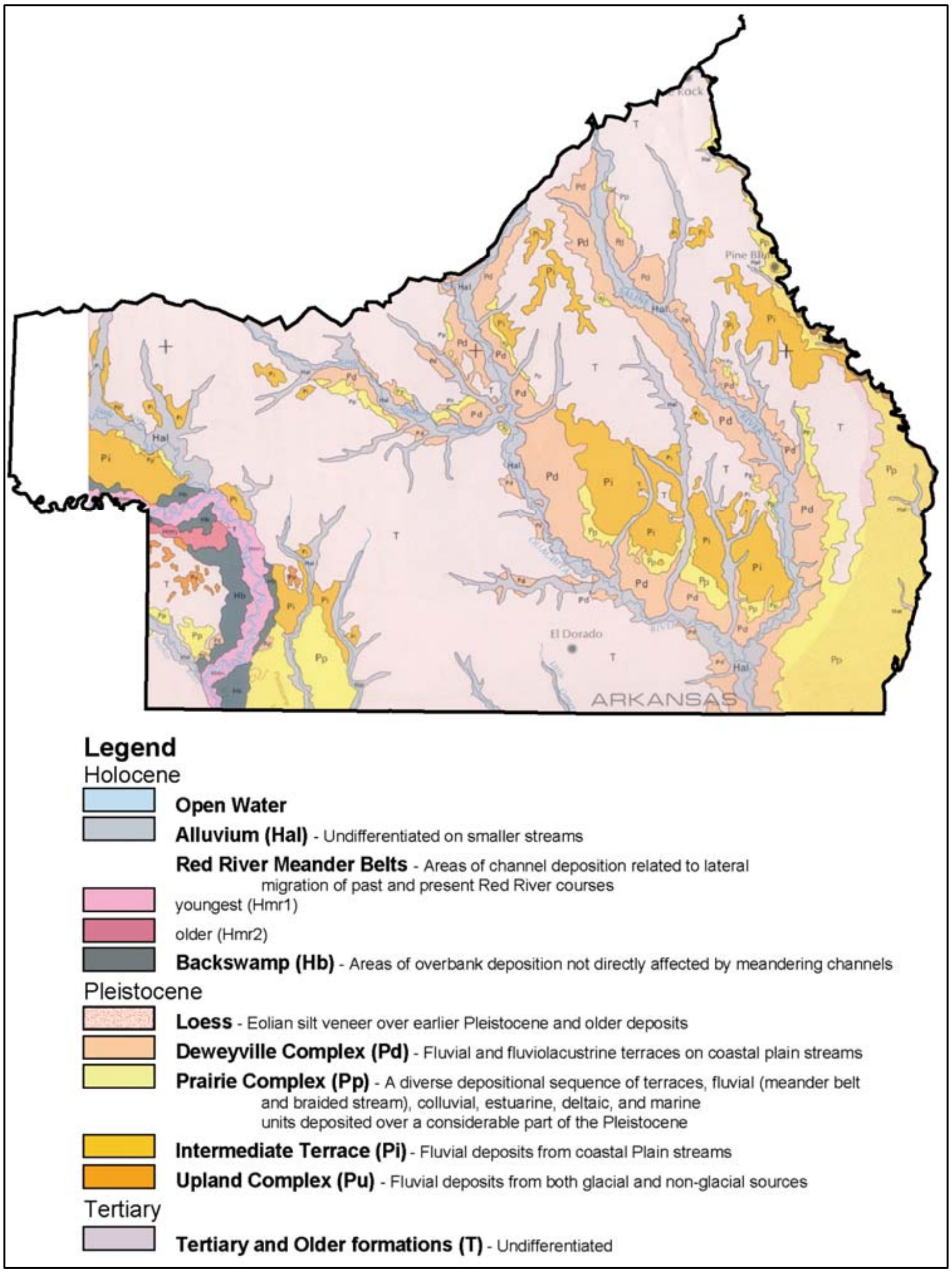


Figure 7. Quaternary geology of the Coastal Plain Region of Arkansas (adapted from Saucier and Snead 1989)

Deweyville Complex. The Ouachita, Saline, and Little Missouri Rivers all are flanked by nearly continuous terrace systems that belong to the Deweyville sequence (Figures 6 and 7). This landform is also extensive on the lower Red River, but only a few fragments are present on the Arkansas portion of that drainage. Unlike the older terraces described above, the Deweyville terraces did not originate during interglacial periods of high sea levels. Rather, they are believed to have been created during a period of maximum or waxing glaciation that occurred over a span of more than 15,000 years, beginning approximately 30,000 ybp. Climatic changes during this period apparently resulted in much higher discharges than currently exist in the streams of southern Arkansas, as well as many other streams throughout the Gulf Coastal Plain. The higher discharges are manifested in the abandoned channel scars and point bar ridge-and-swale features still visible on many of the Deweyville terraces, where stream channels were evidently three times wider than the adjacent modern river channel.

Four levels of the Deweyville terrace sequence have been recognized within southern Arkansas, with the highest and oldest being designated as level 1. The lowest terrace, level 4, is uncommon, being buried by subsequent valley aggradation in most locations. The terraces are separated vertically by several meters to more than seven meters, and the scarps between terraces are often sharp and distinct (Figure 8). This vertical separation is not always maintained between the lowest terraces (either level 3 or level 4) and the Holocene floodplain (i.e., the river meander belts that have been relatively stable since the last glaciation, over the past 12,000 years). Because the modern rivers have significantly aggraded their valleys in places, the Holocene floodplain is sometimes at or near the elevation of the lowest Deweyville terrace. In those cases, the Deweyville terraces are recognized and mapped as non-Holocene features on the basis of their oversized relict meander features.

Figure 8. Transition between two Deweyville terraces in the Saline River valley

Wetlands occur commonly on the Deweyville terraces, and differ distinctively between terraces. The oldest, highest terraces tend to be more highly dissected than younger terraces, and their meander features are more muted by erosion, thus they support wetlands tolerant of both winter saturation and summer drought. Lower terraces are progressively more likely to include depressions (relict channels and swales) and expansive flats where water ponds well into the growing season. Where Deweyville terraces are contiguous with Holocene floodplains, as described above, they support wetlands adapted to periodic river flooding.

Pleistocene lacustrine features

In the lower Ouachita River valley within southern Arkansas and northern Louisiana, a unique set of features have been described that somewhat confuse the mapped distribution of the Deweyville terraces in that region. The presence of relict beach features led Saucier and Fleetwood (1970) to postulate the existence, in the Early Wisconsin period, of a massive lake (designated Lake Monroe) that inundated an area of 500-700 square miles and persisted for centuries, and perhaps several millennia. This lake apparently was created by impounding of the Ouachita River behind a mass of glacial outwash that was transported down the Mississippi Valley and impinged against the uplands in Louisiana, near Monroe. Saucier (1994) redesignated some terraces in that region as lacustrine in origin, rather than fluvial (Deweyville) terraces, and he mapped their distribution within Louisiana. Unfortunately, he did not extend that mapping into southern Arkansas. However, it appears that some Deweyville features mapped in Arkansas, south of the confluence of the Saline and Ouachita Rivers, are probably actually lacustrine terraces, or are blanketed with lacustrine deposits (Figure 6), although no published mapping exists to distinguish them.

This problem has been partly alleviated by recent studies undertaken by Pagan and Foti (in preparation). As part of an effort to locate and map unique wetland communities known as sand prairies (described in the following section of this report), which were known to occur on the relict beach features of Lake Monroe, they developed a general model for determining the likely locations of those features. Because a lake creates terrace and beach features with nil down valley gradient, they were able to identify a narrow elevational range (65 to 75 ft msl, spanning parts of Deweyville terraces 1 and 2) wherein these features were likely to occur. Subsequent field studies verified that beach features occur as isolated remnants within that elevation range throughout the Felsanthal National Wildlife Refuge and adjacent forestlands.

Remarkably, Pagan and Foti were able to expand the known inventory of sand prairie communities from two to fifteen sites using this elevational search criterion. Based on this study, therefore, when using the available geomorphic maps to classify wetlands in the southern extremes of the Ouachita River valley within Arkansas, the user should be aware that features mapped as Deweyville terraces may in fact be lacustrine in origin, or have lacustrine surface deposits if they fall within the 10-foot elevational range defined by Pagan and Foti (in preparation).

Holocene alluvium

Over the course of the past 12,000 years, the major rivers within the study area have meandered within the vicinity of their present courses. On the lower Ouachita and Saline Rivers, they have created flat, poorly-drained alluvial valleys 2 to 3 miles wide, on average. On the Red River, the Holocene valley within Arkansas is more than 6 miles wide in places (Figures 6 and 7). The large rivers have been accreting through most of that time, creating meander belt features such as abandoned channels, natural levees, and point bars. In the tributaries and in portions of the larger streams, there is both accretion topography and evidence of downcutting in the form of Holocene terraces, depending on topography, gradient, and recent land use. Only in the extreme headwater areas is there little or no evidence of alluvial deposition adjacent to stream channels. In all other settings, a suite of fluvial depositional features may exist, differing in scale with stream size and each having differing hydrologic and sediment properties that influence the characteristics of the wetlands they support. Note that these same features also may exist as relict features on both Holocene and Pleistocene fluvial terraces.

Two types of sediments that are mapped for the Saline and Ouachita Rivers (Saucier and Smith 1986) are not meander belt features, but are widely distributed. These are alluvial fans, which are deposition areas created where streams abruptly change gradient (usually where a tributary enters the valley of a larger stream) and alluvial aprons, which occur where a terrace scarp has eroded sufficiently to create a gradual slope between terrace levels. Seep wetlands have been noted on some relatively minor alluvial aprons, and alluvial fans are incised by streams and therefore may support riverine wetlands in the vicinity of the channel.

Holocene meander belt features are mapped in detail for the Red River and lower Ouachita River portions of the study area (see map sources described above). For the Ouachita River above Camden, as well as the Saline and Little Missouri Rivers and all smaller tributaries, Holocene alluvium is mapped as a single unit, and no detailed mapping exists. In these areas, geomorphic features must be recognized in the field, or by using aerial photos and topographic maps. Similarly, on most first-order (headwater) streams, and many other smaller channels, no alluvium is mapped, but it may be present. The principal geomorphic features created in floodplain environments are described below and illustrated in Figure 6.

Backswamps. Backswamps are flat, poorly drained areas bounded by uplands and/or other higher features such as natural levees. In the Arkansas Coastal Plain, they are common on the lower Ouachita River, and they predominate in much of the Red River valley. Because sedimentation rates are highest along the active stream channel, meander belts tend to develop into an alluvial ridge, where elevations are higher than the adjacent floodplain. The result is that local drainage is directed away from the major stream channel, and the areas between meander belts become basins (backswamps) that collect runoff, pool floodwaters, and accumulate fine sediments. Backswamp deposits may overlay point bar deposits, or, in the Ouachita valley, Pleistocene Deweyville terraces and lake sediments. Under unmodified conditions, backswamps characteristically have substrates of massive clays and are incompletely drained by small, sometimes anastomosing streams. They may include large areas that do not fully drain through channel systems but remain ponded well into the growing season.

Point Bars. In Arkansas, point bar deposits predominate within the Holocene environments of the Ouachita River and its tributaries and are similar in extent to backswamps along the Red River. On small streams, point bars may be the only alluvial deposits of significance outside of the stream channel itself. Point bars generally consist of relatively coarse-grained materials (silts and sands) laid down on the inside (convex) bend of a meandering stream channel. The rates at which point bar deposition occurs and the height and width of individual deposits vary with sediment supply, flood stage, and other factors. The result is a characteristic pattern of low arcuate ridges separated by swales ("ridge-and-swale" or "meander scroll" topography). Point bar swales range from narrow and shallow to broad and deep and are usually closed at each end to form depressions. The scale and depth of point bar swales depend on the depositional environment that formed the adjacent ridges and the degree of sedimentation within the swale since it formed.

Abandoned Channels. These features are the result of cutoffs, where a stream abandons a channel segment either because flood flows have scoured out a point bar swale and created a new main channel (chute cutoff), or because migrating bendways intersect and channel flow moves through the neck (neck cutoff). Chute cutoffs tend to be relatively small and to fill rapidly with sediment. They do not usually form lakes, but may persist as large depressions. The typical sequence of events following a neck cutoff (which is much more common than a chute cutoff) is that the upper and lower ends of the abandoned channel segment quickly fill with coarse sediments, creating an open oxbow lake. Usually, small connecting channels (batture channels) maintain a connection between the river and the lake, at least at high river stages, so river-borne, fine-grained sediments gradually fill the abandoned channel segment. If this process is not interrupted, the lake eventually fills completely, the result being an arcuate swath of cohesive, impermeable clays within a better-drained point bar deposit. Often, however, the river migrates away from the channel segment and the hydraulic connection is lost, or the connection is interrupted by later deposition of point bar or natural levee deposits. In either case, the filling process is dramatically slowed, and abandoned channel segments may persist as open lakes or depressions of various depths and dimensions.

Abandoned Courses. An abandoned course is a stream channel segment left behind when a stream diverts flow to a new meander belt. Abandoned course segments can be miles long, or only short segments may remain where the original course has been largely obliterated by subsequent stream activity. In some cases, they are captured by smaller streams, which meander within the former channel and develop their own point bars and other features. For example, Caney Bayou in Union County occupies an abandoned course of the Ouachita River, and Finn and McKinney Bayous in Miller County occupy very long abandoned course segments of the Red River. Where the stream course is abandoned gradually, the remnant stream may fill the former channel with point bar deposits even as its flow declines. Thus, while abandoned channels often become depressions with heavy soils, abandoned courses are more likely to be fairly continuous with the point bar deposits of the original stream, or to become part of the meander belt of a smaller stream.

Natural Levees. A natural levee forms where overbank flows result in deposition of relatively coarse sediments (sand and silt) adjacent to the stream channel. The material is deposited as a continuous sheet that thins with distance from the stream, resulting in a relatively high ridge along the bankline and a gradual backslope that becomes progressively more fine-grained with distance from the channel. Natural levees may be deposited in association with sheetflow, or as a series of crevasse splays, which are deltaic deposits formed by small channels that breach the existing natural levee during high flows.

Soils

Fluvial sediments form the parent material of soils within the Arkansas Coastal Plain Holocene floodplains and terraces, and the Pleistocene terraces, except where lacustrine sediments or materials eroded from adjacent uplands have replaced or buried the alluvium. As described previously, stream meander activity creates complex but characteristic landforms, where sediments are sorted to varying degrees based on their mode and environment of deposition. The sorting process has produced textural and topographic gradients that are fairly consistent on a gross level and result in distinctive soils. Generally, within a Holocene meander belt, surface substrates grade from relatively coarse-textured, well-drained, higher elevation soils on natural levees directly adjacent to river channels, through progressively finer-textured and less well-drained materials on levee backslopes and point bar deposits, to very heavy clays in closed basins such as large swales and abandoned channels. Backswamp deposits between meander belts are also filled with heavy clays. The gradient of increasingly fine soil textures from high-energy to low-energy environments of deposition (natural levees and point bars to abandoned channels and backswamps) implies increasing soil organic matter content, increasing cation exchange capacity, and decreasing permeability. However, all of these patterns are generalizations, and quite different conditions occur regularly. The nature of alluvial deposition varies between and within flood events, and laminated or localized deposits of varying textures are common within a single general landform.

Soils of the Pleistocene terraces vary depending on the age of the deposits and parent materials. Generally, the older Upland and Intermediate Complex soils are well weathered, with distinct soil development. Prairie Terrace soils, particularly along the eastern flank of the Coastal Plain, have significant loess deposits influencing the character of the surface soils. Soils of the Deweyville terraces are derived from materials eroded from older, highly weathered landscapes and tend to be relatively acid and well developed for their age (Autin et al. 1991). Despite these types of generalizations, specific soil associations often are not restricted to a single geomorphic setting, and some span a range of sites of very different age and origins. In general, the age and elevation of a terrace is predictive of the types of wetlands likely to occur there, but within that geomorphic setting, unique wetlands of highly limited distribution tend to be associated with particular soil series. For example, sand prairie communities of the Lake

Monroe lacustrine deposits are found on Haggerty soils, and alkali wet prairies of the Deweyville terraces occur on Lafe soils. Pine flatwoods of the Deweyville terraces occur on Guyton and Pheba soils; on the Prairie Terrace, pine flatwoods are found on Amy and Pheba soils (Pagan and Foti in preparation). Wetlands dominated by lowland hardwoods show much weaker affinities to particular soil series or associations, and most slope wetlands occur as small units associated with groundwater discharge points, and their soils may not be differentiated from the surrounding upland units.

The general distribution of the major soil associations in the Coastal Plain region of Arkansas is illustrated in Figure 9. Table 4 presents brief descriptions of the principal soil associations of the Holocene lowlands and Pleistocene terraces, where most wetlands are located. Note that the association names vary slightly between Figure 9 and Table 4. This is because the STATSGO mapping used in Figure 9 is the most recent available, but descriptions of the map units have not yet been published. Therefore, the classification and terminology used in Table 4 are based on the published descriptions accompanying the general soil map of Arkansas (USDA-SCS/UAAES 1982). Selected individual updated soil series descriptions can be found on the web at *http://ortho.ftw.nrcs.usda.gov/osd/osd.html*. More detailed soil mapping for some counties in Arkansas is available at *http://soils.uark.edu/*.

Vegetation

The Coastal Plain region of Arkansas is in the northern third of the West Gulf Coastal Plain Ecoregion (Omernik 1987; USEPA 1998). Braun (1950) divided the area into 3 separate forest regions. She included the vicinities of the lower Saline and Ouachita Rivers in the Southeastern Evergreen Forest Region (Mississippi Alluvial Plain Section), recognizing communities similar to those of the Delta region. The southwestern part of Arkansas, roughly coincident with the area characterized by outcrops of Tertiary and Cretaceous rocks, she included in the Forest-Prairie Transition Area of the Oak-Hickory Forest Region. This area is a mix of forests, scrubby woodlands, and more open communities that occur on calcareous soils where prairie species dominate in the ground cover layer (the "blackland prairies"). She classified the remainder of the Coastal Plain region of Arkansas as belonging to the Gulf Slope Section of the Oak-Pine Forest Region, where loblolly and shortleaf pines (*Pinus taeda, P. echinata*) are characteristic components of the oak-hickory forest types that dominate in the uplands.

Braun's (1950) classification is similar to other approaches to classifying natural vegetation distribution in Arkansas (e.g., Kuchler 1969), in that the focus is on the predominant cover types over large areas. While this provides a useful regional context, it does not provide much insight on potential occurrence and characteristics of wetlands. As stated previously, in the Coastal Plain region of Arkansas, the most useful context for considering wetlands is geological setting, geomorphology, and hydrology. The following discussion outlines the basic relationships of interest. The final section in this chapter specifically defines and describes the principal wetland communities in terms of the HGM classification system.

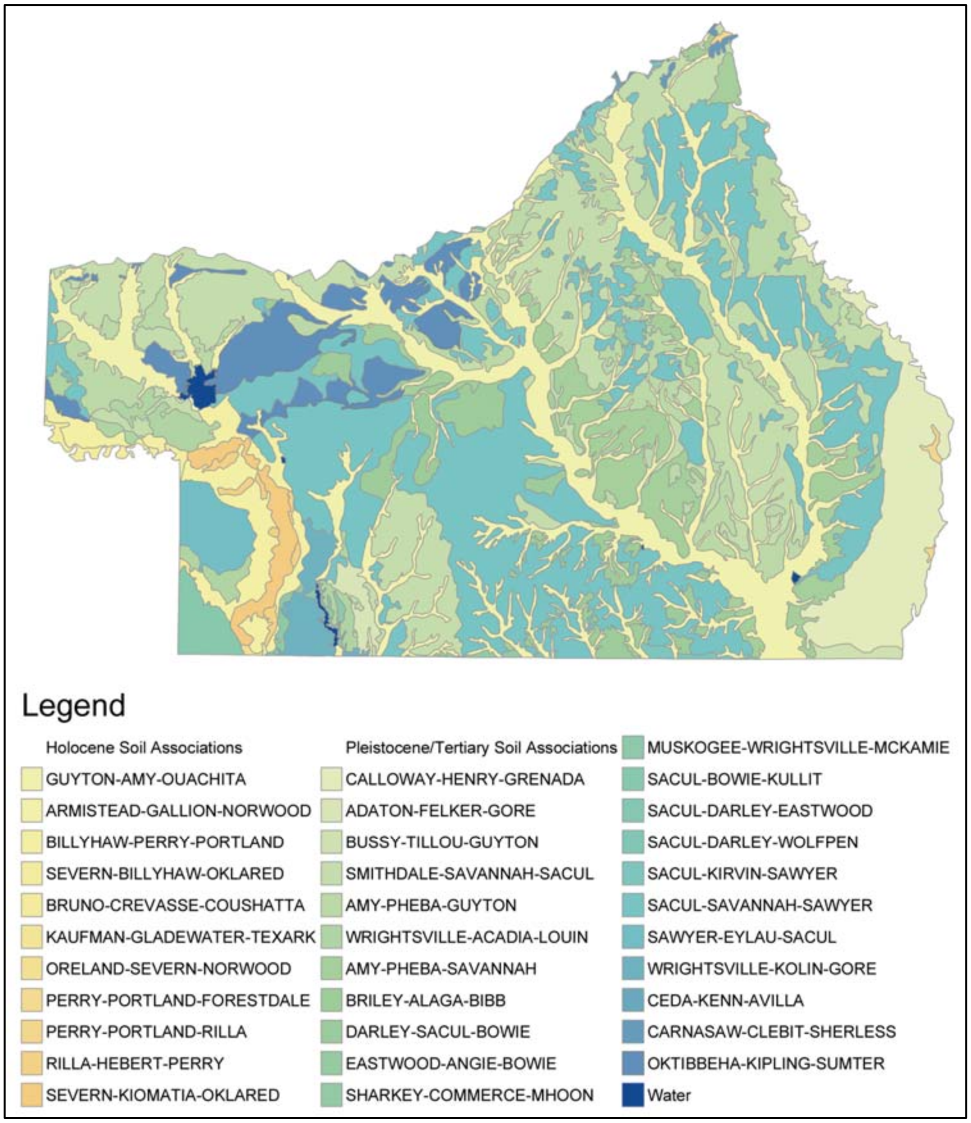


Figure 9. Principal soil associations of the Coastal Plain region of Arkansas (USDA-NRCS 1995)

Table 4
Soil Associations that Include Significant Wetlands Within the Coastal Plain Region of Arkansas (USDA-SCS/UAAES 1982)

Map Units	Principal Landscape Settings Within the Coastal Plain	Characteristics
Holocene Lowlands		
Guyton-Ouachita-Sardis	Holocene lowlands of all major river valleys other than the main-stem of the Red River.	Poorly drained, slowly permeable Guyton soils make up the majority of this unit in the Coastal Plain river floodplains. They are loamy soils with silty or silty-clay subsoils.
Rilla-Hebert	Holocene natural levee deposits of the Red River valley.	Well-drained Rilla silt loams interspersed with poorly drained Perry clays make up the majority of this unit, which occurs on both active and former channels of the Red River.
Billyhaw-Perry	Backswamp deposits of the Red River.	Deep, somewhat poorly drained and poorly drained, very slowly permeable clay soils.
Severn-Oklared	Point bar deposits of the Red River.	Deep, well drained, moderately permeable, level to gently undulating loamy soils.
Pleistocene Terraces		
Amy-Smithton-Pheba Pheba-Amy-Savannah	Principal soils of the Deweyville Terraces; also commonly mapped on the Intermediate Terrace, and the Prairie Terrace units flanking the Ouachita, Saline, and Little Missouri Rivers.	Deep, moderately well drained to poorly drained, moderately permeable to slowly permeable loamy soils.
Smithdale-Sacul-Savannah-Saffell Sacul-Smithdale-Sawyer	Principal soils of the Intermediate Terrace units flanking the Ouachita, Saline, and Little Missouri Rivers. Also commonly mapped on the Deweyville Terraces.	These heterogenous soils range from well drained and moderately permeable to moderately well drained and slowly permeable. The loamy surface soils often are underlain by clays, and there are numerous inclusions of Amy, Pheba, Guyton, and other soils.
Wrightsville-Louin-Acadia Adaton	Dominant soils of the Prairie and Intermediate Terraces in the Dorcheat Bayou / Bodcau Bayou drainages and along the Red River valley.	Deep, level, poorly drained, very slowly permeable loams and silty loams with clayey subsoils.
Calloway-Henry-Grenada-Calhoun	Dominant soils of the Prairie Terrace on the eastern margin of the Coastal Plain.	Deep, moderately well-drained to poorly drained silt loams that developed in loess and alluvium.

Holocene floodplains and terraces

Wetlands of the Holocene floodplains and terraces of the Ouachita, Saline, and Red Rivers and their tributaries are generally similar to those of the Delta region. They are referred to as bottomland hardwoods, a term that incorporates a wide range of species and community types that can tolerate inundation or soil saturation for at least some portion of the growing season (Wharton et al. 1982).

Bottomland hardwood forests are among the most productive and diverse ecosystems in North America. Under pre-settlement conditions, they interacted with the entire watershed, via floodwaters, to import, store, cycle, and export nutrients (Brinson et al. 1980; Wharton et al. 1982). Although these conditions have changed in some areas in modern times (see Alterations to Environmental Conditions, below), the remaining forests still exist as a complex mosaic of community types that reflect variations in alluvial and hydrologic environments. Within-stand diversity varies from dominance by one or a few species to forests with a dozen or more overstory species and diverse assemblages of understory, ground cover, and vine species (Putnam 1951; Wharton et al. 1982). These forests support a detritus-based trophic network that includes numerous resident and migratory wildlife species that are adapted to the highly dynamic and diverse environment (Fredrickson 1978; Wharton et al. 1982).

Within the Holocene environment on larger rivers, where floodplains are wide, most of the natural variation in community distribution and composition can be related directly to the landscape complexity resulting from channel migration processes. Point bars, abandoned channels, swales, and backswamps each tend to have different combinations of soil texture and depressional characteristics that influence soil moisture and ponding. These conditions in turn influence species composition and forest structure, with water-tolerant trees such as baldcypress (*Taxodium distichum*) dominating in large abandoned channels with near-permanent flooding, overcup oak dominating in swales and abandoned channels inundated throughout the spring in most years, and pioneer species such as cottonwood predominating on relatively well-drained riverfront natural levees, where flooding occurs frequently, but ponding is uncommon. Extensive point bar and backswamp deposits support highly diverse forests, where species dominance shifts with barely-perceptible changes in drainage and topography.

In addition to the basic drainage characteristics of the lowland forest system, flood frequency, depth, and duration also influence wetland characteristics. Frequently-flooded sites tend to exhibit a "wetter" character than sites where precipitation is the principal, or only, source of water. Thus, sites protected by levees and sites along streams where flood control projects effectively reduce inundation may shift in character and function somewhat, but if the basic microtopographic variation remains intact, these sites retain wetland characteristics and composition.

Upstream of the broad lowlands, Coastal Plain streams increase in gradient, and their floodplains and Holocene terraces become increasingly narrower. Frequently, sediments also become coarser, sites capable of long-term ponding are less common, and flooding is "flashier," with high velocities but relatively short duration. Vegetation composition shifts, with species such as river birch (*Betula nigra*), box elder (*Acer negundo*), and sycamore (*Platanus occidentalis*) becoming more common on floodplains, and a mix of moderately flood-tolerant species such as water oak (*Quercus nigra*), cow oak (*Q. michauxii*), and cherrybark oak (*Q. pagoda*) occupying terraces. In the narrowest valleys near headwater areas, floodplains and terraces may be reduced to discontinuous fragments, and streamside vegetation reflects the predominant hillslope communities where soil depth and aspect are the principal determinants of composition.

In any of the Holocene environments, primary succession may occur on recently deposited substrates, which include abandoned stream channels, point bars, crevasse splays, and abandoned beaver ponds. One familiar example is the colonization of new bars adjacent to river channels by pioneer species such as black willow, which are replaced over time by other species such as sugarberry and green ash, and eventually by long-lived, heavy-seeded species such as oaks and hickories (Putnam et al. 1960). Although this sequential replacement does occur, it is actually a complex process that includes changes in the elevation and composition of the substrate as colonizing plants and flood flows interact to induce sedimentation, and on a longer-term scale, as soils mature and river channels migrate away from the site and cease delivering new sediments.

The typical natural regeneration process in established forest stands is initiated by single tree-falls, periodic catastrophic damage from fire, ice, or windstorm, and inundation mortality due to prolonged growing-season floods or beaver dams. Small forest openings occur due to windthrow, disease, lightening strikes, and similar influences that kill individual trees or small groups of trees (Dickson 1991). The resulting openings are rapidly colonized, but the composition of the colonizing trees may vary widely depending on factors such as existing advanced reproduction, seed rain from adjacent mature trees, and importation of seed by animals or floodwaters. Often, this pattern results in small, even-aged groves of trees, sometimes of a single species (Putnam et al. 1960).

In pre-settlement conditions, fire may have been a significant factor in stand structure, but the evidence regarding the extent of this influence is unclear. Putnam (1951) stated that southern bottomland forests experience a "serious fire season" every 5–8 years, and that fires typically destroy much of the understory and cause damage to some larger trees that eventually provides points of entry for insects and disease. Similarly, it is difficult to estimate the influence of beaver in the pre-settlement landscape, because they were largely removed very early in the settlement process. However, it is likely that the bottomland forest ecosystem included extensive areas that were affected by beaver and were dominated by dead timber, open water, marsh, moist soil herbaceous communities, or shrub swamp at any given time.

Pleistocene terraces

As mentioned above, the lowest Pleistocene terraces (Deweyville levels 4 or 3) are sometimes essentially continuous with the active floodplain of the river. In parts of the southernmost portion of the Ouachita River valley in Arkansas, the Deweyville level 3 and level 2 terraces are elevated above the Holocene floodplain but are still subject to periodic flooding. In all of these situations, the flood-prone Pleistocene terraces usually support typical bottomland hardwood communities similar to those described above. They differ primarily in the scale of the depressional wetlands that occur in abandoned channels and point bar swales, which tend to be several times larger than similar features on Holocene surfaces.

Older terraces are not subject to flooding and sit sequentially higher in the landscape with increasing age. In order from youngest and lowest to oldest and highest, the Pleistocene terraces are the Deweyville level 2 (excepting certain flood-prone sites), Deweyville level 1, Prairie Terrace, Intermediate Terrace, and Upland Terrace. Meander features (swales, abandoned channels, etc.) become less apparent with age of surface, such that they are no longer distinct features on the Prairie and higher terraces. At the same time, dissection by streams is pronounced on the higher older terraces. The result is that occasional depressional wetlands, with overcup oak (*Q. lyrata*), willow oak (*Q. phellos*), and similar species, occur on the Deweyville terraces in the former channels and swales. These and the older, higher terraces are more likely to support flats, which are precipitation-maintained wetlands on sites with relatively impermeable soils and poor drainage. Flats become less extensive, due to dissection by streams, on the oldest terraces, such that extensive wetland areas are unlikely to occur on the Upland Complex.

The compositional and structural characteristics of wetlands on flats change with the age and relative elevation of the terrace. In general, the Deweyville terraces transition from bottomland hardwoods in the flooded zones to hardwood-pine flats (known as "flatwoods") on the unflooded terraces, which are typically extensively ponded well into the growing season. The lower flatwoods are commonly dominated by a mix of loblolly pine and bottomland hardwood species, such as overcup oak, Delta post oak (*Q. stellata var. paludosa*), and laurel oak (*Q. laurifolia*). On higher, older terraces, the percentage of pine increases, ponding decreases, and hardwood species tend to occur in the wettest vernal pool sites (especially willow oak) or are locally dominant on the drier sites (e.g. post oak (*Q. stellata*), southern red oak (*Q. falcata*)). Shortleaf pine also becomes increasingly common, and prairie species are important components of the ground layer flora in open-canopy, pine-dominated stands.

In certain settings, non-forested wetlands occur on the Pleistocene terraces. As discussed above, the beach deposits associated with the relict shoreline of Lake Monroe support a unique "sand prairie" community. Soils on these sites are extremely droughty, but also have toxic levels of aluminum, and both of these conditions together, probably augmented by fire, are evidently enough to discourage invasion by woody species. These extreme conditions promote a "weedy" character in the flora of the sand prairies but also support at least one species (*Bonamia aquatica*) that occurs nowhere else in Arkansas (Pagan and Foti in preparation).

In isolated sites on the Deweyville terraces, another unique grass- and forb-dominated community occurs, called "alkali prairie." Soils on these sites have extreme levels of magnesium and sodium salts, which probably accumulated from repeated ponding and drying of large, shallow basins on the surfaces of the terraces. As in the sand prairies, species diversity in these communities is high, and a variety of rare and unusual plants occur consistently, including the federally threatened *Geocarpon minimum* (Pagan and Foti in preparation). A third wet prairie type occurs on non-alkali soils of the Prairie terrace, where a variant of the tallgrass prairie community occurs in slight depressions within broader, flat expanses of dry tallgrass prairie.

As in the Holocene environments, wetlands of the Pleistocene terraces are influenced by catastrophic events such as storm and ice damage. But the communities of the Pleistocene environments seem to be particularly influenced and adapted to periodic fire, which can modify community structure and composition dramatically. Within the pine flatwoods communities, fire tends to reduce hardwood abundance and create a savanna-like structure, where prairie species and ericaceous shrubs increase in importance under an open pine canopy.

In the prairie-dominated communities, fire is important in preventing hardwood invasion. In some cases, the scarp face of a terrace can discharge groundwater, creating a seep community dominated by a characteristic suite of ferns, forbs, and graminoids, as well as ericaceous shrubs. This most commonly occurs in areas where pines predominate, and the seep community can largely disappear unless an open canopy structure is maintained to supply sufficient light to the wetland plants in the ground layer.

Tertiary uplands

The interbedded sands, silts, and clays of the Claiborne, Jackson, and Wilcox deposits of the Coastal Plain uplands create local sites of groundwater discharge that support unique wetlands on slopes and within minor drainages. In the northern part of the Coastal Plain region, these seeps are typically forested and are dominated by a mix of hardwoods that commonly include American beech (*Fagus grandifolia*), umbrella magnolia (*Magnolia tripetala*), red maple (*Acer rubrum*), and blackgum (*Nyssa sylvatica*). To the south, the mix of species that dominate seeps often includes sweetbay (*M. virginiana*), and communities with a significant sweetbay component are called "bayheads." Both bayheads and other seep wetlands typically have a diverse flora that often includes various uncommon species. Ferns are particularly abundant in these seeps.

Alterations to Environmental Conditions

Wetlands within the Coastal Plain region of Arkansas have been affected by changes in land use and hydrology and by forest management practices. However, most of these changes have not been as dramatic as those that have occurred in the Delta region, where large-scale channel modifications, levee construction, and agricultural conversion have resulted in major losses of wetlands. Rather, wetland losses in the Coastal Plain have been focused on specific landscape settings, while more extensive changes have occurred that affect wetland processes and structure in the remaining, altered wetlands.

Land use and management

Early in the 16th century, Hernando De Soto and his army were the first Europeans to traverse the coastal plain region of Arkansas, where they encountered a very large Native American population engaged in maize agriculture along all of the major river bottoms (Hudson 1997). More than 280 years later, in 1804, the government-sponsored Dunbar and Hunter expedition explored the Ouachita River valley and encountered few people, Native American or otherwise. But by 1824, steamboats were traveling as far upstream as Camden, and settlers had moved into the region in large numbers (Weinstein and Kelley 1984). By the time Arkansas became a state in 1836, settlers were already cutting timber commercially (Faulkner 2001), and large sawmills fed by railroads were common in the pinelands of the coastal plain between the 1890's and the 1920's (Reynolds 1980). After the virgin forests were removed, the forest products industry shifted to small sawmill and pulpwood operations for several decades, but by the 1950's, the forest resources of the region had once again attracted large commercial sawmill and paper operations (Reynolds 1980; Faulkner 2001).

Today, large areas that were formerly pine and hardwood flatwoods are managed as commercial forests, usually in the form of loblolly pine plantations. As of 1995, there were more than 1.6 million acres of softwood plantations in the Coastal Plain region (Rosson 2001), accounting for approximately 20 percent of the total forested acreage (Rudis 2001). This has had a variety of effects, including a reduction in overall diversity and a change in structure to even-aged blocks that are clearcut and planted on short rotations. Site preparation and drainage has altered soils and microtopography (Pagan and Foti in preparation). Changes in fire frequency and intensity have occurred, and there is little evidence of what constitutes "natural" patterns of fire needed to maintain some of the unique wetland communities that must burn periodically.

Many natural wetland communities have been converted to agriculture in the Holocene environments of the major river bottoms, and to a lesser extent on the Pleistocene terraces. The most extensive conversions to row crops have occurred in the Red River valley, and farming has also eliminated significant lowland forest acreage in the Ouachita and Saline River bottoms and along many tributary streams. On the Pleistocene terraces, most of the agricultural conversions have been to pasture. Many hillslope wetlands have also been converted to pasture or ponds, and many others remain forested, but are grazed by livestock. A general representation of land cover in the Coastal Plain region is presented in Figure 10. A more detailed version is available in Appendix E.

The Coastal Plain region also produces large amounts of oil and natural gas, and this industry has had considerable impact on the landscape. Exploration and production have left road networks, drill pads, and pipeline corridors, as well as spills of chemicals and brine (Smith et al. 1984). Other materials extracted in the region include sand and gravel, various minerals, and spring water (Arkansas Geological Commission 1999).

Ninety-seven percent of the land in the Coastal Plain region is privately owned, with non-industrial private forests accounting for approximately 3.27 million acres and forest industry holdings at 3.42 million acres (Williams 2001). Federally-owned public land in the Coastal Plain includes Felsenthal National Wildlife Refuge (approximately 65,000 acres), Pond Creek National Wildlife Refuge (27,500 acres), and more than 50,000 acres associated with Corps of Engineers reservoir and navigation projects. State-owned lands include the Poison Springs State Forest and a dozen state parks. The Arkansas Natural Heritage Commission system of natural areas includes 17 unique sites in the Coastal Plain that are protected through state ownership or easements. The state also owns a variety of large wildlife management areas and works with landowners to manage wildlife on many commercial timberlands.

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 Commission. Within the Coastal Plain region, only the NRCS is actively engaged in wetland restoration on a large scale. That agency administers the Wetlands Reserve Program (WRP), which enrolled more than 30,000 acres of Coastal Plain farmland in conservation easements, almost all of it in the lowlands of the Red River valley. The enrolled lands have been or will be restored to native wetland and open water habitats.

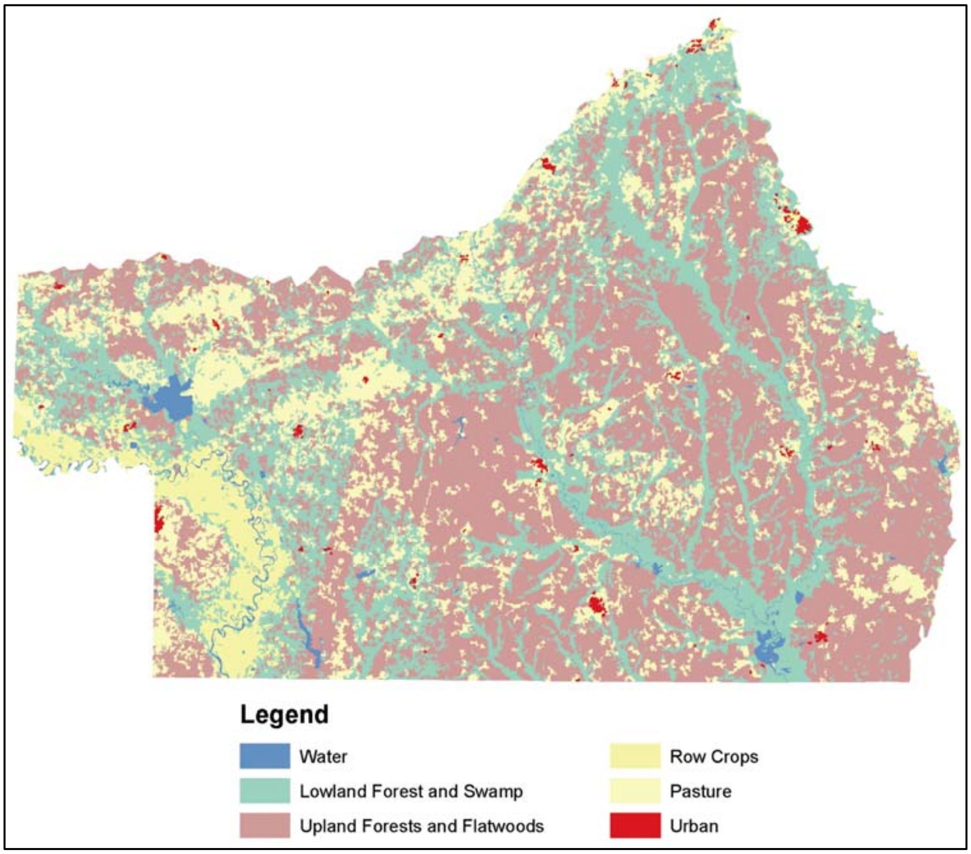


Figure 10. Land cover of Arkansas, based on landsat imagery from 1990-1993. This graphic was adapted from CAST (1996), using the classification system of Foti et al. (1994)

On a broader scale, six Arkansas State agencies are members of the Arkansas 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).

Hydrology

As noted above, each of the major rivers that traverse the Arkansas Coastal Plain is impounded by one or more dams before entering the study area. All of these reservoirs are managed for multiple purposes such as recreation and flood control. Within the Arkansas Coastal Plain there are few major man-made lakes, the largest being Millwood Lake, a federal flood control reservoir on the Little River. The lower Ouachita River in Arkansas is part of the Ouachita-Black Rivers Navigation Project, which allows barge traffic to travel as far upriver as Camden, via a 9-ft year-round channel. Within Arkansas, the project consists of two pools impounded by the Felsenthal Lock and Dam and the H.K. Thatcher Lock and Dam (Vicksburg District, U.S. Army Corps of Engineers 2003).

The Red River above Shreveport is currently not part of the Red River navigation project, although bank protection (revetment) and channel modifications are present at various locations. However, additional locks and dams are currently under consideration. The most ambitious alternative would extend navigation as far as Index, Arkansas, which would convert most of the Red River in Arkansas into a series of navigation pools (Vicksburg District, U.S. Army Corps of Engineers 2003).

In general, groundwater has been abundant and readily extracted throughout most of the region, but withdrawals have had some adverse impacts in certain areas. Prior to development of the Coastal Plain aquifers early in the 20th century, groundwater recharge in the uplands was discharged into the major stream valleys. Within the Arkansas Coastal Plain, nearly all of the Ouachita, the lower Saline, and the lower Red Rivers were net discharge zones. By the end of the century, all of these river valleys, with only very local exceptions, had become net recharge areas (Renken 1998). The influence of this fundamental change in subsurface and surface water levels, and related effects on seeps and baseflows, has presumably had significant impacts on wetlands, but these have not been defined. Five counties in south-central Arkansas have been designated as Critical Ground Water Areas, indicating significant declines in water levels and/or water quality (Arkansas Soil and Water Conservation Commission 2001).

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 Coastal Plain region 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, therefore a set of specific criteria have been established to assist the user in assigning any particular wetland in the Arkansas Coastal Plain to the appropriate class, subclass, and community type. These criteria are presented in the form of dichotomous keys in Figures 11 and 12. In addition, each wetland type identified in the keys is described in the following section, which also includes a series of block diagrams illustrating the major wetland types and their relationships to various landforms and man-made structures. These relationships are also summarized in Table 5.

Some of the criteria that are used in the keys in Figures 11 and 12 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.

Key to Wetland Classes of the Coastal Plain Region of Arkansas

1. Wetland is within the 5-year floodplain of a stream .... Riverine
1. Wetland is not within the 5-year floodplain of a stream 2
2. Wetland is not in a topographic depression or impounded...5
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 associated with a water body that is ephemeral, or less than 2-m deep in most years .... Depression
5. Topography is flat, principal water source is precipitation...Flat
5. Topography is sloping to flat, principal water source is groundwater discharge or subsurface flow.. Slope

Figure 11. Key to the wetland classes in the Coastal Plain Region of Arkansas

The classification system recognizes that certain sites functioning primarily as fringe or depression wetlands are also 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.

Key to wetland subclasses and community types in the Coastal Plain Region of Arkansas		
CLASS: FLAT		
	Subclass	**Community Type**
1. Soil reaction circumneutral to alkaline (lake bed deposits)	Alkali Flat	*alkali wet prairie*
1. Soil reaction acid	Non-Alkali Flat (2)	
2. Vegetation dominated by graminoids		*wet tallgrass prairie*
2. Vegetation dominated by woody species		
2a. Vegetation dominated by pine		*pine flat*
2b. Vegetation dominated by post oak		*post oak flat*
2c. Vegetation dominated by hardwoods other than post oak		*hardwood flat*
CLASS: RIVERINE		
1. Wetland associated with low-gradient stream	3	
1. Wetland associated with mid-gradient stream	Mid-gradient Riverine (2)	
2. Water source primarily overbank flooding or lateral saturation		*mid-gradient floodplain*
2. Wetland an impoundment	Riverine Impounded (4)	
3. Wetland not an impoundment	Low-gradient Riverine (5)	
3. Wetland an impoundment	Riverine Impounded (4)	
4. Wetland impounded by beaver		*beaver complex*
4. Wetland impounded for wildlife management (greentree reservoirs and moist soil units)		*managed wildlife impoundments*
5. Wetland a prairie, substrate is a Pleistocene lake beach deposit		*sand praire*
5. Wetland dominated by woody or non-prairie species, site not a beach deposit	6	
6. Water source primarily overbank flooding (5-year zone) that falls with stream water levels, or lateral saturation from channel flow		*low-gradient overbank*
6. Water source primarily backwater flooding or overbank flows (5-year zone) that remain in the wetland due to impeded drainage after stream water levels fall		*low-gradient backwater*
CLASS: DEPRESSION		
1. Depression not subject to direct stream flooding during a 5-year event; precipitation, runoff, and groundwater are the dominant inflows	Unconnected Depression	*unconnected alluvial depression*
1. Depression has significant direct stream inflows and outflows relative to stored volume and/or is influenced by overbank or backwater flooding during a 5-year event	Connected Depression	*floodplain depression*
CLASS: FRINGE		
1. Wetland on the margin of a man-made reservoir	Reservoir Fringe	*reservoir shore*
1. Wetland on the margin of water body other than a reservoir	2	
2. Water body is subject to stream flooding during 5-year flood events	Connected Lacustrine Fringe	*connected lake margin*
2. Water body not subject to flooding during a 5-year event	Unconnected Lacustrine Fringe	*unconnected lake margin*
CLASS: SLOPE		
1. Sweetbay (Magnolia virginiana) common or dominant	Non-calcareous Slope	*bayhead*
1. Sweetbay not common, wetland dominated by other species	Non-calcareous Slope	*non-calcareous perennial seep*

Figure 12. Key to the wetland subclasses and community types in the Coastal Plain region of Arkansas

Table 5
Hydrogeomorphic Classification of Wetlands in the Coastal Plain Region of Arkansas, and Typical Geomorphic Settings of Community Types

Wetland Classes, Subclasses, & Communities	Typical Geomorphic Setting
Class: Flat	
Subclass: Alkali Flat	
Alkali Wet Prairie	Lacustrine sediments deposited in shallow lakes and playas.
Subclass: Non-Alkali Flat	
Wet Tallgrass Prairie	Pleistocene terraces
Pine Flat	Pleistocene terraces
Post Oak Flat	Pleistocene terraces.
Hardwood Flat	Pleistocene terraces and Holocene meander features not subject to regular stream flooding.
Class: Riverine	
Subclass: Mid-Gradient Riverine	
Mid-Gradient Floodplain	Point bar and natural levee deposits within active meander belts of streams transitioning from uplands to alluvial plain, or dissecting terrace deposits.
Subclass: Low-Gradient Riverine	
Low-Gradient Overbank	Point bar and natural levee deposits adjacent to streams.
Low-Gradient Backwater	Backswamp and point bar deposits of both active and inactive meander belts of streams.
Sand Prairie	Pleistocene lacustrine beach deposits within the lower Ouachita River basin.
Subclass: Impounded Riverine	
Beaver Complex	Any flowing waters.
Wildlife Management Impoundment	Various settings.
Class: Depression	
Subclass: Unconnected Depression	
Unconnected Alluvial Depression	Abandoned channels and large swales in former and current meander belts of larger rivers (including both Holocene and Pleistocene terrace meander belt deposits).
Subclass: Connected Depression	
Floodplain Depression	Abandoned channels and large swales in former and current meander belts of larger rivers within the 5-year floodplain. Holocene or youngest Deweyville terraces
Class: Fringe	
Subclass: Reservoir Fringe	
Reservoir shore	Primarily on hillslopes where they occur within the fluctuation zones of large man-made reservoirs.
Subclass: Unconnected Lacustrine Fringe	
Unconnected Lake Margin	Abandoned channels and man-made impoundments. Pleistocene terraces and Holocene areas outside 5-year floodplain (i.e. leveed)
Subclass: Connected Lacustrine Fringe	
Connected Lake Margin	Abandoned channels and man-made impoundments within the 5-year floodplain.
Class: Slope	
Subclass: Non-Calcareous Slope	
Bayhead	Slopes and adjacent colluvial deposits in minor stream bottoms.
Non-Calcareous Perennial Seep	Slopes and adjacent colluvial deposits in stream bottoms.

The following sections briefly describe the classification system developed for this guidebook for wetlands in the Coastal Plain region of Arkansas. It includes the five principal wetland classes that occur in the Coastal Plain, each of which comprises a number of subclasses and community types.

All of the Coastal Plain wetland types are described below, but assessment models and supporting reference data were developed for only a subset of these types, as described in Chapter 4. Additional details, including photos and distribution maps, for each of the wetlands described below, as well as wetlands in the other regions of the state, can be found on the Arkansas Multi-Agency Wetland Planning Team Web site (*www.mawpt.org*).

Class: Flat

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 Coastal Plain region, there are two subclasses and six community types in the Flat Class (Table 5).

Figure 13 illustrates common landscape positions where wetlands in the Flat Class are found. See Figure 6 to identify land surfaces.

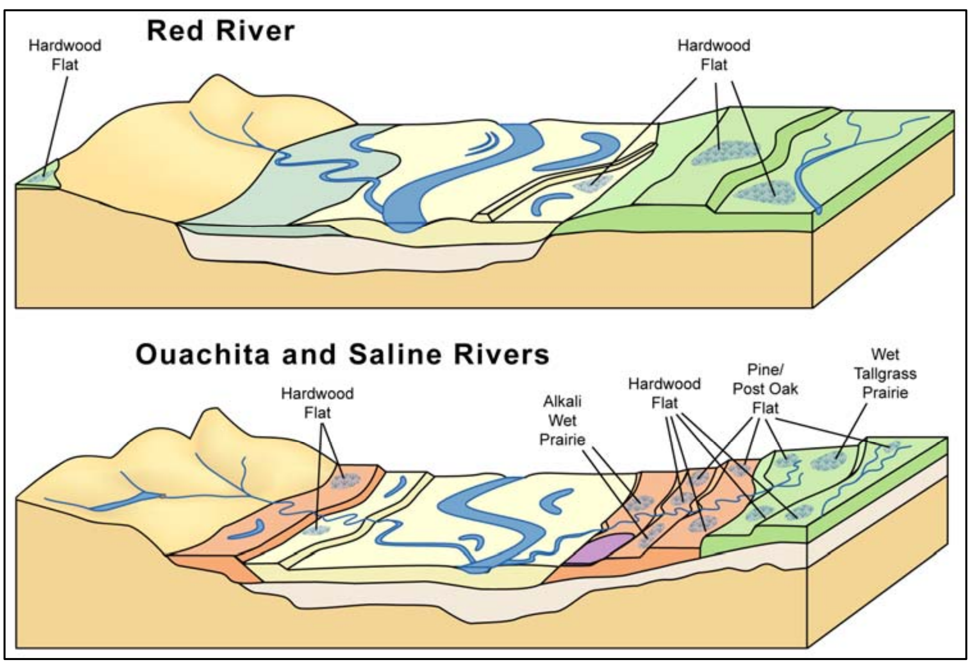


Figure 13. Typical locations of flat wetlands on common geomorphic settings of the Ouachita and Red River valleys

Subclass: alkali flat. Alkali flats (also called sodic or saline flats) have soils with high pH and high levels of sodium or magnesium salts in or near the surface layer. They typically have very poor drainage and a shallow hardpan. Most sites with alkali soils are believed to be former lakebeds. The combination of impeded drainage and unusual soil chemistry restricts the potential plant communities, and provides habitats for certain rare species. A single community type, the alkali wet prairie, represents this subclass in the Coastal Plain region. Assessment models are not presented for non-forested wetland types in this document, and alkali wet prairie communities are best assessed using a floristic approach, augmented by a site-specific evaluation of the drainage, soils, management programs and proposed impacts to the wetland.

Community type. The following community type occurs within the Alkali Flat Subclass:

a. Alkali wet prairie. The ancient lake beds that support alkali wet prairie (also called saline prairie) have high soil salinity and poor drainage. Where the salts accumulate on the surface, it is common to find a hard white or gray surface, termed a "slick spot." These areas may have salt crystals visible on the surface during dry periods, and they are largely devoid of vegetation. The perimeter of the slick spot often supports a crust of lichens, mosses, and liverworts. In Arkansas, the endangered plant species *Geocarpon minimum* is almost entirely restricted to this slick spot perimeter zone in alkali wet prairies. Beyond the slick spot edge, prairie species are able to colonize as the depth to the zone of concentrated salts increases, and stunted trees and shrubs occur on still deeper soils. Species of three-awn (*Aristida spp.*) and crotonopsis (*Crotonopsis elliptica*), as well as little bluestem (*Andropogon scoparius*), are particularly characteristic of these communities.

Only 17 individual alkali wet prairie sites are known in the Coastal Plain region of Arkansas, and all have been examined and documented to some degree. Therefore, no HGM assessment models have been developed for this type. Monitoring and any required assessment should be based on baseline floristic and soils data specific to each site.

Subclass: non-alkali flat. Flats with neutral and acid soils can support a variety of community types. They are differentiated based on predominant vegetation, which generally reflects drainage conditions. Fire history may also be an important factor in certain instances. These wetlands are widely distributed within the Coastal Plain region, but large areas of formerly wet flats have been effectively drained and converted to commercial pine production and, to a lesser extent, rowcrops or pasture. Some former riverine sites that have been isolated from streamflows by modern man-made levees are now classified as non-alkali flats.

This document includes assessment models applicable to all of the forested non-alkali flats in the Coastal Plain region. Assessment models were not developed for the wet tallgrass prairie type. As with the alkali wet prairie type, tallgrass prairie wetlands are best assessed based on floristic composition and site-specific evaluation of drainage, soils, management programs, and proposed impacts.

Community types. The following community types occur within the Non-Alkali Flat Subclass.

a. Wet tallgrass prairie. The wet tallgrass prairie community type typically occurs on the Prairie Terrace where it intergrades with pine flatwoods (see below). Wet prairies occur within broad basins or headwater draws that have poor drainage, or in minor swales within larger expanses of dry prairie. All of these sites tend to stay wet, with areas of standing surface water through spring. They usually become extremely dry in late summer. Wet tallgrass prairie is dominated by typical prairie species such as big and little bluestem, Indian grass, switch grass, and numerous perennial forbs. However, it also includes wetland species such as beakrush (*Rhynchospora spp.*), marsh fleabane (*Pluchea foetida*), sundews (*Drosera spp.*), and sphagnum moss (*Sphagnum spp.*). Wet prairie is also likely to support species that are rare or unusual in Arkansas, such as prairie cordgrass (*Spartina pectinata*). Fire is essential to maintain prairies in Arkansas — without fire, trees will gradually establish and gain dominance. No HGM models are presented here for assessment of wet prairie communities. In the event that assessment or monitoring of these wetlands is required, it should be based on a site-specific evaluation of floristics, soils, hydrology, and fire management.

b. Pine flat. Pine flats, also called pine flatwoods, occur widely on the Prairie Terrace, Intermediate Terrace, and the higher Deweyville terraces along the Ouachita and Saline valleys. Originally, these wetlands had very open canopies, with prairie species beneath the scattered large loblolly pines. In some settings, post oak was a common component and occasionally dominated. The open canopy structure and prairie components were maintained by periodic fire, which also prevented most hardwoods from invading, except in ponded vernal pool areas. Many historic pine flatwoods are now commercial timberland managed to maximize pine biomass and have lost their open, savanna-like character. The remaining examples in relatively good condition have large loblolly pines, but even these sites generally have a large hardwood component, including sweetgum (*Liquidambar styraciflua*) and a variety of oaks.

c. Hardwood flat. Hardwood flats occur on fairly level terrain that is not within the 5-year floodplain of stream systems, but nevertheless remains wet throughout winter and spring due to rainfall that collects in small shallow pools (vernal pools). These pools often re-fill and remain wet for days or weeks following summer rains. Hardwood flats typically occur on Pleistocene terraces but are also found on younger surfaces. Willow oak is the characteristic dominant species, but numerous other species occur on hardwood flats and may dominate.

d. Post oak flat. Post oak flats occur on the Prairie Terrace on sites with clay soils and poor drainage. While this is a fairly distinctive wetland type on the Grand Prairie in the Delta region, it is less so in the Coastal Plain, where it intergrades with pine flatwoods. Like the pine-dominated wetlands, post oak flats tend to have a park-like appearance maintained by periodic fire. For the purposes of applying the assessment models presented in this guidebook, post oak flats are considered a phase or subtype of the pine flatwoods.

Class: Riverine

Riverine wetlands are those areas directly flooded by streamflow, including backwater and overbank flow, at least once in 5 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 and wildlife management impoundments are usually considered to be riverine because they typically maintain a constant inflow and outflow. Riverine wetlands encompass many different types of wetland communities; there are three subclasses and six community types in the Riverine Class in the Coastal Plain region (Table 5). Figure 14 illustrates common landscape positions where wetlands in the Riverine Class are found. See Figure 6 to identify land surfaces.

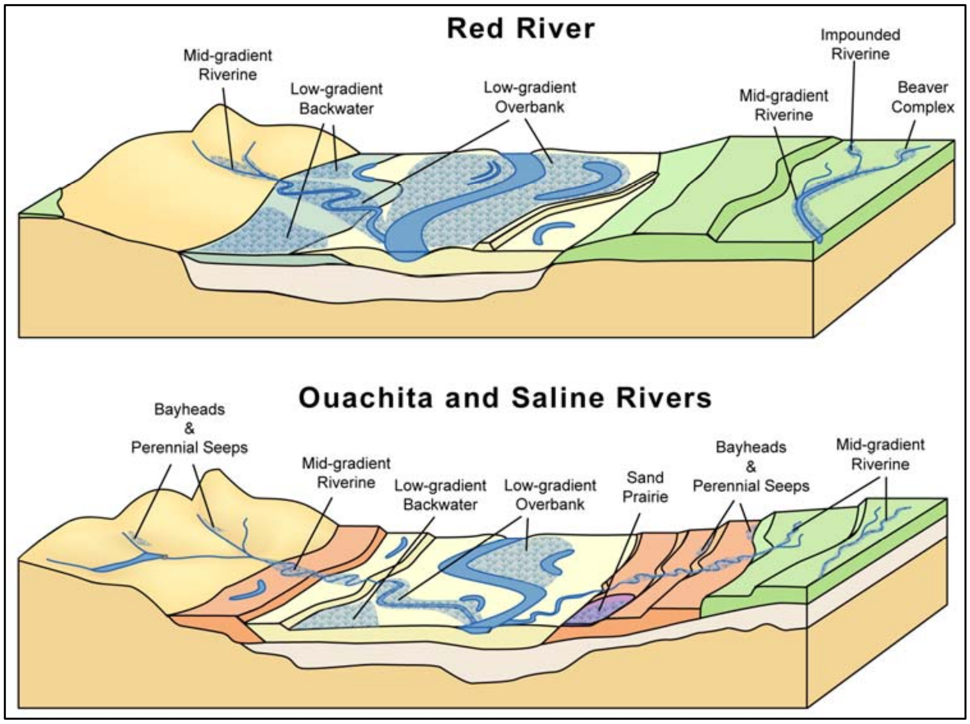


Figure 14. Typical locations of riverine and slope wetlands on common geomorphic settings of the Ouachita and Red River valleys

Subclass: mid-gradient riverine. Mid-gradient riverine wetlands occur within the 5-year floodplain of stream reaches that do not meander extensively. Typically, these streams have small floodplains, and any associated Holocene terraces tend to be relatively narrow and discontinuous. Headwater streams and reaches transitioning from the hills to the major river valleys are usually included in this category in the Coastal Plain region.

Community types: The following community type occurs within the Mid-Gradient Riverine subclass.

a. Mid-gradient floodplain. Mid-gradient floodplain wetlands occur along small streams with significant bar and floodplain formation. Riparian wetlands along mid-gradient streams are usually fairly small floodplain units that occur repeatedly, often alternating from one side of the channel to the other. They combine elements of upland and lowland forests and can be highly diverse. Species such as river birch, red maple, American elm (*Ulmus americana*), and green ash (*Fraxinus pennsylvanica*) are characteristic.

Subclass: low-gradient riverine. 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 terrace systems. They include a wide variety of community types and have important functions related to habitat as well as sediment and water storage.

Community types: The following community types occur within the Low-Gradient Riverine Subclass.

a. Low-gradient backwater. Low-gradient backwater wetlands occupy sites that flood frequently (1–5-year flood frequency), but flooding is primarily by slack water, rather than by the high-velocity flows that predominate in overbank flood zones. Backwater flooding usually occurs when mainstem streams are in high stages, impeding the discharge of tributaries and causing them back up onto their floodplains. This results in sediment accumulation and ponding that persists long after water levels have fallen in the stream channels. Sediments tend to be fine-grained, with considerable accumulation of organic material. Backwater sites that flood for long durations and are very poorly drained are usually dominated by overcup oak and water hickory (*Carya aquatica*). Less flooded sites are often dominated by green ash, Nuttall oak (*Q. nuttallii*), or willow oak, and the driest backwater sites may have species such as water oak and cherrybark oak as important components in the overstory. As with flats, vernal pools may be an important component of the low-gradient backwater community type.

Some sites that were subject to backwater flooding in historic times are now protected by levees, or flooding has been reduced by upstream dams. Wetlands on these altered sites are classified as flats if flooding now occurs on return intervals longer than 5 years on average.

b. Low-gradient overbank. Low-gradient overbank wetlands occur on regularly flooded sites (1–5-year flood frequency zone) along or near streambanks and on bars and islands within channel systems. These sites are usually point bar deposits, often with a natural levee veneer. This type differs from the low-gradient backwater community type because floodwater usually moves through the overbank zone at moderate to high velocities, parallel to the channel. Sediments, nutrients, and other materials are exported downstream or imported from upstream sites differently than they are in backwater wetlands. Whereas backwater sites may tend to accumulate fine sediments and organic material and to export dissolved materials in the water column, overbank sites tend to be subject to 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 sand bars and riverfront areas are usually dominated by willows, sycamore, cottonwood (*Populus deltoides*), and similar pioneer species, while older and less exposed substrates support more diverse communities. In most cases, however, plant communities in the overbank flood zone tend to be dominated by species with broad tolerances to inundation, sedimentation, and high-velocity flows.

Overbank sites sometimes include vernal pools, usually in the form of long, arched swales between the depositional ridges of meander-scroll topography, rather than the irregularly-shaped pools typically found in backwater areas.

c. Sand prairie. Sand prairies are unique wetlands that occur only in the floodplain of the Ouachita River in southeastern Arkansas and northeastern Louisiana. They are restricted to a range of elevations (65 to 75 ft msl) that correspond to the shoreline of a large lake (Lake Monroe) that formed during the Pleistocene and persisted for hundreds of years. The lakeshore gradually built a sandy beach, remnants of which remain today as prairie-dominated gaps in the lowland forest system. The beach deposits occur on or near the transition zone between Deweyville Terraces 2 and 3, an elevation that is subject to long-duration flooding in that part of the Ouachita River valley. The reason for prairie dominance on these sites is unclear, but may be related to droughtiness, toxic aluminum concentrations, fire, or all of these factors.

Sand prairie wetlands are dominated by typical prairie forbs and grasses, including a large complement of somewhat weedy species that tolerate the extreme stresses of the sites, but they also support a variety of rare or uncommon species. No assessment models have been developed specifically for sand prairies. As with alkali wet prairies, so few examples of this type are known that they all can be regarded as unique. Monitoring and any required assessment should be based on baseline floristic and soils data specific to each site.

Subclass: impounded riverine. These wetlands occur in shallow impoundments that detain and slow stream flows but generally remain flow-through systems. They include highly dynamic and unique beaver- (*Castor canadensis*) dominated wetlands, as well as systems that are intensively managed to benefit particular groups of wildlife species.

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.

Wildlife Management Impoundments are designed specifically to maximize a single wetland function (habitat) and are often targeted toward a specific wildlife group (usually waterfowl). They are intended to allow managers to flood large areas at times when water is not naturally present in those areas. Because the hydrological modifications usually imposed do not reflect the patterns observed in reference systems, this guidebook does not include models designed specifically for application to managed impoundments.

Community types: The following community types occur within the Impounded Riverine Subclass.

a. Beaver complex. Beaver complexes were once nearly ubiquitous here and elsewhere in the continental United States, but became relatively uncommon during the past two centuries following the near extirpation of beaver. Usually, they consist of a series of impounded pools on flowing streams. Beaver cut trees for dams and food, and they have preferences for certain species (e.g., sweet-gum), 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.

b. Wildlife management impoundment. Wildlife management impoundments are areas managed specifically to provide habitat for waterfowl and other waterbirds. There are two versions of this management approach: greentree reservoirs and moist soil units. They are included in the Riverine Class because they usually draw water from and return it to stream systems, but the wetlands are contained within low levee systems that allow managers to create shallow flooding conditions suitable for use by foraging and resting birds. Greentree reservoirs are leveed sections of mature oak bottomland forest, which provide access to acorns and forest invertebrates when artificially flooded to provide shallow water for waterfowl foraging. Occasionally, large greentree systems are created behind dams that are operated primarily for other purposes (e.g. navigation). Moist soil units are leveed cleared fields, where water management and farm machinery are employed to maintain marsh-like conditions, which provide small seeds and different invertebrates than are found in forested wetlands.

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 ponded areas that occur within the Flat and Riverine Subclasses in several ways. Depressions tend to occur in abandoned channels, abandoned courses, and large point bar swales, while vernal pools within Flat and Riverine wetlands occur in minor swales or in areas bounded by natural levee deposits. Depressions hold water for extended periods due to their size, depth, and ability to collect surface and subsurface flows from an area much larger than the depression itself. They tend to fill during the winter and spring and dry very slowly. Prolonged rains may fill them periodically during the growing season, after which they again dry very slowly. Vernal pools in Flats and Riverine settings, in contrast, fill primarily due to direct precipitation inputs and dry out within days or weeks. Depression Subclass wetlands usually exhibit two or more of the following characteristics:

- Depressional soils may have one or both of the hydric soil indicators F2 (Loamy Gleyed Matrix) or A4 (Hydrogen Sulfide; USDA-NRCS 1998).

- Depressions are distinct, closed units with relatively abrupt transitions to flats, riverine wetlands, or uplands (as opposed to extensive riverine backwater zones).

- Vegetation in depressions is usually dominated by one or more of the following species: baldcypress, swamp tupelo (*Nyssa aquatica*), swamp privet (*Forestiera accuminata*), water elm (*Planera aquatica*), and buttonbush (*Cephalanthus occidentalis*). Many depressions are fringed (and some are dominated) by species such as overcup oak and water hickory.

In the Coastal Plain region of Arkansas, there are two subclasses in the Depression Class, each represented by a single community type (Table 5). Figure 15 illustrates common landscape positions where wetlands in the Depression Class are found. See Figure 6 to identify land surfaces.

Subclass: unconnected depression. Unconnected depressions are found in abandoned channels and point bar swales in Holocene alluvium outside the five-year floodplain, and in relict abandoned channels on Pleistocene terraces. They are maintained by precipitation, runoff, and sometimes by groundwater. Some may have small influent and outlet channels, but they are not overwhelmed by floodwaters during 5-year events; therefore, the import or export of materials is not a significant function of these wetlands except during extreme events. Their isolation from river systems may result in very different wildlife functions than those associated with connected depressions. For example, unconnected depressions may lack predatory fish populations, and thereby provide vital habitat for certain invertebrate and amphibian species.

Community types: The following community type occurs within the Unconnected Depression Subclass.

a. Unconnected alluvial depression. Unconnected alluvial depressions occur in major river floodplains that have been cut off from the channel by levees and on terraces (former floodplains, either Holocene or Pleistocene in age, that are higher than the modern floodplain). They are not affected by river flooding during common flood events (1–5-year flood frequency zone). This lack of connection to the river distinguishes this wetland type from floodplain depressions, but otherwise the two types are very similar. Unconnected alluvial depression wetlands typically occur in abandoned river channels and large swales. Depressions that are deep enough to hold water year-round will have an open-water zone (less than 2 m deep) in the center, with baldcypress and buttonbush in areas that are rarely dry, and relatively narrow zones of progressively “drier” plants, such as overcup oak, around the depression perimeter.

Subclass: connected depression. Connected depressions occur within the 5-year floodplain of streams and are integral components of the stream ecosystem with regard to materials exchange and storage. They are often used by fish and other aquatic organisms that move in and out of the wetland during floods.

Community type: The following community type occurs within the Connected Depression Subclass.

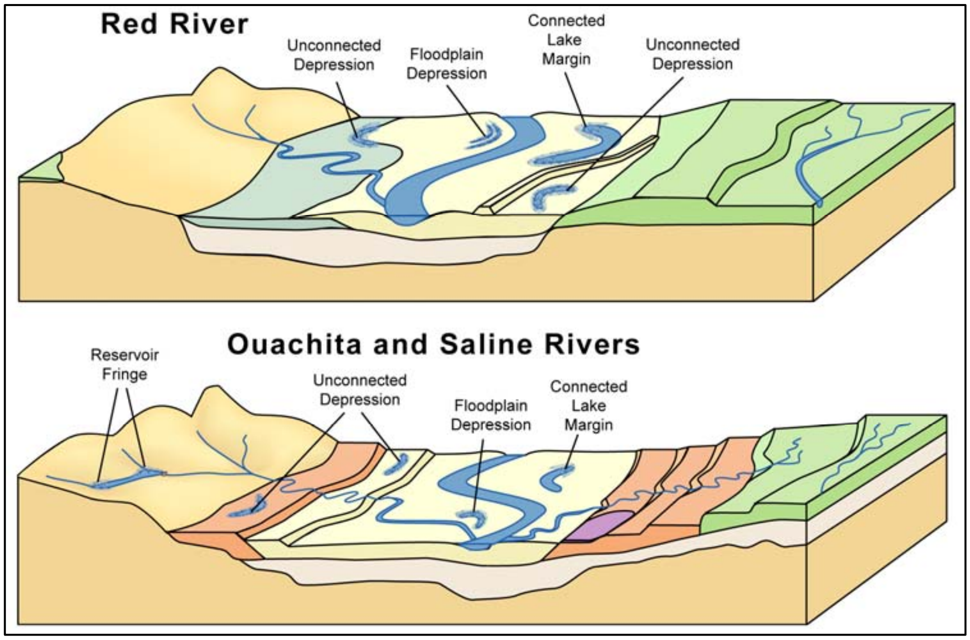


Figure 15. Typical locations of depression and fringe wetlands on common geomorphic settings of the Ouachita and Red River valleys

a. Floodplain depression. Floodplain depression wetlands are most commonly found in 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 (1–5-year) flood events. They typically support swamp forests or shrub swamps in deeper water zones that remain flooded most of the time and overcup oak-water hickory forests in areas that dry out in summer.

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 depressional.

In Arkansas, natural lakes occur mostly in the abandoned channels of large rivers (oxbows), but numerous man-made impoundments also support fringe wetlands. Typical examples within the Coastal Plain include the baldcypress fringe common on oxbow lakes and the black willow (*Salix nigra*) fringe that is often associated with borrow pits. There are three subclasses and three community types in the Fringe Class (Table 5). No assessment models have been developed for any of the fringe wetland subclasses in Arkansas, primarily because no single reference system can reflect the range of variability they exhibit. In particular, many water bodies that support fringe wetlands are subject to water-level controls, but the resulting fluctuation patterns are highly variable depending on the purpose of the control structure. Figure 15 illustrates common landscape positions where wetlands in the Fringe Class are found. See Figure 6 to identify land surfaces.

Subclass: reservoir fringe. Wetlands that occur within the fluctuation zone of man-made reservoirs are classified as reservoir fringe. Reservoirs are distinguished from other man-made water bodies (such as borrow pits) in that they are specifically constructed and operated to store water for flood control, water supply, or similar purposes. As a result, they tend to have fluctuation regimes that are different from any natural pattern in the region.

Community type: The following community type occurs within the Reservoir Fringe Subclass.

a. Reservoir shore. Man-made reservoirs include a wide array of features, such as large farm ponds, municipal water storage reservoirs, and state recreational lakes. In almost all cases, these lakes are managed specifically to modify natural patterns of water flow, therefore their shoreline habitats are subjected to inundation at times and for durations not often found in nature. Steep reservoir shores usually support little perennial wetland vegetation other than a narrow fringe of cattails (*Typha spp.*) and willows (*Salix spp.*). 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 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. Fringe wetlands are considered to be "connected" to other aquatic systems if they become contiguous with river flows during a 5-year flood event. This means that aquatic organisms can move freely between the river and the lake on a regular basis, and nutrients, sediments, and organic materials are routinely exchanged between the riverine and lake systems.

Community type: The following community type occurs within the Connected Lacustrine Fringe Subclass.

a. Connected lake margin. Connected lake margin wetlands occur primarily in oxbow lakes near large rivers, where they are frequently inundated during floods (that is, they are within the 5-year floodplain). Many lakes that would have met this criterion early in this century have gradually been disconnected from river flows due to the completion of large levees and other flood-protection works, and the wetlands in those lakes are now classified as unconnected lake margins. Connected lake margins differ from unconnected systems in that they routinely exchange nutrients, sediments, and aquatic organisms with the river system. Shoreline cypress-tupelo stands and fringe marshes are common, and the upper reaches of oxbow lakes often contain buttonbush swamps and expansive marsh systems. In addition to natural oxbows, there are man-made bodies of water, such as borrow pits, which support connected fringe wetlands.

Subclass: unconnected lacustrine fringe. These fringe wetlands occur on lakes that are not within the 5-year floodplain of a river, although they may have small inflow and outflow streams. Many oxbow lakes that have been isolated from big rivers by levees are in this category. Managed flood control and water supply reservoirs are not included here, but deeply flooded borrow pits are included.

Community type: The following community type occurs within the Unconnected Lacustrine Fringe Subclass.

a. Unconnected lake margin. Unconnected lakes are lakes that are not within the portion of a floodplain that is inundated by a river on a regular basis (that is, they are not within the 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 oxbow lakes, where baldcypress wetlands normally form in a narrow band along the shoreline. Shallow filled areas in the upper and lower ends of the lake sometimes develop more extensive wetland complexes of willows, buttonbush, and marsh species.

Most of these natural lake systems have been modified in various ways. Frequently, their outlets have been fitted with control structures to allow added storage and manipulation of water. Inflows have been altered by farm drainage and other diversions, and adjacent lands have been cleared or developed in many areas. All of these actions have caused accelerated sedimentation within the lakes.

Naturally-occurring unconnected lake margins are most common in the former floodplains of large rivers, where levees now prevent flooding. Man-made lakes in this subclass can occur anywhere.

Class: Slope

Slope wetlands occur on sloping land surfaces where groundwater discharge or shallow subsurface flow create saturated conditions. There is one subclass comprising two community types in the Coastal Plain region (Table 5). Figure 14 illustrates common landscape positions where wetlands in the Slope Class are found. See Figure 6 to identify land surfaces.

Subclass: non-calcareous slope. In the Coastal Plain, slope wetlands with non-calcareous substrates are classified into two wetland types that are similar in many ways but tend to have different dominant overstory species. The two types also tend to occur in different geographic areas, with bayheads predominating in the southeastern part of the Coastal Plain region and non-calcareous perennial seeps more commonly found north of there. Both of these communities are floristically rich and often support sensitive plant species.

Community types: The following community types occur within the Non-Calcareous Slope Subclass.

a. Bayhead. Bayheads are forested seeps that occur on slopes in the Coastal Plain and on colluvial material on adjacent floodplains of small streams. Usually, they have silty soils overlain by thick organic deposits. Subsurface sandy lenses often carry seepage that maintains a saturated condition within the root zone.

Sweetbay is the indicator species for this wetland type and is usually dominant or co-dominant in the overstory. A large variety of other tree and shrub species commonly occur, along with a lush and diverse ground cover. Ferns are particularly prominent components of the ground cover, including species that are of relatively restricted distribution in Arkansas.

b. Non-calcareous perennial seep. This wetland type also occurs on lower slopes and adjacent small stream bottoms, and like bayheads, usually is floristically rich with an abundance of ferns. However, sweetbay is generally absent, or a minor component; the overstory is dominated by any of a suite of species that include American beech, red maple, umbrella magnolia, and blackgum (baldcypress is dominant on two known seeps). Sedges (*Carex spp.*) may be dominant in the ground layer on some sites. Soils are generally sandy, but thick organic deposits may accumulate where topography allows.

4 Wetland Functions and Assessment Models

This Regional Guidebook contains seven sets of assessment models applicable to wetlands in the Coastal Plain Region 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 Riverine Impounded subclass wetlands are addressed in this guidebook, 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 Coastal Plain 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. Also, the Low-Gradient Riverine subclass is sufficiently complex that separate models have been developed for its constituent community types: Low-Gradient Overbank and Low-Gradient Backwater wetlands. To maintain consistency, they will also be referred to as separate subclasses 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:

a. Flat.

b. Low-Gradient Riverine Overbank.

c. Low-Gradient Riverine Backwater.

d. Mid-Gradient Riverine.

e. Unconnected Depression.

f. Connected Depression.

g. 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 a Guidebook for Application of Hydrogeomorphic Assessments to Riverine Wetlands (Brinson et al. 1995). Based on the workshop recommendations, this regional guidebook provides models and reference data required to determine the extent to which forested wetlands of the Arkansas Coastal Plain perform the following functions:

a. Detain Floodwater.

b. Detain Precipitation.

c. Cycle Nutrients.

d. Export Organic Carbon.

e. Maintain Plant Communities.

f. Provide Habitat for Fish and Wildlife.

It should be noted that not all functions are performed by each regional wetland subclass. Thus, assessment models for each subclass may not include all seven 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 these functions is discussed generally in terms of the following topics:

a. 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.

b. Rationale for selecting the function. This section discusses the reasons a function was selected for assessment, and the onsite and offsite effects that may occur as a result of lost functional capacity.

c. 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.

d. 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. In the final chapter (Chapter 6), detailed descriptions are presented 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 Coastal Plain Region of Arkansas: Low-Gradient Riverine Overbank, Low-Gradient Riverine Backwater, Mid-Gradient Riverine, and Connected Depression.

The recommended procedure for assessing this function involves estimation of “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 (Campbell and Johnson 1975; Demissie and Kahn 1993; Dewey and Kropper Engineers 1964; Dybvig and Hart 1977; Novitski 1978; Ogawa and Male 1983, 1986; Thomas and Hanson 1981). Generally, floodwater interaction with wetlands dampens and broadens the flood wave, which reduces peak discharge downstream. Similarly, wetlands can reduce the velocity of water currents and, as a result, reduce erosion (Ritter et al. 1995). Some portion of the floodwater volume detained within floodplain wetlands is likely to be evaporated or transpired, reducing the overall volume of water moving downstream. The portion of the detained flow that infiltrates into the alluvial aquifer, or which returns to the channel very slowly via low-gradient surface routes, may be sufficiently delayed that it contributes significantly to the maintenance of baseflow in some streams long after flooding has ceased (Saucier 1994; Terry et al. 1979). Retention of particulates is also 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 these physical influences on flow and sediment dynamics. Floodwater interaction with floodplain wetlands influences a variety of other wetland functions in the Coastal Plain Region of Arkansas, including nutrient mobility and storage and the quality of habitat for plants and animals. The role of flooding in maintenance of 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 antecedent conditions, the characteristics of the particular flood event, the configuration and slope of the floodplain and channel, and the physical obstructions present within the wetland that interfere with flows. The intensity, duration, and spatial extent of precipitation events affect the magnitude of the stream discharge response. Typically, rainfall events of higher intensity, longer duration, and greater spatial extent result in greater flood peaks. Watershed characteristics such as size and shape, channel and watershed slopes, drainage density, and the presence of wetlands and lakes have pronounced effects on the stormflow response (Brooks et al. 1991; Dunne and Leopold 1978; Leopold 1994; Patton 1988; Ritter et al. 1995). The larger the watershed, the greater the volume and peak stream discharge that results from a rainfall event. Watershed shape affects how quickly surface and subsurface flows reach the outlet to the watershed. For example, a rounded watershed concentrates runoff more quickly than an elongated one and will tend to have higher peak flows. Steeper hillslopes and channel gradients also result in quicker response and higher peak flows. The higher the drainage density (i.e., the sum of all the channel lengths divided by the watershed area), the faster water is concentrated at the watershed outlet and the higher the peak flow. 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 and are considered constant for the purposes of rapid assessment.

The physical characteristics of the floodplain and the stream channel also are important determinants of flood-flow interactions. The morphology of the stream channel and its floodplain reflect the discharges and sediment loads that have occurred in the past. Under stable flow and sediment conditions, the stream and its floodplain will eventually achieve equilibrium. Alteration to the stream channel or its watershed may cause instability that results in channel aggradation or degradation and a change in depth, frequency, and duration of overbank flow events (Dunne and Leopold 1978; Rosgen 1994). As the stream channel aggrades, available water storage in the channel decreases, resulting in greater depth, frequency, and duration of flooding, and an increase in amount of surface water stored in the wetland over an annual cycle. Conversely, as the stream channel degrades, available water storage in the channel increases, resulting in less depth, frequency, and duration of flooding and a decrease in the amount of surface water stored in the wetland over an annual cycle. 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 all of these characteristics, only flood frequency and the roughness component can be reasonably incorporated into a rapid assessment. The extensive channel modifications and levee construction that have taken place in the region make it difficult to ascribe detailed flood characteristics to any particular point on the ground, especially if it is not directly adjacent to a channel and near a stream gauge. At best, flood frequency can be estimated 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, shrub and sapling density, V_{SSD}, have their greatest influence on flows that intercept understory canopies (usually 1–3 m deep), and tree stems, V_{TDENS}, interact with a full range of flood depths. Both tree stems and logs are equally effective in disrupting flows at all times of the year, while understory and ground cover interactions are less effective during winter floods than during the growing season. Other components of wetland structure contribute to roughness, but are not assessed here because they do not commonly influence flows to the same degree as these components (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 Coastal Plain Region 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 Coastal Plain Region of Arkansas: Flat, Low-Gradient Riverine Overbank, Low-Gradient Riverine Backwater, and Mid-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. 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 formerly deeper depressions such as cutoffs or oxbows. In addition, the presence of surface organic accumulations 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 onsite, where it supports biological processes, contributes to subsurface water storage, and eventually helps maintain baseflow in nearby streams. Clearing of 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 seven wetland subclasses.

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 (gm/m^2), annual litter fall (gm/m^2), or standing stock of living and/or dead biomass (gm/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; Perry 1994; Whittaker 1975). The plant community, in turn, provides a pool of nutrients and source of energy for secondary production and also provides the habitat structure necessary to maintain the animal community (Fredrickson 1978; Wharton et al. 1982). Plant and animal communities serve as the source of detritus, which provides nutrients and energy necessary to maintain a characteristic community of decomposers. These decomposers, in turn, break down organic material into simpler elements and compounds that can then reenter the nutrient cycle (Dickinson and Pugh 1974; Harmon et al. 1986; Hayes 1979; Pugh and Dickinson 1974; Reiners 1972; Schlesinger 1977; Singh and Gupta 1977; 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 (Brinson 1990; Brown and Peterson 1983; Conner and Day 1976;

Day 1979; Elder and Cairns 1982; Harmon et al. 1986; Mulholland 1981; Nadelhoffer and Raich 1992; Raich and Nadelhoffer 1989; Symbula and Day 1988).

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

General form of the assessment model

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

V_{TBA} = tree basal area

V_{SSD} = shrub-sapling density

V_{GVC} = ground vegetation cover

V_{OHOR} = O horizon thickness

V_{AHOR} = A horizon thickness

V_{WD} = woody debris biomass

V_{SNAG} = snag density

The model can be expressed in a general form:

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

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

All of these components are combined here in a simple arithmetic model, which weights each element equally. Note that one detrital component, litter accumulation, is not used in this model. 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, discussed in the next section.

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 ground water 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 Coastal Plain Region of Arkansas: Low-Gradient Riverine Overbank, Low-Gradient Riverine Backwater, Mid-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 (Elwood et al. 1983; Sedell et al. 1989; Vannote et al. 1980). Dissolved organic carbon is a significant source of energy for the microbes that form the base of the detrital food web in aquatic ecosystems (Dahm 1981; Edwards 1987; Edwards and Meyers 1986). 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), therefore 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 (Brinson et al. 1981; Elder and Mattraw 1982; Johnston et al. 1990; Mulholland and Kuenzler 1979). This is attributable to several factors: (a) the large amount of organic matter in the litter and soil layers that comes into contact with floodwaters, overland flow, or groundwater discharge; (b) relatively long periods of inundation or saturation and, consequently, contact between surface water and organic matter, thus allowing for significant leaching; (c) the ability of the labile carbon fraction to be rapidly leached from organic matter when exposed to water (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 (used in riverine and connected depression subclasses)

V_{OUT} = outflow from wetland (used in slope subclasses)

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:

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

This model is similar to the model used to assess the biogeochemical 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 biogeochemical cycling model in that materials stored in the soil are not included due to their relative immobility, and an export mechanism is a required component of this model. The export mechanism is 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 includes consideration of litter, despite the fact that it is a highly seasonal functional indicator that is difficult to estimate reliably, and therefore is not included in other models where it may seem appropriate. It is included in this model because it represents the most mobile dead organic 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. These include quantitative measures based on vegetation composition and abundance such as similarity indices (Ludwig and Reynolds 1988), and indirect multivariate techniques such as detrended correspondence analysis (Kent and Coker 1995). 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 seven wetland subclasses.

Rationale for selecting the function

The ability to maintain a characteristic plant community is important because of the intrinsic value of the plant community and the many attributes and processes of wetlands that are influenced by the plant community. For example, primary productivity, nutrient cycling, and the ability to provide a variety of habitats necessary to maintain local and regional diversity of animals are directly influenced by the plant community (Harris and Gosselink 1990). In addition, the plant community of a river-connected wetland influences the quality of the physical habitat, nutrient status, and biological diversity of downstream systems (Bilby and Likens 1979; Elder 1985; Gosselink et al. 1990; Hawkins et al. 1982).

Characteristics and processes that influence the function

Numerous studies describe the environmental factors that influence the occurrence and characteristics of plant communities in wetlands (Hodges 1997; Messina and Conner 1997; Robertson 1992; Robertson et al. 1978; Robertson et al. 1984; Smith 1996; Wharton et al. 1982). 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 guidebook. Soil characteristics are also significant determinants of plant community composition (see Soils Section in Chapter 3). In addition to physical factors, system dynamics and disturbance history are also important in determining the condition of a wetland plant community at any particular time. These include past land use, timber harvest history, hydrologic changes, sediment deposition, and events such as storms, fire, beaver activity, insect outbreaks, and disease. Clearly, some characteristics of plant communities within a particular wetland subclass may be determined by factors too subtle or variable to be assessed using rapid field estimates. Therefore, this function is assessed primarily by considering the degree to which the existing plant community structure and composition are appropriate to site conditions and the expected stage of maturity for the site. Secondarily, in some subclasses, soil and hydrologic conditions are assessed to determine if fundamental requirements are met to maintain wetland conditions appropriate to the geomorphic setting.

General form of the assessment model

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

V_{TBA} = tree basal area

V_{TDEN} = tree density

V_{COMP} = composition of tallest woody stratum

V_{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:

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

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, V_{TBA}, and density, 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, the Composition Variable, considers plant species composition. In most instances, 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. As described in Chapter 3, plant communities of the Coastal Plain Region of Arkansas are strongly affiliated with particular soil types, which in turn are the product of distinct alluvial processes. 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 wetland character in many wetlands in the Coastal Plain Region 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. As noted elsewhere, characterization of flood frequency and duration in the Coastal Plain Region of Arkansas is difficult, and cannot often be interpreted in a way that would add meaningfully to the assessment of plant community maintenance.

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 use wetlands during some part of their life cycles. Potential independent, quantitative measures of this function are animal inventory approaches, with data analysis usually employing comparisons between sites using a similarity index calculated from species composition and abundance (Odum 1950; Sorenson 1948).

This function is assessed in all seven wetland subclasses.

Rationale for selecting the function

Terrestrial, semi-aquatic, and aquatic animals use wetlands extensively. Maintenance of this function ensures habitat for a variety 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 Coastal Plain Region of Arkansas depend on certain aspects of wetland structure and dynamics, such as periodic flooding or ponding of water, specific vegetation composition, and proximity to other habitats.

Characteristics and processes that influence the function

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

Forested wetlands are typically floristically and hydrologically complex (Wharton et al. 1982). In most forest systems, structural diversity in the vertical plane generally increases with vegetation maturity (Hunter 1990). On the horizontal plane, vegetation structure varies due to gap-phase regeneration dynamics and microsite variability. Such variability includes the interspersion of low ridges, swales, abandoned channel segments, and other features on floodplains that differentially flood or pond rainwater, and support distinctively different plant communities (see Chapter 3). This structural diversity provides habitat conditions and food resources that allow numerous animal species to coexist in the same area (Allen 1987; Schoener 1986). In some Coastal Plain systems, periodic fire may control habitat structure and favor a smaller group of more specialized animal species, by maintaining an open savanna rather than a closed, complex forest.

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) that is vital to some of the more visible members of the community. For example, prior to laying eggs, wood ducks forage extensively on macro-invertebrates found in the floodplain. Similarly, mallards heavily utilize the abundant litter invertebrate populations associated with flooded or ponded bottomland forests during winter (Batema et al. 1985). Logs and other woody debris provide cover and a moist environment for many species including invertebrates, small mammals, reptiles, and amphibians (Hunter 1990). Animals found in forested wetlands use logs as resting sites, cover, feeding platforms, and as sources of food (Harmon et al. 1986; Loeb 1993). Standing dead trees (snags) are used by numerous bird species, and several species are dependent on them (Scott et al. 1977). Stauffer and Best (1980) found that most cavity-nesting birds, particularly the primary cavity nesters such as woodpeckers, preferred snags to live trees. Mammals such as bats, squirrels, and raccoon (*Procyon lotor*) also are dependent on snags to varying extents (Howard and Allen 1989), and most species of forest-dwelling mammals, reptiles, and amphibians, along with numerous invertebrates, seek shelter in cavities, at least occasionally (Hunter 1990).

In wetlands of the Coastal Plain Region of Arkansas, hydrology is one of the major factors influencing wildlife habitat quality. A significant hydrologic component is precipitation, particularly where it is captured in vernal pools and small puddles. These sites are sources of surface water for various terrestrial animals, and provide reproductive habitat for invertebrates and amphibians, many of which are utilized as a food source by other animals (Johnson 1987; Wharton et al. 1982). 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 slope wetlands that remain saturated through much of the year.

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, wetlands that are periodically river-connected also provide vital habitat for some species. Wharton et al. (1982) provided an overview of fish use of bottomland hardwoods in the Piedmont and eastern Coastal Plain, and stated that at least 20 families comprising 53 species of fish use various portions of the floodplain for foraging and spawning. Baker and Killgore (1994) reported similar results from the Cache River drainage in Arkansas, where they found that most fish species exploit floodplain habitats at some time during the year, many for spawning and rearing. In addition to flooding itself, the complex environments of floodplains are of significance to fish. Wharton et al. (1982) listed numerous examples of fish species being associated with certain portions of the floodplain. Baker et al. (1991) noted that the different microhabitats on the floodplain typically supported different fish assemblages from those of the channel. Baker and Killgore (1994) stated that “the structurally complex environment of irregularly flooded oak-hickory forests provide optimum habitat for many wetland fish.”

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

One particularly complex component of wildlife habitat quality involves “landscape-level” features. This general term encompasses a wide variety of considerations, including the size of the “patch” that includes the assessment area, surrounding land uses, connections to other systems, and the scale and periodicity of disturbance (Hunter 1990; Morrison et al. 1992). It is generally assumed that reduction and fragmentation of forest habitat, coupled with changes in the remaining habitat, resulted in the loss of the ivory-billed woodpecker (*Campephilus principalis*), Bachman’s warbler (*Vermivora bachmanii*), and the red wolf (*Canis rufus*), as well as severe declines in the black bear (*Ursus americanus*) and Florida panther (*Puma concolor coryi*). The extent to which patch size affects animal populations has been most thoroughly investigated with respect to birds, but the results have been inconsistent (Askins et al.1987; Blake and Karr 1984; Howe 1984; Keller et al. 1993; Kilgo et al. 1997; Lynch and Whigham 1984; Sallabanks et al. 1998; Stauffer and Best 1980). 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 3 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 (*Limnothlypis swainsonii*) are in the first group; more sensitive species such as the cerulean warbler (*Dendroica cerulea*) are in the second group; and those with very large home ranges (e.g., raptors such as the red-shouldered hawk) (*Buteo lineatus*) are in the third group.

The land-use surrounding a tract of forest also has a major effect on avian populations. Recent studies (Robinson et al. 1995; Sallabanks et al. 1998; Thompson et al. 1992; Welsh and Healy 1993) 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 Coastal Plain Region of Arkansas (Rudis 2001). However, in savanna-like wetlands, where the conservation priorities focus on particular specialized species, such as the red-cockaded woodpecker (*Dendocopos borealis*), much smaller patches with specific structural attributes may be adequate. Rheinhardt et al. (2002) indicate that approximately 100 ha of contiguous, fire-maintained, open-canopied forest is adequate to support such species in pine flatwoods of the Gulf and South Atlantic coastal region.

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

The characteristics of the buffer zones (or adjacent habitats) determine whether they can be used effectively by the semi-aquatic species that depend on small wetlands of depressions, 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 (Rothermal and Semlitsch 2002).

General form of the assessment model

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

V_{FREQ} = 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_{FIRE} = fire-maintained landscape

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:

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

The expressions within the model reflect the major habitat components described previously. The first expression concerns hydrology, and includes indicators of both extensive seasonal inundation, which allows river access by aquatic organisms, V_{FREQ}, as well as 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 Variable)* may incorporate different terms, depending on the subclass being assessed. In the low-gradient riverine and hardwood flat subclasses, a single variable, V_{PATCH}, is used to represent the importance of large blocks of contiguous forest in systems that historically included extensive 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 pine flats, the landscape component of the assessment model keys on whether adequate area of very specialized, fire-maintained habitat is available, V_{FIRE}. For mid-gradient riverine, slope, and depression 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-meter "general use" buffer zone, V_{BUF30}, as well as a 250-meter 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 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 seven 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 (Batista and Platt 1997; Greenberg et al. 1997; Kennedy and Nowacki 1997; Meadows and Nowacki 1996; Tyrrell et al. 1998) and sample data from similar settings in the Delta Region of Arkansas (Klimas et al. 2003) were used to resolve occasional ambiguities in the data set. In the case of pine flats, which are highly dependent on fire to maintain their characteristic structure and unique herbaceous species composition (see Chapter 3), there are no sites within Arkansas that are considered to be of “reference standard” quality. Therefore, subindex curves for pine flats were calibrated partly by consulting reference data collected from similar systems along the Gulf Coast (Rheinhardt et al. 1997; Rheinhardt et al. 2002), and with consideration of the fire management experiences of the Arkansas Natural Heritage Commission.

Subclass: 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. Figures 16 and 17 illustrate relationship between the variable metrics and the subindex (for Pine Flats and Hardwood Flats, respectively) for each of the assessment models based on the reference data. Note that, unlike other subclasses, the Flat subclass subindex curves for percent ponding reflect three different geomorphic settings, and it is necessary to identify the setting when assembling field data. Specific guidance is provided on the field data forms in Appendix B1.

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 for pine flats:

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

Applicable in the following modified format for hardwood flats:

$$FCI = \left\{ V_{POND} \times \left[\frac{\left(V_{TCOMP} + V_{STRATA} + V_{SNAG} + V_{TBA} \right)}{4} \right] \times \left[\frac{\left(V_{LOG} + V_{OHOR} \right)}{2} \right] \times V_{PATCH} \right\}^{1/4} \quad (12)$$

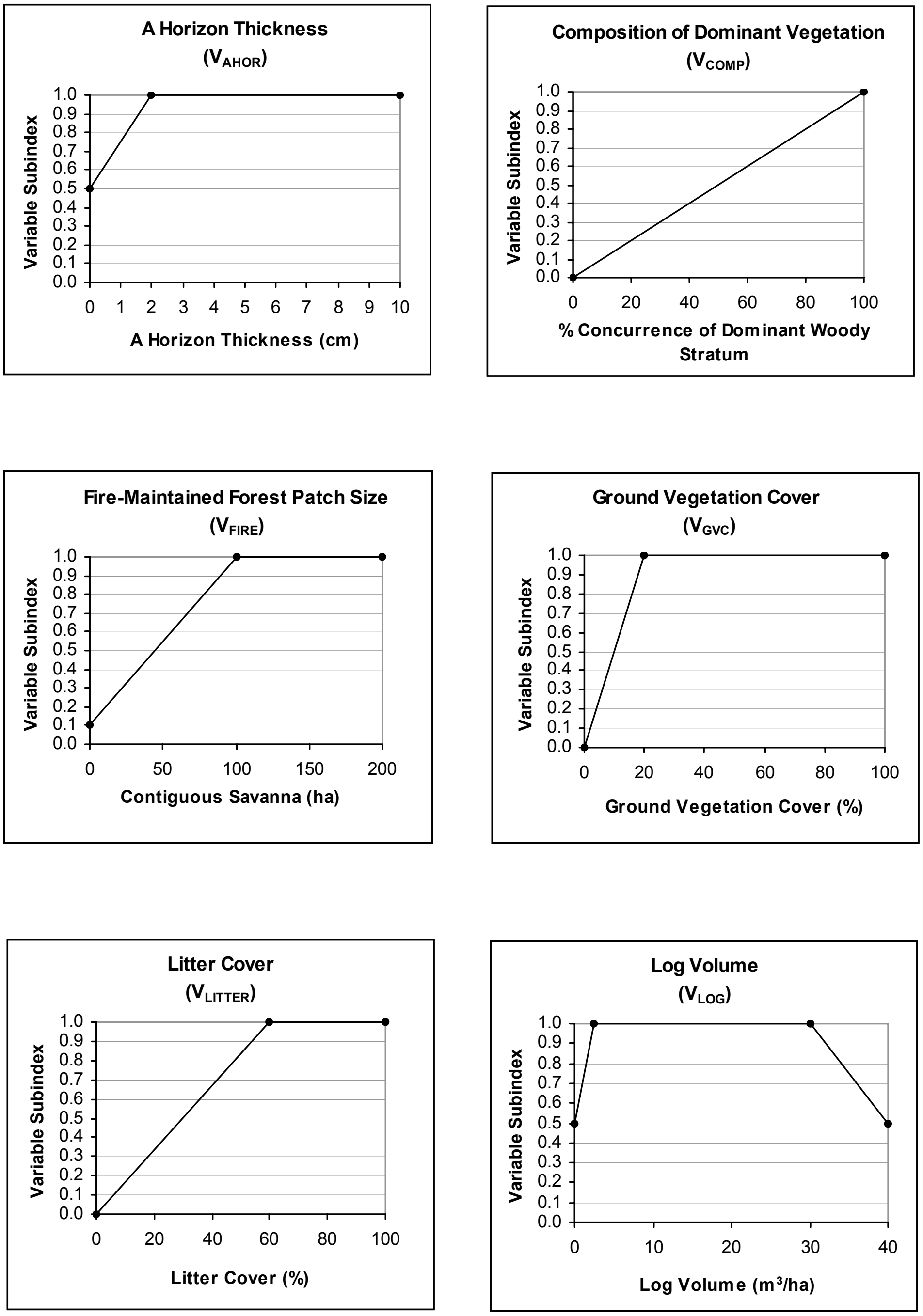


Figure 16. Subindex graphs for pine flat wetlands (Sheet 1 of 3)

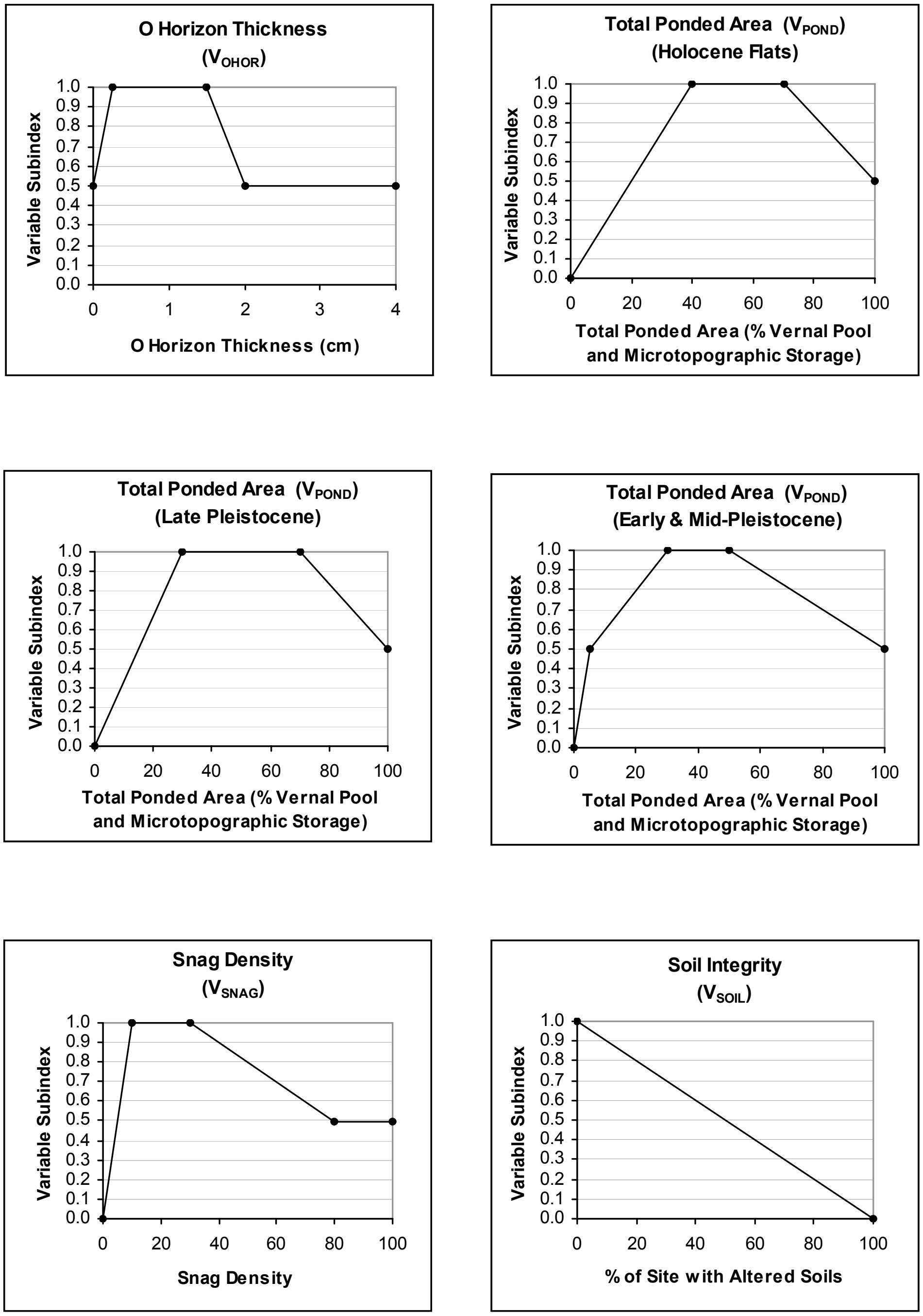


Figure 16. (Sheet 2 of 3)

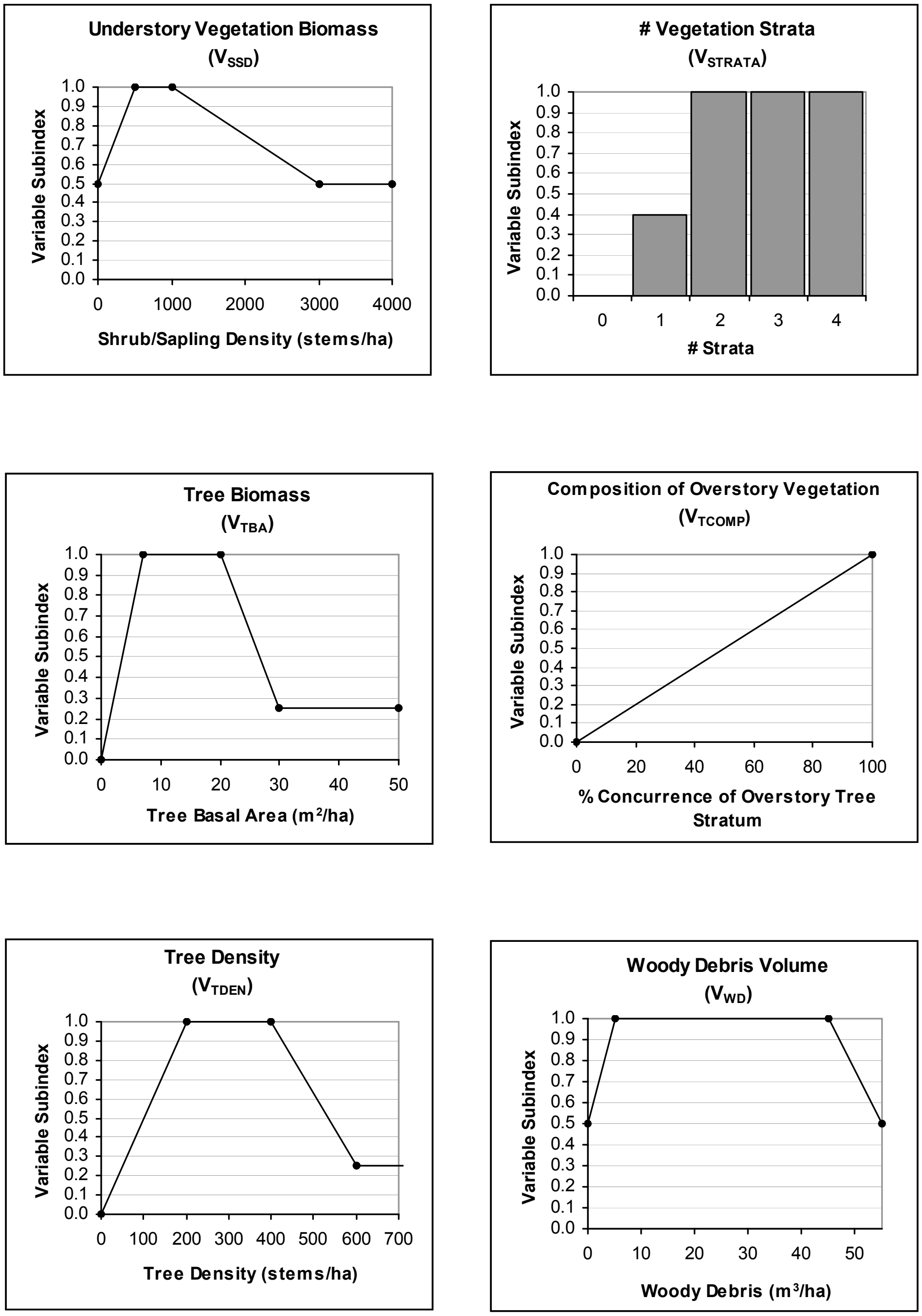


Figure 16. (Sheet 3 of 3)

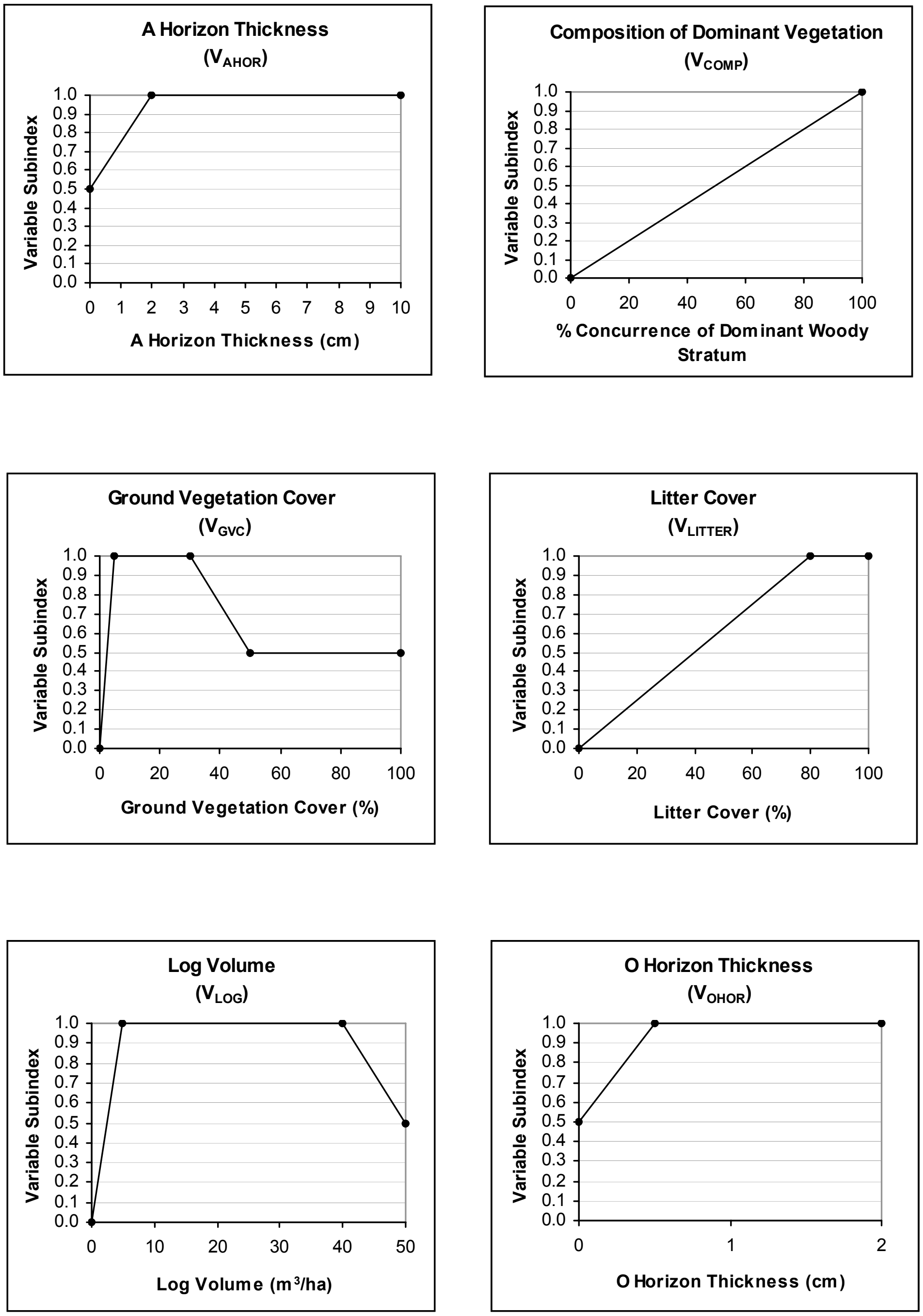


Figure 17. Subindex graphs for hardwood flat wetlands (Sheet 1 of 3)

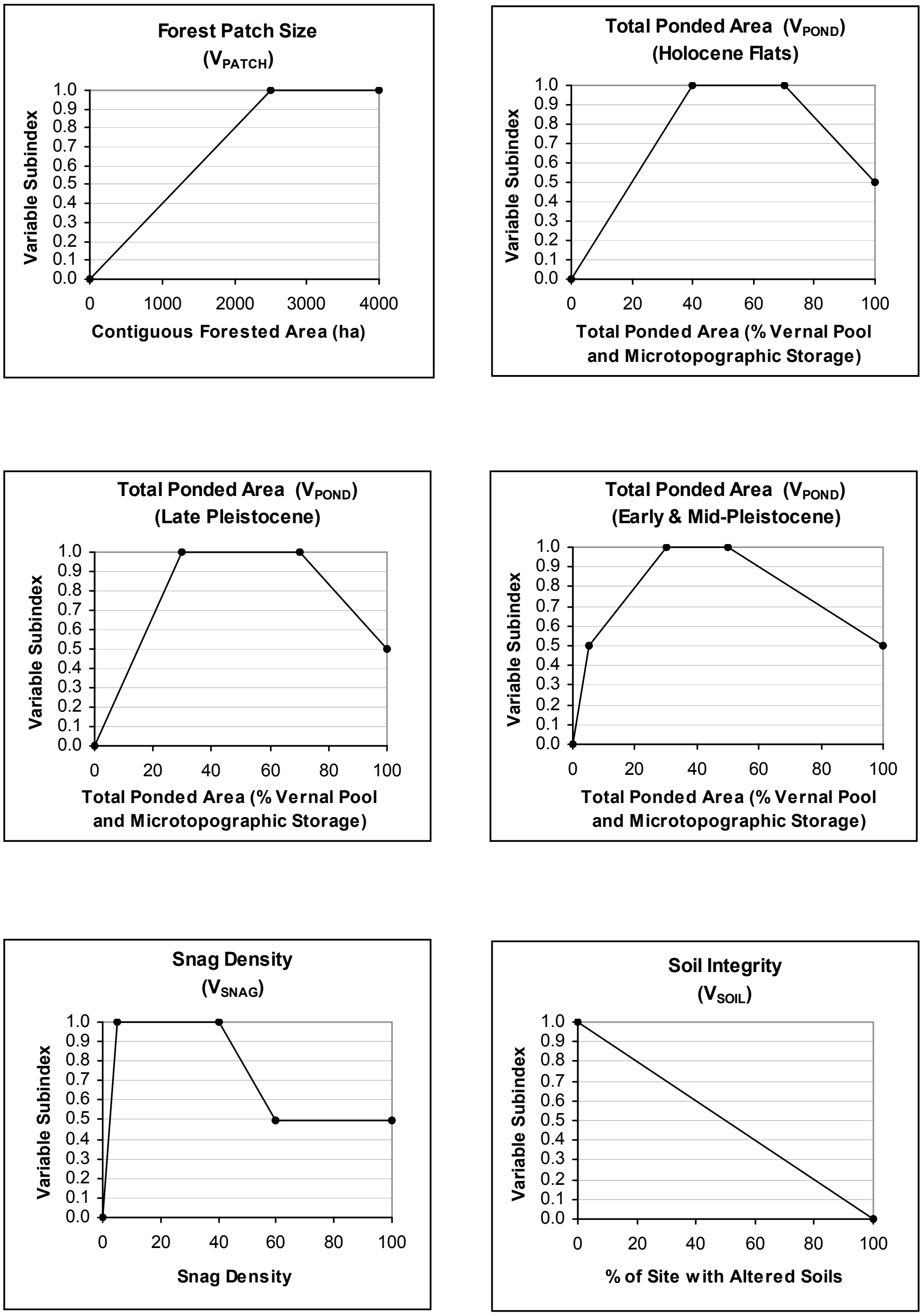


Figure 17. (Sheet 2 of 3)

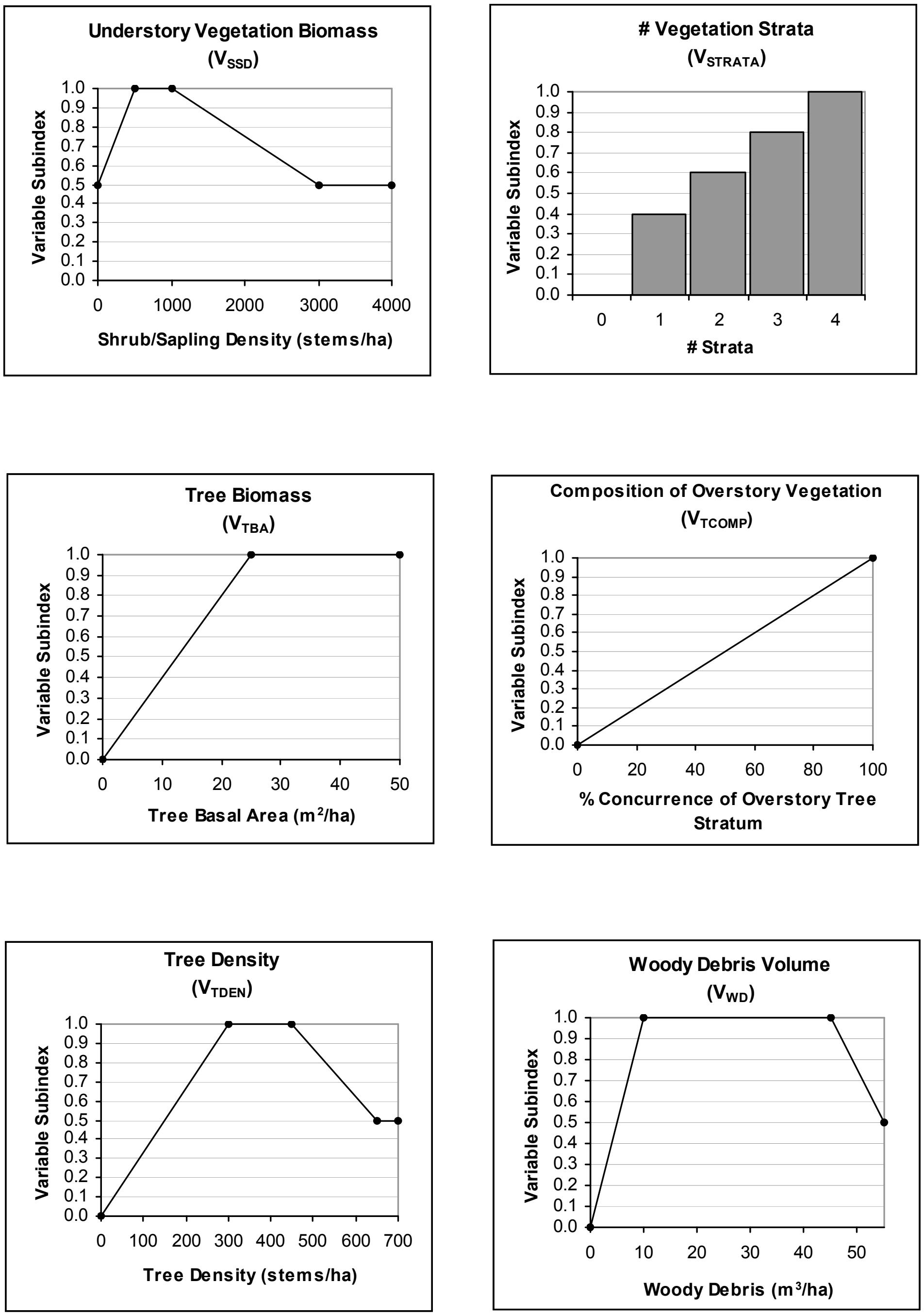


Figure 17. (Sheet 3 of 3)

Subclass: Low-Gradient Riverine Overbank

All functions are assessed for this subclass using the general form of each assessment model presented in Chapter 4 as follows. Figure 18 provides the relationship between the variable metrics and the subindex for each of the assessment variables based on the riverine overbank reference data.

a. *Function 1: Detain Floodwater.*

$$FCI = V_{FREQ} \times \left[\frac{\left(V_{LOG} + V_{GVC} + V_{SSD} + V_{TDEN} \right)}{4} \right] \tag{13}$$

b. *Function 2: Detain Precipitation.*

$$FCI = \frac{\left[V_{POND} + \frac{\left(V_{OHOR} + V_{LITTER} \right)}{2} \right]}{2} \tag{14}$$

c. *Function 3: Cycle Nutrients.*

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

d. *Function 4: Export Organic Carbon.*

$$FCI = V_{FREQ} \times \frac{\left[\frac{\left(V_{LITTER} + V_{OHOR} + V_{WD} + V_{SNAG} \right)}{4} \right] + \left[\frac{V_{TBA} + V_{SSD} + V_{GVC}}{3} \right]}{2} \tag{16}$$

e. *Function 5: Maintain Plant Communities.*

$$FCI = \left\langle \left\{ \frac{\left[\frac{\left(V_{TBA} + V_{TDEN} \right)}{2} + V_{COMP} \right]}{2} \right\} \times \left[\frac{\left(V_{SOIL} + V_{POND} \right)}{2} \right] \right\rangle^{1/2} \tag{17}$$

f. *Function 6: Provide Wildlife Habitat.*

$$FCI = \left\{ \left[\frac{\left(V_{FREQ} + V_{POND} \right)}{2} \right] \times \left[\frac{\left(V_{TCOMP} + V_{STRATA} + V_{SNAG} + V_{TBA} \right)}{4} \right] \times \left[\frac{\left(V_{LOG} + V_{OHOR} \right)}{2} \right] \times V_{PATCH} \right\}^{1/4} \tag{18}$$

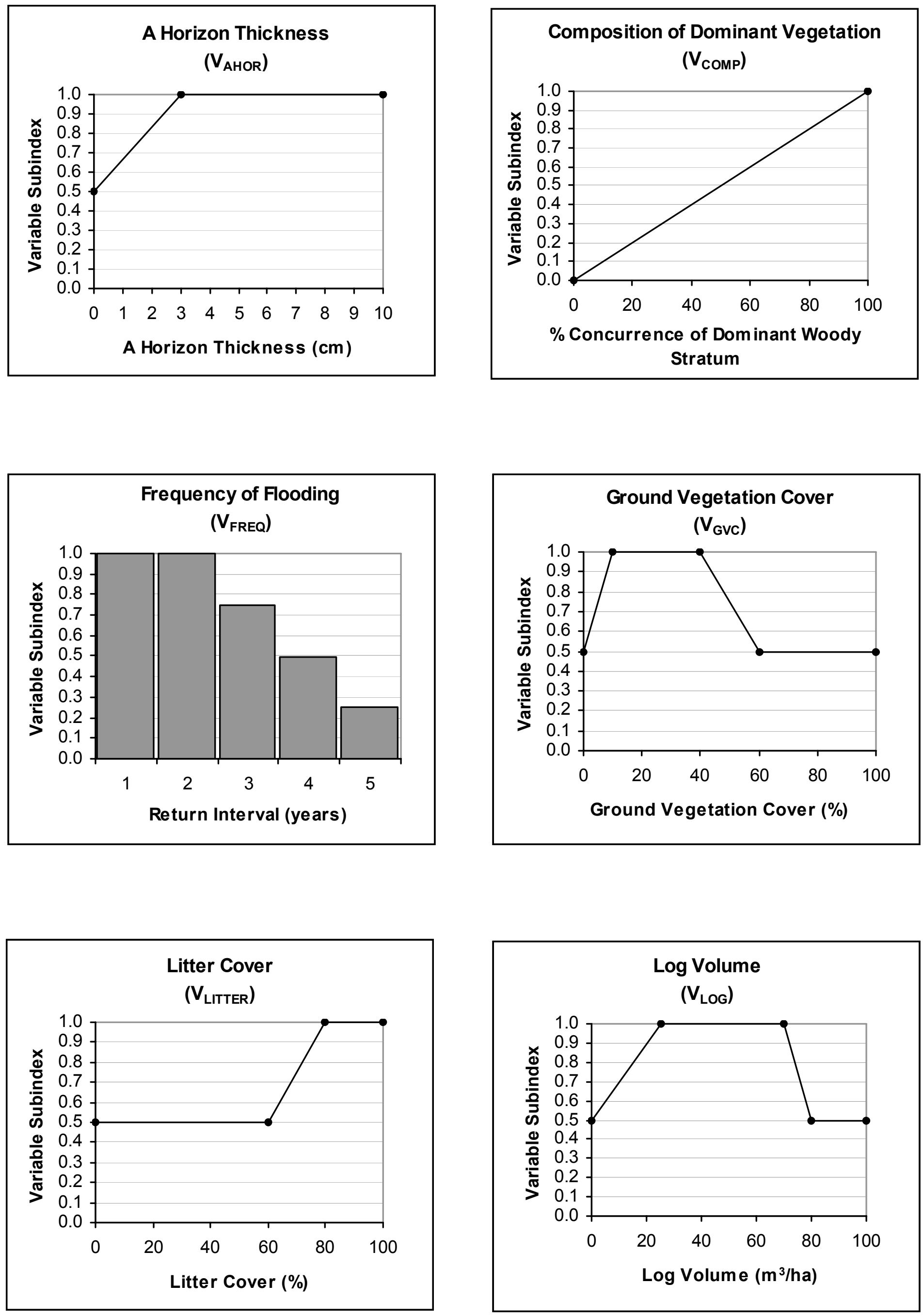


Figure 18. Subindex graphs for low-gradient riverine overbank wetlands (Sheet 1 of 3)

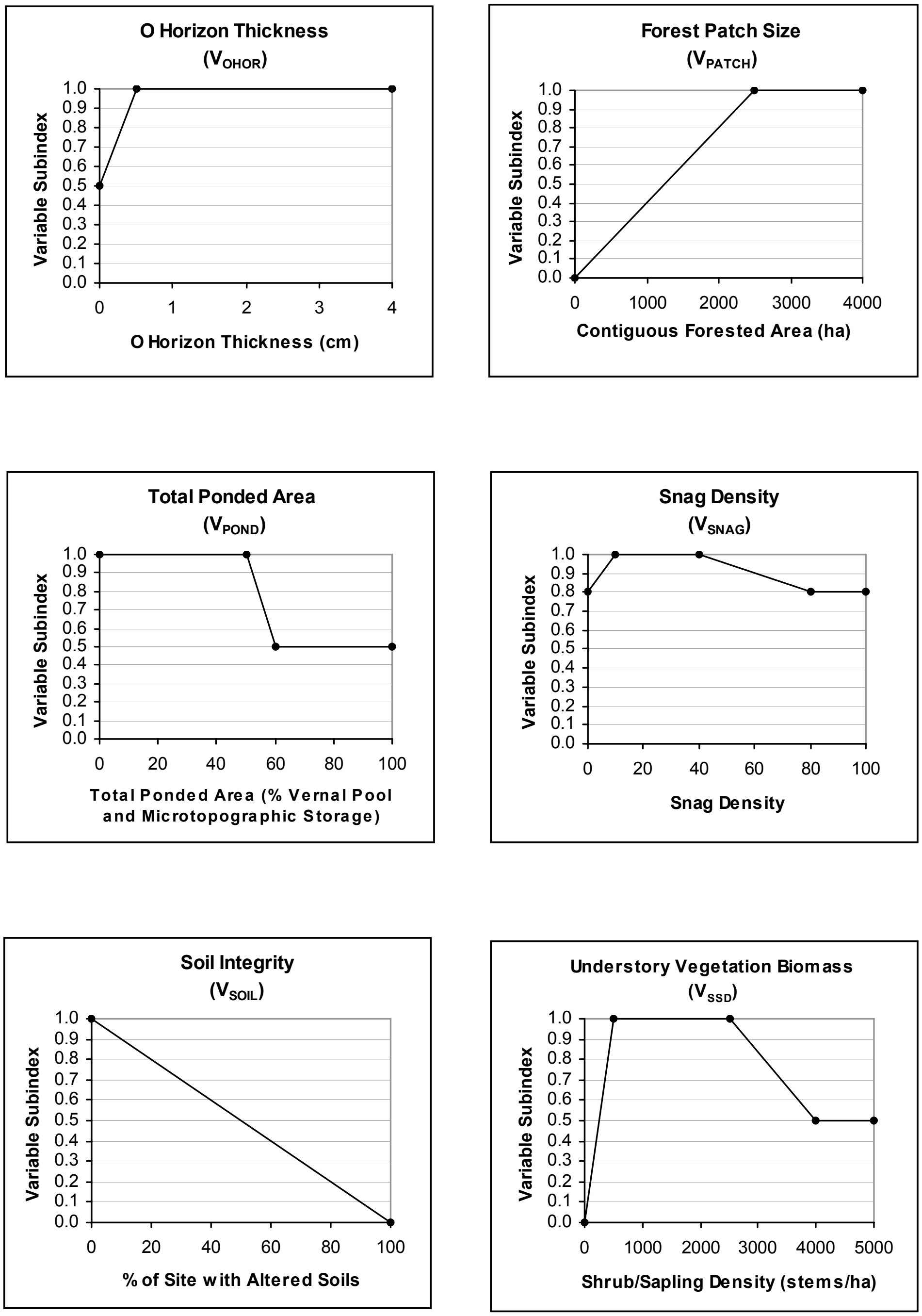


Figure 18. (Sheet 2 of 3)

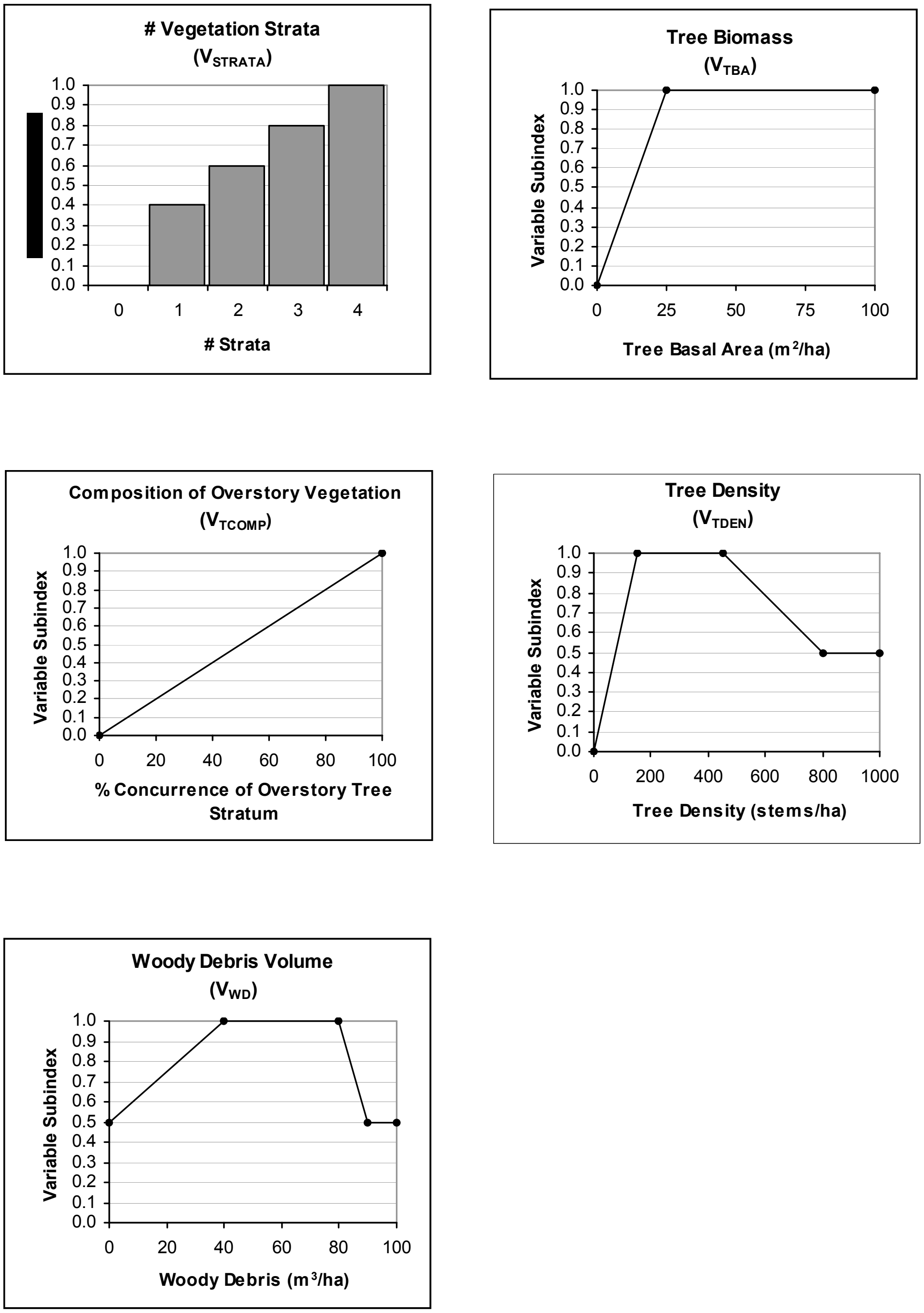


Figure 18. (Sheet 3 of 3)

Subclass: Low-Gradient Riverine Backwater

All functions are assessed for this subclass using the general form of each assessment model presented in Chapter 4 as follows. Figure 19 provides the relationship between the variable metrics and the subindex for each of the assessment variables based on the riverine backwater reference data.

a. Function 1: Detain Floodwater.

$$FCI = V_{FREQ} \times \left[\frac{\left(V_{LOG} + V_{GVC} + V_{SSD} + V_{TDEN} \right)}{4} \right] \tag{19}$$

b. Function 2: Detain Precipitation.

$$FCI = \frac{\left[V_{POND} + \frac{\left(V_{OHOR} + V_{LITTER} \right)}{2} \right]}{2} \tag{20}$$

c. Function 3: Cycle Nutrients.

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

d. Function 4: Export Organic Carbon.

$$FCI = V_{FREQ} \times \frac{\left[\frac{\left(V_{LITTER} + V_{OHOR} + V_{WD} + V_{SNAG} \right)}{4} \right] + \left[\frac{\left(V_{TBA} + V_{SSD} + V_{GVC} \right)}{3} \right]}{2} \tag{22}$$

e. Function 5: Maintain Plant Communities.

$$FCI = \left\langle \left\{ \frac{\left[\frac{\left(V_{TBA} + V_{TDEN} \right)}{2} + V_{COMP} \right]}{2} \right\} \times \left[\frac{\left(V_{SOIL} + V_{POND} \right)}{2} \right] \right\rangle^{1/2} \tag{23}$$

f. Function 6: Provide Wildlife Habitat.

$$FCI = \left\{ \left[\frac{\left(V_{FREQ} + V_{POND} \right)}{2} \right] \times \left[\frac{\left(V_{TCOMP} + V_{STRATA} + V_{SNAG} + V_{TBA} \right)}{4} \right] \times \left[\frac{\left(V_{LOG} + V_{OHOR} \right)}{2} \right] \times V_{PATCH} \right\}^{1/4} \tag{24}$$

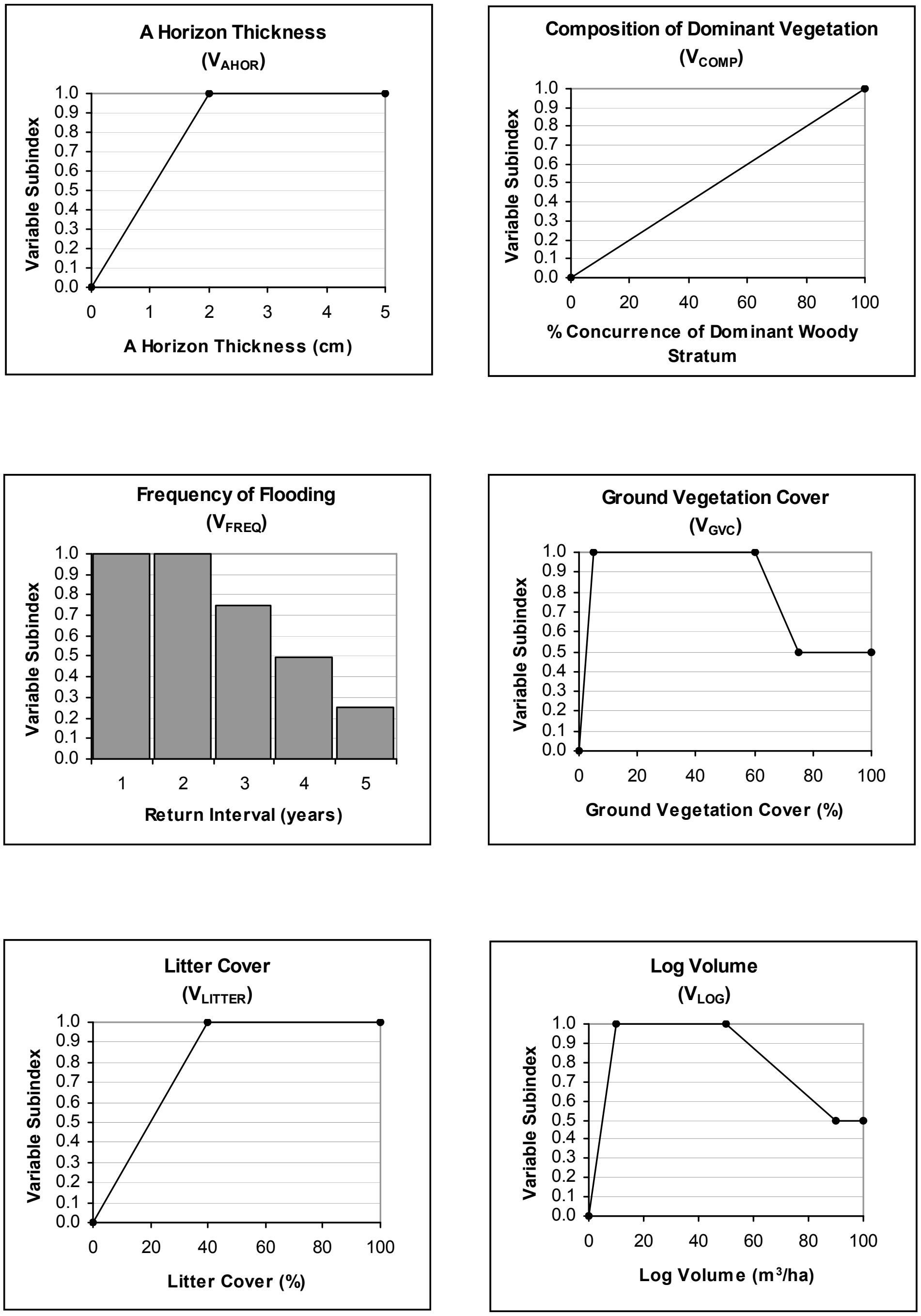


Figure 19. Subindex graphs for low-gradient riverine backwater wetlands (Sheet 1 of 3)

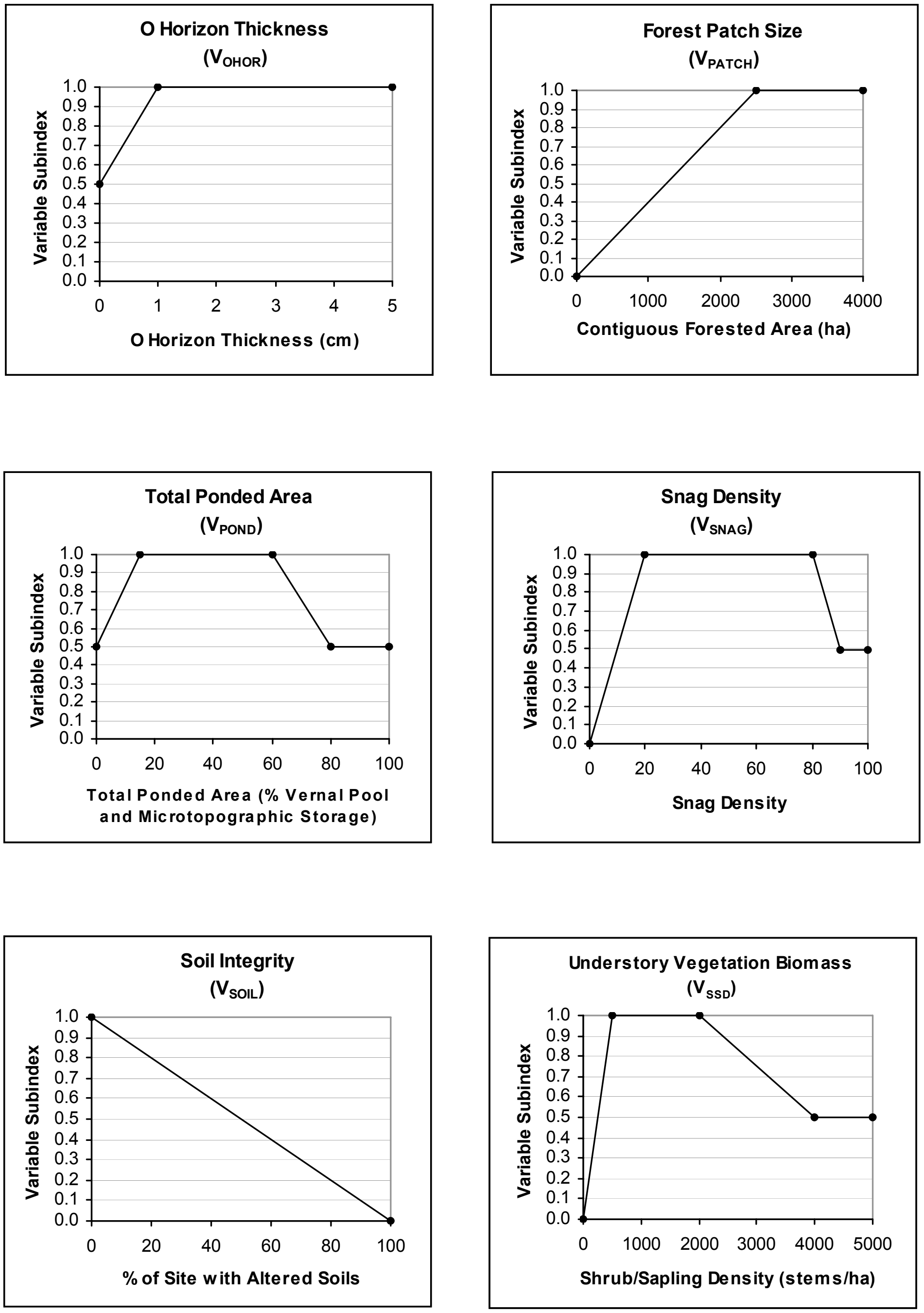


Figure 19. (Sheet 2 of 3)

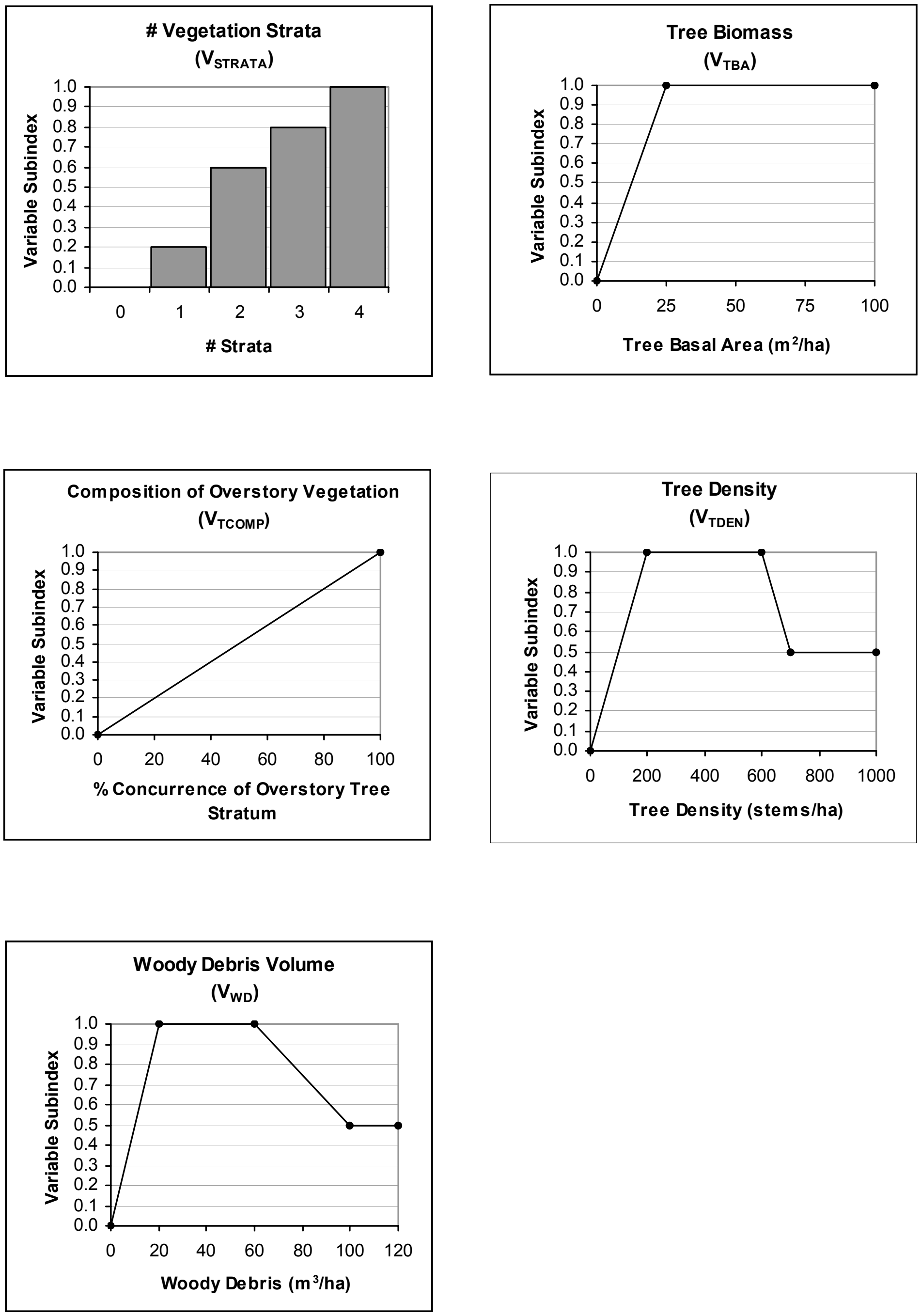


Figure 19. (Sheet 3 of 3)

Subclass: Mid-Gradient Riverine

All functions are assessed for this subclass using the general form of each assessment model presented in Chapter 4 as follows. Figure 20 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.*

$$FCI = V_{FREQ} \times \left[\frac{\left(V_{LOG} + V_{GVC} + V_{SSD} + V_{TDEN} \right)}{4} \right] \tag{25}$$

b. *Function 2: Detain Precipitation.*

$$FCI = \frac{\left[V_{POND} + \frac{\left(V_{OHOR} + V_{LITTER} \right)}{2} \right]}{2} \tag{26}$$

c. *Function 3: Cycle Nutrients.*

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

d. *Function 4: Export Organic Carbon.*

$$FCI = V_{FREQ} \times \frac{\left[\frac{\left(V_{LITTER} + V_{OHOR} + V_{WD} + V_{SNAG} \right)}{4} \right] + \left[\frac{\left(V_{TBA} + V_{SSD} + V_{GVC} \right)}{3} \right]}{2} \tag{28}$$

e. *Function 5: Maintain Plant Communities.*

$$FCI = \left\langle \left\{ \frac{\left[\frac{\left(V_{TBA} + V_{TDEN} \right)}{2} + V_{COMP} \right]}{2} \right\} \times \left[\frac{\left(V_{SOIL} + V_{POND} \right)}{2} \right] \right\rangle^{1/2} \tag{29}$$

f. *Function 6: Provide Wildlife Habitat.*

$$FCI = \left\{ \begin{array}{l} \left[\frac{\left(V_{FREQ} + V_{POND} \right)}{2} \right] \times \left[\frac{\left(V_{TCOMP} + V_{STRATA} + V_{SNAG} + V_{TBA} \right)}{4} \right] \times \\ \left[\frac{\left(V_{LOG} + V_{OHOR} \right)}{2} \right] \times \left[\frac{\left(V_{BUF30} + V_{BUF250} \right)}{2} \right] \end{array} \right\}^{1/4} \tag{30}$$

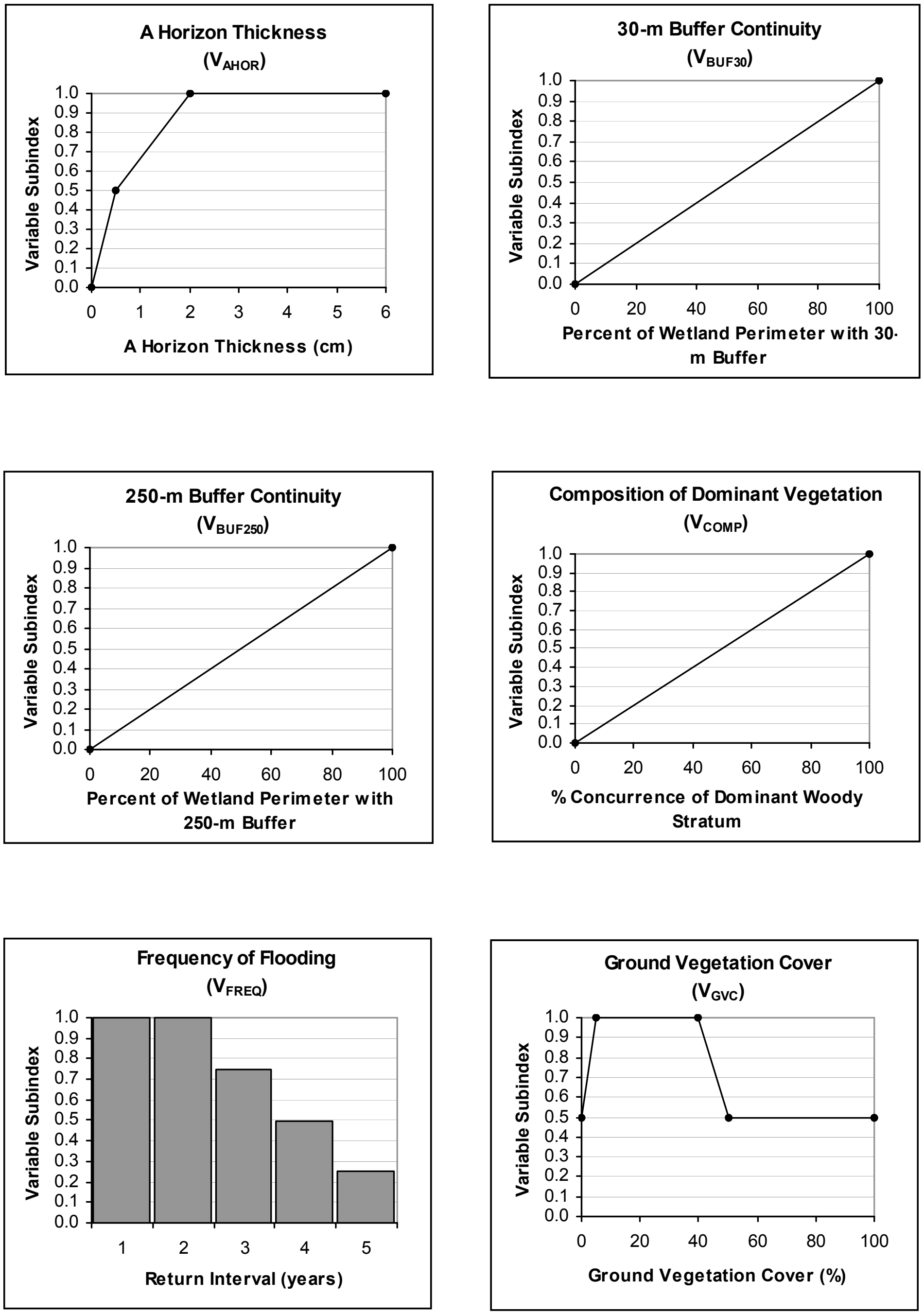


Figure 20. Subindex graphs for mid-gradient riverine wetlands (Sheet 1 of 3)

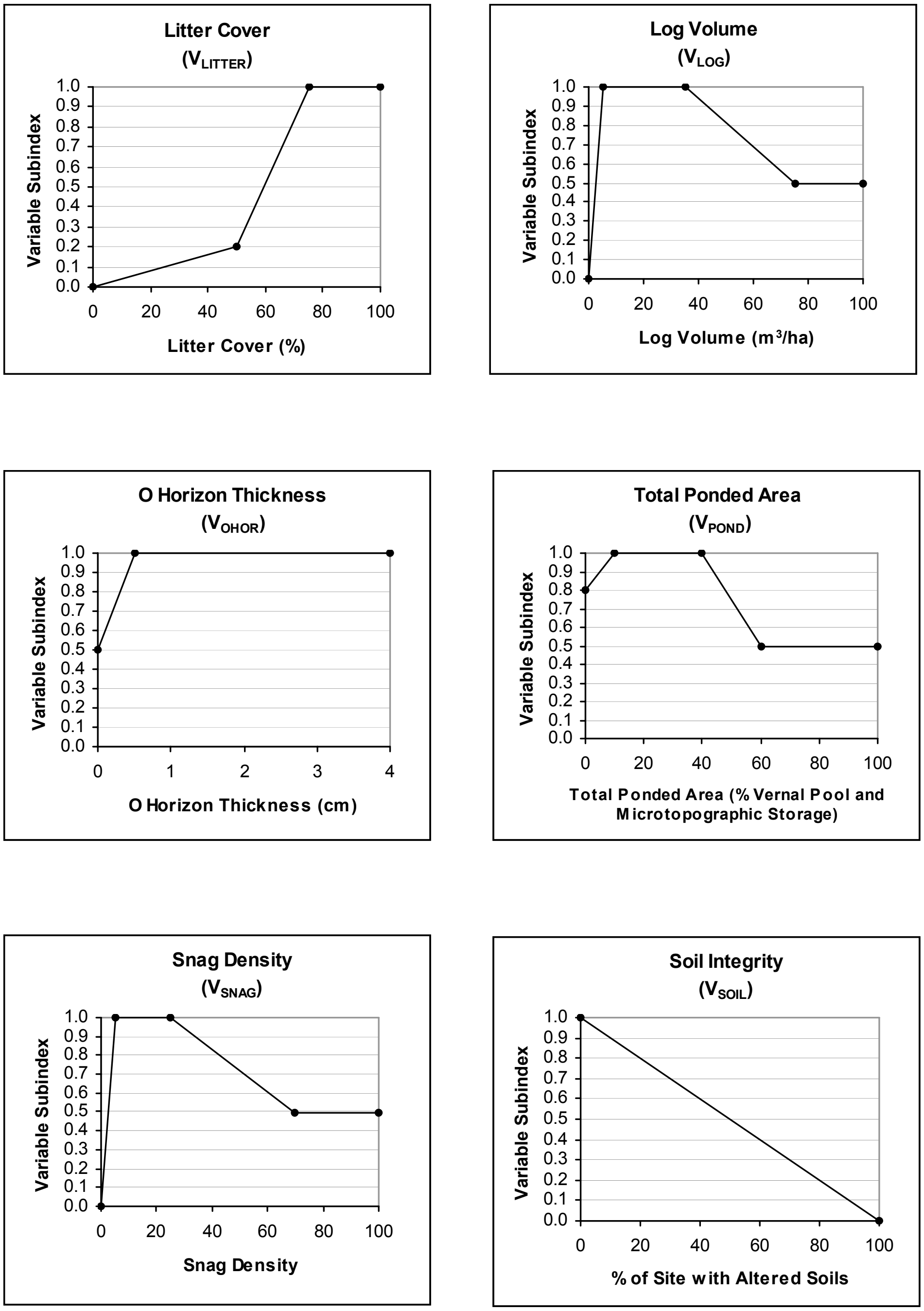


Figure 20. (Sheet 2 of 3)

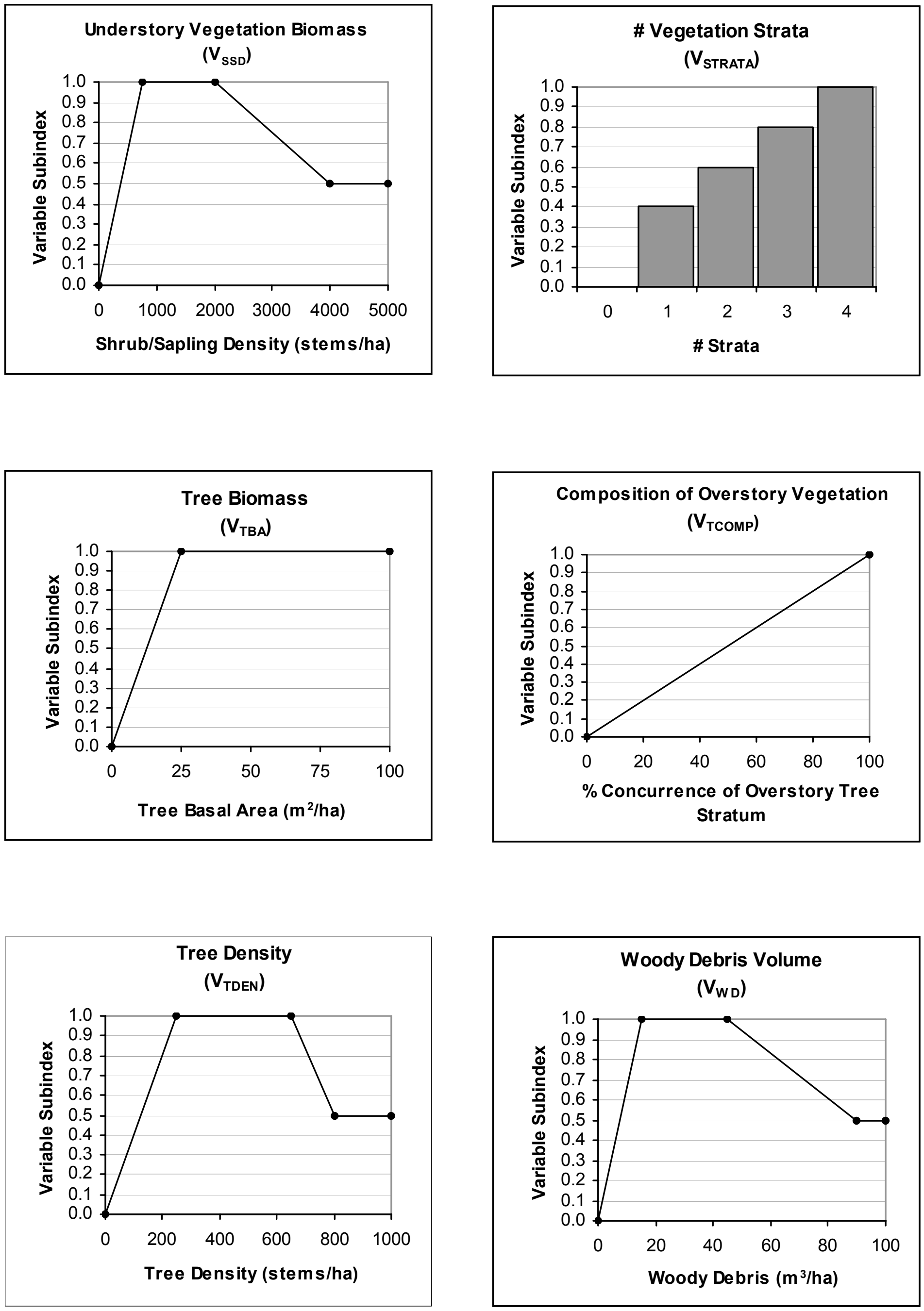


Figure 20. (Sheet 3 of 3)

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 as follows. Alternate versions are also provided that can be used in the event that ground-level observations cannot be made due to inundation. Figure 21 provides the relationship between the variable metrics and the subindex for each of the assessment variables based on the isolated depression reference data.

a. Function 1: Detain Floodwater. Not Assessed.

b. Function 2: Detain Precipitation. Not Assessed.

c. Function 3: Cycle Nutrients.

$$FCI = \frac{\left[\frac{(V_{TBA} + V_{SSD} + V_{GVC})}{3} + \frac{(V_{OHOR} + V_{AHOR} + V_{WD} + V_{SNAG})}{4}\right]}{2} \quad (31)$$

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

$$FCI = \frac{(V_{TBA} + V_{SSD} + V_{SNAG})}{3} \quad (32)$$

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

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

$$FCI = \left\langle \left\{ \frac{\left[\frac{(V_{TBA} + V_{TDEN})}{2} + V_{COMP}\right]}{2} \right\} \times V_{SOIL} \right\rangle^{1/2} \quad (33)$$

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

$$FCI = \frac{\left[\frac{(V_{TBA} + V_{TDEN})}{2} + V_{COMP}\right]}{2} \quad (34)$$

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

$$FCI = \left\{ \begin{array}{l} \left[\dfrac{\left(V_{TCOMP} + V_{STRATA} + V_{SNAG} + V_{TBA} \right)}{4} \right] \times \\ \left[\dfrac{\left(V_{LOG} + V_{OHOR} \right)}{2} \right] \times \left[\dfrac{\left(V_{BUF30} + V_{BUF250} \right)}{2} \right] \end{array} \right\}^{1/3} \qquad (35)$$

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

$$FCI = \left\{ \begin{array}{l} \left[\dfrac{\left(V_{TCOMP} + V_{STRATA} + V_{SNAG} + V_{TBA} \right)}{4} \right] \\ \times \left[\dfrac{\left(V_{BUF30} + V_{BUF250} \right)}{2} \right] \end{array} \right\}^{1/2} \qquad (36)$$

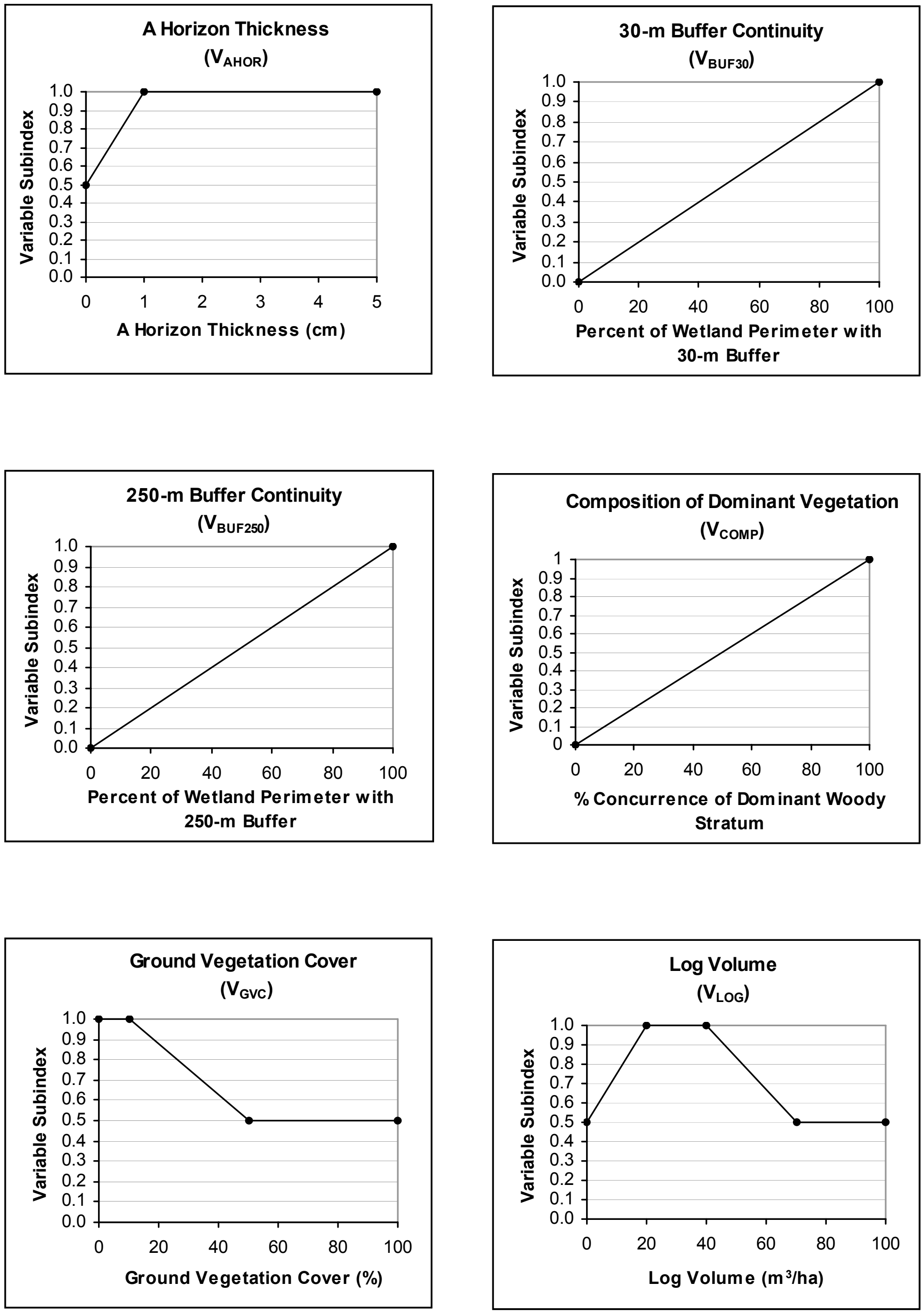


Figure 21. Subindex graphs for unconnected depression wetlands (Sheet 1 of 3)

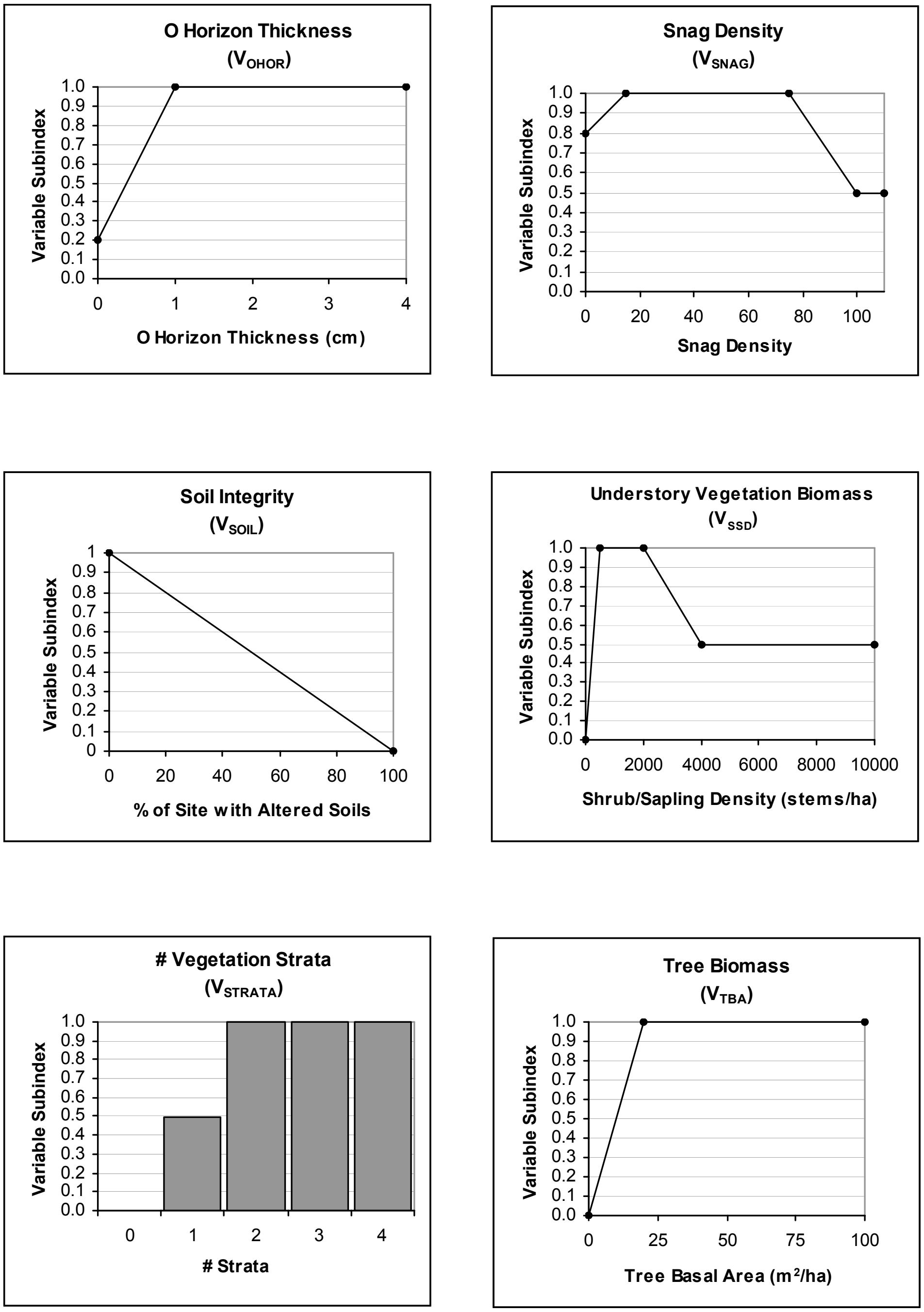
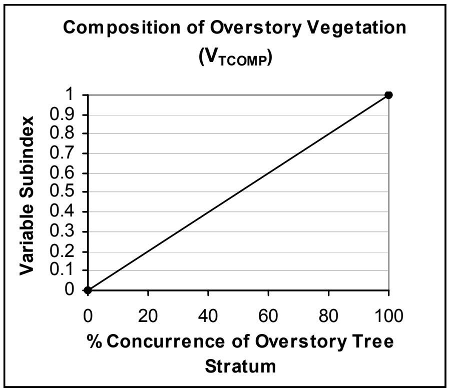
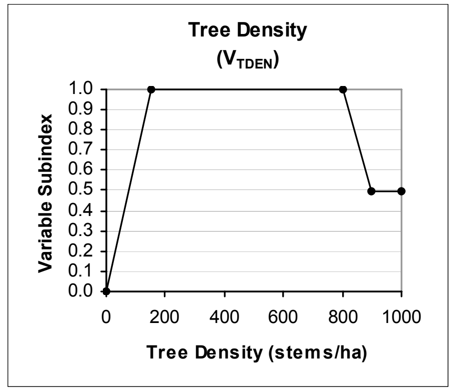


Figure 21. (Sheet 2 of 3)





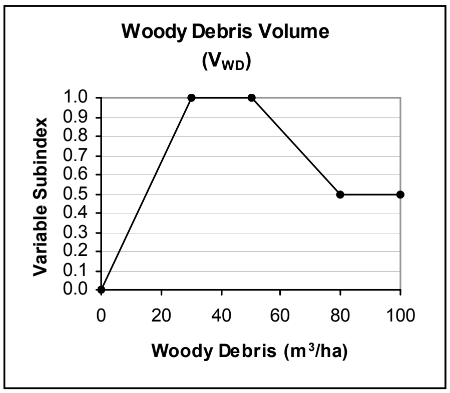


Figure 21. (Sheet 3 of 3)

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 22 provides the relationship between the variable metrics and the subindex for each of the assessment variables based on the connected depression reference data.

a. *Function 1: Detain Floodwater.*

$$FCI = V_{FREQ} \times \left[\frac{(V_{LOG} + V_{GVC} + V_{SSD} + V_{TDEN})}{4} \right] \quad (37)$$

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

$$FCI = V_{FREQ} \times \left[\frac{(V_{SSD} + V_{TDEN})}{2} \right] \quad (38)$$

b. Function 2: Detain Precipitation. Not Assessed.

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

$$FCI = \frac{\left[\frac{(V_{TBA} + V_{SSD} + V_{GVC})}{3} + \frac{(V_{OHOR} + V_{AHOR} + V_{WD} + V_{SNAG})}{4}\right]}{2} \quad (39)$$

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

$$FCI = \frac{(V_{TBA} + V_{SSD} + V_{SNAG})}{3} \quad (40)$$

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

$$FCI = V_{FREQ} \times \frac{\left[\frac{(V_{LITTER} + V_{OHOR} + V_{WD} + V_{SNAG})}{4}\right] + \left[\frac{(V_{TBA} + V_{SSD} + V_{GVC})}{3}\right]}{2} \quad (41)$$

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

$$FCI = V_{FREQ} \times \left[\frac{(V_{TBA} + V_{SSD} + V_{SNAG})}{3}\right] \quad (42)$$

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

$$FCI = \left\langle \left\{ \frac{\left[\frac{(V_{TBA} + V_{TDEN})}{2} + V_{COMP}\right]}{2} \right\} \times V_{SOIL} \right\rangle^{1/2} \quad (43)$$

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

$$FCI = \frac{\left[\frac{\left(V_{TBA} + V_{TDEN}\right)}{2} + V_{COMP}\right]}{2} \tag{44}$$

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

$$FCI = \left\{ \begin{aligned} & V_{FREQ} \times \left[\frac{\left(V_{TCOMP} + V_{STRATA} + V_{SNAG} + V_{TBA}\right)}{4}\right] \times \\ & \left[\frac{\left(V_{LOG} + V_{OHOR}\right)}{2}\right] \times \left[\frac{V_{BUF\,30} + V_{BUF\,250}}{2}\right] \end{aligned} \right\}^{1/4} \tag{45}$$

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

$$FCI = \left\{ V_{FREQ} \times \left[\frac{\left(V_{TCOMP} + V_{STRATA} + V_{SNAG} + V_{TBA}\right)}{4}\right] \times \left[\frac{\left(V_{BUF30} + V_{BUF250}\right)}{2}\right]\right\}^{1/3} \tag{46}$$

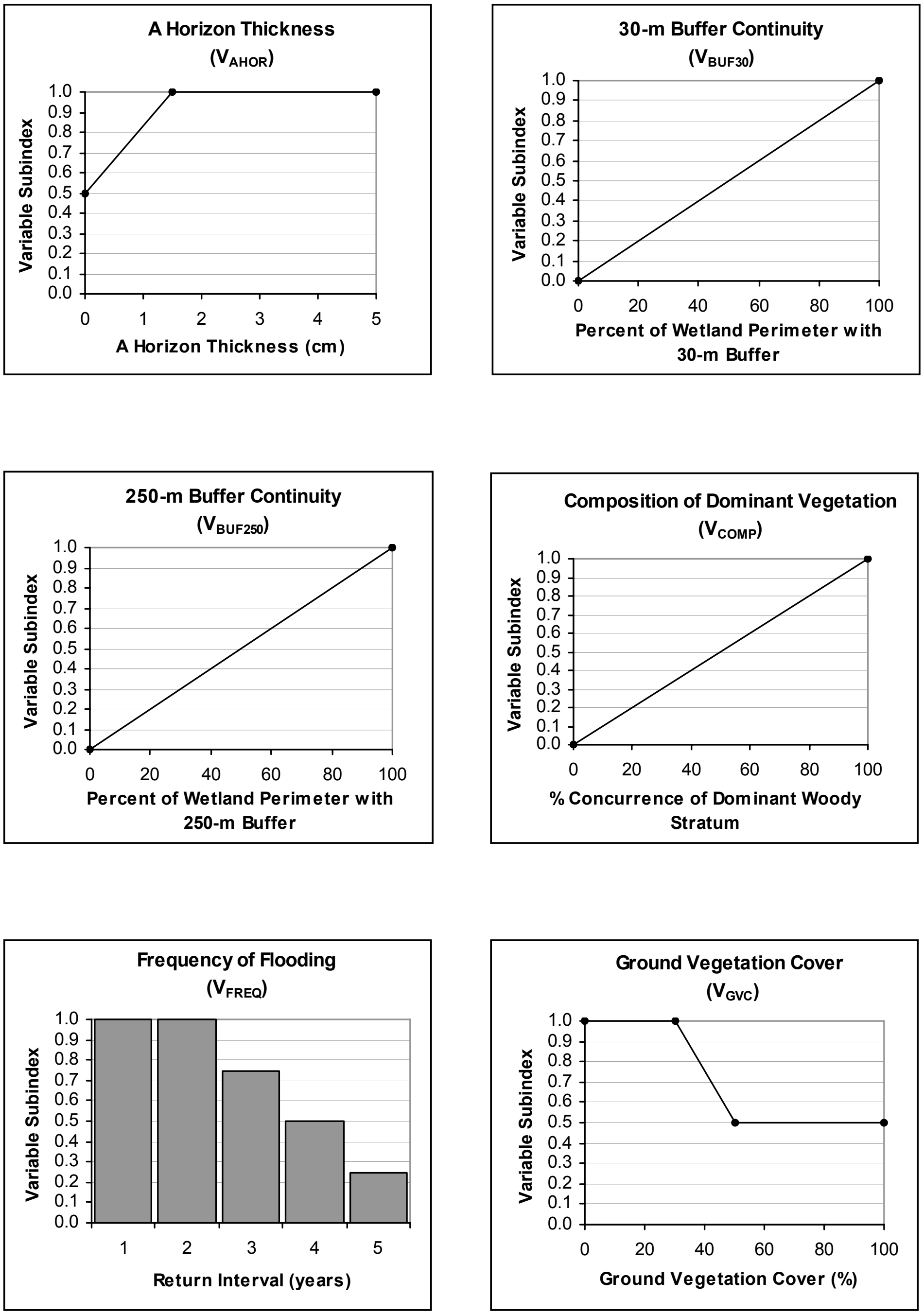


Figure 22. Subindex graphs for connected depression wetlands (Sheet 1 of 3)

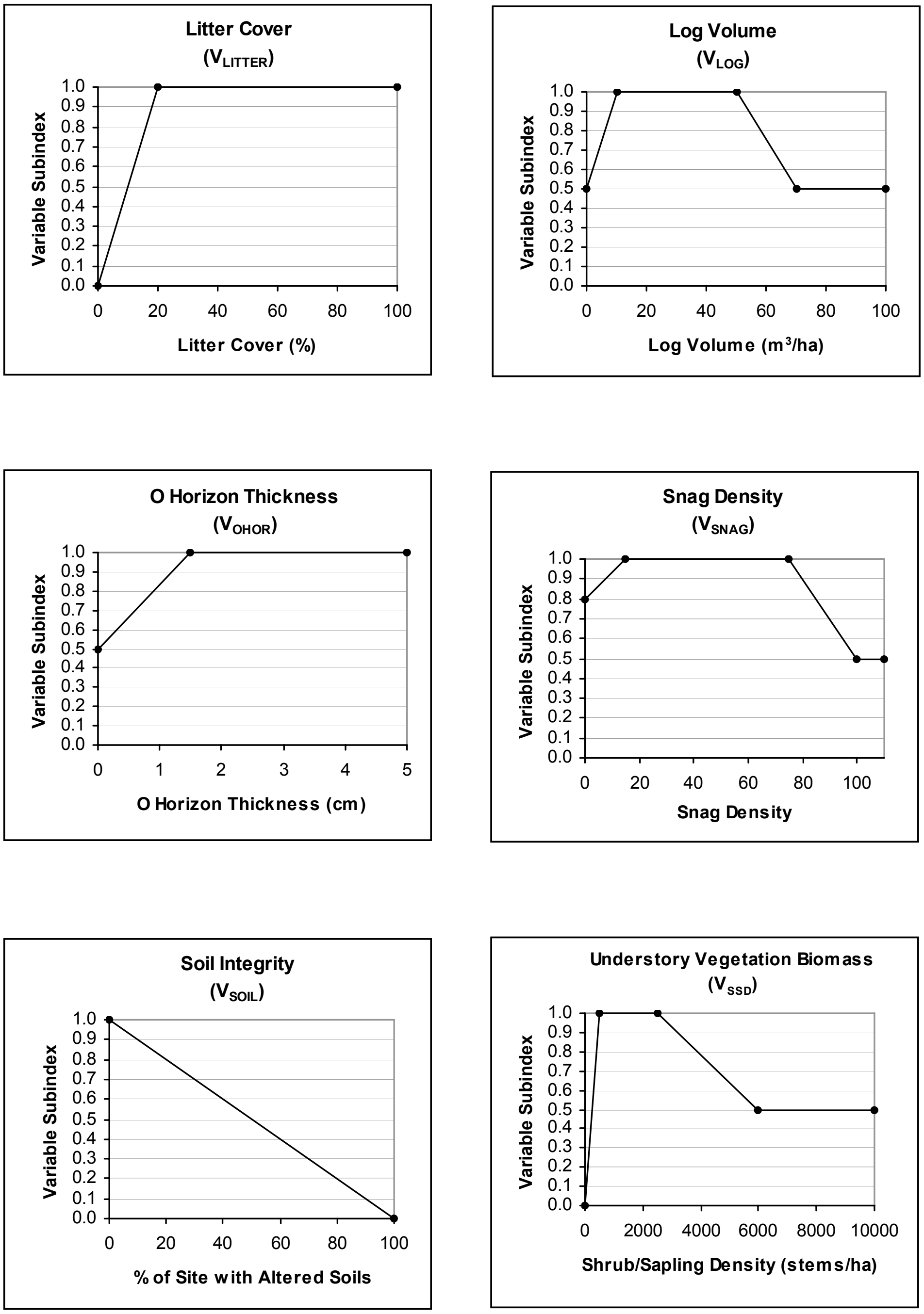


Figure 22. (Sheet 2 of 3)

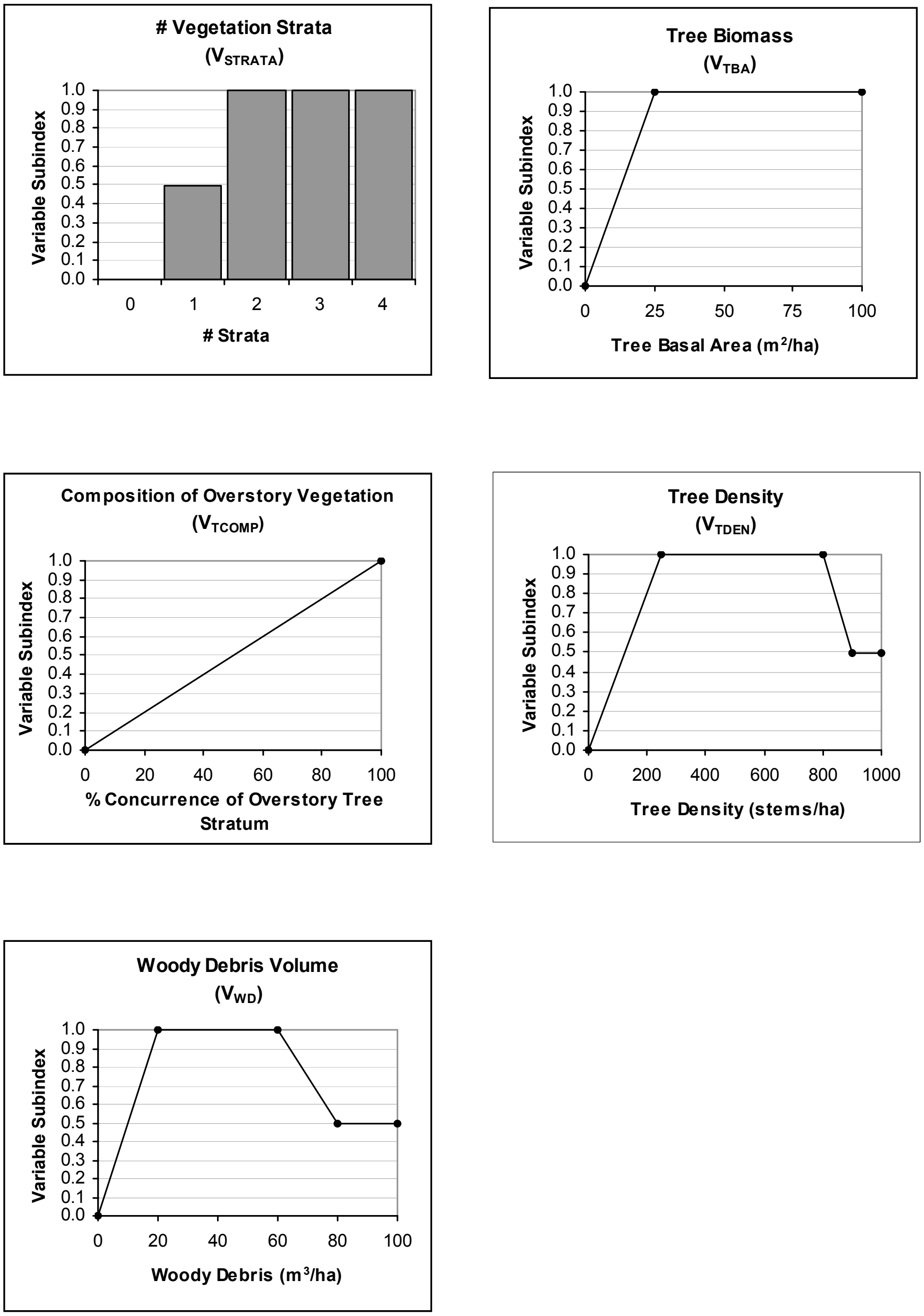


Figure 22. (Sheet 3 of 3)

Subclass: 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. Figures 23 and 24 illustrate the relationship between the variable metrics and the subindex for each of the assessment variables for both non-calcareous seeps and bayheads, based on reference data.

a. Function 1: Detain Floodwater. Not Assessed.

b. Function 2: Detain Precipitation. Not Assessed.

c. Function 3: Cycle Nutrients.

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

d. Function 4: Export Organic Carbon.

$$FCI = V_{OUT} \times \frac{\left[\frac{\left(V_{LITTER} + V_{OHOR} + V_{WD} + V_{SNAG}\right)}{4}\right] + \left[\frac{\left(V_{TBA} + V_{SSD} + V_{GVC}\right)}{3}\right]}{2} \tag{48}$$

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

$$FCI = \left\langle \left[\frac{V_{TBA} + V_{TDEN} + V_{COMP} + V_{GCOMP}}{4}\right] \times V_{SOIL} \right\rangle^{1/2} \tag{49}$$

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

$$FCI = \left\{ \begin{array}{l} \left[\frac{\left(V_{TCOMP} + V_{STRATA} + V_{SNAG} + V_{TBA}\right)}{4}\right] \times \\ \left[\frac{\left(V_{LOG} + V_{OHOR}\right)}{2}\right] \times \left[\frac{\left(V_{BUF30} + V_{BUF250}\right)}{2}\right] \end{array} \right\}^{1/3} \tag{50}$$

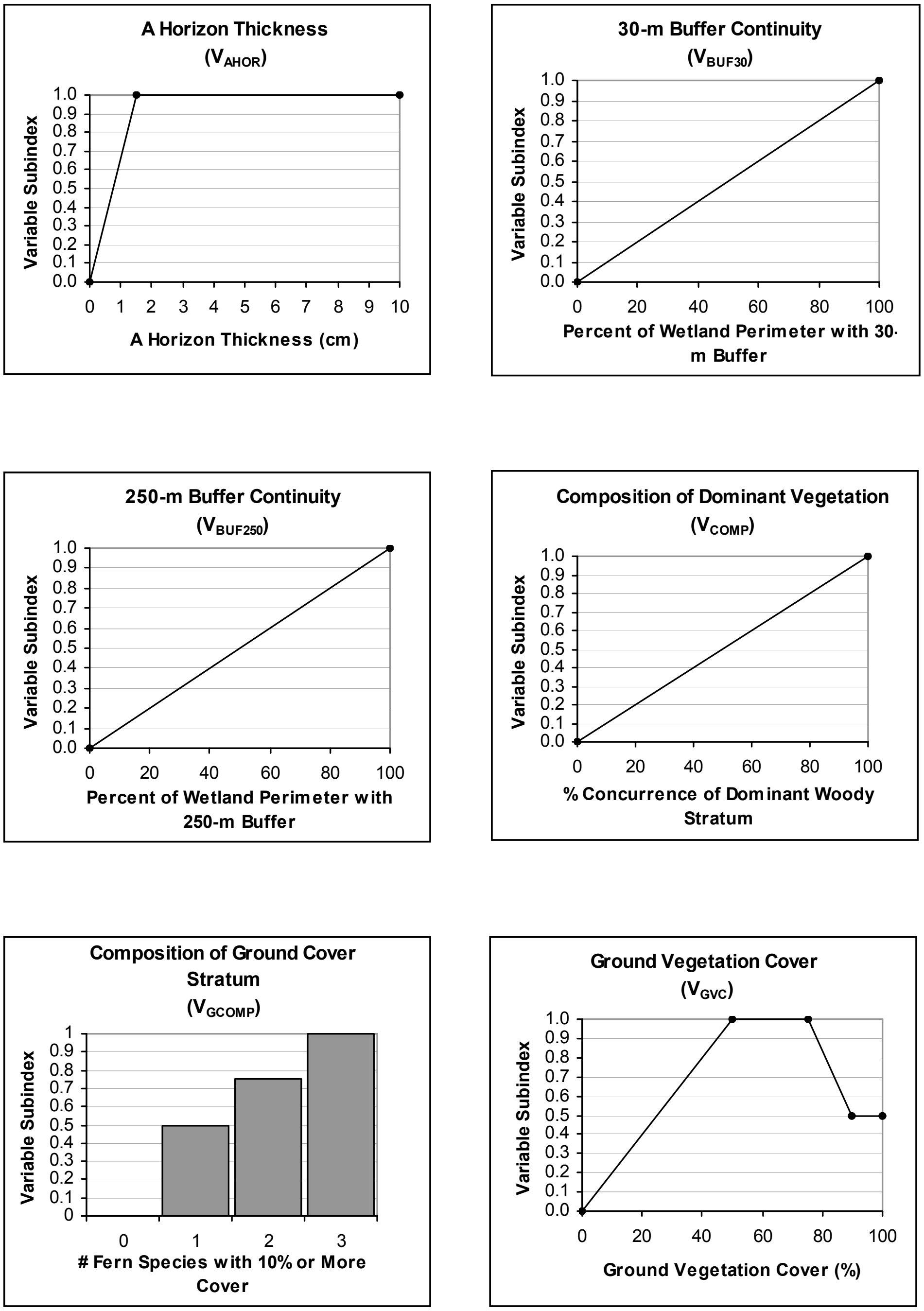


Figure 23. Subindex graphs for non-calcareous seep wetlands (Sheet 1 of 3)

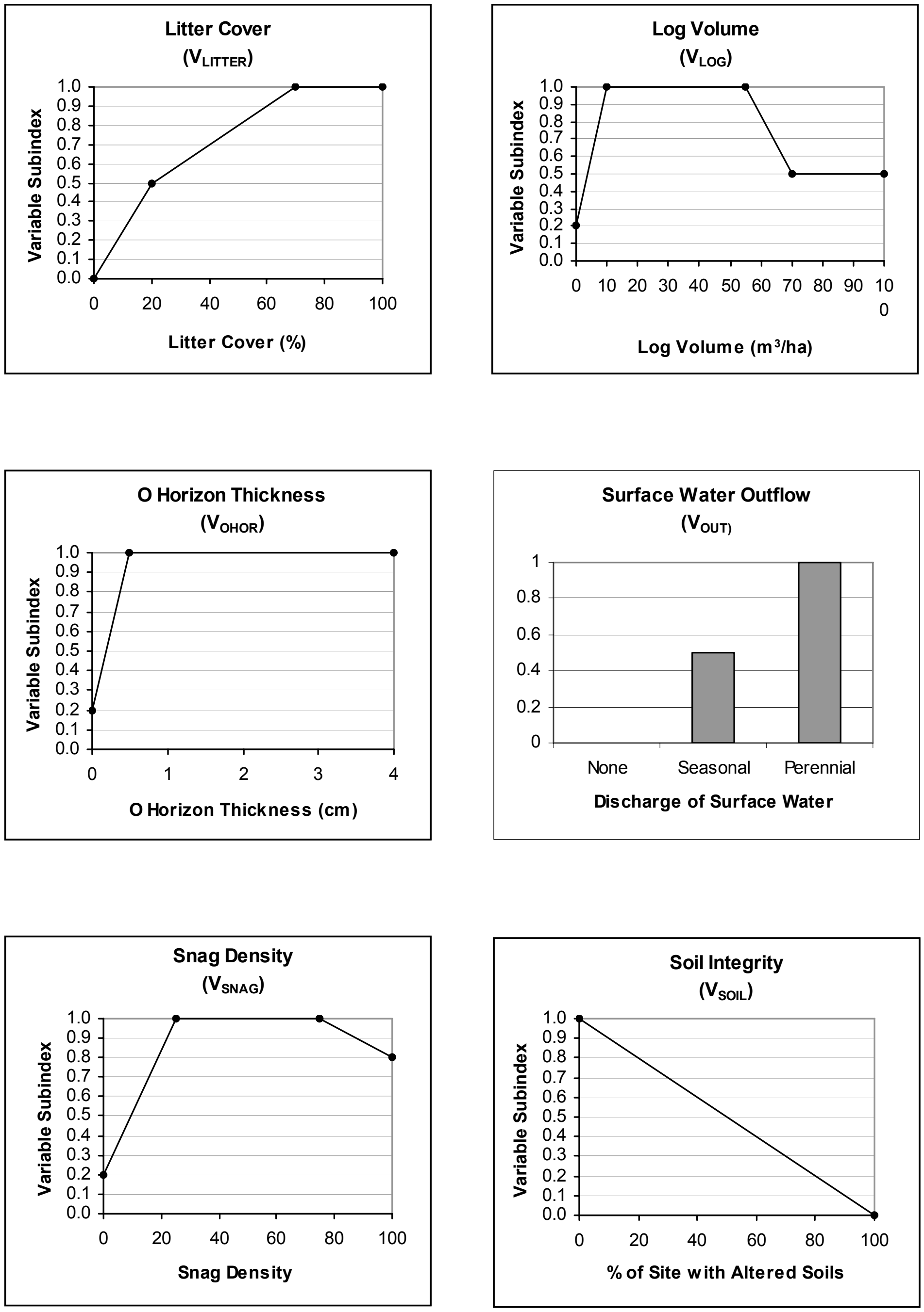


Figure 23. (Sheet 2 of 3)

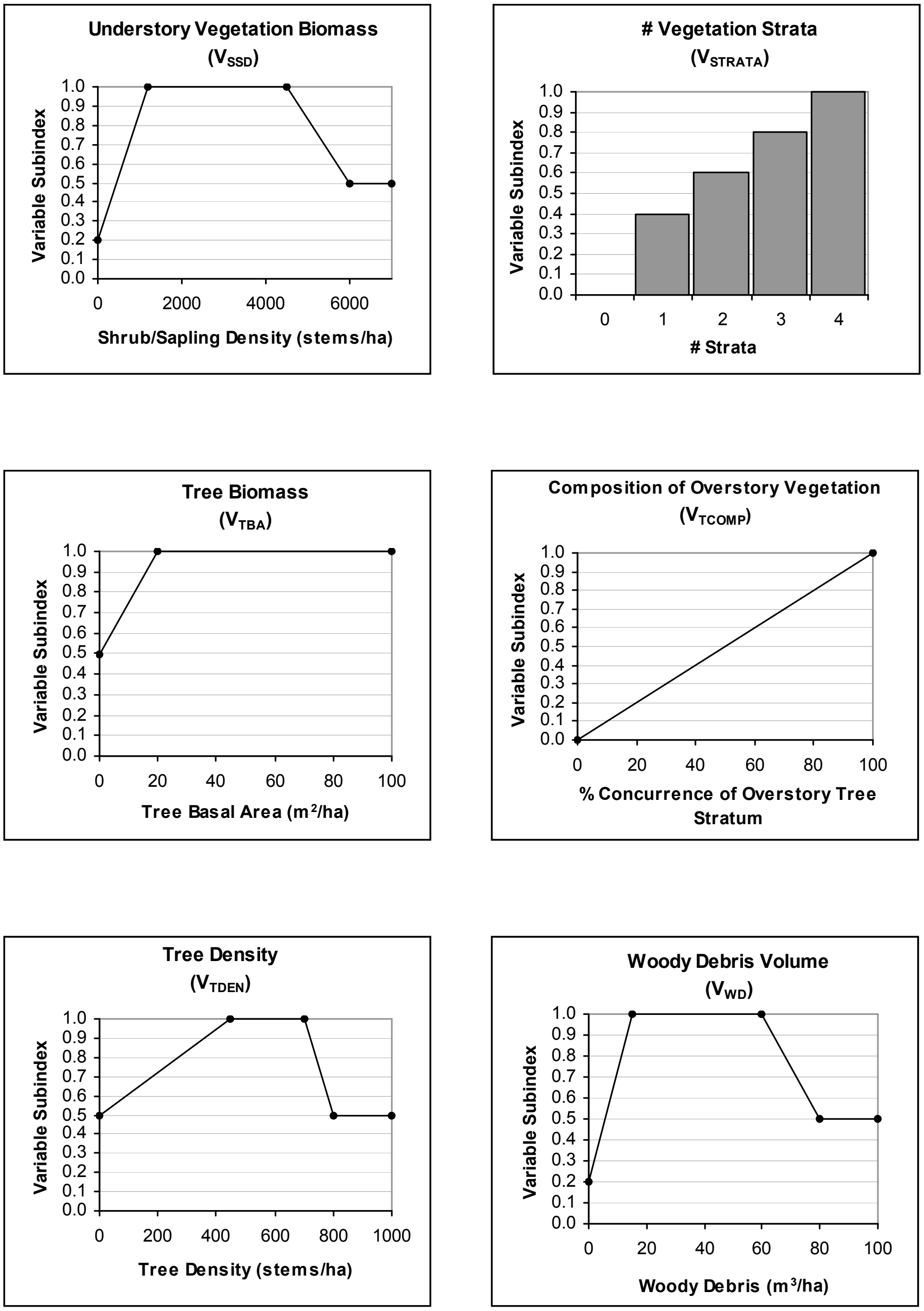


Figure 23. (Sheet 3 of 3)

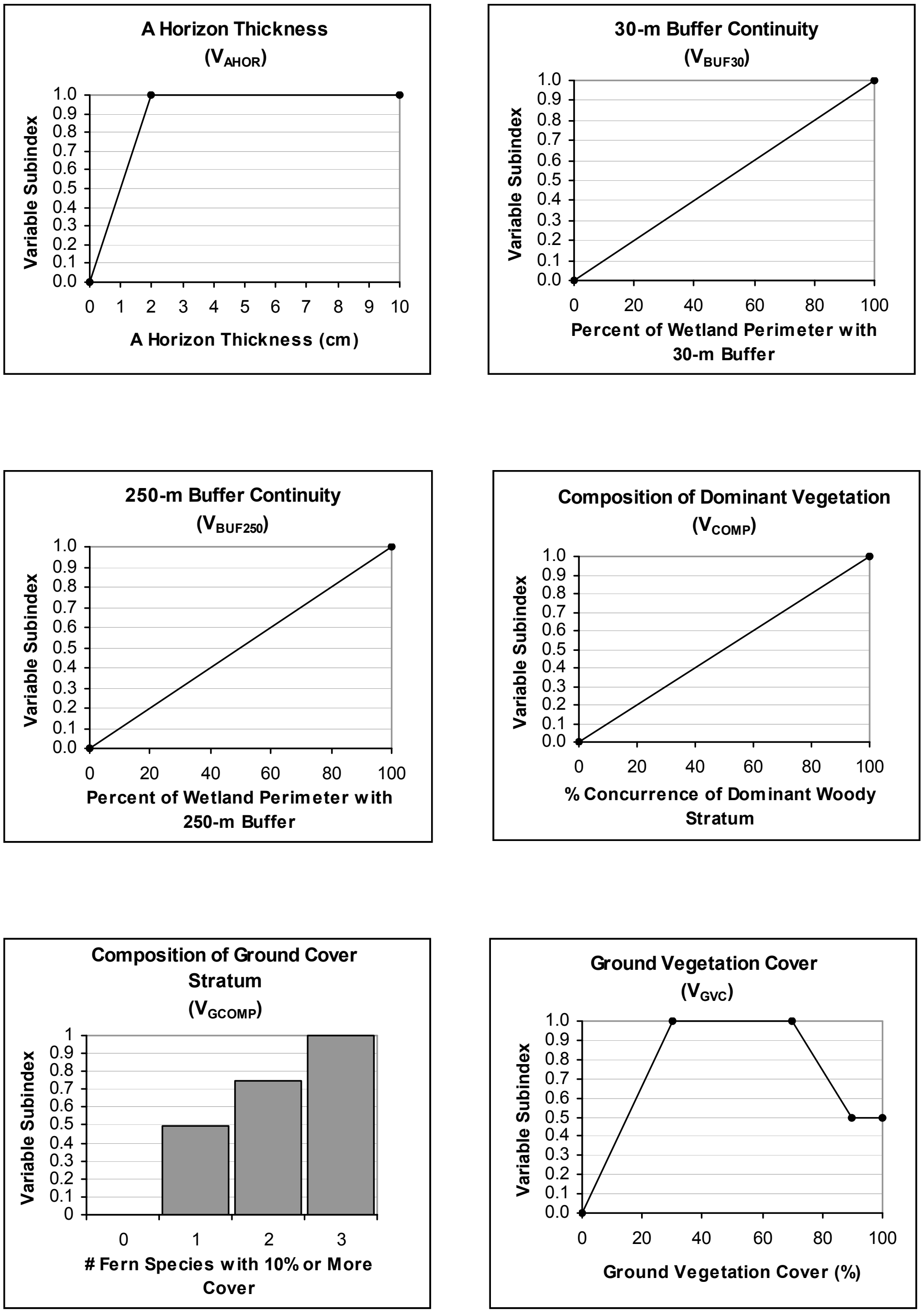


Figure 24. Subindex graphs for bayhead wetlands (Sheet 1 of 3)

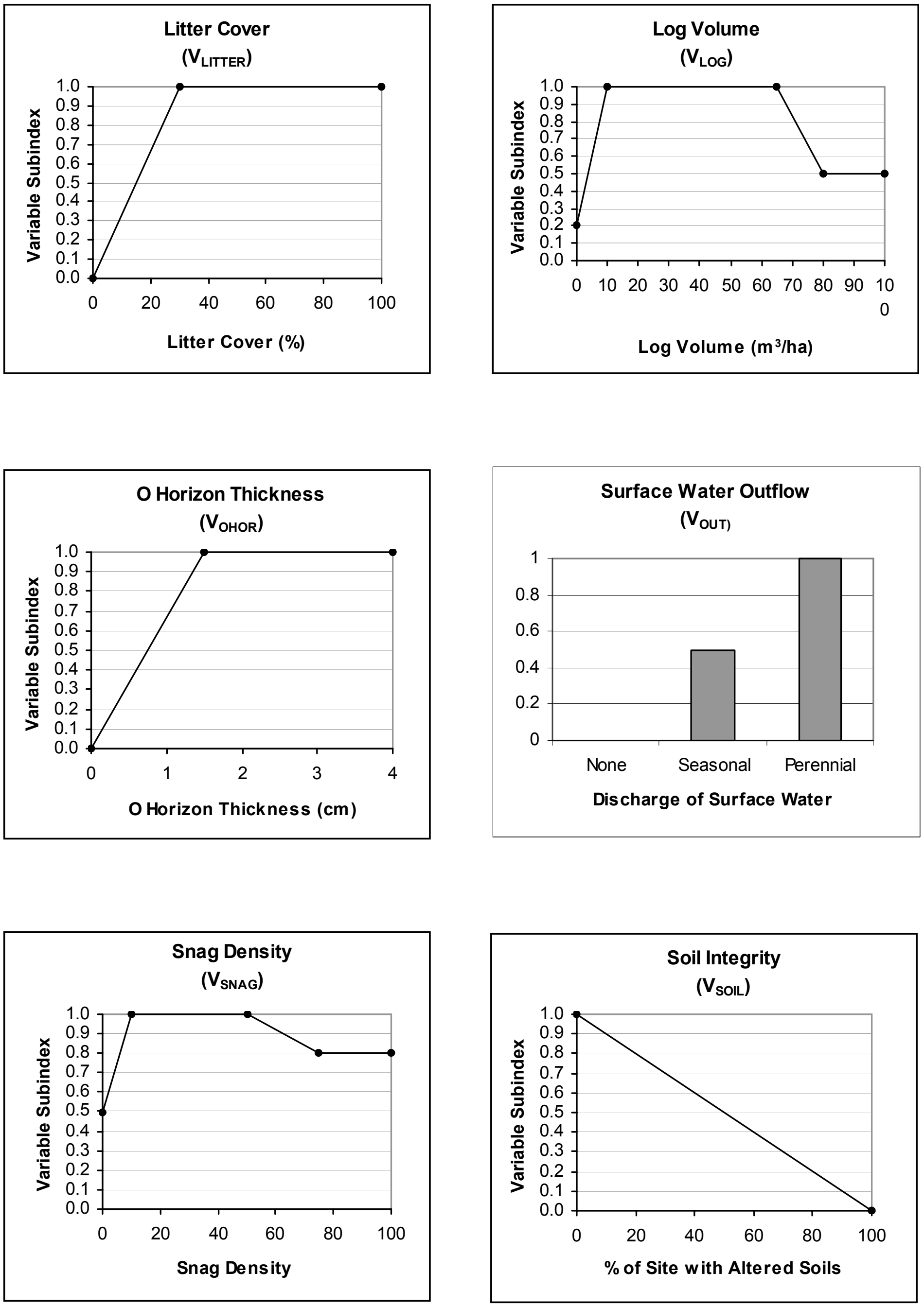


Figure 24. (Sheet 2 of 3)

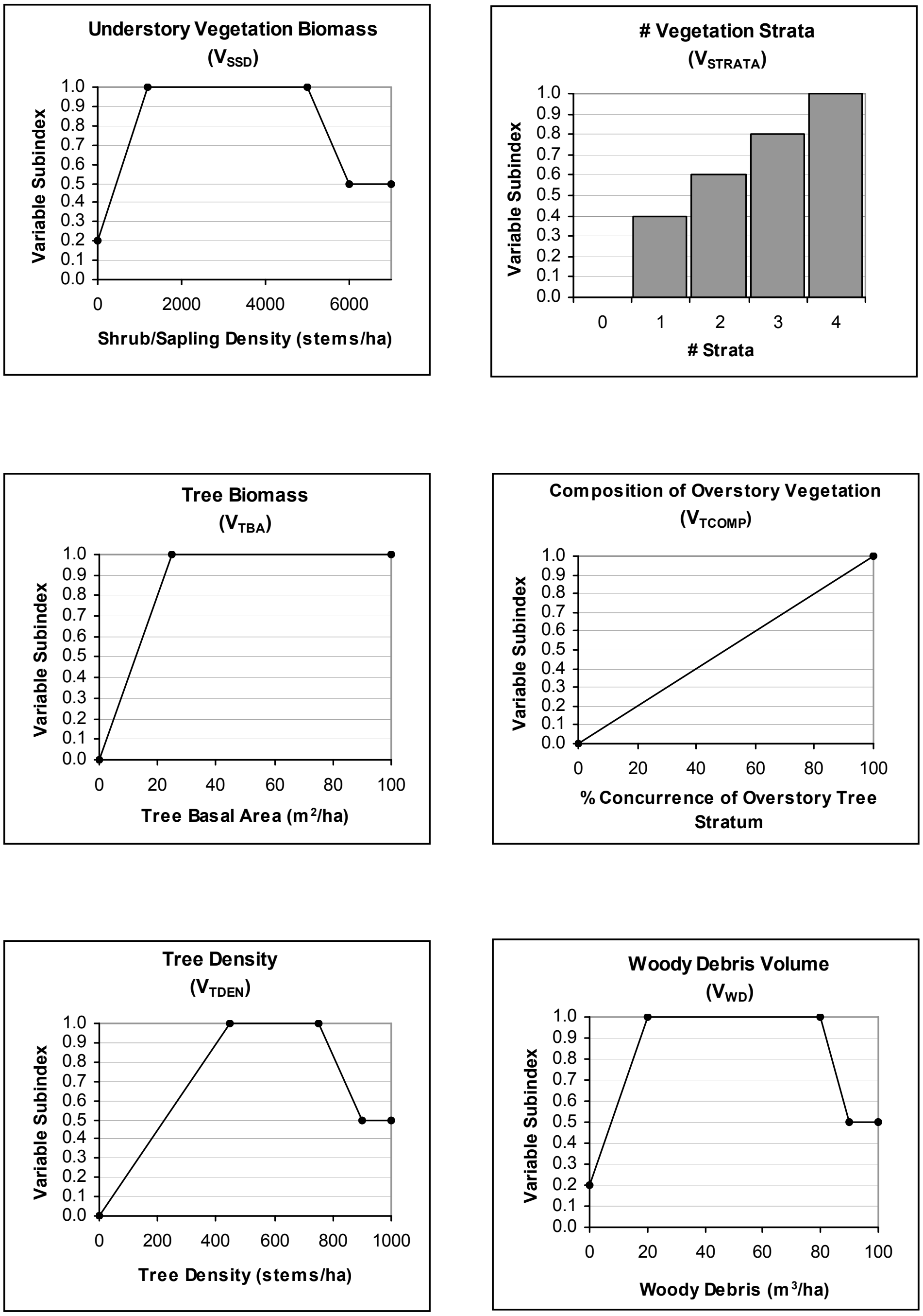


Figure 24. (Sheet 3 of 3)

6 Assessment Protocol

Introduction

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

In most cases, permit review, restoration planning, and similar assessment applications require that a comparison be made between pre- and post-project conditions of wetlands at the project site to develop estimates of 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 is normally based on a prediction of the conditions that can reasonably be expected to exist following proposed project impacts. A well-documented set of assumptions should be provided with the assessment to support the predicted post-project conditions used in making an assessment.

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

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

a. Document the project purpose and characteristics.

b. Screen for red flags.

c. Define assessment objectives and identify regional wetland subclass(es) present, and assessment area boundaries.

d. Collect field data.

e. Analyze field data.

f. Document assessment results.

g. Apply assessment results.

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

Document the Project Purpose and Characteristics

Data Form A1 (Project Information and Documentation – Appendix A) provides a checklist of information needed to conduct a complete assessment, and serves as a cover sheet for all compiled assessment maps, drawings, data forms, and other information. It requires the assignment of a project name, identification of personnel involved in the assessment, and attachment of supporting documentation. 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, 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:

a. Aerial photographs.

b. Topographic maps.

c. Geomorphic maps (Appendix E).

d. County soil survey.

e. National Wetland Inventory maps.

f. Flood frequency maps.

g. 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 (from Appendix E) to develop a preliminary classification of wetlands for the project area and vicinity prior to going to the field. Figure 25 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.

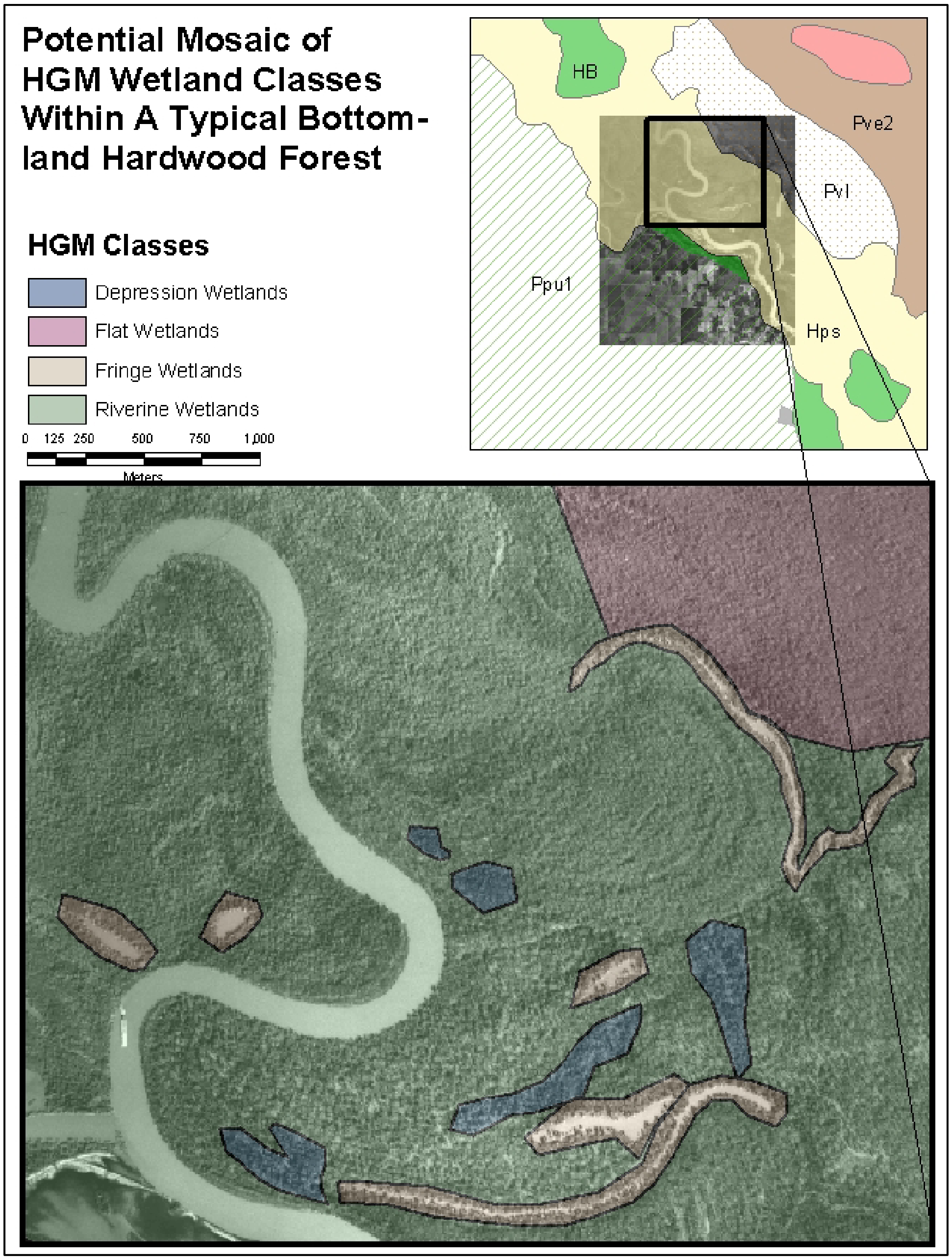


Figure 25. Example application of geomorphic mapping and aerial photography to develop a preliminary wetland classification for a proposed project area

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:

a. Compare several wetlands as part of an alternatives analysis.

b. Identify specific actions that can be taken to minimize project impacts.

c. Document baseline conditions at a wetland site.

d. Determine mitigation requirements.

e. Determine mitigation success.

f. 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 26 through 29 present a simplified project scenario to illustrate the steps used to designate the boundaries of Wetland Assessment Areas, each of which will require a separate HGM assessment. Figure 26 illustrates a land cover map for a hypothetical project area. Figure 27 shows the project area (in yellow) superimposed on the land cover map. To determine the boundaries of the Wetland Assessment Areas, first use the Keys to Wetland Classes and Subclasses (Figures 11 and 12) and identify the wetland subclasses within and contiguous to the project area (Figure 27). Overlay the project area boundary and the wetland subclass boundaries to identify the Wetland Assessment Areas for which data will be collected (Figure 28). Attach these maps, photos and drawings to Data Form A1 and complete the first three columns of the table on Data Form A1 by assigning an identifying number to each Wetland Assessment Area (WAA), specifying the subclass it belongs to, and calculating the area (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, 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 Wetland Assessment Areas, because the assessment process includes consideration of the size and isolation of individual wetland units. The second situation occurs where more than one regional wetland subclass occurs within a project area, as illustrated in Figure 27, where both Flat and Low-gradient Riverine Overbank 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 where a contiguous wetland area of the same regional subclass exhibits spatial heterogeneity in terms of hydrology, vegetation, soils, or other assessment criteria. This is illustrated in Figure 28, where the area designated as Riverine Overbank Wetlands in Figure 27 is further subdivided into two Wetland Assessment Areas based on land use and vegetation cover. The farmed area clearly will have different characteristics than the forested wetland, and they will be assessed separately (though using the same models and reference data).

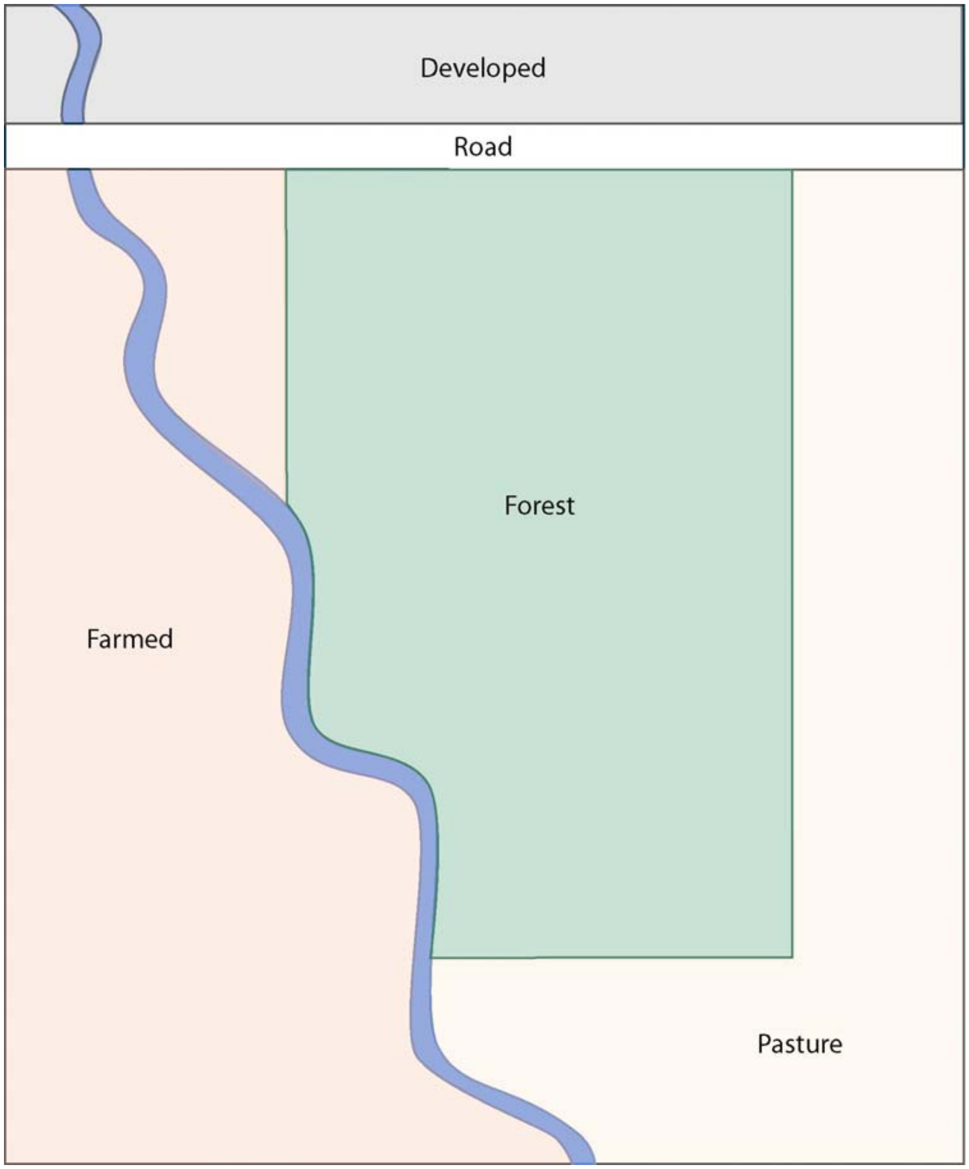


Figure 26. Land cover

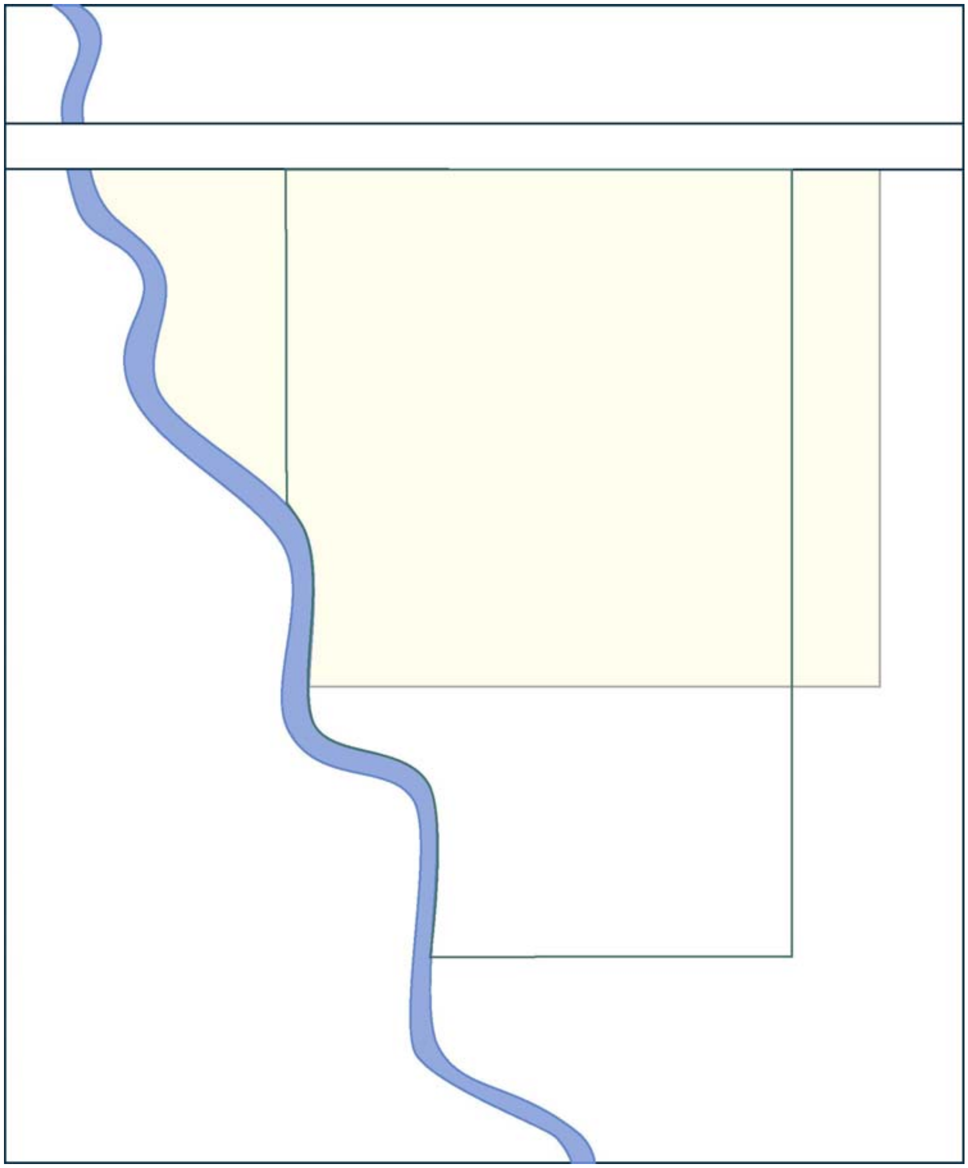


Figure 27. Project area (in yellow)

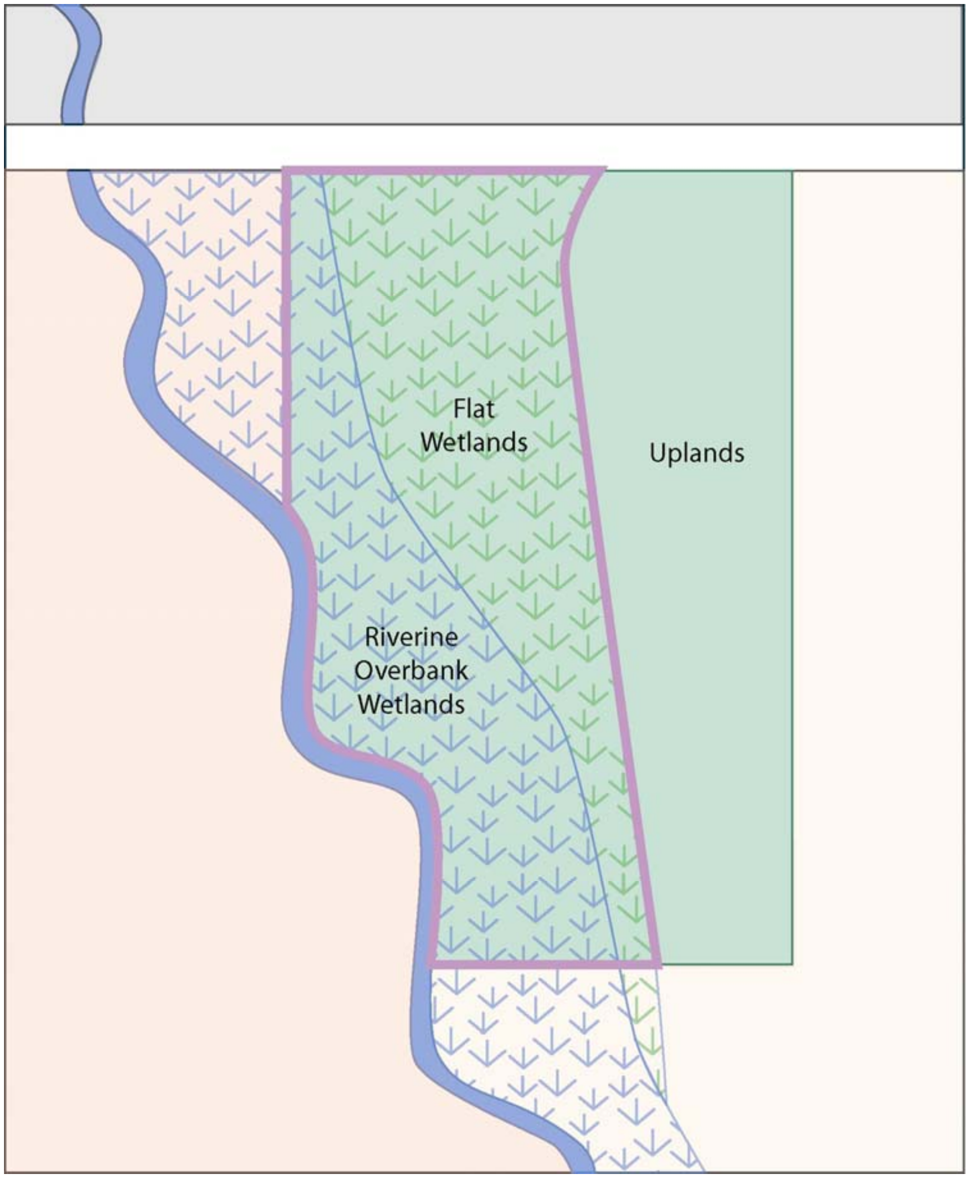


Figure 28. Wetland subclasses (purple line indicates extent of the “wetland tract”)

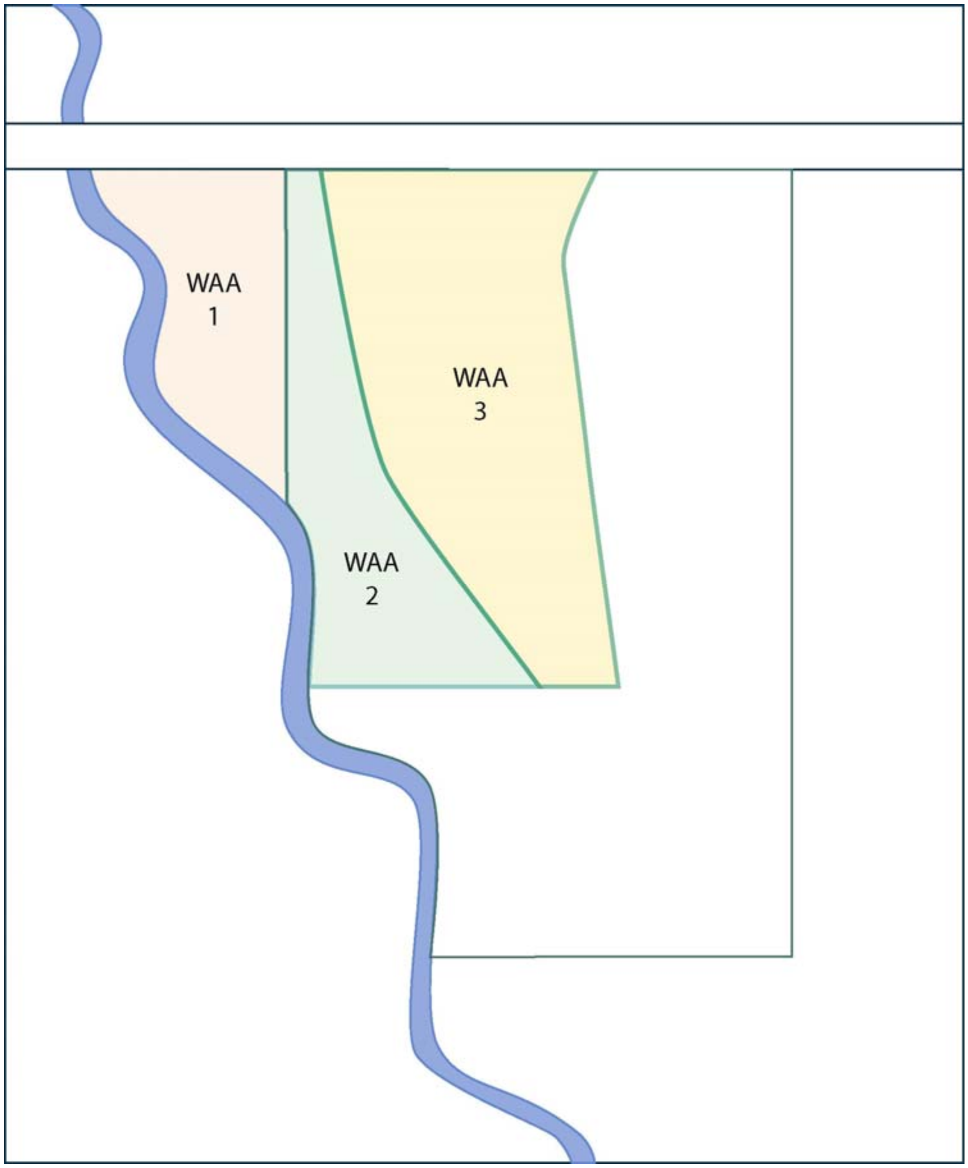


Figure 29. Wetland Assesment Areas

In the Coastal Plain Region of Arkansas, the most common scenarios requiring designation of multiple Wetland Assessment Areas involve tracts of land with interspersed regional subclasses (such as depressions scattered within a matrix of flats or riverine wetlands) 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 Wetland Assessment Areas that are cleared land, early successional sites, and mature forests. However, be cautious about splitting a project area into many Wetland Assessment Areas based on relatively minor differences, such as local variation due to canopy gaps and edge effects. The reference curves used in this document (Chapter 5) incorporate such variation, and splitting areas into numerous Wetland Assessment Areas based on subtle differences will not materially change the outcome of the assessment. It will, however, greatly increase the sampling and analysis requirements. Field experience in the region should provide a sense of the range of variability that typically occurs, and is sufficient to make reasonable decisions in defining multiple WAAs.

Collect Field Data

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

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

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

Table 7 **Applicability of Variables by Regional Wetland Subclass**							
Variable Code	**Pine Flat**	**Hardwood Flat**	**Low-Gradient Riverine (Backwater and Overbank)**	**Mid-Gradient Riverine**	**Unconnected Depression**	**Connected Depression**	**Slope (Bayhead and Seep)**
V_{AHOR}	+	+	+	+	*	*	+
V_{BUF30}	not used	not used	not used	+	+	+	+
V_{BUF250}	not used	not used	not used	+	+	+	+
V_{COMP}	+	+	+	+	+	+	+
V_{FIRE}	+	not used	not used	not used	not used	not used	not used
V_{FREQ}	not used	not used	+	+	not used	+	not used
V_{GCOMP}	not used	not used	not used	not used	not used	not used	+
V_{GVC}	+	+	+	+	*	*	+
V_{LITTER}	+	+	+	+	not used	*	+
V_{LOG}	+	+	+	+	*	*	+
V_{OHOR}	+	+	+	+	*	*	+
V_{OUT}	not used	not used	not used	not used	not used	not used	+
V_{PATCH}	not used	+	+	not used	not used	not used	not used
V_{POND}	+	+	+	+	not used	not used	not used
V_{SNAG}	+	+	+	+	+	+	+
V_{SOIL}	+	+	+	+	*	*	+
V_{SSD}	+	+	+	+	+	+	+
V_{STRATA}	+	+	+	+	+	+	+
V_{TBA}	+	+	+	+	+	+	+
V_{TCOMP}	+	+	+	+	+	+	+
V_{TDEN}	+	+	+	+	+	+	+
V_{WD}	+	+	+	+	*	*	+
Note: Variables not used in assessment of a particular subclass are identified. Variables always used in assessment of the subclass are indicated by "+". Variables used unless site conditions preclude their observation are indicated by a shaded box marked with *.							

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 Coastal Plain Region. A conversion factor is built into the data form to make the needed adjustments to the recorded field data. The second instance involves use of a diameter tape for determining basal area, which is an alternative approach to the prism method. Because English diameter 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 Wetland Assessment Areas is shown in Figure 30. As in defining the WAA, there are elements of subjectivity and practicality in determining the number of sample locations for collecting plot-based and transect-based site-specific data. The exact numbers and locations of the plots and transects are dictated by the size and heterogeneity of the WAA. If the WAA is relatively small (i.e., less than 2–3 acres, or about a hectare) and homogeneous with respect to the characteristics and processes that influence wetland function, then three or four 0.04 ha plots, with associated nested transects and subplots in representative locations, are probably adequate to characterize the Wetland Assessment Area. Experience has shown that the time required to complete an assessment of an area that size is 2–4 hours, depending primarily on the experience of the assessment team. However, as the size and heterogeneity of the Wetland Assessment Area 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 to differentially emphasize or exclude any of these local conditions, but to represent the site as a whole. Therefore, on large sites, the best approach is often 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 2 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 8 sampled plot locations, which should be adequate for a relatively diverse 12 ha forested wetland area. On Figure 30, WAA 2 illustrates this approach for establishing fairly high-density, uniformly distributed samples. Larger or more uniform sites can usually be sampled at a lower plot density. One approach is to establish a series of transects, as described above, and sample at intervals along alternate transects (see WAA 3 on Figure 30). 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 an overall stabilization of the dominant species list and average basal area values. Other variables may stabilize more quickly or slowly than tree composition and basal area, but these two factors are generally good indicators and correspond well to the overall suite of characteristics of interest within a particular Wetland Assessment Area. In some cases, such as sites where trees have been planted or composition and structure are highly uniform (e.g. sites dominated by a single tree species), it may be apparent that relatively few samples are adequate to reasonably characterize the wetland. In Figure 30, 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.

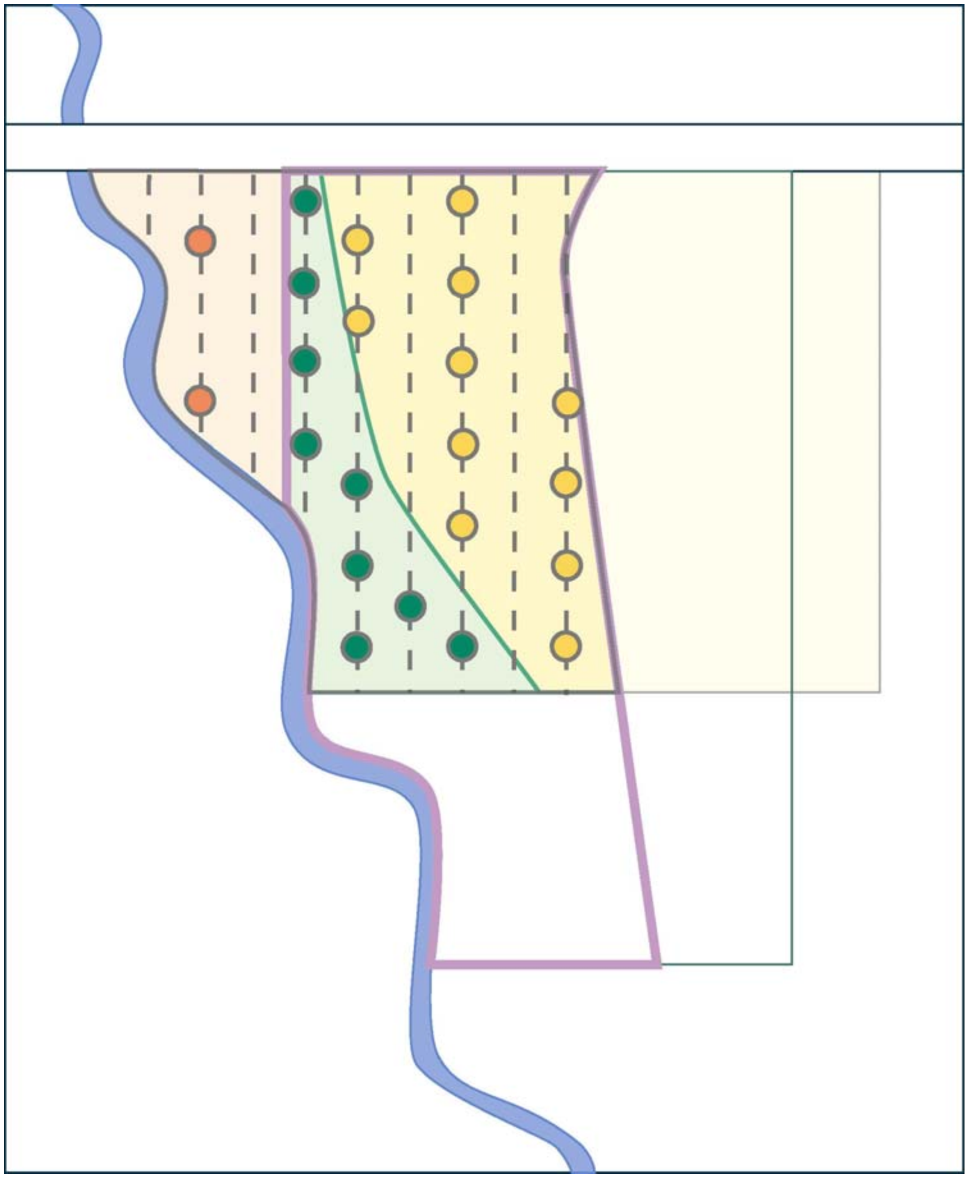


Figure 30. Example sample distribution. Refer to Figure 29 for WAA designations

The information on Data Form 1 and on the multiple copies of Data Form 2 are transferred to Data Form 3 where they are 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 31. 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 total mass of organic matter in the A soil horizon. The A soil horizon is defined as a mineral soil horizon that occurs at the ground surface, below the O soil horizon, consisting of an accumulation of unrecognizable decomposed organic matter mixed with mineral soil (USDA SCS 1993). In practice, the HGM models using this variable are concerned with the storage of organic matter, so for our purposes the A horizon is identified in the field simply as a zone of darkened soil.

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

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

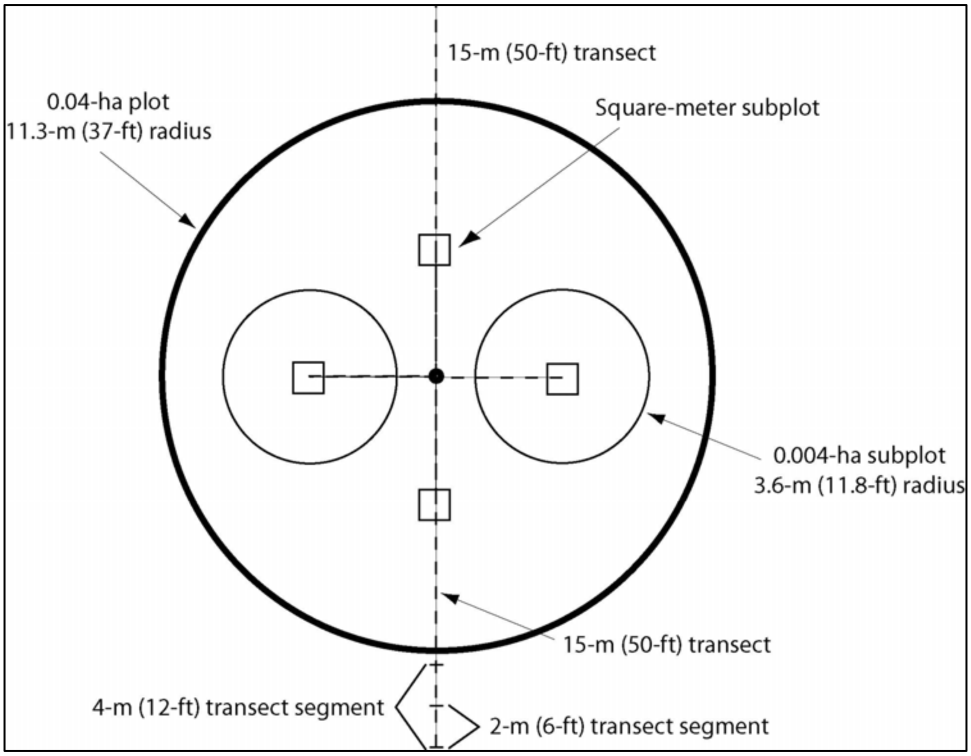


Figure 31. Layout of plots and transects for field sampling

V_{BUF30} – Percent contiguous 30-meter buffer

This variable describes the percentage of the wetland perimeter bounded by a 30-meter buffer that provides contiguous habitat with appropriate characteristics to meet the general use habitat needs (basking, feeding, limited nesting, and hibernation) of many reptiles and amphibians. 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 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 and on slopes. However, for wetlands along mid-gradient streams, the variable is approached differently. In most cases, mid-gradient streams are wide and deep enough 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 instances where streams are small and do not represent a barrier to animal movement, this buffer variable should be calculated as it is for depression and slope wetlands.

Determine the value of this metric using the procedure below, and refer to Figure 28 as needed:

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

(2) Draw a second line 30 m outside the wetland boundary line. This defines the outer limit of the 30-m buffer zone (Figure 32a,b).

(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-meter buffer, draw a line perpendicular to the wetland boundary to determine where along the perimeter the full 30-meter buffer ends. Areas of appropriate habitat that are not contiguous with the wetland boundary will not be considered in this metric (Figure 32c).

(4) Visually estimate the percentage of the wetland perimeter bounded by a full 30-meter buffer. This is actually measured as a lineal percentage. Consider the wetland outline to be a clock face. In Figure 32a, the full 30-meter buffer runs from roughly 12:15 to 9:30 and then again from 10:00 to 11:45 or 11/12= 92 percent. Record that percentage on Data Form 1 in the box at the right hand side of the V_{BUF30} row, and transfer the same number to the right hand side of the V_{BUF30} row on Data Form 4.

(5) For mid-gradient riverine wetlands, use the same approach described above, but restrict the procedure to the same side of the stream where the wetland occurs (Figure 32b). In the example shown in Figure 32b, the continuity of the 30-m buffer is 100 percent.

V_{BUF250} – Percent contiguous 250-meter buffer

This variable describes the percentage of the wetland perimeter bounded by a 250-meter 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 and on slopes. However, for wetlands along mid-gradient streams, the variable is approached differently. In most cases, mid-gradient streams are wide and deep enough 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 instances where streams are small and do not represent a barrier to animal movement, this buffer variable should be calculated as it is for depression and slope wetlands.

Determine the value of this metric using the procedure below, and refer to Figure 32 as needed:

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

(2) Draw a second line 250 m outside the wetland boundary line. This defines the outer limit of the 250-m buffer zone (Figure 32a).

(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-meter buffer, draw a line perpendicular to the wetland boundary to determine where along the perimeter the full 250-meter buffer ends. Areas of appropriate habitat that are not contiguous with the wetland boundary will not be considered in this metric (Figure 32a).

(4) Visually estimate the percentage of the wetland perimeter bounded by a full 250-meter buffer. This is actually measured as a lineal percentage. Consider the wetland outline to be a clock face. In Figure 32a, the full 250-meter buffer runs from roughly 1:15 to 5:00 and then again from 6:00 to 8:30, or 6.25/12= 52 percent. Record that percentage on Data Form 1 in the box at the right hand side of the V_{B250} row, and transfer the same number to the right hand side of the V_{B250} row on Data Form 4.

(5) For mid-gradient riverine wetlands, use the same approach described above, but restrict the procedure to the same side of the stream where the wetland occurs (Figure 32b). In the example shown in Figure 32b, the continuity of the 250-m buffer is approximately 70 percent.

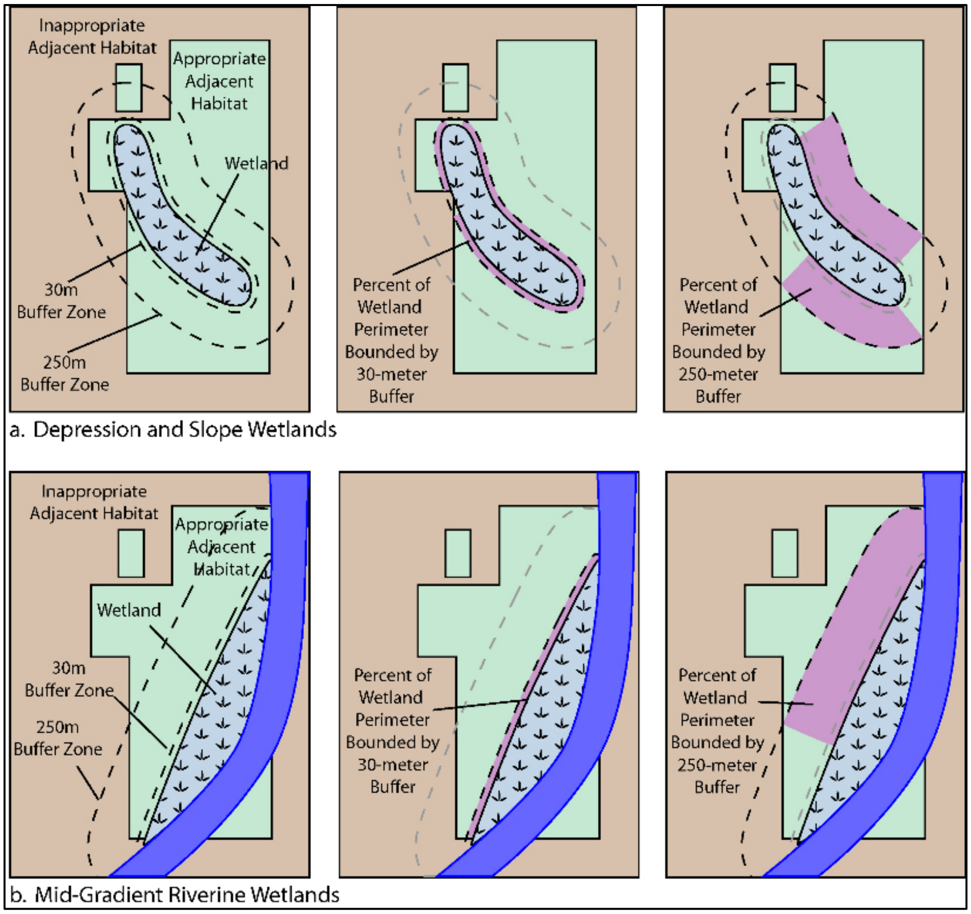


Figure 32. Measurement of buffer characteristics

V_{COMP} – Composition of tallest woody vegetation stratum

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

(1) Determine percent cover of the tree stratum by visually estimating what percentage of the sky is blocked by leaves and stems of the tree stratum, or vertically projecting the leaves and stems to the forest floor. If the percent cover of the tree stratum is estimated to be at least 20 percent, go to Step 2. If the percent cover of the tree stratum is estimated to be less than 20 percent, skip Step 2 and go directly to Step 3.

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

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

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

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

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

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

V_{FIRE} – Fire-maintained forest patch size

This variable applies only to pine (or pine/post oak) flats, which are fire-adapted systems that typically have a savanna-like structure (open canopy, sparse understory) unless they are protected from periodic burns. (Note that included vernal pool areas may be dominated by species typical of hardwood flats and are a normal component of the pine flats system). Determine the value using the following procedure (adapted from Rheinhardt et al. 2002):

(1) Using recent (within 5 years) aerial photos, delineate the fire-maintained forested area that is contiguous to and includes the WAA (see Figure 33). This should include both wet flats and upland systems that have canopy cover of less than 50 percent, and are dominated by pines (although post oak may be a co-dominant on some sites). (Note that in Arkansas, experimental habitat management may involve creation of savanna-like structure using timber harvesting methods, with the intention of reintroducing fire after excess fuel has been removed. These sites may be considered as fire-maintained if there is no evidence of bedding, which is mounding of the soil in preparation for planting trees in wet sites). Fire-maintained habitats separated by discontinuities wider than 50 m are not included in the contiguous area. Subtract any discontinuities (closed-canopy forest, bedded areas, developed areas, highways) enveloped by the contiguous boundary from the total area delineated if the discontinuity exceeds 1 ha in size. Include the area of the WAA if it is a fire-maintained savanna.

(2) Determine the total area of fire-maintained savanna using a dot grid or GIS. If the area clearly exceeds 100 ha, there is no need to determine the exact area.

(3) Record the total area of fire-maintained savanna in the box at the right hand side of the V_{FIRE} row on Data Form 1. Enter "100 ha" if the savanna clearly exceeds that area.

(4) Transfer the V_{FIRE} value to Data Form 3.

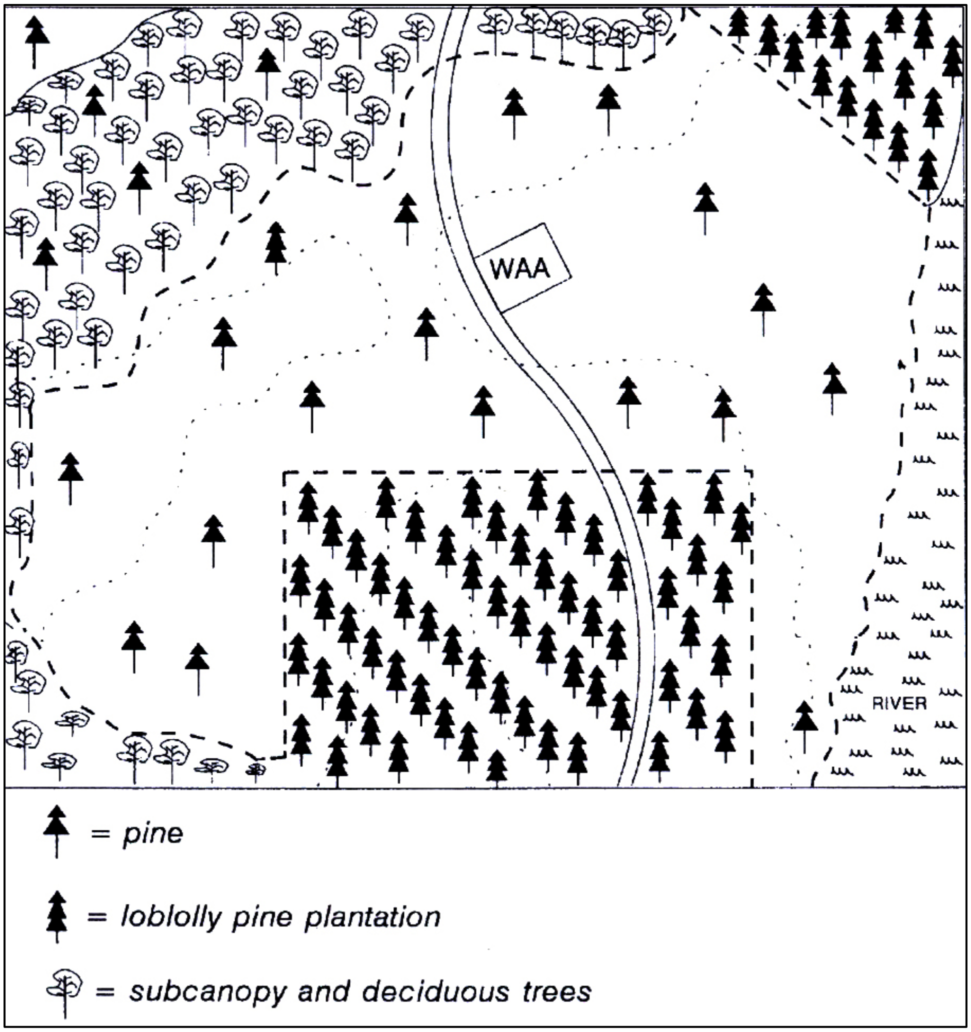


Figure 33. Determination of fire-maintained forest patch size in pine flat wetlands (from Rheinhardt et al. 2002). The dashed line delineates the area of the fire-maintained landscape, and the dotted line delineates the portions of that area that are wet pine flats or pine/post-oak flats. Deciduous tree symbols indicate fire-excluded areas

V_{FREQ} - Frequency of flooding

Frequency of flooding refers to the frequency with which overbank or backwater flooding from a stream inundates the Wetland Assessment Area. 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:

(1) Determine recurrence interval using one of the following methods:

(a) Recurrence interval map.

(b) Data from a nearby stream gage.

(c) 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).

(d) Hydrologic models such as HEC-2 (USACE 1981, 1982), HEC-RAS (USACE 1997), or HSPF (Bicknell et al. 1993).

(e) Local knowledge.

(f) A regional dimensionless rating curve.

(2) 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 Coastal Plain region, 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 of their abundance to allow evaluation during the dormant season as well as the growing season. Determine the value of the metric using the procedures outlined below:

(1) Count the number of fern species characteristic of slope wetlands that account for at least 10 percent 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 30. Record measurements for each subplot on Data Form 2, and enter the average value for the entire plot in the right hand column of the V_{GVC} row on Data Form 2.

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

V_{LITTER} - Litter cover

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

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

(1) Visually estimate the proportion of the ground surface that is covered by litter. Do this in each of the four 1-m^2 subplots (the same subplots established for estimating ground vegetation cover, Figure 30). Record measurements for each subplot on Data Form 2, and enter the average value for the entire plot in the right hand column of the V_{LITTER} row on Data Form 2.

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

V_{LOG} - Log biomass

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

V_{OHOR} - O horizon organic accumulation

The O horizon is defined as the soil layer dominated by organic material that consists of partially decomposed organic matter such as leaves, needles, sticks or twigs < 0.6 cm in diameter, flowers, fruits, insect frass, dead moss, or detached lichens on or near the surface of the ground (USDA SCS 1993). The O horizon does not include recently fallen material (e.g., whole leaves) 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 2 or more measurements per plot, which are recorded as subplot values in the V_{OHOR} section of Data Form 2.

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

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

V_{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 Form 2. 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 percent canopy tree cover.

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 2500 ha, you can simply record 2500) on the 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 Wetland Assessment Area 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 Wetland Assessment Area 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 square meters in area. Larger vernal pools (usually at least 0.04 ha) occur in the broad swales typical of meander scroll topography or in other areas where impeded drainage produces broad, shallow pools during rainy periods. The wetlands where these features are important typically have a mix of both the small microdepressions and the larger vernal pools.

Estimate total ponded area using the following procedure:

(1) During a reconnaissance walkover of the entire Wetland Assessment Area, 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. Note that, in the case of the Flats subclass, Data Form 4 also requires that you identify the geomorphic surface on which the Wetland Assessment Area is located, because percent ponding differs markedly among surfaces in the reference data set, which is reflected in the calibration curves and the summary spreadsheets. Older, higher surfaces are less ponded than younger, lower surfaces, reflecting the greater amount of erosion and filling that has occurred over time. The geomorphic surface can be identified using the supplemental spatial data in Appendix E, or the map in Figure 7 may be adequate in many cases. Assign the Wetland Assessment Area to one of three possible surfaces:

(a) Early- and Mid-Pleistocene Terraces, identified as Prairie Complex (map symbol Pp) or Intermediate Complex (Pi) on the 1:1,100,000 map of Quaternary Geology of the Lower Mississippi Valley (Saucier and Snead 1989). More detailed (1:62,500) maps (Fleetwood 1969; Smith and Russ 1974) further subdivide some of these units or use alternate terminology. Surfaces identified on those maps as Upland or Undifferentiated Complex (Qtu) or Montgomery Terrace (Qm) also are included in this category.

(b) Late Pleistocene Terraces, identified on the Saucier and Snead (1989) map as Deweyville Terraces (Pd) comprise this category. They are delineated in much greater detail on the Saucier and Smith (1986) 1:24,000 maps, where they are identified by map symbols Qtd1, Qtd2, or Qtd3.

(c) Holocene Alluvium, including any of the multiple surfaces (reflecting environments of deposition) within the Holocene group on Saucier and Snead (1989), or the recent group on Fleetwood (1969) and Smith and Russ (1974). Saucier and Smith (1986) map Holocene surfaces of the Ouachita and Saline River systems from a slightly different perspective, recognizing active meander belts (Qal) and a set of Holocene terraces (Qf1, Qf2).

V_{SNAG} - Snag density

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

(1) Count the number of snag stems within each 0.04-ha circular plot. Record the number of snag stems in the indicated box on the V_{SNAG} row on Data

Form 2. Multiply this number by 25 and enter the result in the right hand box on V_{SNAG} row on Data Form 2.

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

V_{SOIL} - Soil integrity

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

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

(1) As part of the reconnaissance walkover of the entire Wetland Assessment Area, 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 the Data Form 1 in the box on the right of the V_{SOIL} row, and transfer that value to the box on the right of the V_{SOIL} row on Data Form 3.

V_{SSD} - Shrub-sapling density

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

(1) Count woody stems less than 10 cm (4 in) and greater than 1.4 m (4.5 ft) in height in two 0.004-ha circular subplots (radius 3.6 m or 11.8 ft) nested within the 0.04-ha plot (Figure 30). 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 Wetland Assessment Area using the following procedure:

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

(a) Canopy (trees greater than or equal to 10 cm dbh which are in the canopy layer).

(b) Subcanopy (trees greater than or equal to 10 cm dbh which are below the canopy layer —recognize this layer if it is distinctly different from a higher, more mature canopy).

(c) Understory (shrubs and saplings less than 10 cm dbh but at least 4.5 ft tall).

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

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

V_{TBA} - Tree basal area

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

(1) Use a basal area wedge prism (or other basal area estimation tool) as directed to tally eligible tree stems, and enter the tally in the indicated space on the V_{TBA} line on Data Form 3. Basal area prisms are available in various Basal

Area Factors 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 in most forests in the Coastal Plain region, and it is readily available.

(2) Calculate 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 2.3. Enter the total basal area figure in the right hand box on the V_{TBA} row on Data Form 2.

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

An alternative method also is available to directly measure tree diameters in the 0.04-ha plot, rather than using 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 a wedge prism or similar tool is not available, 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. The direct measurement approach may be used to facilitate more rigorous data collection, particularly if the relative dominance of each tree species to the total basal area of the WAA is an important consideration. 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, which can be summed to determine the total basal area by species. This can be used simply to provide more detailed documentation of the assessment process, or to improve the rigor of your estimates for the V_{TCOMP} variable. Tree counts directly from the basal area sheets also can 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, 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) Square the dbh measurement for each woody stem and enter that number in Column 3.

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

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

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

A spreadsheet is available (Appendix D) to complete the calculations in Steps 2–5, or they can be calculated by hand as described above.

V_{TCOMP} - Tree composition

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

(1) If the tree stratum has at least 20 percent cover, identify the dominant species (based on cover, or on basal area if dbh measurements are taken) and circle them on Data Form 3 of the appropriate wetland subclass. To identify dominants, apply the 50/20 rule (U. S. Army Corps of Engineers 1992). This requires species to be ranked in descending order of percent cover, summing relative dominance in descending order until 50 percent is exceeded. Additional species with 20 percent relative dominance should also be included as dominants. Accurate identification of woody species is critical for determining the dominant species in each plot. Sampling during the dormant season may require proficiency in recognizing plant form, bark, and dead or dormant plant parts. Users who do not feel confident in identifying trees and shrubs should get help.

(2) Calculate percent concurrence using the formula provided on Data Form 2, which weights dominant species based on their likelihood of being dominant in reference stands of varying condition. Note that the species lists on Form 2 are specific to each subclass.

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

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

V_{TDEN} - Tree density

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

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

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

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

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

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

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

(1) Lay out two 50-ft. (15.24 m) east-west transects, originating at the 0.04-ha plot center point (Figure 30).

(2) Count the number of nonliving stems in Size Class 1 (small) (greater than or equal to 0.6 and less than 2.5 cm or greater than or equal to 0.25 and less than 1 in) that intersect a vertical plane above a 6-ft segment of each 50-ft. transect. This can be any 6-ft segment, as long as it is consistently placed. Figure 30 illustrates it as placed at the end furthest from the plot center point. Record the number of Size Class 1 stems from each transect in the spaces provided on the V_{WD} (Size Class 1) line on Data Form 2.

(3) Count the number of nonliving stems in Size Class 2 (medium) (greater than or equal to 2.5 cm and less than 7.6 cm or greater than or equal to 1 in and less than 3 in) that intersect the plane above a 12-ft segment of each 50-ft transect. This can be any 12-ft segment, as long as it is consistently placed. Figure 30 illustrates it as placed at the end furthest from the plot center point, overlapping with the 6-ft transect segment. Record the number of Size Class 2 stems from each transect in the spaces provided on the V_{WD} (Size Class 2) line on Data Form 2.

(4) Measure and record the diameter of nonliving stems in Size Class 3 (large) (greater than or equal to 7.6 cm 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.

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 (FCU) 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 due to 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) and to completely fill out the green-shaded boxes to identify the project and the Wetland Assessment Area and to specify the size (ha) of the Wetland Assessment Area. Do not attempt to clear or enter data into any non-shaded boxes—the spreadsheet will not accept direct changes to those cells.

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

Document Assessment Results

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

Apply Assessment Results

Once the assessment and analysis phases are complete, the results can be used to compare the same Wetland Assessment Area at different points in time, compare different Wetland Assessment Areas at the same point in time, or compare different alternatives to a project. The basic unit of comparison is the 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 tend to focus on the functions most directly associated with those resources. For example, wildlife functions may be particularly important in an area that has been extensively converted to agriculture. Hydrologic functions may be of greatest interest if the project being assessed will alter water storage or flooding patterns. Conversely, this type of analysis can help 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 beaver in the modern landscape is to adopt the perspective that beaver complexes are fully functional, but transient, components of riverine wetland systems for all functions. At the same time, if beaver are not present (even in an area where they would normally be expected to occur), the resulting riverine wetland can be assessed using the models, but the overall Wetland Assessment Area is not penalized either way. Other situations that require special consideration include areas affected by fire, sites damaged by ice storms, and similar occurrences. Fire, in particular, can cause dramatic short-term changes in many of the indicators measured to assess function, such as ground cover, woody debris, and litter accumulation. Note however, that normal, non-catastrophic disturbances to wetlands (i.e., tree mortality causing small openings) are accounted for in the reference data used in this guidebook.

Because the HGM models are calibrated with reference to mature, complex plant communities, and the wildlife habitat models emphasize the requirements of species needing large, contiguous blocks of habitat, early successional wetlands in fragmented landscapes will receive very low assessment scores for the wildlife habitat function. In such situations, it may be useful to supplement the wildlife habitat assessment models with alternative methods such as the Habitat Evaluation Procedures (HEP) (U.S. Fish and Wildlife Service 1980). This approach can provide a more sensitive assessment of the early developmental period following wetland restoration or changes in management than the HGM models presented here.

Another potential consideration in the application of the assessment models presented here concerns the projection of future conditions. This may be particularly important in determining the rate at which functional status will improve as a result of restoration actions intended to offset impacts to jurisdictional wetlands. The graphs in Figure 34 represent general recovery trajectories for forested hardwood wetlands within the Coastal Plain Region of Arkansas based on a subset of the reference data collected to develop this guidebook. In selected stands, individual trees were aged using an increment corer to develop a general relationship between the age of sampled stands and the site-specific variables employed in the assessment models. Thus, a user can estimate the overstory basal area, shrub density, woody debris volume, and other functional indicators for various time intervals, and calculate functional capacity indices for all assessed functions. These curves are specifically constructed to reflect wetland recovery following restoration of agricultural land. Therefore, they assume that the initial site condition includes bare ground that has been tilled. Varying degrees and types of tillage within reference areas confused recovery patterns for soil development, therefore no trajectory curve is presented for V_{AHOR}—users should base projections for this variable on the initial site condition, or modify the assessment equations so that this variable is not considered in future projections. Note that landscape variables are not included here, because they require site-specific knowledge to project future conditions. Ponding development rates also are not estimated, because ponding is the result of both geomorphic and biotic factors and the initial site conditions (i.e., extent of land leveling). The degree of microtopographic relief will be dependent on the extent of site contouring work done prior to planting, in most cases. Similarly, the rates of compositional change (V_{COMP} and V_{TCOMP}) are dependent on initial site conditions; generally, a site planted with appropriate species should have an FCI score of 1.0 soon after planting for the compositional variable V_{COMP}, and maintain that fully functional status indefinitely as V_{TCOMP} becomes the applicable compositional variable.

Estimation of future composition for unplanted areas will require site-specific evaluation of seed sources and probable colonization patterns. However, it is also important to carefully consider the changing nature of the block size and connectivity variables used in the HGM models as the site matures. The spatial habitat variables (V_{TRACT}, V_{CORE}, and $V_{CONNECT}$) are focused to a great extent on vegetation structure as it provides concealment and movement corridors. Thus, a wetland isolated from nearby forests at the initial assessment may be fully connected within a decade or two if the intervening fields have been allowed to grow into scrub and young forest habitats.

Note also that the graphs in Figure 34 are amalgams of data from all wetland subclasses. In situations where a site is expected to be unusual in one or more respects (such as a cottonwood stand, where basal areas are likely to increase more quickly than in hardwood forests), more specific data may exist, and should be substituted for these general curves as appropriate. Similarly, the influence of fire is not assumed — changes to system characteristics depicted in the graphs reflect conditions where fire has been suppressed, as it has in the majority of the reference sites.

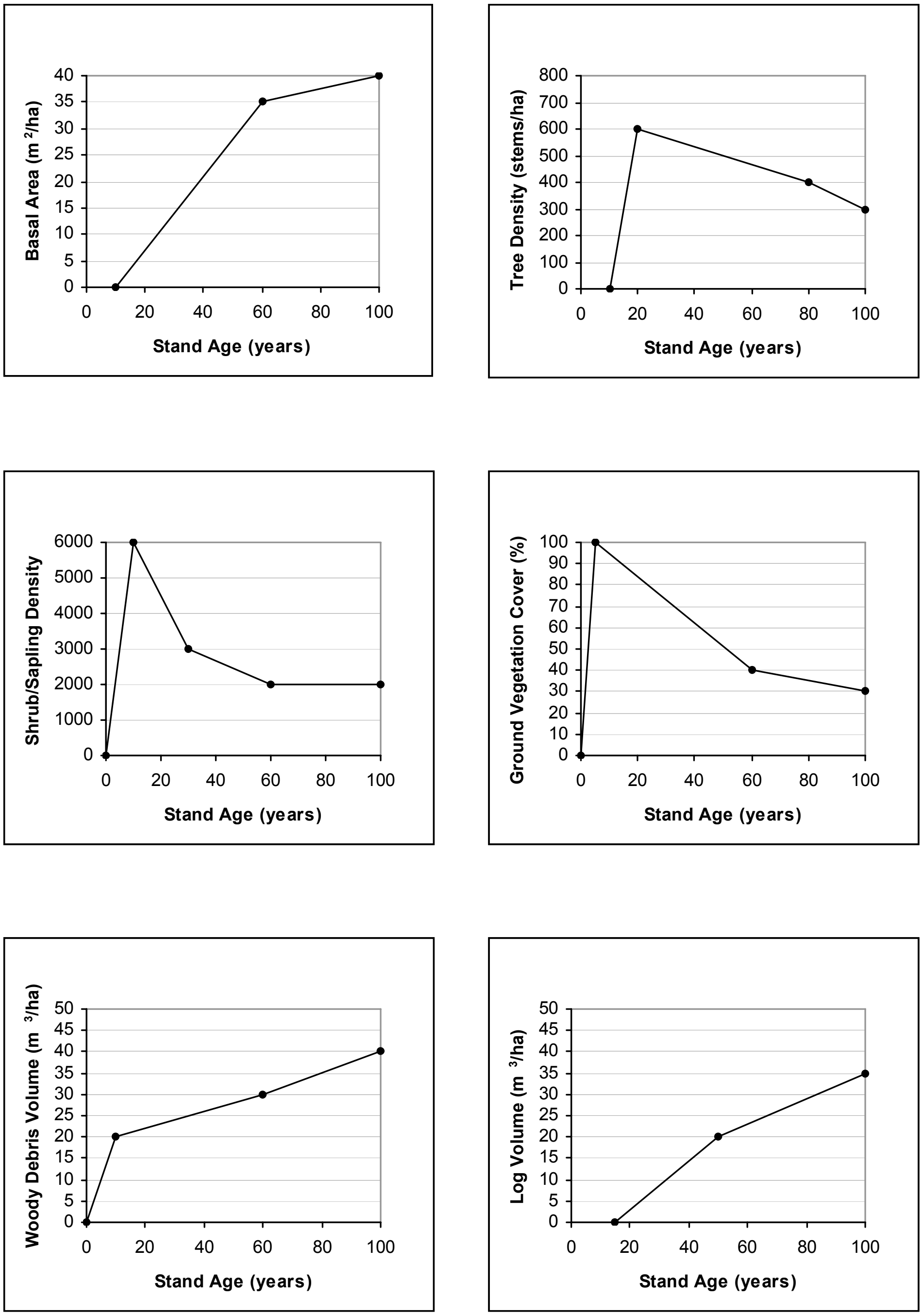


Figure 34. Projected recovery trajectories for selected assessment variables (Continued)

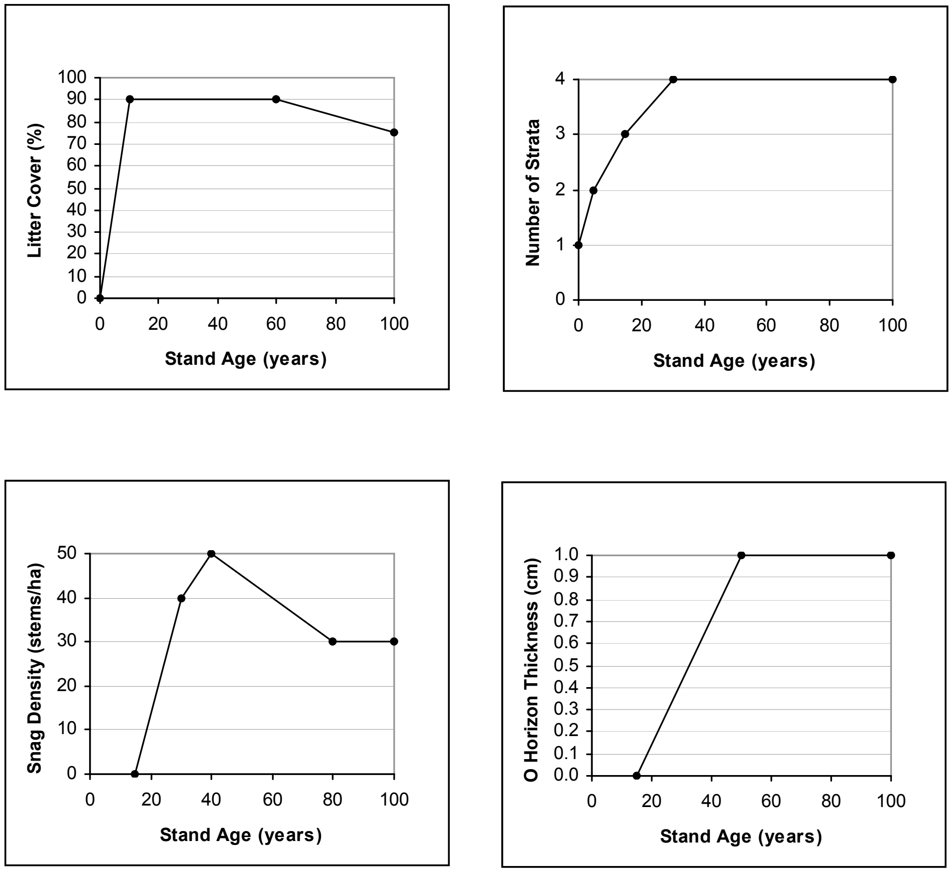


Figure 34. (Concluded)

References

Ainslie, W. B., Smith, R. D., Pruitt, B. A., Roberts, T. H., Sparks, E. J., West, L., Godshalk, G. L., and Miller, M. V. (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 Temple, S. A. (1983). "Area-dependent changes in the bird communities and vegetation of southern Wisconsin forests," *Ecology* 64, 1057-68.

Arkansas Geological Commission. (1991). "Mineral producers of Arkansas." http://www.state.ar.us/agc/producer.htm.

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

Arkansas Soil and Water Conservation Commission. (2001). "Critical groundwater designation fact sheet," Arkansas Soil and Water Conservation Commission, Little Rock.

Askins, R. A., Philbrick, M. J., and Sugeno, D. S. (1987). "Relationship between the regional abundance of forest and the composition of forest bird communities," *Biological Conservation* 39, 129-52.

Autin, W. J., Burns, S. F., Miller, B. J., Saucier, R. T., and Snead, J. I. (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, 547-82.

Bailey, M. A., and Bailey, K. A. (2000). "Wetland fauna and drainage basin studies: Amphibian and reptile habitat utilization," Arnold Engineering Development Center, Arnold AFB, TN.

Baker, J. A., and Killgore, K. J. (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.

Baker, J. A., Killgore, K. J., and Kasul, R. L. (1991). “Aquatic habitats and fish communities in the lower Mississippi River,” *Reviews in Aquatic Sciences* 3, 313-56.

Batema, D. L., Henderson, G. S., and Fredrickson, L H. (1985). “Wetland invertebrate distribution in bottomland hardwoods as influenced by forest type and flooding regime.” *Proceedings, Fifth Annual Hardwood Conference*, University of Illinois, Urbana. 196-202.

Batista, W. B., and Platt, W. J. (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., Imhoff, J. C., Kittle, J. L., Donigan, A. S., and Johanson, R. C. (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 Karr, J. R. (1984). “Species composition of bird communities and the conservation benefit of large versus small forests,” *Biological Conservation* 30, 173-87.

Bormann, F. H., and Likens, G. E. (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.

Brinson, M. M. (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., Bradshaw, H. D, Holmes, R. N., and Elkins, J. B., Jr. (1980). "Litterfall, stemflow, and throughfall nutrient fluxes in an alluvial swamp forest," *Ecology* 61, 827-35.

Brinson, M. M., Bradshaw, H. D., and Kane, E. S. (1984). "Nutrient assimilative capacity of an alluvial floodplain swamp," *Journal of Applied Ecology* 21, 1041-57.

Brinson, M. M., Hauer, F. R., Lee, L. C., Nutter, W. L., Rheinhardt, R. D., Smith, R. D., and Whigham, D. (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., Lugo, A. E., and Brown, S. (1981). "Primary productivity, decomposition and consumer activity in freshwater wetlands," *Annual Review of Ecology and Systematics* 12, 123-61.

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

Brooks, K. N., Ffolliott, P. F., Gregerson, H. M., Thames, J. L. (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., Oberheu, R. D., and Johnston, C. M. (1982). "Handbook for inventorying surface fuels and biomass in the interior west," General Technical Report INT-129, U.S. Department of Agriculture Forest Service Intermountain Forest and Range Experiment Station, Ogden UT.

Brown, S., and Peterson, D. L. (1983). "Structural characteristics and biomass production of two Illinois bottomland forests," *American Midland Naturalist* 110, 107-17.

Burke, V. J., and Gibbons, J. W. (1995). "Terrestrial buffer zones and wetland conservation: A case study of freshwater turtles in a Carolina bay," *Cons. Biol.* 9, 1365-1369.

Campbell, K. L., and Johnson, H. P. (1975). "Hydrologic simulation of watersheds with artificial drainage," *Water Resources Research* 11, 120-26.

Center for Advanced Species Technologies. (1996). "Land cover of Arkansas: GAP analysis," Center for Advanced Spatial Technologies, University of Arkansas, Fayetteville.

Conner, W. H., and Day, J. W., Jr. (1976). "Productivity and composition of a baldcypress-water tupelo site and bottomland hardwood site in a Louisiana swamp," *American Journal of Botany* 63, 1354-64.

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.

Day, F. P. (1979). "Litter accumulation in four plant communities in the Dismal Swamp, Virginia," *American Midland Naturalist* 102, 281-89.

Demissie, M., and Kahn, A. (1993). "Influence of wetlands on streamflow in Illinois," Contract Report 561, Illinois State Water Survey, Champaign, IL.

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 Pugh, G. (1974). *Biology of plant litter decomposition.* Academic Press, London, England, Vol. I.

Dickson, J. G. (1991). "Birds and mammals of pre-colonial southern old-growth forests," *Natural Areas Journal* 11, 26-33.

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

Dybvig, W. L., and Hart, J. R. (1977). "The effects of agricultural drainage on flood flows at Moose Jaw." *Proceedings, 1977 Canadian Hydrology Symposium.* National Resources Council, 311-21.

Edwards, R. T. (1987). "Sestonic bacteria as a food source for filtering invertebrates in two southeastern blackwater streams," *Limnology and Oceanography* 32, 221-34.

Edwards, R. T., and Meyers, J. L. (1986). “Production and turnover of plantonic bacteria in two sub-tropical blackwater rivers,” *Applied Environmental Microbiology* 52, 1317-23.

Elder, J. F., and Cairns, D. J. (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 Mattraw, H. (1982). “Riverine transport of nutrients and detritus to the Apalachicola Bay Estuary, Florida,” *Water Resources Bulletin* 18, 849-56.

Elwood, J. W., Newbold, J. D., O’Neill, R. V., and Van Winkle, W. (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 Orsborn, J. F. (1986). “Review and analysis of methods for quantifying instream flow requirements,” *Water Resources Bulletin* 22, 389-98.

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*. Gen.Tech. Rep. SRS–41, USDA Forest Service, Southern Research Station, Asheville, NC. 7-10.

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.

Fleetwood, A. R. (1969). “Geological investigation of the Ouachita River area, Lower Mississippi Valley,” Technical Report S-69-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Foti, T., Blaney, M., Li, X., and Smith, K. G. (1994). “A classification system for the natural vegetation of Arkansas.” *Proceedings of the Arkansas Academy of Science* 48, 50-62.

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.

Gibbons, J. W. (2003). “Terrestrial habitat: A vital component for herpetofauna of isolated wetlands,” *Wetlands* 23, 630-635.

Gibbons, J. W., and Buhlmann, K. A. (2001). “Reptiles and amphibians.” *Wildlife of Southern Forests, Habitat and Management*. J. G. Dickson, ed., Hancock House Publishers, Blaine, WA. 372-390.

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

Greenberg, C. H., Mcleod, D. E., and Loftis, D. L. (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., Franklin, J. F., and Swanson, F. J. (1986). "Ecology of coarse woody debris in temperate ecosystems," *Advances in Ecological Research* 15, 133-302.

Harris, L. D., and Gosselink, J. G. (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 Smith, R D. (1998). "The hydrogeomorphic approach to functional assessment of riparian wetlands: evaluating impacts and mitigation on river floodplains in the U.S.A," *Freshwater Biology* 40, 517-30.

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, 117-25.

Howard, R. J., and Allen, J. A. (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.

Hudson, C. (1997). Knights of Spain, warriors of the sun: Hernando De Soto and the south's ancient chiefdoms. University of Georgia Press, Athens. 566 pages.

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

Hunter, W. C., Dickson, J. G., Pashley, D. N., and Hamel, P. B. (2001). "Bird communities of southern forests." *Wildlife of Southern Forests, Habitat and Management*. J. E. Dickson, ed., Hancock House Publishers, Blaine, WA, 480 pp.

Jennings, M. E., Thomas, W. O., Jr., and Riggs, H. C. (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., Detenbeck, N. E., and Niemi, G. J. (1990). "The cumulative effect of wetlands on stream water-quality and quantity: A landscape approach," *Biogeochemistry* 10, 105-41.

Keller, C. M. E., Robbins, C. S., and Hatfield, J. S. (1993). "Avian communities in riparian forests of different widths in Maryland and Delaware," *Wetlands* 13, 137-44.

Kennedy, H. E., and Nowacki, G. J. (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.

Kent, M., and Coker, P. (1995). *Vegetation description and analysis, a practical approach.* John Wiley and Sons, New York.

Kilgo, J. C., Sargent, R. A., Miller, K. V., and Chapman, B. R. (1997). "Landscape influences on breeding bird communities in hardwood fragments in South Carolina," *Wildl. Soc. Bull*. 25, 878-85.

Klimas, C. V., Murray, E. O., Pagan, J., Langston, H., and Foti, T. (2004). "A regional guidebook for applying the hydrogeomorphic approach to assessing wetland functions of forested wetlands in the delta region of Arkansas, lower Mississippi River alluvial valley," ERDC/EL TR-04-16, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Kuchler, A. W. (1969). "Potential natural vegetation," Map Sheet No. 90, U.S. Geological Survey, Washington, DC.

Kuenzler, E. J., Mulholland, P. J., Yarbro, L. A., and Smock, L. A. (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.

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, 108-18.

Ludwig, J. A., and Reynolds, J. F. (1988). *Statistical ecology: A primer on methods and computing.* John Wiley and Sons, New York.

Lynch, J. F., and Whigham, D. F. (1984). “Effects of forest fragmentation on breeding bird communities in Maryland, USA,” *Biological Conserv*. 28, 287-324.

McWilliams, S. R. and Bachman M.D. (1988). “Using life history and ecology as tools to manage a threatened salamander species,” *J. Iowa Acad. Sci.* 95, 66-71.

Meadows, J. S., and Nowacki, G. J. (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 Conner, W. H. (1997). *Southern forested wetlands: Ecology and management*. Lewis Publishers, Boca Raton, FL.

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.

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

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

Mueller, A. J., Loesch, C. R., and Twedt, D. J. (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, 307-32.

Mulholland, P. J., and Kuenzler, E. J. (1979). “Organic-carbon export from upland and forested wetland watersheds,” *Limnology and Oceanography* 24, 960-66.

Nadelhoffer, K. J., and Raich, J. W. (1992). “Fine root production estimates and belowground carbon allocation in forest ecosystems,” *Ecology* 73, 1139-47.

National Interagency Implementation Team. (1996). "National action plan to implement the hydrogeomorphic approach (NAP)," Federal Register Volume 61 Number 160, 42593-42603, Washington, DC.

Noss, R. F., and Harris, L. D. (1986). "Nodes, networks, and MUMs: Preserving diversity at all scales," *Environmental Management* 3, 299-309.

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, 377-88.

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 Male, J. W. (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, 114-28.

Omernik, J. M. (1987). "Ecoregions of the conterminous United States," Map (scale 1:7,500,000), *Annals of the Association of American Geographers* 77, 118-125.

Ovington, J. D. (1965). "Organic production, turnover and mineral cycling in woodlands," *Biological Review* 40, 772-85.

Patton, P. C. (1988). "Drainage basin morphometry and floods." *Flood geomorphology.* V. R. Baker, R. C. Kochel, and P. C. Patton, ed., John Wiley, New York, 51-64.

Pagan, J. B., and Foti, T. L. "A comprehensive floristic inventory and distribution model of unique wetland communities on terraces along the Ouachita River in southern Arkansas." (in preparation).

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, 171-90.

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

Putnam, J. A. (1951). "Management of bottomland hardwoods," Occasional Paper 116, U.S. Department of Agriculture Forest Service, Southern Forest Experiment Station.

Putnam, J. A., Furnival, G. W., and McKnight, J. S. (1960). "Management and inventory of southern hardwoods," Agricultural Handbook No. 181, U.S. Department of Agriculture Forest Service, Washington, DC.

Raich, J. W., and Nadelhoffer, K. J. (1989). "Belowground carbon allocation in forest ecosystems: Global trends," *Ecology* 70, 1346-54.

Reiners, W. A. (1972). "Terrestrial detritus and the carbon cycle." *Carbon and the biosphere*. Conference Proceedings 720510, G. M. Woodwell and E. V. Pecan, ed., 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.

Reynolds, R. R. (1980). "The Crossett story: The beginning of forestry in southern Arkansas and northern Louisiana," Gen. Tech. Rep SO-32, USDA Forest Service Southern Forest Experiment Station, New Orleans. 40 pp.

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

Rheinhardt, R. D., Rheinhardt, M. G., and Brinson, M. M. (2002). "A regional guidebook for applying the hydrogeomorphic approach to assessing wetland functions of pine flats on mineral soils in the Atlantic and Gulf coastal plains," ERDC/EL TR-02-9, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

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

Ritter, D. F., Kochel, R. C., and Miller, J. R. (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., MacKenzie, M. D., and Elliot, L. F. (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., Weaver, G. T., and Cavanaugh, J. A. (1978). "Vegetation and tree species patterns near the northern terminus of the southern floodplain forest," *Ecological Monographs* 48, 249-67.

Robinson, S. K. (1996). "Setting objectives in forested habitats." *Presentation, partners in flight*, Midwest and Southern Great Plains Workshop, St. Louis, MO, April 8, 1996.

Robinson, S. K., Thompson, F. R., III, Donovan, T. M., Whitehead, D. R., and Faaborg, J. (1995). "Regional forest fragmentation and the nesting success of migratory birds," *Science* 267, 1987-90.

Rosgen, D. L. (1994). "A classification of natural rivers," *Catena* 22, 169-199.

Rosson, J. F., Jr. (2001). "Arkansas forests, 1988-1996: Highlights of the timberland resource from the Seventh Forest Survey of Arkansas." *Proceedings of the symposium on Arkansas forests: A conference on the results of the recent forest survey of Arkansas,* USDA Forest Service Gen.Tech. Rep. SRS–41, Southern Research Station, Asheville, NC, 11-16.

Rothermal, B. B., and Semlitsch, R. D. (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,* Gen.Tech. Rep. SRS–41, USDA Forest Service, Southern Research Station, Asheville, NC. 24-45.

Sallabanks, R., Walters, J. R., and Collazo, J. A. (1998). "Breeding bird abundance in bottomland forests: Habitat, edge, and patch size effects," *Condor* 102, 748-58.

Saucier, R. L. (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.

Saucier, R. T., and Fleetwood, A. R. (1970). "Origin and chronological significance of late Quaternary terraces, Ouachita River, Arkansas and Louisiana," *Geological Society of America Bulletin* 81, 869-890.

Saucier, R. T., and Smith, L. M. (1986). "Geomorphic mapping and landscape classification of the Ouachita and Saline River valleys, Arkansas," Archeological Assessments Report No. 51, AAI, Inc., Nashville, AR.

Saucier, R. T., and Snead, J. I. (1989). *Quaternary geology of the Lower Mississippi Valley.* Louisiana Geological Survey and the Geological Society of America, Boulder, CO.

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

Sedell, J. R., Reeves, G. H., Hauer, F. R., Stanford, J. A., and Hawkins, C. P. (1990). "Role of refugia in recovery from disturbances: Modern fragmented and disconnected river systems," *Environmental Management* 14, 711-24.

Sedell, J. R., Richey, J. E., and Swanson, F. J. (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., and Bodie, J. R. (1998). "Are small, isolated wetlands expendable?" *Cons. Biology* 12, 1129-1133.

Semlitsch, R. D., and Jensen, J. B. (2001). "Core habitat, not buffer zone," *National Wetlands Newsletter* 23, 5-11.

Shafer, D. J., and Yozzo, D. J. (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.

Simberloff, D., Farr, J. A., Cox, J., and Mehlman, D. W. (1992). "Movement corridors: Conservation bargains or poor investments?" *Conservation Biology* 6, 493-504.

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

Smith, F. L., and Russ, D. P. (1974). "Geological investigation of the lower Red River-Atchafalaya basin area," Technical Report S-74-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Smith, K. L., Pell, W. F., Rettig, J. H., Davis, R. H., and Robison, H. W. (1984). *Arkansas's Natural Heritage,* B. Shepherd, ed., August House, Little Rock.

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

Smith, R. D. (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., Ammann, A. A., Bartoldus, C., and Brinson, M. M. (1995). "An approach for assessing wetland functions using hydrogeomorphic classification, reference wetlands, and functional indices," Technical Report WRP-DE-9, U.S. Army Engineer Waterways Experiment Station, 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., Ward, J. V., Liss, W. J., Frissell, C. A., Williams, R. N., Lichatowich, J. A., and Coutant, C. C. (1996). "A general protocol for restoration of regulated rivers," *Regulated Rivers Research and Management* 12, 391-413.

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

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

Symbula, M., and Day, F. W. (1988). "Evaluation of two methods for estimating belowground production in a fresh-water swamp forest," *American Midland Naturalist* 120, 405-15.

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, 301-04.

Terry, J. E., Hosman, R. L., and Bryant, C. T. (1979). "Summary appraisals of the nation's groundwater resources – Lower Mississsippi Region," U.S. Geological Survey Professional Paper 813-N, 41 pp.

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

Thompson, F. R., III, Dijak, W. D., Kulowiec, T. G., and Hamilton, D. A. (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., Nowacki, G. J., Crow, T. R., Buckley, D. S., Nauertz, E. A., Niese, J. N., Rollinger, J. L., and Zasada, J. C. (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, Natural Resources Conservation Service. (1995). "State soil geographic (STATSGO) data base for the conterminous United States," *http://water.usgs.gov*.

__________. (1998). "Field indicators of hydric soils in the United States, Version 4.0," Fort Worth, TX.

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, Soil Conservation Service, and University of Arkansas Agricultural Experiment Station. (1982). "General soil map – State of Arkansas," Cooperative Extension Service, University of Arkansas.

U.S. Environmental Protection Agency. (1998). "Level III ecoregions of the continental United States (map)," National Health and Environmental Effects Laboratory, Corvallis, OR.

U.S. Fish and Wildlife Service. (1980). "Habitat Evaluation Procedures (HEP)," Ecological Services Manual 102, U.S. Department of Interior Fish and Wildlife Service, Washington, D.C.

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

U.S. Army Corps of Engineers, Vicksburg District. (2003). "Southwest Arkansas navigation study," http://www.mvk.usace.army.mil.

Vogt, K. A., Grier, C. C., and Vogt, D. J. (1986). "Production, turnover, and nutrient dynamics of above and belowground detritus of world forests," *Advances in Ecological Research* 15, 303-77.

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

Weinstein, R. A., and Kelley, D. B. (1984). "Archeology and paleogeography of the Upper Felsenthal Region." Report to the U.S. Army Corps of Engineers, Vicksburg District, Coastal Environments, Inc., Baton Rouge.

Welsh, C. J. E., and Healy, W. M. (1993). "Effect of even-aged timber management on bird species diversity and composition in northern hardwoods of New Hampshire," *Wildlife Society Bulletin* 21, 143-54.

Wharton, C. H., Kitchens, W. M., Pendleton, E. C., and Sipe, T. W. (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, New York.

Williams, R. A. (2001). "Arkansas forests–The timber resource." *Proceedings of the symposium on Arkansas forests: A conference on the results of the recent forest survey of Arkansas,* USDA Forest Service Gen.Tech. Rep. SRS–41, Southern Research Station, Asheville, NC, 17-23.

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

Appendix A
Preliminary Project Documentation and Field Sampling Guidance

Contents

Please reproduce these forms locally as needed.

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 1, but 2 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, 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 will 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 Data Form 3D to calculate basal area. Both forms are located in Appendix C)]	Multiple copies (same number as Data Form 2 sets)

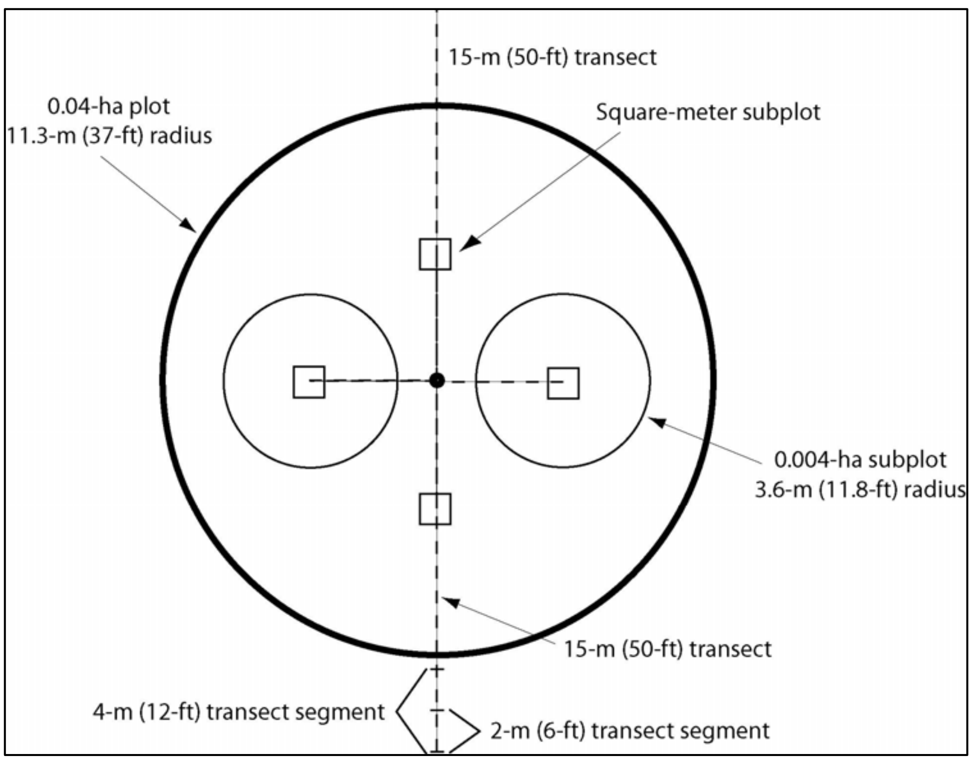


Figure A1. Layout of plots and transects for field sampling

Appendix B
Field Data Forms

Contents

Appendix B1
Field Data Forms for Pine 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) — WAA-Level Data Collection
Subclass: Pine Flat Wetlands
WAA #__________

Complete one copy of this form for each Wetland Assessment Area

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

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
V_{FIRE} Fire-maintained forest patch size	From the aerial photos, measure the size of the fire-maintained forested area that is contiguous to and includes the WAA. Fire-maintained areas separated by discontinuities wider than 50 m are not included in the "contiguous area"." Record the area at right – if the site exceeds 100 ha, record "100."	Size of the fire-maintained tract = _______ ha
Geomorphic surface (used to determine appropriate V_{POND} entry on spreadsheet)	CHECK ONE: Early or Mid-Pleistocene Terrace (map codes beginning with Pp, Pi, Qtu, Qm) ______ Late Pleistocene Terraces (map codes beginning with Pd. Qtd1, Qtd2, Qtd3) _______ Holocene Alluvium (map codes beginning with H or Qal) _______	

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.	percent 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 percent 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: Pine Flat Wetlands
WAA #__________
Plot #__________

Procedure

Establish a plot center, assign a plot number (above), and complete the following 3 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 4 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 2.3). 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 Collections
Subclass: Pine Flat Wetlands
WAA #__________
Plot #__________

Observations Within a 0.04-Ha Plot

Field Procedure		
(1) If tree cover is ≥ 20 percent, use the 50/20 rule, and circle the dominant trees in Columns A, B, and C below (based on estimates of percent 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 percent, identify the next tallest woody stratum with at least 10 percent 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 percent cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.		
A: Common dominants in reference standard sites	**B:** Species commonly present in reference standard sites, but dominance generally indicates fire supression, high-grading, or other disturbances	**C:** Uncommon, minor, or shrub species in reference standard sites, but may dominate in degraded systems
Pinus taeda	*Quercus laurifolia*	*Acer rubrum*
Quercus stellata	*Quercus pagoda*	*Liquidambar styraciflua*
	Quercus phellos	*Quercus falcata*
		Quercus nigra
		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 = _____ percent		
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 percent, record percent concurrence in the V_{TCOMP} and V_{COMP} rows as a plot value. OR If tree cover is < 20 percent, record a "0" in the V_{TCOMP} row, and record percent concurrence of the next tallest woody stratum in the V_{COMP} row.	Percent concurrence: V_{TCOMP} = __________ percent V_{COMP} = ___________ percent

Data Form 2 (3 pages) — Plot-Level Data Collections
Subclass: Pine 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 x1-m square subplot. Within each subplot record the following:

V_{LITTER} Litter cover	Estimate the percent of the plot area covered by undecomposed litter. Average the results of the 4 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 4 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 centimenters at the point of interception.	Stem diameters (cm)
	Transect 1	____, _____, _____, ____, ____
	Transect 2	____, _____, _____, ____, ____

Data Form 3 (1 page) — Wetland Assessment Area-Data Summary
Subclass: Pine 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.

<table>
<tr><th>HGM Variable</th><th colspan="8">Transfer the data below from Data Form 1</th><th>Enter this number in the FCI calculator spreadsheet</th></tr>
<tr><td>V_{FIRE}</td><td colspan="8">Fire-maintained forest patch size</td><td>______ ha</td></tr>
<tr><td>V_{POND}</td><td colspan="8">Percent of the wetland assessment area that ponds water</td><td>_______ %</td></tr>
<tr><td>Geomorphic surface (used to determine appropriate V_{POND} entry on spreadsheet - from Data Form 1)</td><td colspan="9">CHECK ONE:
Early/Mid Pleistocene Terrace ____
Late Pleistocene Terrace ____
Holocene Alluvium ____</td></tr>
<tr><td>V_{STRATA}</td><td colspan="8">Number of vegetation strata</td><td>____ strata</td></tr>
<tr><td>V_{SOIL}</td><td colspan="8">Percent of the wetland assessment area with culturally altered soils</td><td>_______ %</td></tr>
<tr><td colspan="10">Transfer the plot data below from Data Form 2 and average all values</td></tr>
<tr><td></td><td>Plot 1</td><td>Plot 2</td><td>Plot 3</td><td>Plot 4</td><td>Plot 5</td><td>Plot 6</td><td>Plot 7</td><td>Plot 8</td><td>AVERAGES</td></tr>
<tr><td>V_{TBA}</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>BA = _____m^2/ha</td></tr>
<tr><td>V_{TDEN}</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>density = ___stems/ha</td></tr>
<tr><td>V_{SNAG}</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>density = ___stems/ha</td></tr>
<tr><td>V_{TCOMP}</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>concurrence = _______ %</td></tr>
<tr><td>V_{COMP}</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>concurrence = _______ %</td></tr>
<tr><td>V_{SSD}</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>density = ___stems/ha</td></tr>
<tr><td>V_{GVC}</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>cover = _______ %</td></tr>
<tr><td>V_{LITTER}</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>cover = _______ %</td></tr>
<tr><td>V_{OHOR}</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>thickness = ______ cm</td></tr>
<tr><td>V_{AHOR}</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>thickness = ______ cm</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td>V_{LOG}</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>log volume = _____ m^3/ha</td></tr>
<tr><td>V_{WD}</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>wd volume = _____ m^3/ha</td></tr>
</table>

Appendix B2
Field Data Forms for Hardwood 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: Hardwood Flat Wetlands
WAA #__________

Complete one copy of this form for each Wetland Assessment Area

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

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
V_{PATCH} Forest patch size	From aerial photos or field reconnaissance, estimate the size of the forested area that is contiguous to the WAA and accessible to wildlife (including the WAA itself, if it is forested). Include both upland and wetland forests. Record the area at right — if it exceeds 2500 ha, enter "2500."	Size of the forested tract = _______ ha
Geomorphic surface (used to determine appropriate V_{POND} entry on spreadsheet)	CHECK ONE: Early or Mid-Pleistocene Terrace (map codes beginning with Pp, Pi, Qtu, Qm) ______ Late Pleistocene Terraces (map codes beginning with Pd. Qtd1, Qtd2, Qtd3) _______ Holocene Alluvium (map codes beginning with H or Qal) _______	

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: Hardwood Flat Wetlands
WAA #__________
Plot #__________

Procedure

Establish a plot center, assign a plot number (above), and complete the following 3 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 4 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 2.3). 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 Collections
Subclass: Hardwood Flat Wetlands
WAA #__________
Plot #__________

Observations Within a 0.04-Ha Plot

Field Procedure		
(1) If tree cover is ≥ 20%, use the 50/20 rule, and circle the dominant trees in Columns A, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.		
(2) If tree cover is < 20%, identify the next tallest woody stratum with at least 10% cover. Use the 50/20 rule, and circle the dominants in the next tallest woody stratum in Columns A, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.		
A: Common dominants in reference standard sites	**B:** Species commonly present in reference standard sites, but dominance generally indicates fire supression, high-grading, or other disturbances	**C:** Uncommon, minor, or shrub species in reference standard sites, but may dominate in degraded systems
Quercus laurifolia	*Acer rubrum*	*Celtis laevigata*
Quercus lyrata	*Carya cordiformis*	*Diospyros virginiana*
Quercus pagoda	*Fraxinus pennsylvanica*	*Maclura pomifera*
Quercus phellos	*Liquidambar styraciflua*	*Quercus falcata*
Quercus stellata	*Nyssa sylvatica*	*Ulmus alata*
	Pinus taeda	
	Quercus nigra	
Calculations		
Using the dominant species circled in Columns A, B, and C above, calculate percent concurrence according to the following formula: {[(1.0 × number of circled dominants in Column A) + (0.66 × number of circled dominants in Column B) + (0.33 × number of circled dominants in Column C)] / total number of circled dominants in all columns} × 100 = _____ percent		
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 percent 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 percent 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 Collections
Subclass: Hardwood Flat Wetlands
WAA #__________
Plot #__________

Observations Within Two 0.004-Ha Plots

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

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

Observations Within 4 Subplots 1-m × 1-m Square

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

V_{LITTER} Litter cover	Estimate the percent of the plot area covered by undecomposed litter. Average the results of the 4 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 4 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 in.) in diameter at the intercept point, measure and record the diameter of the stem in centimenters at the point of interception.	Stem diameters (cm)
	Transect 1	____, _____, _____, ____, ____
	Transect 2	____, _____, _____, ____, ____

Data Form 3 (1 page) — Wetland Assessment Area-Data Summary
Subclass: Hardwood Flat Wetlands
WAA #__________

Transfer data from Data Form 1 to this form, and also compile and summarize information from all copies of Data Form 2 in the appropriate spaces below. Attach additional copies if more than 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								_______ %
Geomorphic surface (used to determine appropriate V_{POND} entry on spreadsheet - from Data Form 1)	CHECK ONE: Early/Mid Pleistocene Terrace ____ Late Pleistocene Terrace ____ Holocene Alluvium ____								
V_{STRATA}	Number of vegetation strata								____ strata
V_{SOIL}	Percent of the wetland assessment area with culturally altered 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 Low-Gradient Riverine Backwater 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) — WAA-Level Data Collection
Subclass: Low-Gradient Riverine Backwater Wetlands
WAA #__________

Complete one copy of this form for each Wetland Assessment Area

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

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
V_{PATCH} Forest patch size	From aerial photos or field reconnaissance, estimate the size of the forested area that is contiguous to the WAA and accessible to wildlife (including the WAA itself, if it is forested). Include both upland and wetland forests. Record the area at right — if it exceeds 2500 ha, enter "2500."	Size of the forested tract = _______ ha
V_{FREQ} 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)
Geomorphic surface (used to determine appropriate V_{POND} entry on spreadsheet)	CHECK ONE: Early or Mid-Pleistocene Terrace (map codes beginning with Pp, Pi, Qtu, Qm) ______ Late Pleistocene Terraces (map codes beginning with Pd. Qtd1, Qtd2, Qtd3) _______ Holocene Alluvium (map codes beginning with H or Qal) _______	

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 Backwater Wetlands
WAA #__________
Plot #__________

Procedure

Establish a plot center, assign a plot number (above), and complete the following 3 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 4 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 2.3). 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 Collections
Subclass: Low-Gradient Riverine Backwater Wetlands
WAA #__________
Plot #__________

Observations Within a 0.04-Ha Plot

Field Procedure		
(1) If tree cover is ≥ 20%, use the 50/20 rule, and circle the dominant trees in Columns A, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.		
(2) If tree cover is < 20%, identify the next tallest woody stratum with at least 10% cover. Use the 50/20 rule, and circle the dominants in the next tallest woody stratum in Columns A, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.		
A: Common dominants in reference standard sites	**B:** Species commonly present in reference standard sites, but dominance generally indicates fire supression, high-grading, or other disturbances	**C:** Uncommon, minor, or shrub species in reference standard sites, but may dominate in degraded systems
Carya aquatica	*Acer rubrum*	*Carpinus caroliniana*
Fraxinus pennsylvanica	*Diospyros virginiana*	*Crataegus spp*
Liquidambar sytraciflua	*Nyssa sylvatica*	*Forestiera accuminata*
Quercus lyrata	*Ulmus americana*	*Ilex opaca*
Quercus phellos		*Planera aquatica*
Taxodium distichum		*Ulmus crassifolia*
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 = _____ percent		
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 percent 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 percent 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 Collections
Subclass: Low-Gradient Riverine Backwater 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 x1-m square subplot. Within each subplot record the following:

V_{LITTER} Litter cover	Estimate the percent of the plot area covered by undecomposed litter. Average the results of the 4 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 4 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 in.) in diameter at the intercept point, measure and record the diameter of the stem in centimenters at the point of interception.	Stem diameters (cm)
	Transect 1	____, _____, _____, ____, ____
	Transect 2	____, _____, _____, ____, ____

Data Form 3 (1 page) — Wetland Assessment Area-Data Summary
Subclass: Hardwood Flat Wetlands
WAA #__________

Transfer data from Data Form 1 to this form, and also compile and summarize information from all copies of Data Form 2 in the appropriate spaces below. Attach additional copies if more than 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.

<table>
<tr><th>HGM Variable</th><th colspan="8">Transfer the data below from Data Form 1</th><th>Enter this number in the FCI calculator spreadsheet</th></tr>
<tr><td>V_{PATCH}</td><td colspan="8">Forest patch size</td><td>______ ha</td></tr>
<tr><td>V_{FREQ}</td><td colspan="8">Flood recurrence interval in the WAA (1 = annual, 5 = 1 year in 5)</td><td>______</td></tr>
<tr><td>V_{POND}</td><td colspan="8">Percent of the wetland assessment area that ponds water</td><td>_______ %</td></tr>
<tr><td>Geomorphic surface (used to determine appropriate V_{POND} entry on spreadsheet - from Data Form 1)</td><td colspan="9">CHECK ONE:
Early/Mid Pleistocene Terrace ____
Late Pleistocene Terrace ____
Holocene Alluvium ____</td></tr>
<tr><td>V_{STRATA}</td><td colspan="8">Number of vegetation strata</td><td>____ strata</td></tr>
<tr><td>V_{SOIL}</td><td colspan="8">Percent of the wetland assessment area with culturally altered soils</td><td>_______ %</td></tr>
<tr><th colspan="10">Transfer the plot data below from Data Form 2 and average all values</th></tr>
<tr><td></td><td>Plot 1</td><td>Plot 2</td><td>Plot 3</td><td>Plot 4</td><td>Plot 5</td><td>Plot 6</td><td>Plot 7</td><td>Plot 8</td><td>Averages</td></tr>
<tr><td>V_{TBA}</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>BA = _____m^2/ha</td></tr>
<tr><td>V_{TDEN}</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>density = ___stems/ha</td></tr>
<tr><td>V_{SNAG}</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>density = ___stems/ha</td></tr>
<tr><td>V_{TCOMP}</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>concurrence = _______ %</td></tr>
<tr><td>V_{COMP}</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>concurrence = _______ %</td></tr>
<tr><td>V_{SSD}</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>density = ___stems/ha</td></tr>
<tr><td>V_{GVC}</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>cover = _______ %</td></tr>
<tr><td>V_{LITTER}</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>cover = _______ %</td></tr>
<tr><td>V_{OHOR}</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>thickness = ______ cm</td></tr>
<tr><td>V_{AHOR}</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>thickness = ______ cm</td></tr>
<tr><td colspan="10">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.</td></tr>
<tr><td>V_{LOG}</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>log volume = _____ m^3/ha</td></tr>
<tr><td>V_{WD}</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>wd volume = _____ m^3/ha</td></tr>
</table>

Appendix B4
Field Data Forms for Low-Gradient Riverine Overbank 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) — WAA-Level Data Collection
Subclass: Low-Gradient Riverine Overbank Wetlands
WAA #__________

Complete one copy of this form for each Wetland Assessment Area

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

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
V_{PATCH} Forest patch size	From aerial photos or field reconnaissance, estimate the size of the forested area that is contiguous to the WAA and accessible to wildlife (including the WAA itself, if it is forested). Include both upland and wetland forests. Record the area at right — if it exceeds 2500 ha, enter "2500."	Size of the forested tract = _______ ha
V_{FREQ} 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)
Geomorphic surface (used to determine appropriate V_{POND} entry on spreadsheet)	CHECK ONE: Early or Mid-Pleistocene Terrace (map codes beginning with Pp, Pi, Qtu, Qm) ______ Late Pleistocene Terraces (map codes beginning with Pd. Qtd1, Qtd2, Qtd3) _______ Holocene Alluvium (map codes beginning with H or Qal) _______	

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 Overbank Wetlands
WAA #__________
Plot #__________

Procedure

Establish a plot center, assign a plot number (above), and complete the following 3 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 4 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 2.3). 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 Collections
Subclass: Low-Gradient Riverine Overbank Wetlands
WAA #__________
Plot #__________

Observations Within a 0.04-Ha Plot

Field Procedure
(1) If tree cover is ≥ 20%, use the 50/20 rule, and circle the dominant trees in Columns A, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.
(2) If tree cover is < 20%, identify the next tallest woody stratum with at least 10% cover. Use the 50/20 rule, and circle the dominants in the next tallest woody stratum in Columns A, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.

A: Common dominants in reference standard sites	**B:** Species commonly present in reference standard sites, but dominance generally indicates fire supression, high-grading, or other disturbances	**C:** Uncommon, minor, or shrub species in reference standard sites, but may dominate in degraded systems
Carya illinoensis	*Carya cordiformis*	*Carpinus caroliniana*
Carya ovata	*Celtis laevigata*	*Cretaegus spp*
Nyssa sylvatica	*Fraxinus pennsylvanica*	*Diospyros americana*
Quercus pagoda	*Liquidambar styraciflua*	*Ilex opaca*
Quercus phellos	*Quercus lyrata*	*Morus rubra*
	Quercus michauxii	*Ulmus alata*
	Quercus nigra	
	Ulmus americana	
	Ulmus crassifolia	

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 = _____ percent

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 percent 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 percent 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 Collections
Subclass: Low-Gradient Riverine Overbank 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 4 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 4 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 in.) in diameter at the intercept point, measure and record the diameter of the stem in centimeters at the point of interception.	Stem diameters (cm)
	Transect 1	____, _____, _____, ____, ____
	Transect 2	____, _____, _____, ____, ____

Data Form 3 (1 page) — Wetland Assessment Area-Data Summary
Subclass: Low-Gradient Riverine Overbank 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_{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								_______ %
Geomorphic surface (used to determine appropriate V_{POND} entry on spreadsheet - from Data Form 1)	CHECK ONE: Early/Mid Pleistocene Terrace ____ Late Pleistocene Terrace ____ Holocene Alluvium ____								
V_{STRATA}	Number of vegetation strata								____ strata
V_{SOIL}	Percent of the wetland assessment area with culturally altered 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 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) — WAA-Level Data Collection
Subclass: Mid-Gradient Riverine Wetlands
WAA #__________

Complete one copy of this form for each Wetland Assessment Area

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

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
V_{BUF30} Percent contiguous 30-m buffer	On a map or photo, outline a 30-m-wide buffer area 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 = _____%
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)
Geomorphic surface (used to determine appropriate V_{POND} entry on spreadsheet)	CHECK ONE: Early or Mid-Pleistocene Terrace (map codes beginning with Pp, Pi, Qtu, Qm) ______ Late Pleistocene Terraces (map codes beginning with Pd. Qtd1, Qtd2, Qtd3) _______ Holocene Alluvium (map codes beginning with H or Qal) _______	

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 3 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 4 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 2.3). 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 Collections
Subclass: Mid-Gradient Riverine Wetlands
WAA #__________
Plot #__________

Observations Within a 0.04-Ha Plot

Field Procedure		
(1) If tree cover is ≥ 20%, use the 50/20 rule, and circle the dominant trees in Columns A, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.		
(2) If tree cover is < 20%, identify the next tallest woody stratum with at least 10% cover. Use the 50/20 rule, and circle the dominants in the next tallest woody stratum in Columns A, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.		
A: Common dominants in reference standard sites	**B:** Species commonly present in reference standard sites, but dominance generally indicates fire supression, high-grading, or other disturbances	**C:** Uncommon, minor, or shrub species in reference standard sites, but may dominate in degraded systems
Carpinus caroliniana	*Acer rubrum*	*Cornus florida*
Diospyros virginiana	*Betula nigra*	*Ilex opaca*
Liquidambar styraciflua	*Carya spp*	*Ostrya virginiana*
Nyssa sylvatica	*Fagus grandifolia*	
Pinus taeda	*Fraxinus spp*	
Quercus michauxii	*Magnolia virginiana*	
Quercus nigra	*Platanus occidentalis*	
Quercus pagoda	*Quercus alba*	
Quercus rubra	*Quercus phellos*	
	Quercus shumardii	
	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 = _____ percent		
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 percent 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 percent 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 Collections
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 × 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 4 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 4 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 in.) in diameter at the intercept point, measure and record the diameter of the stem in centimenters at the point of interception.	Stem diameters (cm)
	Transect 1	____, _____, _____, ____, ____
	Transect 2	____, _____, _____, ____, ____

Data Form 3 (1 page) — Wetland Assessment Area-Data Summary
Subclass: 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 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_{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_{POND}	Percent of the wetland assessment area that ponds water	_______ %
Geomorphic surface (used to determine appropriate V_{POND} entry on spreadsheet - from Data Form 1)	CHECK ONE: Early/Mid Pleistocene Terrace ____ Late Pleistocene Terrace ____ Holocene Alluvium ____	
V_{STRATA}	Number of vegetation strata	____ strata
V_{SOIL}	Percent of the wetland assessment area with culturally altered 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 B6
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) — WAA-Level Data Collection
Subclass: Unconnected Depression Wetlands
WAA #__________

Complete one copy of this form for each Wetland Assessment Area

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

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
V_{BUF30} Percent contiguous 30-m buffer	On a map or photo, outline a 30-m-wide buffer area 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_{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 3 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 4 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 2.3). 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 Collections
Subclass: Unconnected 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, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.		
(2) If tree cover is < 20%, identify the next tallest woody stratum with at least 10% cover. Use the 50/20 rule, and circle the dominants in the next tallest woody stratum in Columns A, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.		
A: Common dominants in reference standard sites	**B:** Species commonly present in reference standard sites, but dominance generally indicates fire supression, high-grading, or other disturbances	
Carya aquatica	*Acer saccharinum*	
Fraxinus spp	*Betula nigra*	
Nyssa aquatica	*Celtis laevigata*	
Quercus lyrata	*Cephalanthus occidentalis*	
Taxodium distichum	*Diospyros virginiana*	
	Forestiera accuminata	
	Gleditsia aquatica	
	Gleditsia triacanthos	
	Liquidambar styraciflua	
	Planera aquatica	
	Quercus phellos	
	Salix nigra	
Calculations		
Using the dominant species circled in Columns A, B, and C above, calculate percent concurrence according to the following formula: {[(1.0 × number of circled dominants in Column A) + (0.66 × number of circled dominants in Column B) + (0.33 × number of circled dominants in Column C)] / total number of circled dominants in all columns} × 100 = _____ percent		
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 percent 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 percent 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 Collections
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 4 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 in.) in diameter at the intercept point, measure and record the diameter of the stem in centimenters at the point of interception.	Stem diameters (cm)
	Transect 1	____, _____, _____, ____, ____
	Transect 2	____, _____, _____, ____, ____

Data Form 3 (1 page) — Wetland Assessment Area-Data Summary
Subclass: 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 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_{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 altered 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 B7
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) — WAA-Level Data Collection
Subclass: Connected Depression Wetlands
WAA #__________

Complete one copy of this form for each Wetland Assessment Area

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

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
V_{BUF30} Percent contiguous 30-m buffer	On a map or photo, outline a 30-m-wide buffer area 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 3 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 4 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 2.3). 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 Collections
Subclass: Connected 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, 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 supres-sion, high-grading, or other disturbances</td><td></td></tr>
<tr><td>Carya aquatica</td><td>Acer saccharinum</td><td></td></tr>
<tr><td>Fraxinus spp</td><td>Betula nigra</td><td></td></tr>
<tr><td>Nyssa aquatica</td><td>Cephalanthus occidentalis</td><td></td></tr>
<tr><td>Quercus lyrata</td><td>Diospyros virginiana</td><td></td></tr>
<tr><td>Taxodium distichum</td><td>Forestiera accuminata</td><td></td></tr>
<tr><td></td><td>Gleditsia aquatica</td><td></td></tr>
<tr><td></td><td>Liquidambar styraciflua</td><td></td></tr>
<tr><td></td><td>Planera aquatica</td><td></td></tr>
<tr><td></td><td>Quercus phellos</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 Col-umn B) + (0.33 × number of circled dominants in Column C)] / total number of circled dominants in all columns} × 100 = _____ percent</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 percent 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 percent 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 Collections
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 4 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 4 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 in.) in diameter at the intercept point, measure and record the diameter of the stem in centimeters at the point of interception.	Stem diameters (cm)
	Transect 1	____, _____, _____, ____, ____
	Transect 2	____, _____, _____, ____, ____

Data Form 3 (1 page) — Wetland Assessment Area-Data Summary
Subclass: 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 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_{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 altered 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 B8
Field Data Forms For Bayhead 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) — WAA-Level Data Collection
Subclass: Bayhead Wetlands
WAA #__________

Complete one copy of this form for each Wetland Assessment Area

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

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
V_{BUF30} Percent contiguous 30-m buffer	On a map or photo, outline a 30-m-wide buffer area 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.	Outflow 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: Bayhead Wetlands
WAA #__________
Plot #__________

Procedure

Establish a plot center, assign a plot number (above), and complete the following 3 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 4 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 2.3). 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 Collections
Subclass: Bayhead Wetlands
WAA #__________
Plot #__________

Observations Within a 0.04-Ha Plot

Field Procedure
(1) If tree cover is ≥ 20%, use the 50/20 rule, and circle the dominant trees in Columns A, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.
(2) If tree cover is < 20%, identify the next tallest woody stratum with at least 10% cover. Use the 50/20 rule, and circle the dominants in the next tallest woody stratum in Columns A, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.

A: Common dominants in reference standard sites	**B:** Species commonly present in reference standard sites, but dominance generally indicates fire supression, high-grading, or other disturbances
Magnolia virginiana	*Acer rubrum*
Nyssa biflora	*Ilex opaca*
Nyssa sylvatica	*Liquidambar styraciflua*
	Pinus taeda
	Quercus michauxii
	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 = _____ percent

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 percent 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 percent 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 Collections
Subclass: Bayhead 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 4 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 4 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 in.) in diameter at the intercept point, measure and record the diameter of the stem in centimenters at the point of interception.	Stem diameters (cm)
	Transect 1	____, _____, _____, ____, ____
	Transect 2	____, _____, _____, ____, ____

Data Form 3 (1 page) — Wetland Assessment Area-Data Summary
Subclass: Bayhead 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_{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 altered 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 B9
Field Data Forms for Seep 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) — WAA-Level Data Collection
Subclass: Seep Wetlands
WAA #__________

Complete one copy of this form for each Wetland Assessment Area

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

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
V_{BUF30} Percent contiguous 30-m buffer	On a map or photo, outline a 30-m-wide buffer area 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.	Outflow 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: Seep Wetlands
WAA #__________
Plot #__________

Procedure

Establish a plot center, assign a plot number (above), and complete the following 3 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 4 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 2.3). 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 Collections
Subclass: Seep Wetlands
WAA #__________
Plot #__________

Observations Within a 0.04-Ha Plot

Field Procedure
(1) If tree cover is ≥ 20%, use the 50/20 rule, and circle the dominant trees in Columns A, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.
(2) If tree cover is < 20%, identify the next tallest woody stratum with at least 10% cover. Use the 50/20 rule, and circle the dominants in the next tallest woody stratum in Columns A, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.

A: Common dominants in reference standard sites	**B:** Species commonly present in reference standard sites, but dominance generally indicates fire supression, high-grading, or other disturbances
Acer rubrum	*Ilex opaca*
Fagus grandifolia	*Pinus taeda*
Liquidambar syraciflua	*Quercus alba*
Nyssa biflora	
Nyssa sylvatica	
Quercus michauxii	
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 = _____ percent

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 percent 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 percent 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 Collections
Subclass: Seep 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 4 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 4 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 in.) in diameter at the intercept point, measure and record the diameter of the stem in centimenters at the point of interception.	Stem diameters (cm)
	Transect 1	____, _____, _____, ____, ____
	Transect 2	____, _____, _____, ____, ____

Data Form 3 (1 page) — Wetland Assessment Area-Data Summary
Subclass: Seep 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_{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 altered soils								_______ %
Transfer the plot data below from Data Form 2 and average all values									
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Averages
V_{TBA}									BA = _____m²/ha
V_{TDEN}									density = ___stems/ha
V_{SNAG}									density = ___stems/ha
V_{TCOMP}									concurrence = _______ %
V_{COMP}									concurrence = _____%
V_{SSD}									density = ___stems/ha
V_{GVC}									cover = _______ %
V_{LITTER}									cover = _____%
V_{OHOR}									thickness = ______ cm
V_{AHOR}									thickness = ______ cm
Use the Woody Debris Calculator spreadsheet (or the worksheet in Appendix C) to generate log and woody debris volume based on the transect data on Data Form 2. Enter those values below and average.									
V_{LOG}									log volume = _____ m³/ha
V_{WD}									wd volume = _____ m³/ha

Appendix C
Alternate Field Forms

Contents

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 C2 (2 pages) – Procedures for Manually Calculating Woody Debris and Log Volume

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=**	

Alternate Data Form C2 (2 pages) – Procedures for Manually Calculating Woody Debris and Log Volume
Subclass: __________
WAA # __________
Plot # __________

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

Appendix D Spreadsheets

Contents

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

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

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

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

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

	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. (concluded)

FCI and FCU Calculations for the Pine Flats Regional Subclass in the Arkansas Coastal Plain (Version of 8/2003)

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_{BUFFER}	N/A	%	N/A
V_{COMP}		%	
V_{FIRE}		ha	
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}	N/A	ha	N/A
V_{POND} (Holocene Flats)		%	
V_{POND} (Late Pleistocene)		%	
V_{POND} (Early & Mid-Pleistocene)		%	
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 FCI/FCU calculator spreadsheet

Appendix E
Spatial Data

The following digital spatial data pertinent to the coastal plain region of Arkansas are available for downloading to assist in orienting field work, assembling project area descriptions, and identifying geomorphic surfaces and soils. Unless otherwise indicated, the files are in ArcView format, and a copy of ArcExplorer is included in the download folder at *www.wes.army.mil/* 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)
- Geomorphology of Ouachita River Valley (Smith and Russ 1974) (images)
- Geomorphology of Ouachita and Saline River Valleys (Saucier and Smith 1986) (georectified images)
- Geomorphology of Red River Valley (Fleetwood 1969) (images)
- Hydrology
- STATSGO soils
- Wetland Planning Regions and Wetland Planning Areas

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

swamp red maple	*Acer drummondii*
box elder	*Acer negundo*
red maple	*Acer rubrum*
silver maple	*Acer saccharinum*
leadplant	*Amorpha fruticosa*
bluestem	*Andropogon spp.*
threeawn	*Aristida spp*
paw-paw	*Asimina triloba*
river birch	*Betula nigra*
water dawnflower	*Bonamia aquatica*
beautyberry	*Callicarpa americana*
sedges	*Carex spp.*
ironwood	*Carpinus caroliniana*
water hickory	*Carya aquatica*
bitternut hickory	*Carya cordiformis*
pecan	*Carya illinoensis*
shellbark hickory	*Carya laciniosa*
shagbark hickory	*Carya ovata*
hickory	*Carya spp.*
mockernut hickory	*Carya tomentosa*
catalpa	*Catalpa speciosa*
sugarberry	*Celtis laevigata*
buttonbush	*Cephalanthus occidentalis*
smooth dogwood	*Cornus drummondii*
flowering dogwood	*Cornus florida*

swamp dogwood	*Cornus foemina*
hawthorn	*Crataegus spp.*
crotonopsis	*Crotonopsis elliptica*
persimmon	*Diospyros virginiana*
sundew	*Drosera spp.*
American beech	*Fagus grandifolia*
swamp privet	*Forestiera acuminata*
green ash	*Fraxinus pennsylvanica*
ash	*Fraxinus spp.*
geocarpon	*Geocarpon minimum*
water locust	*Gleditsia aquatica*
honey locust	*Gleditsia triacanthos*
hibiscus	*Hibiscus spp.*
deciduous holly	*Ilex decidua*
American holly	*Ilex opaca*
Virginia willow	*Itea virginica*
common privet	*Ligustrum spp.*
pondberry	*Lindera melissifolia*
sweetgum	*Liquidambar styraciflua*
Osage orange	*Maclura pomifera*
umbrella magnolia	*Magnolia tripetala*
sweetbay	*Magnolia virginiana*
red mulberry	*Morus rubra*
sweetbay	*M. virginiana*
swamp tupelo	*Nyssa aquatica*
swamp tupelo	*Nyssa biflora*
blackgum	*Nyssa sylvatica*
sensitive fern	*Onoclea sensibilis*
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*
marsh fleabane	*Pluchea foetida*
eastern cottonwood	*Populus deltoides*
swamp cottonwood	*Populus heterophylla*
chickasaw plum	*Prunus angustifolia*

black cherry	*Prunus serotina*
southern red oak	*Quercus falcata*
laurel oak	*Quercus laurifolia*
overcup oak	*Quercus lyrata*
cow oak	*Quercus michauxii*
water oak	*Quercus nigra*
Nuttall oak	*Quercus nuttallii*
cherrybark oak	*Quercus pagoda*
pin oak	*Quercus palustris*
willow oak	*Quercus phellos*
Shumard oak	*Quercus shumardii*
post oak	*Quercus stellata*
black oak	*Quercus velutina*
white oak	*Querus alba*
northern red oak	*Querus rubra*
beakrush	*Rhynchospora spp.*
blackberry	*Rubus spp.*
black willow	*Salix nigra*
willows	*Salix spp.*
elderberry	*Sambucus canadensis*
prairie cordgrass	*Spartina pectinata*
sphagnum moss	*Sphagnum spp.*
storax	*Styrax americana*
baldcypress	*Taxodium distichum*
cattails	*Typha spp.*
winged elm	*Ulmus alata*
American elm	*Ulmus americana*
cedar elm	*Ulmus crassifolia*
blueberry	*Vaccinium spp.*

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
August 2005

2. REPORT TYPE
Final report

3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE
A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Wetlands in the West Gulf Coastal Plain Region of Arkansas

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Charles V. Klimas, Elizabeth O. Murray, Jody Pagan, Henry Langston, and Thomas Foti

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
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8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Environmental Laboratory, U.S. Army Engineer Research and Development Center, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199; Arkansas Multi-Agency Planning Team, #2 Natural Resources Dr., Little Rock, AR 72205-1572; U.S. Environmental Protection Agency, Region VI, State and Tribal Program Section, Dallas, TX 75202-2733

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
ERDC/EL TR-05-12

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The Hydrogeomorphic (HGM) Approach is a method for developing and applying indices for the site-specific assessment of wetland functions. The HGM Approach was initially designed to be used in the context of the Clean Water Act Section 404 Regulatory Program permit review process 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 design of wetland restoration projects and management of wetlands.

This Regional Guidebook presents the HGM Approach for assessing the functions of most of the wetlands that occur in the West Gulf Coastal Plain Region of Arkansas. The report begins with an overview of the HGM Approach and then classifies and characterizes the principal wetlands that have been identified within the Coastal Plain Region of Arkansas. Detailed HGM assessment models and protocols are presented for nine of those wetland types, or subclasses, representing all of the forested wetlands in the region other than those associated with lakes and impoundments. The following wetland subclasses are treated in detail: Pine Flat, Hardwood Flat, Low-gradient Riverine Backwater, Low-gradient Riverine Overbank, Mid-gradient Riverine, Unconnected Depression, Connected Depression, Bayhead, and Seep. For each wetland subclass, the guidebook presents (a) the rationale used to select the wetland functions considered in the assessment process, (b) the rationale used to select assessment model variables, (c) the rationale used to develop assessment models, and (d) the functional index calibration curves developed from reference wetlands that are used in the assessment models. The guidebook outlines an assessment protocol for using the model variables and functional indices to assess each of the wetland subclasses. The appendices provide field data collection forms, spreadsheets for making calculations, and a variety of supporting spatial data intended for use in the context of a Geographic Information System.

15. SUBJECT TERMS
See reverse.

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER *(include area code)*
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED		250	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. 239.18

15. SUBJECT TERMS

404 Regulatory Program
Arkansas coastal plain
Clean Water Act
Functional assessment
Geomorphology
Hydrogeomorphic (HGM) approach
Hydrology
Impact assessment
Mitigation
National Action Plan
Reference wetlands
West Gulf Coastal Plain
Wetland
Wetland assessment
Wetland classification
Wetland function
Wetland restoration