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A Regional Guidebook for Conducting Functional Assessments of Forested Wetlands in the Arkansas Valley Region of Arkansas

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

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Final report

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

Corps of Engineers Research Report Summary, August 2008

Assessing Wetland Functions

A Regional Guidebook for Conducting Functional Assessments of Forested Wetlands in the Arkansas Valley Region of Arkansas (ERDC/EL TR-08-23)

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

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

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

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

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Preface

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

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

This report was prepared in accordance with guidelines established by the U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS. In addition, the methods and protocols used to develop this Guidebook were closely coordinated with similar projects undertaken in the Delta Region of Mississippi (the Yazoo Basin) and in other regions of Arkansas. Therefore, portions of the text and some figures are similar or identical to sections of those HGM Guidebooks (Smith and Klimas 2002, Klimas et al. 2004, 2005, 2006). The Western Kentucky Regional Guidebook (Ainslie et al. 1999) served as a template for the development of the Delta Guidebooks and portions of this one. Parts of the discussion in the Western Kentucky Guidebook are included here without significant modification, particularly portions of the wildlife section originally developed by Tom Roberts (Tennessee Technological University) and basic information on the HGM Approach and wetland functions originally developed by R. Daniel Smith, ERDC.

1 Introduction

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

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

This Regional Guidebook addresses various objectives:

- To characterize selected regional wetland subclasses in the Arkansas Valley 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 development and application of Regional Guidebooks. Chapter 3 characterizes the regional wetland subclasses in the Arkansas Valley 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 Arkansas Valley Region of Arkansas. Appendix A presents preliminary project documentation and field sampling guidance. Field data forms are presented in Appendix B. Appendix C contains alternate field forms, and Appendix D contains demonstration printouts of calculation spreadsheets. Pertinent digital spatial data information is provided in Appendix E, and common and scientific names of plant species referenced in the text and data forms are listed in Appendix F.

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

2 Overview of the Hydrogeomorphic Approach

Development and Application Phases

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

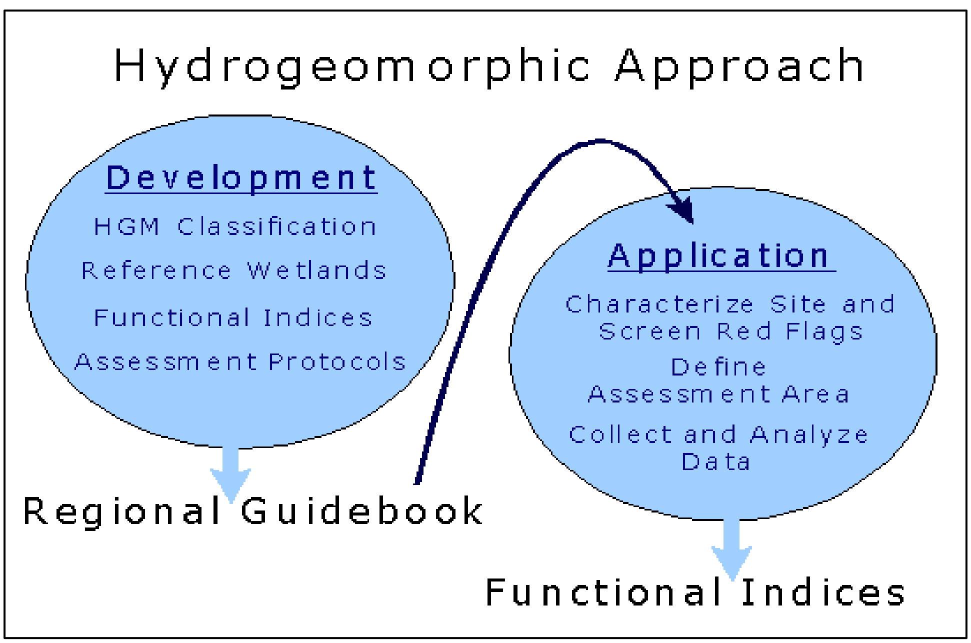

Figure 1. Development and Application Phases of the HGM Approach (from Ainslie et al. 1999)

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

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

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

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

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

Hydrogeomorphic Classification

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

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

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

Generally, the level of variability encompassed by wetlands at the continental scale of hydrogeomorphic classification is too great to allow development of assessment indices that can be applied rapidly and still retain the level of sensitivity necessary to detect changes in function at a level of resolution appropriate to the 404 permit review. In order to reduce both inter- and intraregional variability, the three classification criteria must be applied at a smaller, regional geographic scale, thus creating regional wetland subclasses. In many parts of the country, existing wetland classifications can serve as a starting point for identifying these regional subclasses (e.g., Golet and Larson 1974; Stewart and Kantrud 1971; Wharton et al. 1982). Regional subclasses, like the continental scale wetland classes, are distinguished on the basis of geomorphic setting, water source, and hydrodynamics. Examples of potential regional subclasses are shown in Table 2. In addition, certain ecosystem or landscape characteristics may be useful for distinguishing regional subclasses. For example, depression subclasses might be based on water source (i.e., groundwater versus surface water) or the degree of connection between the wetland and other surface waters (i.e., the flow 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	Depressional wetlands occur in topographic depressions (i.e., closed elevation contours) that allow the accumulation of surface water. Depressional wetlands may have any combination of inlets and outlets, or lack them completely. Potential water sources are precipitation, overland flow, streams, or groundwater flow from adjacent uplands. The predominant direction of flow is from the higher elevations toward the center of the depression. The predominant hydrodynamics are vertical fluctuations that may occur over a range of time, from a few days to many months. Depressional wetlands may lose water through evapotranspiration, intermittent or perennial outlets, or recharge to groundwater. Prairie potholes, playa lakes, and cypress domes are common examples of depressional wetlands.
Tidal Fringe	Tidal fringe wetlands occur along coasts and estuaries and are under the influence of sea level. They intergrade landward with riverine wetlands where tidal current diminishes and riverflow becomes the dominant water source. Additional water sources may be groundwater discharge and precipitation. Because tidal fringe wetlands are frequently flooded and water table elevations are controlled mainly by sea surface elevation, tidal fringe wetlands seldom dry for significant periods. Tidal fringe wetlands lose water by tidal exchange, by overland flow to tidal creek channels, and by evapotranspiration. Organic matter normally accumulates in higher elevation marsh areas where flooding is less frequent and the wetlands are isolated from shoreline wave erosion by intervening areas of low marsh or dunes. *Spartina alterniflora* salt marshes are a common example of tidal fringe wetlands.
Lacustrine Fringe	Lacustrine fringe wetlands are adjacent to lakes where the water elevation of the lake maintains the water table in the wetland. Additional sources of water are precipitation and groundwater discharge, the latter dominating where lacustrine fringe wetlands intergrade with uplands or slope wetlands. Surface water flow is bidirectional. Lacustrine wetlands lose water by evapotranspiration and by flow returning to the lake after flooding. Organic matter may accumulate in areas sufficiently protected from shoreline wave erosion. Unimpounded marshes bordering the Great Lakes are an example of lacustrine fringe wetlands.
Slope	Slope wetlands are found in association with the discharge of groundwater to the land surface or on sites with saturated overland flow with no channel formation. They normally occur on slightly to steeply sloping land. The predominant source of water is groundwater or interflow discharging at the land surface. Precipitation is often a secondary contributing source of water. Hydrodynamics are dominated by downslope unidirectional water flow. Slope wetlands can occur in nearly flat landscapes if groundwater discharge is a dominant source to the wetland surface. Slope wetlands lose water primarily by saturated subsurface flows, surface flows, and 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 nonwetland areas by their poor vertical drainage due to impermeable layers (e.g., hardpans), slow lateral drainage, and low hydraulic gradients. Pine flatwoods with hydric soils are an example of mineral soil flat wetlands.

(Continued)

Table 1 (Concluded)	
HGM Wetland Class	**Definition**
Organic Soil Flats	Organic soil flats, or extensive peatlands, differ from mineral soil flats in part because their elevation and topography are controlled by vertical accretion of organic matter. They occur commonly on flat interfluves, but may also be located where depressions have become filled with peat to form a relatively large flat surface. Water source is dominated by precipitation, while water loss is by overland flow and seepage to underlying groundwater. They occur in relatively humid climates. Raised bogs share many of these characteristics but may be considered a separate class because of their convex upward form and distinct edaphic conditions for plants. Portions of the Everglades and northern Minnesota peatlands are examples of organic soil flat wetlands.
Riverine	Riverine wetlands occur in floodplains and riparian corridors in association with stream channels. Dominant water sources are overbank or backwater flow from the channel. Additional sources may be interflow, overland flow from adjacent uplands, tributary inflow, and precipitation. When overbank flow occurs, surface flows down the floodplain may dominate hydrodynamics. In headwaters, riverine wetlands often intergrade with slope, depressional, poorly drained flat wetlands, or uplands as the channel (bed) and bank disappear. Perennial flow is not required. Riverine wetlands lose surface water via the return of floodwater to the channel after flooding and through surface flow to the channel during rainfall events. They lose subsurface water by discharge to the channel, movement to deeper groundwater, and evapotranspiration. Bottomland hardwood forests on floodplains are examples of riverine wetlands.

Table 2
Potential Regional Wetland Subclasses in Relation to Classification Criteria

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

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

Reference Wetlands

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

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

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

Table 3
Reference Wetland Terms and Definitions

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

Assessment Models and Functional Indices

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

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

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

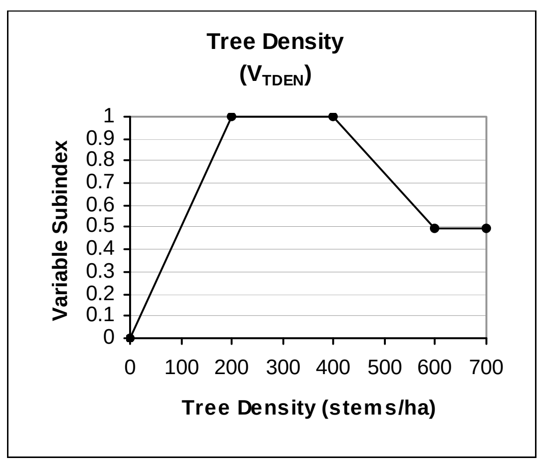

Figure 2. Example subindex graph for the Tree Density (V_{TDEN}) assessment variable for a particular wetland subclass

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

Assessment Protocol

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

3 Characterization of Wetland Subclasses in the Arkansas Valley 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 Arkansas Valley Region of Arkansas, which extends through the west-central portion of the state from the Mississippi Alluvial Valley to the Oklahoma border. It is one of five Wetland Planning Regions established for planning purposes (Arkansas Multi-Agency Wetland Planning Team 1997), which generally reflect the major physiographic divisions within the state (Figure 3). This region includes the alluvial valley of the Arkansas River, as well as bottomlands and terraces associated with tributary streams, and other landforms that occur within the portion of the Ouachita Mountains that drains to the Arkansas River. The northern boundary of the region is the southern limit of the Boston Mountains. Consequently, this region includes wetlands similar to those of the Delta lowlands, as well as elements of mountain wetland systems. Intensive agricultural development on the fertile terraces and river bottoms, and navigation projects on the Arkansas River have altered or eliminated many historic wetlands.

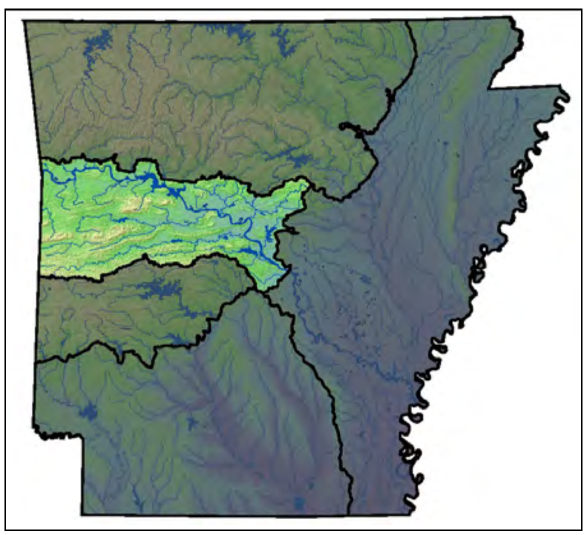

Figure 3. Arkansas Valley Wetland Planning Region

Most of the remaining wetlands within the reference domain occur on alluvial soils deposited by the Arkansas River or its tributaries. The characteristics of those wetlands vary with the age of the sediments they occupy, the soils that occur there, and their hydrology. In limited areas, wetlands occur that are associated with the mountainous terrain that fringes the region. In such cases, the characteristics of the wetlands are controlled by the geology, terrain, and subsurface hydrology of the bedrock.

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

Climate

Climate within the Arkansas Valley Region of Arkansas is characterized by temperate winters and long hot summers. Thunderstorms and tornadoes occur commonly. Temperature and precipitation vary little across the region, although higher elevations may be locally wetter and colder than the lowlands that dominate the landscape, and rainfall distribution patterns vary between east and west. At North Little Rock, on the eastern edge of the region, mean daily maximum temperatures range from 92.6 °F (33.6 °C) in July to 48.2 °F (9.0 °C) in January. Mean daily minimum temperatures range from 73.1 °F (22.8 °C) in July to 31.2 °F (-0.4 °C) in January. Average annual precipitation is 49.19 in. (124.9 cm), with a peak of 5.74 in. (14.6 cm) in November and the lowest monthly average of 2.97 in. (7.5 cm) falling in August. Average annual snowfall is 6.0 in. (15.2 cm). At Fort Smith, on the western edge of the region, mean maximum daily temperatures are highest in July at 93.2 °F (34.0 °C) and lowest in January at 48.3 °F (9.0 °C). Mean daily minimum temperatures range from 70.6 °F (21.4 °C) in July to 26.9 °F (-2.8 °C) in January. Precipitation averages 43.87 in. (111.4 cm) annually, with a maximum of 5.29 in. (13.4 cm) falling in May, and a minimum of 2.37 in. (6.0 cm) falling in August. Snowfall averages 6.7 in. (17.0 cm) annually (Southern Regional Climate Center 2005).

Physiography and Geology

The Arkansas Valley Region as defined in this report conforms to the Arkansas Valley Wetland Planning Region used by state agencies to coordinate wetland mitigation, restoration, protection, and management (Arkansas Multi-Agency Wetland Planning Team 1997). The boundaries of the state Wetland Planning Regions were established based on watershed boundaries and wetland characteristics, which often, but not always, reflect physiographic divisions. In this case, the Arkansas Valley Wetland Planning Region incorporates two major land units that are sometimes classified as parts of different physiographic areas. Figure 4 illustrates this in terms of a recent map delineating ecoregions within Arkansas (Woods et al. 2004).

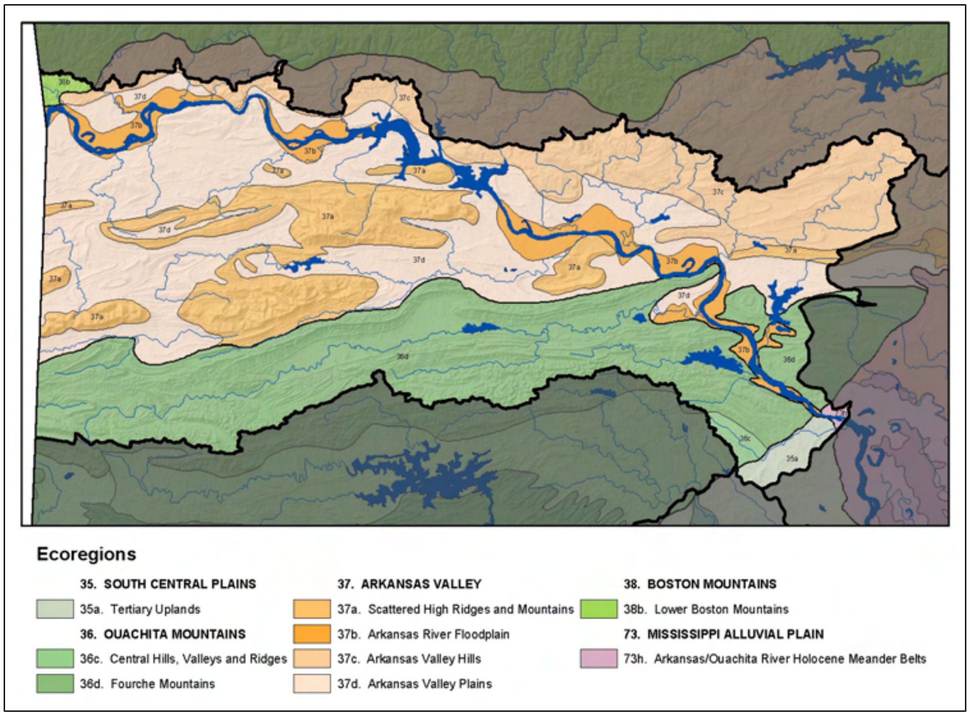

Figure 4. Ecoregions in relation to the Arkansas Valley Wetland Planning Region (adapted from Woods et al. 2004)

The majority of the Arkansas Valley Ecoregion of Arkansas is characterized by relatively low, east-west trending ridges and valleys that give a rolling character to the landscape. However, it is also punctuated with high mountains such as Petit Jean Mountain, Mount Nebo, and Magazine Mountain, the latter being the highest point in the state. The northern portion of the region includes the broad alluvial deposits of the Arkansas River, and therefore has expansive plains among the low ridges. The valley bottoms generally range from 300 to 500 ft (91 to 152 m) in elevation, while the ridges rise 1,000 to 2,000 ft (305 to 610 m) above them.

In contrast, the southern portion of the Arkansas Valley Wetland Planning Region is considered part of the Ouachita Mountains Ecoregion, specifically the Fourche Mountains subdivision, which has relatively narrow valleys and rugged terrain (Foti 1974). Small areas designated as parts of various other ecoregions also occur within the Arkansas Valley Wetland Planning Region (Figure 4).

Geologically, most of the Arkansas Valley is affiliated with the Ouachita Mountains Region. The bedrock is principally folded, faulted Pennsylvanian shale and sandstones. More recent Pleistocene deposits occur in the northern part of the valley, mostly along the flanks of the Boston Mountains, where fragments of old Arkansas River alluvial terraces occur high above the modern floodplain level. The Pleistocene terraces are made up of silts, sands, clays, and gravels. Still more recent alluvium occurs as narrow Holocene floodplain and terrace deposits of the Arkansas and smaller streams throughout the region. The Holocene deposits along small streams may include gravels, but the Holocene deposits of the Arkansas River are primarily sands, silts, or clays. Figure 5 illustrates the general relationships among major landforms within the Arkansas Valley Wetland Planning Region. Figure 6 identifies the specific geological formations found within the region.

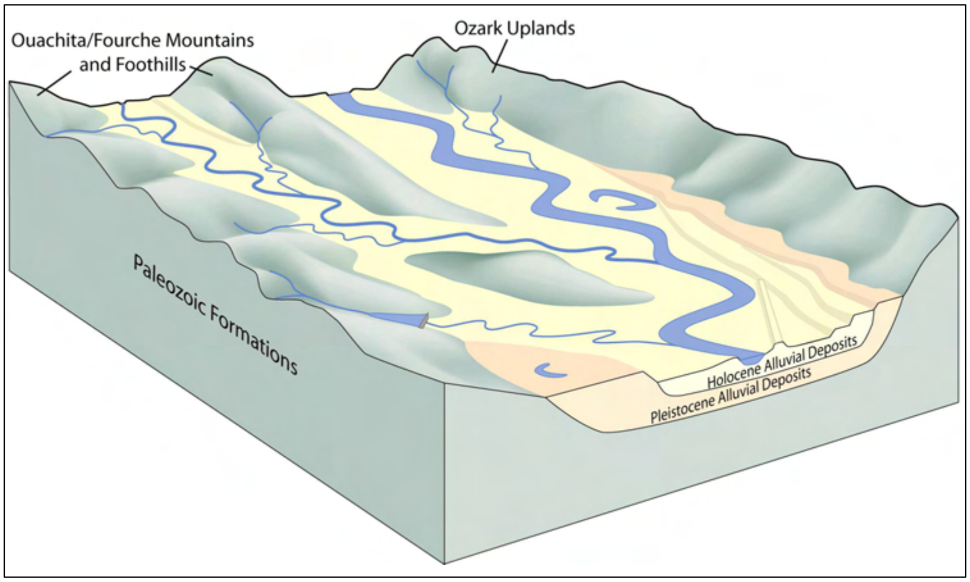

Figure 5. Origins and affiliations of major landforms within the Arkansas Valley Wetland Planning Region

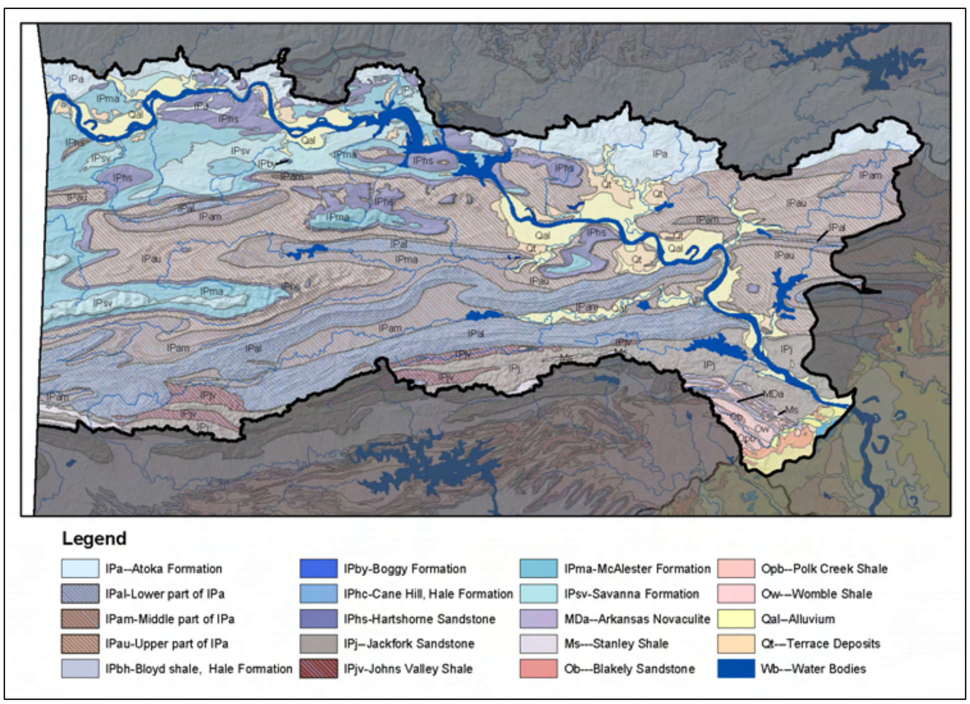

Figure 6. Surficial geology of the Arkansas Valley Wetland Planning Region (adapted from Haley 1993)

Geomorphology

Most of the wetlands that historically existed in the Arkansas Valley occurred on alluvial deposits associated with low-gradient, meandering streams. In particular, the Arkansas River meandered widely in some reaches, creating complex terrain similar to that found in the alluvial valley of the Mississippi River. In other reaches, the Arkansas River is relatively confined by bedrock. The following descriptions of the principal landforms created by the Arkansas River and its tributaries are adapted from Smith (1986a, 1986b) and Smith and Breland (2004). These three publications include descriptions and geomorphic mapping of the entire Arkansas River and the lower reaches of its tributaries within the Arkansas Valley Region of Arkansas. The landforms described in the following text include the common features that formed during long periods in the Pleistocene when the Arkansas River was incising into the sedimentary rocks of the valley, and periods in the Holocene when the river was aggrading caused by changes in climate. Figure 7 illustrates the general form and locations of these features, as well as the typical locations of common man-made features such as levees and reservoirs.

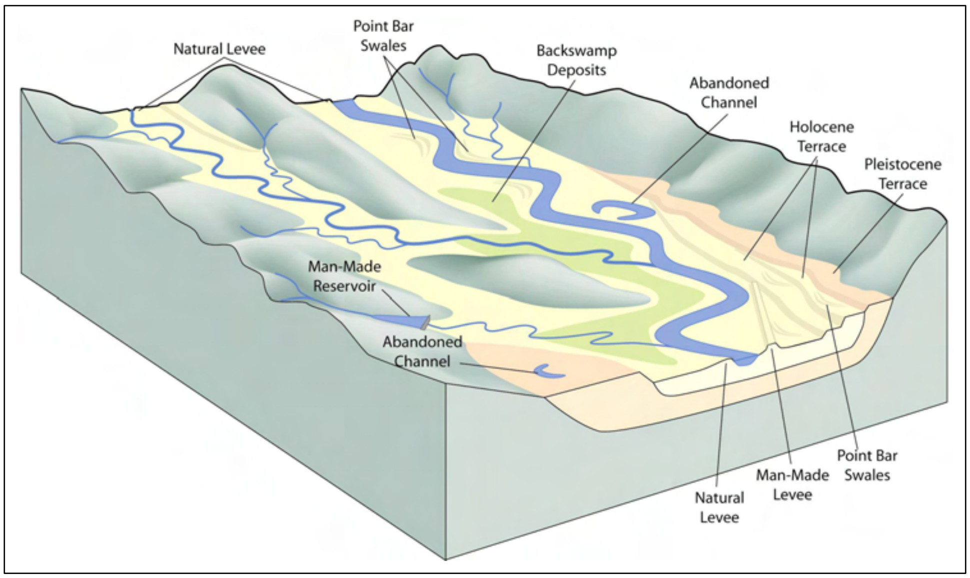

Figure 7. Typical form and locations of geomorphic and man-made features within the Arkansas Valley Wetland Planning Region

Point bars

The majority of the Arkansas Valley alluvium is mapped as point bar deposits. Point bars form on the inside bend of stream channels as they migrate laterally and downstream, eroding the opposite bank and depositing material on the inside of the bend. The deposited material accumulates as a series of sand ridges and intervening swales. The swales usually become lined or filled with silty or clayey sediments left by floodwaters trapped behind the ridges, but the overall texture of point bar deposits tends to be relatively coarse sands or gravels. The typical ridge and swale topography of point bar deposits is sometimes referred to as a meander scroll or point bar complex.

Backswamps

Backswamps are flat, poorly drained areas bounded by higher alluvial features. 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. They characteristically have clay substrates 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. Two features mapped by Smith (1986a, 1986b) and Smith and Breland (2004) are similar to backswamps with regard to the wetlands they support, and are not separately illustrated in Figure 7. **Rimswamps** occur along the valley walls and receive drainage from the adjacent upland slopes. **Slackwater deposits** formed from aggradation of the Arkansas River during the Holocene, which in turn caused tributary streambeds to aggrade, resulting in "drowning" of the tributaries and deposition of thick deposits of fine-grained sediments. This process influenced nearly all of the major tributaries to the Arkansas River, and slackwater deposits extend more than 10 km upstream in some cases. Where slackwater deposits occur, soils are poorly drained, but do not necessarily experience the extensive ponding typical of backswamp settings.

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 fill with sediment, leaving an open-water oxbow lake in the remainder of the channel. Where an abandoned stream channel incorporates two or more meander loops, it is referred to as an **Abandoned Course**.

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 low, wedge-shaped ridge paralleling the channel. Natural levee deposits along the Arkansas River extend for great distances across the floodplain, blanketing large areas of point bar and backswamp. However, many of the deepest natural levee deposits were excavated during the construction of flood control levees during the 20th century, often leaving the terrain near the channel highly disturbed. Natural levee deposits exist on most tributary streams, but are relatively small (0.3 to 0.6 m (1 to 2 ft) thick).

Terraces

Alluvial terraces are former floodplains abandoned by a stream when it passed through a period of bed erosion and established a new floodplain at a lower level. The abandoned floodplain surface is composed of the sediments and landforms described in the preceding text, and frequently sustains wetlands in the relic swales, channels, and backswamps. However, the wetland character is maintained primarily by precipitation rather than flooding. On very old terraces, the alluvial features may be so subdued from erosion that the surface appears flat. Where internal drainage is well developed, the terrace becomes dissected and may not sustain any wetland environments.

Numerous terrace levels exist along the Arkansas River. Smith (1986a) identified six separate terrace levels in the upper part of the valley, ranging in height from 5 to about 250 m (16 to about 820 ft) above the active floodplain. The highest of these are Pleistocene in age, and occur as discontinuous fragments along upland slopes throughout the length of the valley. The largest units occur in the vicinity of Morrilton (Haley 1993). Holocene terraces are lower and more continuous, and are also found along tributary streams, where they range from less than a meter to more than 3 m (10 ft) in height above the current floodplain.

Soils

The soils of the Arkansas Valley are derived from sandstones and shales. Generally, they are of medium texture and are slowly to moderately permeable. However, there is considerable variation between the soils of the ridges and slopes and the alluvial soils of the valley bottoms. The principal soil associations in the region are shown in Figure 8. Descriptions of the individual soil series that occur within each association can be found at http://soils.usda.gov/technical/classification/scfile/index.html.

The soils flanking much of the Arkansas River, such as the Roxana-Roellen-Crevasse association (Figure 8), are typical soils of large river lowlands. They include both well-drained, sandy soils of natural levee deposits as well as poorly drained soils that formed in backswamps. They are mapped on both recent and old sediments (terraces). On smaller rivers and streams, alluvial soils such as the Ceda-Kenn-Avilla complex mapped along the Fourche LaFavre River, and the Spadra and Barling soils mapped on other streams (Figure 8) are relatively deep and loamy in texture.

Some terraces and flat uplands have less permeable silty soils, often with a fragipan, such as the Leadvale-Taft-Cane association and Guthrie series soils. The poor drainage and flat settings of these soils may support wetlands similar to those on alluvium. Deeper, better drained silty soils of the Falkner-Wrightsville-Leadvale association also may have fragipans, but are unlikely to sustain wetlands.

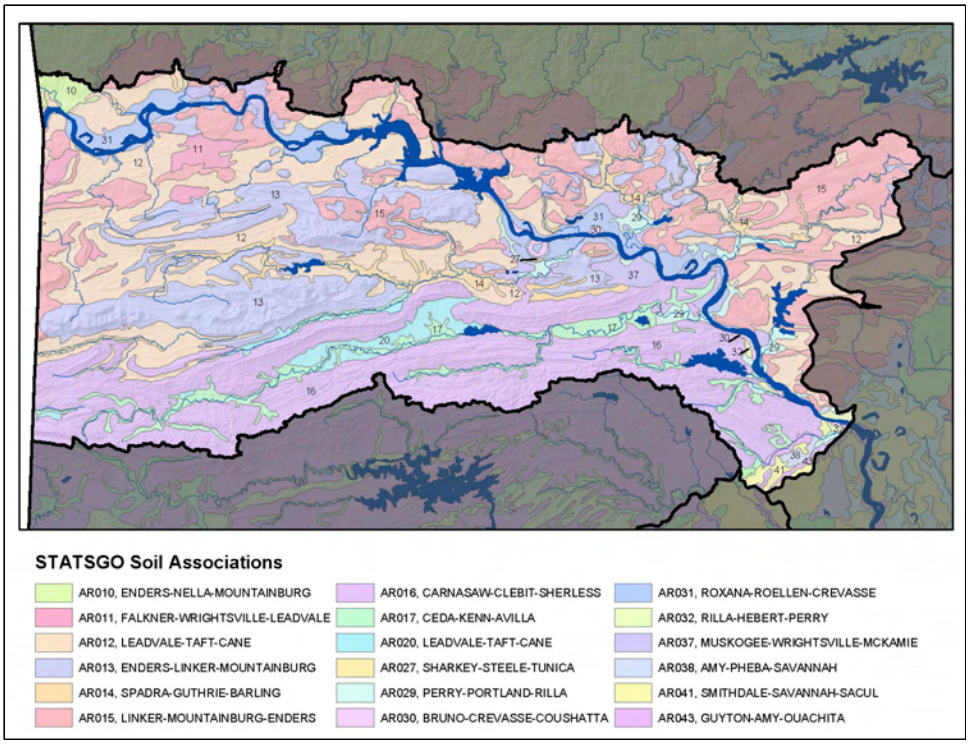

Figure 8. State Soil Geographic (STATSGO) soil associations of the Arkansas Valley Wetland Planning Region (U.S. Department of Agriculture, Natural Resources Conservation Service 1995)

On hillslopes and mountains, soils range from shallow (Mountainburg, Clebit) to moderately deep (Linker) and are generally well-drained sandy loams. Where they are weathered primarily from shale (Enders, Carnasaw), soils may be very slowly permeable.

Hydrology

The Arkansas Valley Wetland Planning Region is divided into two Wetland Planning Areas that reflect major watershed boundaries and physiographic variation (Arkansas Multi-Agency Wetland Planning Team 1997) (Figure 9).

The Arkansas River Wetland Planning Area extends along the northern border and much of the eastern portion of the region and includes the Arkansas River and its associated broad floodplain and terraces. It also includes the lower reaches of tributary streams including the Fourche and Petit Jean Rivers, Cadron Creek, and Mill Creek.

The Petit Jean/Fourche Rivers Wetland Planning Area spans much of the southern and western part of the region and includes drainages that originate in the Fourche and northern Ouachita Mountains. The major streams are the Fourche and Petit Jean Rivers, but there are numerous smaller mid-gradient and high-gradient stream systems that originate in the mountains.

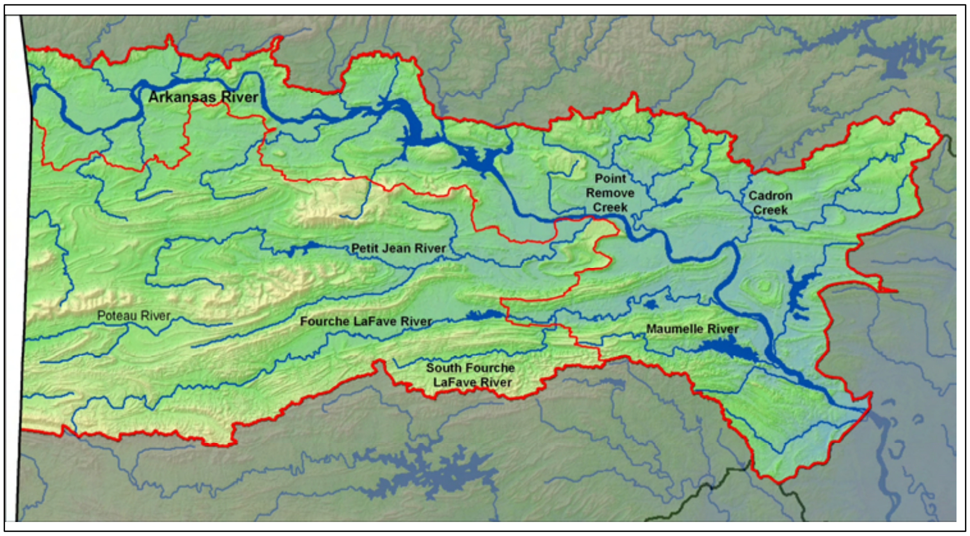

Figure 9. Drainage network of the Arkansas Valley Wetland Planning Region and boundaries of the included Wetland Planning Areas

Some of the larger streams in the Arkansas Valley Region are similar to Delta streams in that they have meandering, low-gradient channels with silt- and clay-dominated substrates, but the low-gradient streams of the Arkansas Valley are more likely than Delta streams to cease flowing in the late summer or early fall. Smaller streams tend to resemble those of either the Boston Mountains to the north, where stream gradients are steep and bedrock dominates the channel, or the Ouachita Mountains to the south, which are less steep in general, and usually are dominated by gravel or boulder substrates (Giese et al. 1987). Streams originating on the flanks of the Ouachita Mountains may have base flows augmented by groundwater discharging from fractured bedrock (Renken 1998). Groundwater discharge also sustains numerous seep wetlands on rocky slopes within the central portion of the Ouachitas, and some similar seep areas may occur within the Arkansas Valley region. In the low-relief portions of the Arkansas River Valley, a shallow aquifer occurs in the soils and highly weathered bedrock near the surface and discharges to the streams (Renken 1998), but does not form seep wetlands.

The drainage system of the Arkansas Valley has been modified greatly since the time of settlement. Agricultural development has focused on the fertile alluvial soils along stream courses, resulting in erosion of channel banks and beds as well as the loss of wetlands and riparian vegetation that moderate runoff, sediment movement, and flooding. However, the most dramatic impacts have occurred as the result of nearly two centuries of river engineering efforts on the Arkansas River.

Steamboat travel on the Arkansas River began in the early 1820s. By 1832, Congress had directed the U.S. Army Corps of Engineers to maintain a navigation channel on the river, which was pursued with a program of snagging, dredging, channel contraction, and bank stabilization. Attention to the channel maintenance program waxed and waned through the next century, depending on political and economic priorities in the region and the nation (Rathburn 1987). However, by the late 1930s, the Corps had been given a new mission, and it embarked on a flood control program for the entire lower Mississippi Valley and its major tributaries that fundamentally altered the behavior of the Arkansas River. Today, flows on the Arkansas River are controlled for a variety of purposes, including flood control, primarily by a system of Corps-operated reservoirs. Much of the flow is modified prior to reaching Arkansas by 11 reservoirs in Oklahoma. Two reservoirs in the system are on tributary streams within Arkansas: Blue Mountain Lake on the Petit Jean River and Nimrod Lake on the Fourche LaFavre River. Non-federal large lakes on tributaries within the Arkansas Valley Wetland Planning Region include Lake Maumelle, on the Maumelle River, which is the drinking water supply reservoir for Little Rock, and Lake Conway, constructed and operated by the Arkansas Game and Fish Commission for recreation and fish and wildlife management. Various smaller man-made lakes lie within the region, most of which are managed for fish and wildlife and recreation purposes.

In the 1950s, the Corps initiated a program to provide navigation, power production, and other benefits on the Arkansas River that would eventually involve construction of 18 locks and dams as well as numerous dikes, revetments, and levees. Six of the locks and dams form a continuous series of pools along the main stem channel of the Arkansas River within the Arkansas Valley Wetland Planning Region. In sequence, moving upstream from Little Rock to the Oklahoma border, these lock and dam projects are Murray, Toad Suck Ferry, A. V. Ormond, Dardanelle, Ozark-J. Taylor, and J. W. Trimble. Dardanelle and Ozark-J. Taylor include hydropower production as project features. In 1970, the entire 716-km- (445-mile-) long project was opened as the McClellan-Kerr Arkansas River Navigation System (Robinson 2003).

Vegetation

The major ecoregion divisions shown in Figure 4 correspond to some fundamental differences in the distribution of natural vegetation in the Arkansas Valley Wetland Planning Region. In the Fourche Mountains subdivision, forests dominated by loblolly pine (*Pinus taeda*), shortleaf pine (*P. echinata*), and a variety of oaks (*Quercus* spp.) blanket most of the upland slopes. Protected north-facing lower slopes may support communities that include sugar maple (*Acer saccharum*), northern red oak (*Q. rubra*), Shumard oak (*Q. shumardii*), cucumber magnolia (*Magnolia accuminata*), and similar mesic-site species. The relatively narrow valley bottoms generally support mesic-site species as well as typical riparian species such as river birch (*Betula nigra*), sycamore (*Platanus occidentalis*), and red maple (*Acer rubrum*). Broader bottoms include components of floodplain communities such as sweetgum (*Liquidambar styraciflua*) and green ash (*Fraxinus pennsylvanica*). Much of the more rugged terrain of the Fourche Mountains area is within the Ouachita National Forest, and is almost entirely forested. However, outside the boundaries of the National Forest, most of the large stream bottoms have been cleared and converted to pasture.

In the remainder of the Arkansas Valley, the natural vegetation on the slopes and ridgetops is primarily a mixture of oaks, hickories, and pines. The stream terraces and floodplains support species such as cottonwood (*Populus deltoides*), sugarberry (*Celtis laevigata*), green ash, sweetgum, and a mix of lowland oaks.

In the wettest areas such as abandoned channels and backswamps, baldcypress (*Taxodium distichum*) occurs commonly. However, much the forest cover has been replaced with pasture, cropland, and other agricultural operations on all but the wettest and most rugged sites.

These general patterns do not fully reflect the complexity and diversity of plant communities within the Arkansas Valley Wetland Planning Region. For example, although most of the uplands are typically forested as described previously, prairies occurred naturally on sites with impervious subsoils (clay pans) or shallow rocky soils, particularly in the upper valley. They have been greatly reduced in extent (usually converted to pasture), but remnants remain. Grasses typically dominate, and the most common species include big bluestem (*Andropogon gerardi*), Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), and little bluestem (*Andropogon scoparius*). Lowland prairies differ somewhat from upland prairies in terms of species composition, but both are maintained by seasonally droughty conditions and periodic fire (Foti 1974). Lowland prairies include some areas ("wet prairies") that pond water extensively in the spring.

On steep, south-facing slopes and rocky ridges, forests of blackjack oak (*Q. marilandica*), post oak (*Q. stellata*), and black hickory (*Carya texana*) tend to predominate in the modern landscape. A similar forest composed almost entirely of post oak sometimes occurs on very poorly drained flats. At the time of settlement, many of these forests burned regularly, which produced an open savanna, or a complete transition to prairie. At the extreme western edge of the valley, much of the landscape is this transitional prairie/forest tension zone, but the exclusion of fire has resulted in complete canopy closure in most areas where native vegetation remains.

Lowland forests exhibit similar types of variation, which most often reflects geomorphic setting and the related influence of soil texture and drainage on the overall moisture status of a site. For example, Figure 10, which is based on field data collected for this guidebook, illustrates the distribution of dominant tree species across a range of geomorphic settings in the vicinity of Morrilton, where the Arkansas River and small tributary streams have created a series of terraces as well as point bars, backswamps, abandoned channels, and natural levees. The species distribution in Figure 10 reflects a complex gradient of flooding frequency and duration, drainage conditions, and the age of the alluvial deposits that support wetland communities. In general, the species are arrayed in order as follows: from frequently and long-flooded swamp sites; to flashier frequently flooded streamfront; to poorly drained backswamps; to well-drained natural levees, point bars and low, recent terraces (T1); to higher, older, Holocene terraces (T2, T3); and then to the very high Pleistocene terraces. This example shows that some species have very narrow ranges of distribution; e.g., black willow (*Salix nigra*), cottonwood, and silver maple (*Acer saccharinum*) were each dominant only in streamfront habitats where flood velocities and sediment deposition and scouring can be extreme, and species such as baldcypress and water tupelo (*Nyssa aquatica*) are the only significant dominants in oxbow lakes and within river channel swamps. In off-channel habitats, most species achieve particular dominance in just one or two settings, but are present as a community

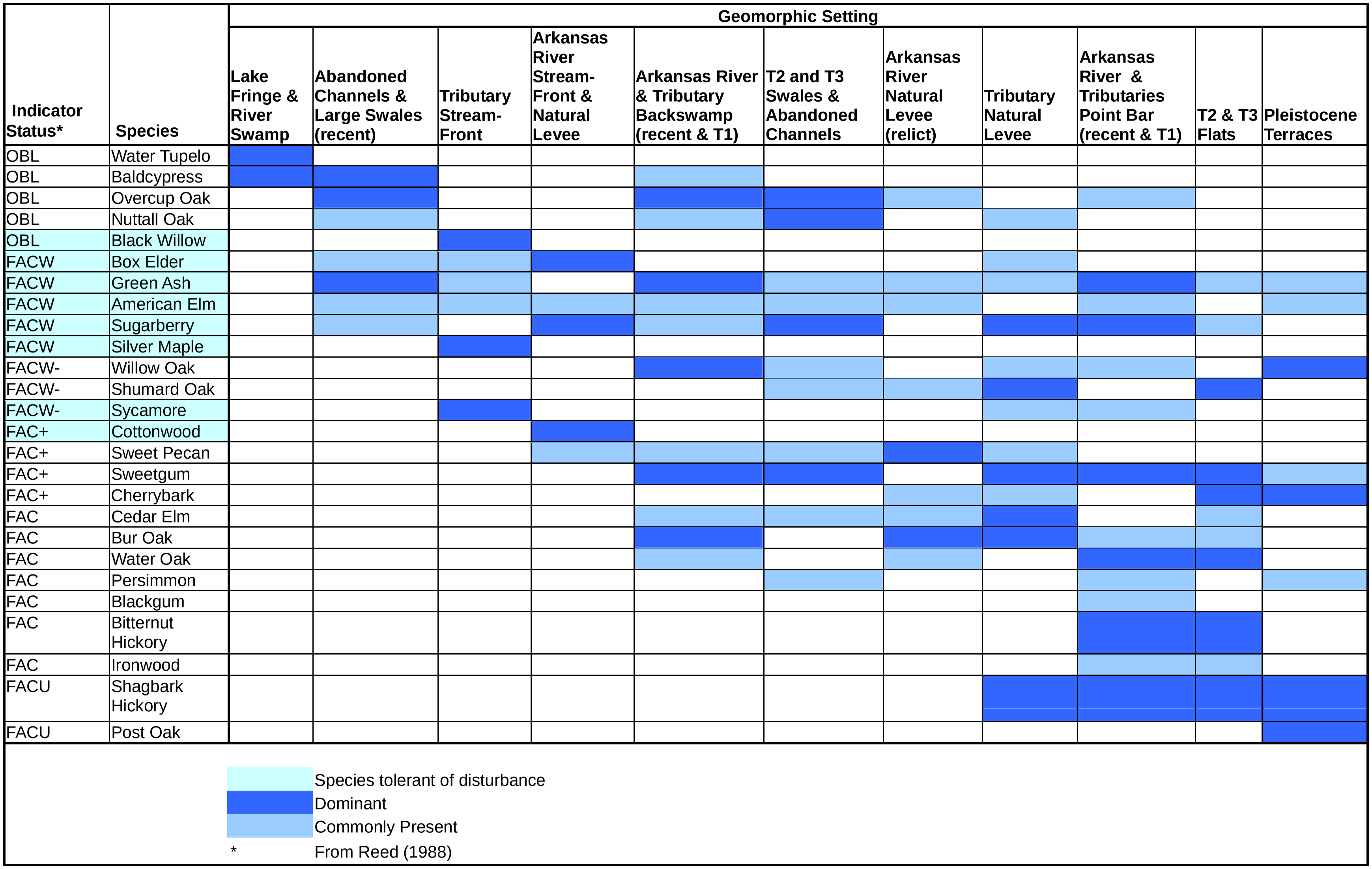

Figure 10. Typical distribution of tree species across a variety of alluvial geomorphic settings within the Arkansas Valley Wetland Planning Region

component on a variety of sites, and a few species—American elm (*Ulmus americana*), green ash, and sugarberry—have little site fidelity and occur nearly everywhere. As a result, off-channel forests tend to have highly diverse canopies in comparison to riverfront and swamp forests. Particularly on tributary natural levees and point bars of the Arkansas River and its tributaries, species exhibit water tolerances ranging from obligate (OBL) to facultative upland (FACU), and disturbance tolerance and intolerance, illustrating the broad range of microsites typical of these forests. Further off-channel, forests on the Pleistocene terraces exhibit less diversity, as the most hydrophytic species drop out of the mix.

Figure 10 also illustrates that the source of wetland hydrology in the Arkansas Valley varies with geomorphic setting. The extreme, near-permanent inundation in abandoned channels differs from the periodic high-velocity flood flows seen on natural levees, and from the prolonged growing-season flooding that occurs in backswamps and large point bar swales. On terraces, flooding is less of a consideration, and ponding of rainwater in vernal pools (the remnants of former point bar swales and abandoned channels) provides the hydrologic conditions that sustain wetlands on these sites. On the highest, oldest Pleistocene terraces, ponding may be less of a factor than it is on younger deposits, but because the material is alluvium, drainage remains poor unless the terrace becomes dissected by streams.

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 Arkansas Valley 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 to the appropriate class (Figure 11). Subclass and community type designations can best be assigned using the descriptions of wetlands and their typical landscape positions presented in the following paragraphs and summarized in Table 4.

Some of the criteria that are used in Figure 11 and Table 4 require some elaboration. For example, a fundamental criterion is that a wetland must be in the 5-year floodplain of a stream system to be included within the Riverine Class. This return interval is regarded as sufficient to support major functions that involve periodic connection to stream systems. It was also selected as a practical consideration because, where flood return intervals are mapped, the 5-year return interval is a commonly used increment.

Key to Wetland Classes
of the
Arkansas Valley Region of Arkansas

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

Figure 11. Key to Wetland Classes in the Arkansas Valley Region of Arkansas

Table 4
Hydrogeomorphic Classification of Wetlands in the Arkansas Valley Region of Arkansas, and Typical Geomorphic Settings of Community Types

Wetland Class	Subclass	Community	Typical Hydrogeomorphic Setting
Flat	Nonalkali Flat	Hardwood flat	High terraces and poorly drained basins, not subject to regular stream flooding (not within the 5-year floodplain).
		Wet tallgrass prairie	High terraces, nonalluvial flats, and poorly drained basins, not subject to regular stream flooding (not within the 5-year floodplain).
Riverine	High-Gradient Riverine	High-gradient riparian zone	Narrow floodplains, streambanks, and terraces along headwater and other low-order streams (within the 5-year floodplain).
	Mid-Gradient Riverine	Mid-gradient floodplain	Point bar and natural levee deposits within the 5-year floodplain of streams transitioning from headwaters to broad basins.
	Low-Gradient Riverine	Low-gradient overbank	Point bar and natural levee deposits immediately adjacent to meandering streams (within the 5-year floodplain).
		Low-gradient backwater	Point bar and backswamp deposits of meandering streams where floodwaters are impeded from returning to the channel (within the 5-year floodplain).
	Impounded Riverine	Beaver complex	All flowing waters.
Depression	Unconnected Depression	Unconnected alluvial depression	Abandoned channels and large swales in former and current meander belts of larger rivers not subject to regular stream flooding (not within the 5-year floodplain).
	Connected Depression	Floodplain depression	Abandoned channels and large swales in former and current meander features of larger rivers (within the 5-year floodplain).
Fringe	Unconnected Lacustrine Fringe	Unconnected lake margin	Natural and man-made lakes where water levels are not actively managed, and that are not within the 1- to 5-year flood return interval of a larger stream.
	Connected Lacustrine Fringe	Connected lake margin	Natural and man-made lakes where water levels are not actively managed, and that are within the 1- to 5-year flood return interval of a larger stream.
	Reservoir Fringe	Reservoir shore	Fluctuation zone of a man-made reservoir manipulated for water supply, power production, and other purposes. Mostly on former hillslopes of valleys impounded by large dams.
Slope	Noncalcareous Slope	Noncalcareous perennial seep	Slopes and adjacent colluvial deposits at perennial aquifer discharge points, usually at the contact between permeable and less permeable strata, or where fractures or quartz veins occur.
		Wet-weather seep	Slopes and adjacent colluvial deposits at seasonal aquifer discharge points, usually at the contact between permeable and less permeable strata, or where fractures or quartz veins occur.

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

The following sections briefly describe the classification system developed for this guidebook for wetlands in the Arkansas Valley Region of Arkansas. All of the wetland types that occur in the Arkansas Valley Region are described in the following text, 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, as well as wetlands in the other regions of the state, can be found on the Arkansas Multi-Agency Wetland Planning Team Web site (www.mawpt.org).

Class: Flat

Subclass: Nonalkali Flat

Flats with neutral and acid soils can occur in a variety of settings (Figure 12), and are differentiated based on predominant vegetation types, which generally reflect drainage conditions. Fire history may also be an important factor in certain instances. Because wet flats are maintained by precipitation rather than flooding, many were relatively easy to convert to agriculture with fairly minor changes to drainage conditions, and extensive flat areas have been cleared. In addition, many sites that were historically subject to regular flooding have been isolated from streamflows by modern man-made levees, and these sites are now classified as flats.

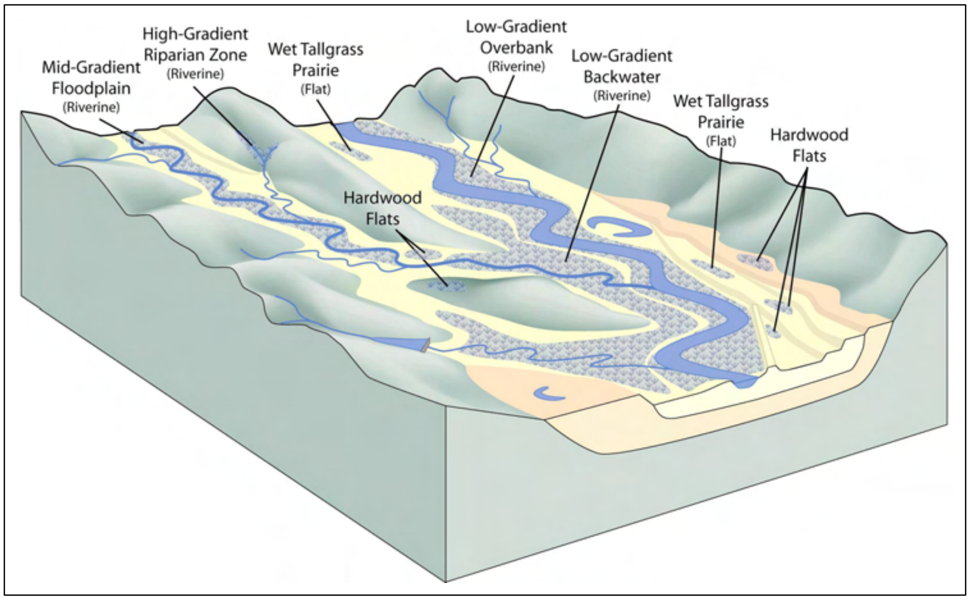

Figure 12. Typical landscape positions of flat and riverine wetlands within the Arkansas Valley Wetland Planning Region

Community Types. The following community types occur within the Nonalkali Flat subclass:

a. *Hardwood flat.* Hardwood flats occur on fairly level terrain that is not within the 5-year floodplain of stream systems, but nevertheless remain wet throughout winter and spring because of rainfall that collects in small shallow pools. These pools often refill and remain wet for days or weeks following summer rains. In the Arkansas Valley Region, hardwood flats on terraces and poorly drained upland surfaces often are dominated by willow oak (*Q. phellos*) and water oak (*Q. nigra*), usually with shagbark hickory (*Carya ovata*) as a common associate. The highest terraces often include post oak as a major component. These same species, except for post oak, also occur on flats within more recent meander belts where flooding has been curtailed, but a wide variety of other species may also be present or dominate, including sweetgum, bur oak (*Q. macrocarpa*), Nuttall oak (*Q. nuttallii*), and bitternut hickory (*C. cordiformis*).

b. *Wet tallgrass prairie*. Extensive expanses of prairie occurred in the Arkansas Valley prior to European settlement, both on dry upland slopes and on poorly drained upland flats, terraces, and broad basins. All of these prairie communities have been drastically reduced by fire suppression and conversion to agriculture, and few remnants in good condition remain, mostly in the western part of the region. Where prairies still exist, they are dominated by grasses, particularly big bluestem, Indiangrass, switchgrass, and little bluestem. On sites with particularly poor drainage, such as swales within flats and where hummocky ("prairie mound") terrain occurs, wetland species also occur, such as beakrush (*Rhynchospora* spp.). This guidebook includes assessment models applicable to forested nonalkali flats in the Arkansas Valley Region. Assessment models were not developed for the wet tallgrass prairie type, for which few high-quality reference sites remain. The rarity of these wetlands dictates that all remaining examples be considered critically important as habitat for uncommon plant species, and they are best assessed using a strictly floristic approach and site-specific evaluation of the drainage, soils, management programs, and proposed impacts.

Class: Riverine

Riverine wetlands are those areas directly flooded by streams 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 are usually considered to be riverine because they typically maintain a constant inflow and outflow. All other riverine wetlands in the Arkansas Valley Region are classified into one of three subclasses based on stream gradient and landscape position, as illustrated in Figure 12.

Subclass: High-Gradient Riverine

Community Type. The high-gradient riparian zone occurs in the High-Gradient Riverine subclass.

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

Where terrace or floodplain deposits occur in high-gradient systems, the accumulation of alluvium is very limited in extent; but distinct communities of riparian and wetland plant species are present. Usually, the coarser cobble bars are colonized by pioneer woody species, such as willows (*Salix* spp.), alders (*Alnus* spp.), and sycamore, but the oldest and highest cobble bars usually support pines and oaks typical of droughty sites. The more fine-grained terraces, low cobble bars, and streambanks support riparian species such as red maple, ironwood (*Carpinus caroliniana*), and sweetgum. The finest materials (usually the low bars that form behind woody debris deposits) characteristically support an herbaceous wetland community of sedges and ferns. The overall character of an intact, functional high-gradient system, then, is a small stream with a narrow, bank line riparian community, punctuated by intermittent bars and terraces of varying character and extent, depending on their age and origins. An intact buffer of upland vegetation is usually considered essential to proper functioning of headwater riparian systems (Fowler 1994; Meyer et al. 2003; Semlitsch and Bodie 2003).

This guidebook does not include assessment models for high-gradient riparian areas in the Arkansas Valley because they are essentially the same as high-gradient systems in the adjacent mountainous regions and should be assessed consistently with those areas. High-gradient riparian systems that occur in steep terrain along the northern flank of the Arkansas Valley west of Conway should be assessed using the models and reference data developed for the Ozark Mountains Region. All other high-gradient systems in the Arkansas Valley Region should be assessed using the Ouachita Mountains guidebook.

Subclass: Mid-Gradient Riverine

Community Type. The mid-gradient floodplain occurs in the Mid-Gradient Riverine subclass.

a. *Mid-gradient floodplain*. Mid-gradient riverine wetlands occur within the 5-year floodplain of stream reaches in valleys that are wide and flat enough to accumulate fairly continuous, but not laterally extensive, deposits of alluvial material flanking the stream channel. Typically, these are reaches that do not meander extensively, but have moved across the valley floor sufficiently to create a zone of alluvial deposition that is considerably wider than the active channel zone. Streams transitioning from the hills to the major river valleys (which may include channels classified as stream orders 2–6) are included in this category in the Arkansas Valley Region.

Mid-gradient streams usually have fairly small floodplains and one or two low terrace units that are nearly continuous along the channel, though they often alternate from one side of the channel to the other. Floodplains may be sparsely vegetated where the stream carries substantial gravel; but where substrates are fine-grained, silver maple, willows, and sycamore are common dominants, American elm is consistently present, and lowland oaks often occur, including water oak, bur oak, and willow oak. Terrace components may combine elements of upland and lowland forests, and can be highly diverse. Sycamore, box elder (*Acer negundo*), and sugarberry are fairly ubiquitous component species on low terraces; but a variety of oaks and hickories (*Carya* spp.), as well as blackgum (*Nyssa sylvatica*), may occur on any terraces present. Terraces may not be flooded frequently enough to be classified as riverine wetlands, but may have sufficient wetland character to be classified as flats.

Subclass: Low-Gradient Riverine

Low-gradient riverine wetlands occur within the 5-year floodplain of streams that typically meander over time across a broad valley floor, although in some parts of the Arkansas Valley, bedrock ridges and the valley walls may confine low-gradient systems and minimize meandering over long reaches. Where low-gradient streams have meandered freely, they have created fairly broad floodplains and extensive, continuous terraces. The largest such surfaces were deposited by the Arkansas River, but much of the historic floodplain and many low terrace areas now lie submerged beneath the chain of lakes that make up the McClellan-Kerr waterway. However, most of the major tributaries to the

Arkansas River still have naturally functioning floodplains and terrace systems in place.

Community Types. The following community types occur within the Low-Gradient Riverine subclass.

a. *Low-gradient overbank.* The low-gradient overbank community type occurs where floodwaters move through quickly and at high velocities, which typically happens on the point bars and natural levee deposits of floodplains and along terrace margins in riverfront areas. Overbank areas often experience scouring or deep deposition of coarse sediments, and litter and other detritus may be completely swept from a site or accumulate in large debris piles. The most exposed floodplain sites usually are dominated by willows, sycamore, silver maple, and similar pioneer species. Higher terrain and natural levees generally have a greater variety of species, such as sugarberry, box elder, and various oaks. Cottonwood may dominate in some areas, particularly along the Arkansas River. Vernal pools are not as common in overbank zones as they are in backwater areas and on flats, because coarse natural levee and point bar deposits often are well drained and preclude ponding of rain and floodwaters.

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

Plant communities of backwater areas in the Arkansas Valley are very similar to those of the Delta Region. A variety of lowland oaks may be present or dominant, including overcup oak (*Q. lyrata*), Nuttall oak, and willow oak. Bur oak may be locally important. The wettest sites may include baldcypress and water tupelo as component species or dominants. Green ash, persimmon (*Diospyros virginiana*), American elm, box elder, cedar elm (*Ulmus crassifolia*) and sugarberry, all common on the Delta, are also typical in backwater communities of the Arkansas River Valley.

Subclass: Impounded Riverine

Community Type. The beaver complex occurs in the Impounded Riverine subclass.

a. *Beaver Complex.* Beaver complexes once were 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 prefer certain species (e.g., sweetgum), which alters the composition of forests within their foraging range. Tree cutting and tree mortality from flooding create patches of dead timber surrounded by open water, shrub swamps, or marshes. Beaver complexes may be abandoned when the animals exhaust local food resources, or when they are trapped out. Following abandonment, the dams deteriorate, water levels fall, and different plants colonize the former ponds. When beaver reoccupy the area, the configuration changes again, the result being that systems with active beaver populations are in a constant state of flux.

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

Class: Depression

Depression wetlands occur in topographic low points where water accumulates and remains for extended periods. Sources of water may include precipitation, runoff, groundwater, and stream flooding. Depressions are distinguished from the vernal pools that occur within the flat and riverine subclasses in several ways. Depressions tend to occur in abandoned channels, abandoned courses, and large swales, while vernal pools within flat and riverine wetlands occur in minor swales or in areas bounded by slight rises and hummocks. Depressions hold water for extended periods because of their size, depth, and ability to collect surface and subsurface flows from an area much larger than the depression itself. They tend to fill during the winter and spring, and dry very slowly. Prolonged rains may fill them periodically during the growing season, after which they again dry very slowly. Vernal pools in flats and riverine settings, in contrast, fill primarily from direct precipitation inputs and dry out within days or weeks. In the Arkansas Valley Region of Arkansas, there are two subclasses in the Depression Class, each represented by a single community type (Table 4). Figure 13 illustrates the landscape positions where wetlands in the Depression Class typically are found.

Subclass: Connected Depression

Community Type. The floodplain depression community type occurs in the Connected Depression subclass.

a. *Floodplain depression.* Floodplain depression wetlands are usually found in remnants of abandoned stream channels, or in broad swales left behind by migrating channels. They are inundated during the more common (1- to 5-year) flood events. Because they are most likely to be associated with large streams, which create large swales and abandoned channels, most of the connected depressions that were in the Arkansas Valley prior to the mid-twentieth century were likely along the Arkansas River, and were submerged by the creation of the navigation pools of the McClellan-Kerr waterway. Few large connected depressions remain today. Those that exist in good condition are similar to depressions of the Delta Region – they are dominated by species such as buttonbush (*Cephalanthus occidentalis*), baldcypress, water tupelo, and overcup oak, with green ash, sweetgum, persimmon, and various oaks as components in shallow areas and along the perimeter of the depression.

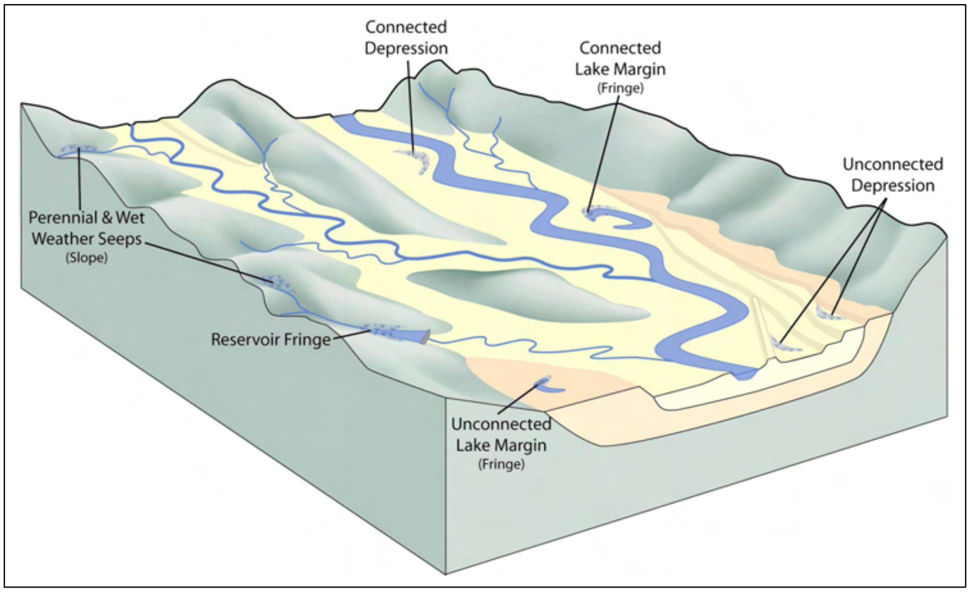

Figure 13. Typical landscape positions of depression, fringe, and slope wetlands in the Arkansas Valley Wetland Planning Region

Subclass: Unconnected Depression

Community Type.

a. Unconnected alluvial depression. Unconnected alluvial depressions are not affected by river flooding during common flood events (1- to 5-year flood frequency zone). They typically occur in abandoned river channels and large swales on the higher terraces flanking large streams or on sites that were within the floodplain prior to levee construction but that are now isolated from flooding. Unconnected depressions are not common in the Arkansas River Valley; but where they occur, they are similar to connected depressions in terms of species composition and plant community structure. However, they are assessed separately because the lack of a river connection implies significant functional differences. For example, because unconnected depressions may lack predatory fish populations, they provide vital habitat for certain invertebrate and amphibian species.

Class: Fringe

Fringe wetlands occur along the margins of lakes. By convention, a lake must be more than 2 m (6 ft) deep; otherwise associated wetlands are classified as depressions.

In Arkansas, natural lakes occur mostly in the abandoned channels of large rivers (oxbows), but numerous man-made impoundments also support fringe wetlands. There are three subclasses and three community types in the fringe class (Table 4). No assessment models have been developed for any of the fringe wetland subclasses in Arkansas, primarily because no single reference system can reflect the range of variability they exhibit. In particular, many water bodies that support fringe wetlands are subject to water level controls, but the resulting fluctuation patterns are highly variable depending on the purpose of the control structure. Figure 13 illustrates typical landscape positions where fringe wetlands may occur.

Subclass: Reservoir Fringe

Community Type. The reservoir shore occurs in the Reservoir Fringe subclass.

a. *Reservoir shore.* Man-made reservoirs include a wide array of features, such as large farm ponds; state, Federal, and utility company lakes; and municipal water storage reservoirs. In almost all cases, these lakes are managed specifically to modify natural patterns of water flow; therefore, their shoreline habitats are subjected to inundation at times and for durations not often found in nature. Steep reservoir shores usually support little perennial wetland vegetation other than a narrow fringe of willows. The most extensive wetlands within reservoirs usually occur where tributary streams enter the lake, and sediments accumulate to form deltas. These sites may be colonized by various marsh species, and sometimes black willow or buttonbush; but even these areas are vulnerable to extended drawdowns, ice accumulation, erosion caused by boat wakes, and similar impacts.

Subclass: Connected Lacustrine Fringe

Community Type. The connected lake margin is a community type in the Connected Lacustrine Fringe subclass.

a. *Connected lake margin*. Large connected lake margin wetlands are uncommon in the Arkansas River Valley, and any that may have existed in oxbow lakes adjacent to the Arkansas River were inundated by creation of the navigation project. However, smaller lakes such as stock ponds and borrow pits that are frequently inundated during floods (that is, they are within the 1- to 5-year flood frequency zone) may support connected lake margin wetlands. Connected lake margins differ from unconnected systems in that they routinely exchange nutrients, sediments, and aquatic organisms with the river system. Shoreline willow stands and fringe marshes are the typical vegetation.

Subclass: Unconnected Lacustrine Fringe

Community Type. The unconnected lake margin is a community type in the Unconnected Lacustrine Fringe subclass.

a. *Unconnected lake margin*. Unconnected lakes are lakes that are not inundated by a river on a regular basis (that is, they are not within the 1- to 5-year floodplain). They are similar in appearance to connected lake margins but are classified separately because they do not regularly exchange nutrients, sediments, or fish with river systems. In the Arkansas River Valley, most unconnected lake margin wetlands are in small man-made ponds.

Class: Slope

Slope wetlands occur on sloping land surfaces where groundwater discharge or shallow subsurface flow creates saturated conditions. One subclass comprises two community types in the Arkansas Valley Region (Table 4). The community types are separated by water regime (perennial versus wet weather) but otherwise are similar in many respects, and they may be difficult to separate in the field without a long period of observation. Both community types are highly variable, but typically are forested, though the overstory may be sparse or dominated by relatively small trees because the saturated substrate makes them susceptible to windthrow. Numerous uncommon herbaceous and shrub species are associated with these sites, and they are particularly vulnerable to degradation caused by modification of hydrology, soil disturbance, and invasion by exotic plant species. Seeps may occur as isolated, small wetlands, or they may occur as complexes that extend for long distances along valley walls and their adjacent stream bottoms.

Although these wetlands are classified as noncalcareous and are sometimes referred to as acid seeps, it is important to recognize that they occur on a wide variety of substrates and vary widely in mineral content and soil and water reaction. Some may in fact be mildly calcareous. However, they are classified here as noncalcareous seeps to stress their differences from the strongly calcareous slope wetlands that occur in the Ozark Mountains region. Figure 13 illustrates common landscape positions where wetlands in the slope class are found.

Neither slope wetland subclass is common in the Arkansas River Valley, and essentially all are within the Ouachita Mountains along the southern flank of the valley. Therefore, this guidebook does not include assessment models for slope wetlands, and the models developed for slope wetlands of the Ouachita Mountains should be used.

Subclass: Noncalcareous Slope

Two community types are recognized in the noncalcareous slope wetland subclass in the Arkansas Valley Region.

Community Types. The following community types are found in the Noncalcareous Slope subclass.

a. *Noncalcareous perennial seep*. Within the Ouachita Mountains, including the portion that flanks the Arkansas River Valley, perennial seeps occur at the discharge point of aquifers large enough to maintain constant flow in all but the driest years. Those with particularly reliable and abundant flow often have been developed as local drinking-water sources, and may be referred to as springs rather than seeps. Perennial seeps usually have thick organic substrates overlying gravels, but on steeper slopes or where soils have been disturbed, substrates may be primarily bare gravels. Sphagnum moss is nearly always present, and may form a continuous mat in some sites. Overstory species usually include some combination of sweetgum, beech (*Fagus grandifolia*), blackgum, red maple, green ash, ironwood, and umbrella magnolia (*Magnolia tripetala*). Understory and shrub species may include alder, American holly (*Ilex opaca*), spicebush (*Lindera benzoin*), witch hazels (*Hamamelis virginiana*, *H. vernalis*), and highbush blueberry (*Vaccinium arboreum*). The groundcover layer is usually very diverse, and may include numerous species that are rare or uncommon elsewhere in the region. Ferns are particularly characteristic, especially cinnamon fern (*Osmunda cinnamomea)*, royal fern (*O. regalis*), and netted chain fern (*Woodwardia areolata*).

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

4 Wetland Functions and Assessment Models

This Regional Guidebook contains six sets of assessment models applicable to wetlands in the Arkansas Valley Region of Arkansas. Not all of the wetland subclasses and community types described in Chapter 3 and Table 4 can be assessed using the models presented here. The excluded subclasses and community types are as follows:

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

b. No models are available at this time to assess fringe wetlands because the high degree of variability, especially with respect to water regimes, makes fringe wetlands beyond the scope of rapid assessment approaches.

c. Slope wetlands should be assessed using the models developed for the Ouachita Mountains, and high-gradient riverine riparian zones should be assessed using the models developed for either the Ouachita Mountains or the Ozark Mountains, as appropriate.

d. No models are available that are specific to managed wildlife impoundments (greentree reservoirs and moist soil management units). However, where existing wetlands are proposed to be converted to managed impoundments, the models appropriate to the impact area (most likely either Riverine Backwater or Hardwood Flat) can be used to assess the functional change likely to occur from altered water regimes (see “Apply Assessment Results” in Chapter 6).

The Arkansas Valley wetlands that can be assessed with the models presented here include all of the subclasses and community types not specifically excluded in the preceding paragraph, and represent most of the common forested wetland types in the region. Models have been developed at the community type level for the Hardwood Flat, Low-Gradient Overbank, and Low-Gradient Backwater community types. For the sake of consistency, these community types will be considered and referred to as subclasses for the remainder of this guidebook.

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

- Hardwood Flat.
- Mid-Gradient Floodplain.
- Low-Gradient Riverine Overbank.
- Low-Gradient Riverine Backwater.
- Unconnected Depression.
- Connected Depression.

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 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 Valley Region perform the following functions:

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

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

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

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

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. Chapter 6 presents detailed descriptions of assessment variables and the methods used to measure or estimate their values.

Function 1: Detain Floodwater

Definition and applicability

This function reflects the ability of wetlands to store, convey, and reduce the velocity of floodwater as it moves through a wetland. The potential effects of this reduction are damping of the downstream flood hydrograph, maintenance of postflood 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 Arkansas Valley Region of Arkansas:

- Mid-Gradient Floodplain.
- Low-Gradient Riverine Overbank.
- Low-Gradient Riverine Backwater.
- Connected Depression.

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

Rationale for selecting the function

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

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

Characteristics and processes that influence the function

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

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

Of these characteristics, only flood frequency and the roughness component can be reasonably incorporated into a rapid assessment. Most stream channels in the region are not close enough to a stream gage to ascribe detailed flood characteristics to any particular point on the ground. At best, 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 a change in flood frequency caused by a proposed project can be estimated, that information can be used in the assessment of this function. Otherwise, the only element of the Floodwater Detention function that is assessed is roughness.

General form of the assessment model

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

V_{FREQ} = change in frequency of flooding

V_{LOG} = log density

V_{GVC} = ground vegetation cover

V_{SSD} = shrub-sapling density

V_{TDEN} = tree density

The model can be expressed in a general form:

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

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

The compound expression of flow resistance includes the major physical components of roughness that can be characterized readily at the level of a field assessment. They include elements that influence flow velocity differently depending on flood depth and time of year. For example, ground vegetation cover (V_{GVC}) and log density (V_{LOG}) can effectively disrupt shallow flows, while shrub and sapling density (V_{SSD}) have their greatest influence on flows that intercept understory canopies (usually 1 to 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 onsite, thereby maintaining wetland characteristics and moderating runoff to streams. This is accomplished chiefly by microdepressional storage, infiltration, and absorption by organic material and soils. Both riverine and flat wetlands are assessed for this function. Depression wetlands also store precipitation, but are not assessed for that function within the Arkansas Valley Region of Arkansas.

The hydrology of depression wetlands is dependent on highly variable source areas, groundwater movement, and 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 Arkansas Valley Region of Arkansas:

- Hardwood Flat.
- Mid-Gradient Floodplain.
- Low-Gradient Riverine Overbank.
- Low-gradient Riverine Backwater.

The recommended procedure for assessing this function is estimation of available microdepression 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 onsite 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 base flow in streams (Meyer et al. 2003). The stream hydrograph has a strong influence on the development and maintenance of habitat structure and biotic diversity of adjacent ecosystems (Bovee 1982; Estes and Orsborn 1986; Stanford et al. 1996). In addition, onsite 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 windthrow, which creates small, shallow depressions when root systems are pulled free of the soil. Vernal pools are usually found in ridge-and-swale topography, or they can be created by the gradual filling of once deeper depressions such as cutoffs or oxbows. In the Arkansas Valley Region, most microdepressional precipitation storage occurs in the floodplains and terraces of low-gradient streams. The presence of surface organic accumulations also reduces runoff and promotes infiltration. Therefore, sites with large amounts of microdepression and vernal pool storage and a thick, continuous litter or duff layer will most effectively reduce the movement of precipitation as overland flow. Instead, the water is detained onsite, where it supports biological processes, contributes to subsurface water storage, and eventually helps maintain base flow in nearby streams. Clearing of natural vegetation cover will remove the source of litter and the mechanism for developing new microdepressions. Land use practices that involve ditching or land leveling can eliminate onsite storage and promote rapid runoff of precipitation.

General form of the assessment model

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

V_{POND} = percent of area subject to ponding

V_{OHOR} = O horizon thickness

V_{LITTER} = thickness of the litter layer

The model can be expressed in a general form:

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

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

Function 3: Cycle Nutrients

Definition and applicability

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

- Hardwood Flat.
- Mid-Gradient Floodplain.
- Low-Gradient Riverine Overbank.

- Low-Gradient Riverine Backwater.
- Unconnected Depression.
- Connected Depression.

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

Rationale for selecting the function

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

Characteristics and processes that influence the function

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

Many of the processes involved in nutrient cycling within wetlands have been studied extensively in wetlands (Brinson et al. 1981). In the southeast specifically, there is a rich literature on the standing stock, accumulation, and turnover of above- and below-ground biomass in forested wetlands (Conner and Day

1976; Day 1979; Mulholland 1981; Brown and Peterson 1983; Harmon et al. 1986; Brinson 1990).

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

General form of the assessment model

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

V_{TBA} = tree basal area

V_{SSD} = shrub-sapling density

V_{GVC} = ground vegetation cover

V_{OHOR} = O horizon thickness

V_{AHOR} = A horizon thickness

V_{WD} = woody debris biomass

V_{SNAG} = snag density

The model can be expressed in a general form:

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

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 horizon where organic accumulation is apparent) (V_{AHOR}) represents a longer-term storage compartment, where nutrients that have been released from other compartments are held within the soil and are available for plant uptake, but are generally conserved within the system and not readily subject to export by runoff or floodwater.

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

Function 4: Export Organic Carbon

Definition and applicability

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

This function is assessed in river-connected wetlands, which include the following subclasses in the Arkansas Valley Region of Arkansas:

- Mid-Gradient Floodplain.
- Low-Gradient Riverine Overbank.
- Low-Gradient Riverine Backwater.
- Connected Depression.

Rationale for selecting the function

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

Characteristics and processes that influence the function

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

General form of the assessment model

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

V_{FREQ} = change in frequency of flooding

V_{LITTER} = thickness of the litter layer

V_{OHOR} = O horizon thickness

V_{WD} = woody debris biomass

V_{SNAG} = snag density

V_{TBA} = tree basal area

V_{SSD} = shrub-sapling density

V_{GVC} = ground vegetation cover

The general form of the assessment model follows:

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

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

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

Function 5: Maintain Plant Communities

Definition and applicability

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

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

- Hardwood Flat.
- Mid-Gradient Floodplain.
- Low-Gradient Riverine Overbank.
- Low-Gradient Riverine Backwater.
- Unconnected Depression.
- Connected Depression.

Rationale for selecting the function

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

Characteristics and processes that influence the function

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

General form of the assessment model

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

V_{TBA} = tree basal area

V_{TDEN} = tree density

V_{COMP} = composition of tallest woody stratum

V_{SOIL} = soil integrity

V_{DUR} = change in growing season flood duration

V_{POND} = microdepressional ponding

The model can be expressed in a general form:

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

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

The second expression of the model considers several factors that may be crucial to plant community maintenance under certain conditions. V_{SOIL} is a simple comparison of the soil on the site to the mapped or predicted soil type for the area and geomorphic setting. The V_{SOIL} variable allows recognition of sites where the native soils have been replaced or buried by materials inappropriate to the site or where the native soils have been damaged significantly, as by compaction. The V_{DUR} variable allows recognition of changes in growing season flood duration in sites where project impacts or land use changes have occurred or are anticipated that will extend or reduce the amount of time that substrates are flooded during the growing season. These changes can have significant effects on plant community structure and composition. The V_{POND} variable focuses on a specific aspect of site alteration—the removal of microtopography and related ponding of water on flats and riverine wetlands. As described previously, ponding of precipitation is a crucial mechanism for maintaining wetland character in many wetlands in the Arkansas Valley 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.

Function 6: Provide Habitat for Fish and Wildlife

Definition and applicability

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

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

- Hardwood Flat.
- Mid-Gradient Floodplain.
- Low-Gradient Riverine Overbank.
- Low-Gradient Riverine Backwater.
- Unconnected Depression.
- Connected Depression.

Rationale for selecting the function

Terrestrial, semiaquatic, and aquatic animals use wetlands extensively. Maintenance of this function ensures habitat for a diversity of vertebrate organisms, contributes to secondary production, and maintains complex trophic interactions. Habitat functions span a range of temporal and spatial scales, and include the provision of refugia and habitat for wide-ranging or migratory animals as well as highly specialized habitats for endemic species. However, most wildlife and fish species found in wetlands of the Arkansas Valley 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 Arkansas Valley Region of Arkansas are dependent on a variety of factors operating at different scales. Habitat components that can be considered in a rapid field assessment include vegetation structure and composition; detrital elements; availability of water, both from precipitation and flooding; and spatial attributes such as patch size and connectivity.

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

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

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

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

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

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

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

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

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

General form of the assessment model

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

V_{FREQ} = change in frequency of flooding

V_{DUR} = change in growing season flood duration

V_{POND} = microdepressional ponding

V_{TCOMP} = tree composition

V_{STRATA} = number of vegetation layers

V_{SNAG} = snag density

V_{TBA} = tree basal area

V_{LOG} = log density

V_{OHOR} = O horizon thickness

V_{PATCH} = forest patch size

V_{BUF30} = percent of wetland perimeter contiguous with a 30-m buffer zone

V_{BUF250} = percent of wetland perimeter contiguous with a 250-m buffer zone

The model can be expressed in a general form:

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

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

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

5 Model Applicability and Reference Data

The assessment models described in Chapter 4 are applied to individual wetland subclasses in different ways. This is because not all of the assessment models and variables are applicable to all of the regional wetland subclasses. For example, the Export Organic Carbon function is assessed only for wetlands in the Riverine class and the Connected Depression subclass, where flooding provides a mechanism for export to aquatic systems. It is not assessed in subclasses that have no export mechanism (i.e., Unconnected Depressions and Flats). Similarly, some variables can be deleted from assessment models for subclasses for which 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. 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 with regard to the reference data associated with subclasses. Each subclass was the focus of detailed sampling during development of this guidebook, and the data collected for each subclass has been independently summarized for application. The following sections present information for each wetland subclass with regard to model applicability and reference data. For each subclass, each of the six potential functions available for assessment is listed, and the applicability of the assessment model is described. The model is presented as described in Chapter 4 if it is applicable in its general and complete form; it is presented in a modified form if certain variables cannot be consistently assessed in certain subclasses; and the function is identified as Not Assessed in cases where the wetland subclass does not perform the function as described in Chapter 4, or where it cannot be assessed with the methods and model available for rapid field assessment. For each wetland subclass, functional capacity subindex curves are presented for every assessment variable used in the applicable assessment models. The subindex curves were constructed based primarily on the field data, although published literature on old-growth forest characteristics (Meadows and Nowacki 1996; Batista and Platt 1997; Kennedy and Nowacki 1997; Tyrrell et al. 1998) were used to resolve occasional ambiguities in the data set. Flood frequency and duration subindex curves are not based on field data, but rather are specifically designed to be used in situations where a project impact or change in land use is being assessed, and the without-project condition is the reference condition.

Subclass: Hardwood Flat

Four functions are assessed for this subclass. Most of the applicable assessment models have not been changed from the general model form presented in Chapter 4. Figure 14 provides the relationship between the variable metrics and the subindex for each of the assessment models based on the reference data. Note that, unlike other subclasses, the Hardwood 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 for Nonalkali Flat Wetlands in Appendix B.

a. *Detain Floodwater*. Not Assessed

b. *Detain Precipitation*.

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

c. *Cycle Nutrients*.

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

d. *Export Organic Carbon*. Not assessed.

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

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

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

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

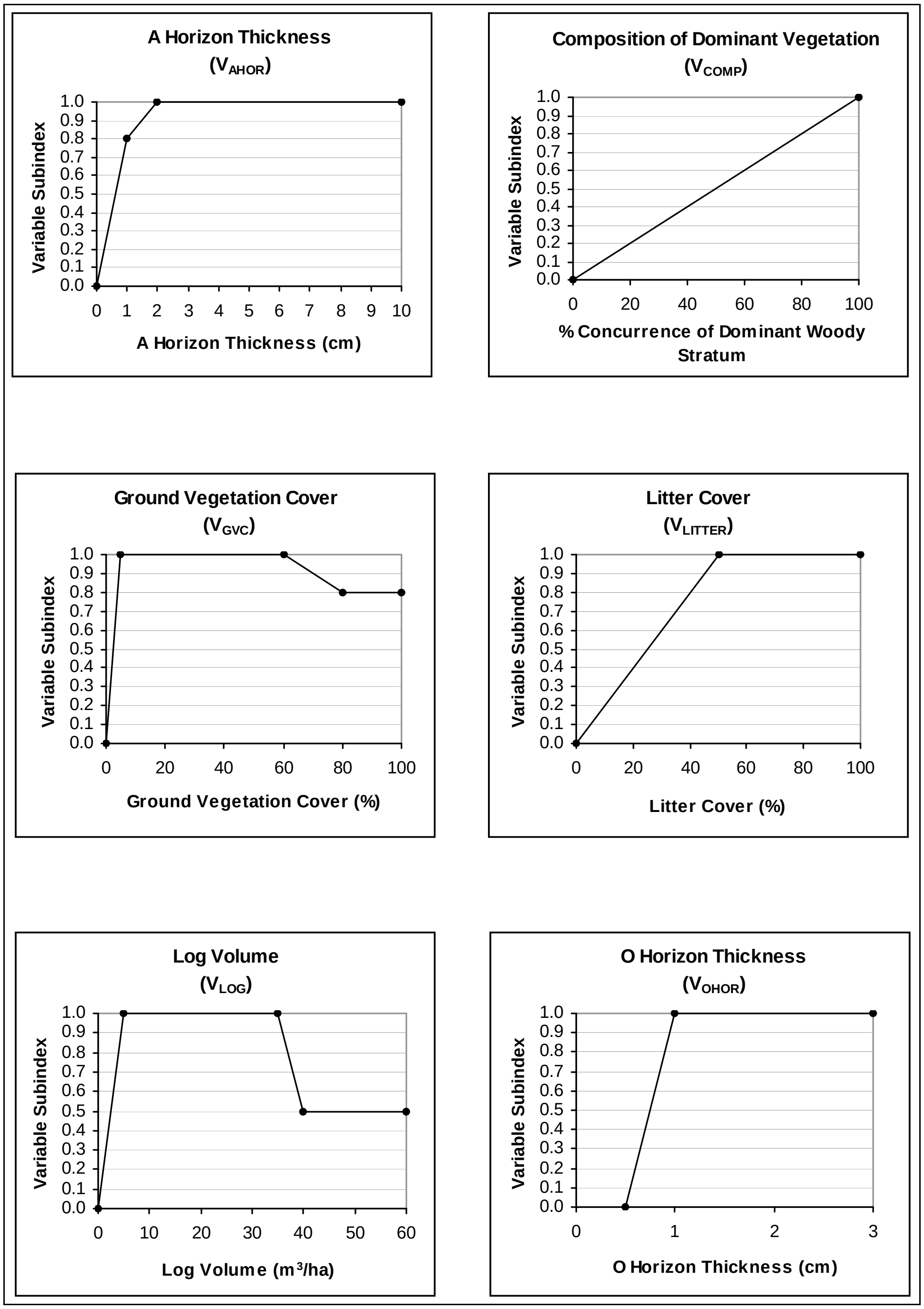

Figure 14. Subindex curves for Flat wetlands (Sheet 1 of 3)

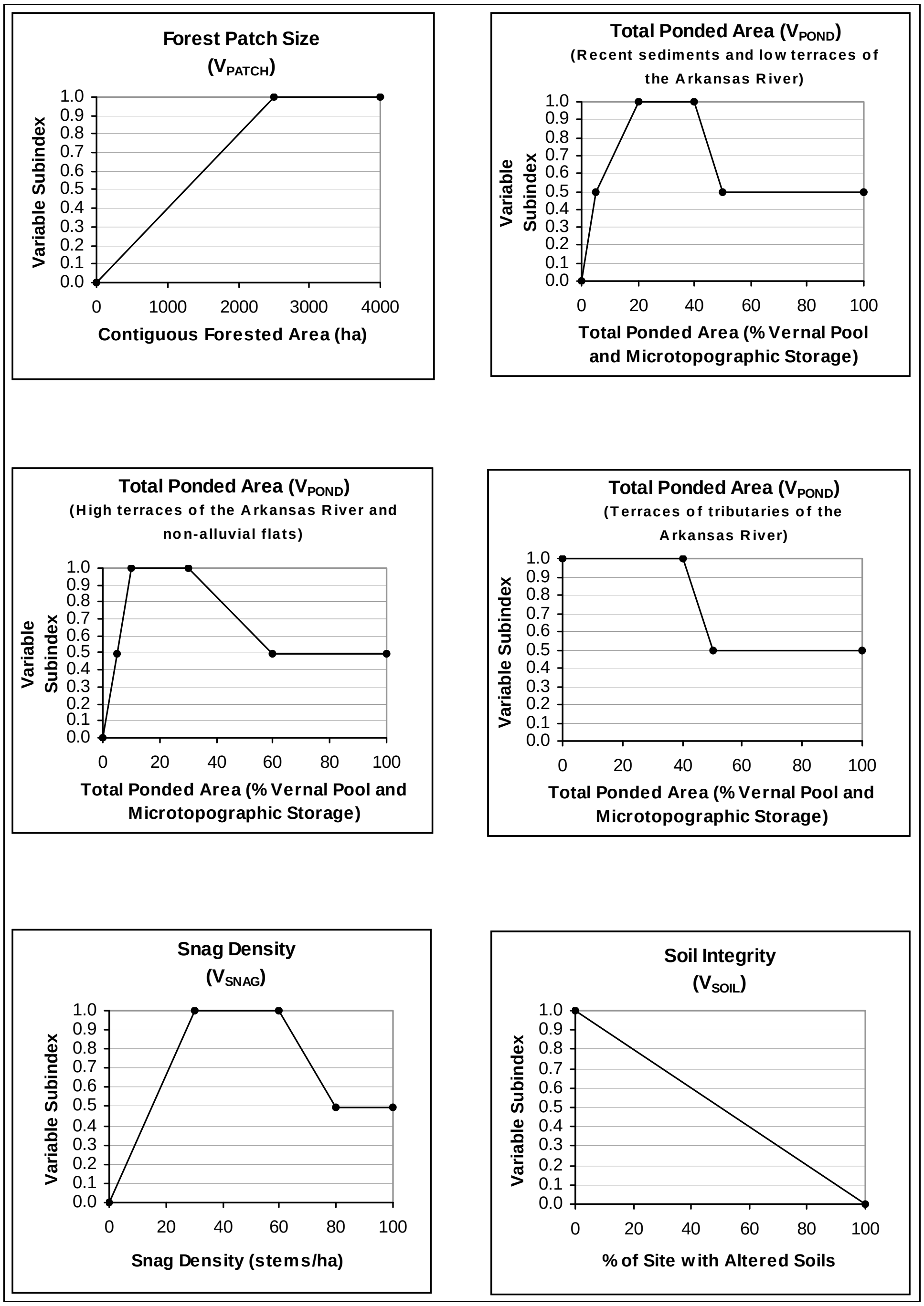

Figure 14. (Sheet 2 of 3)

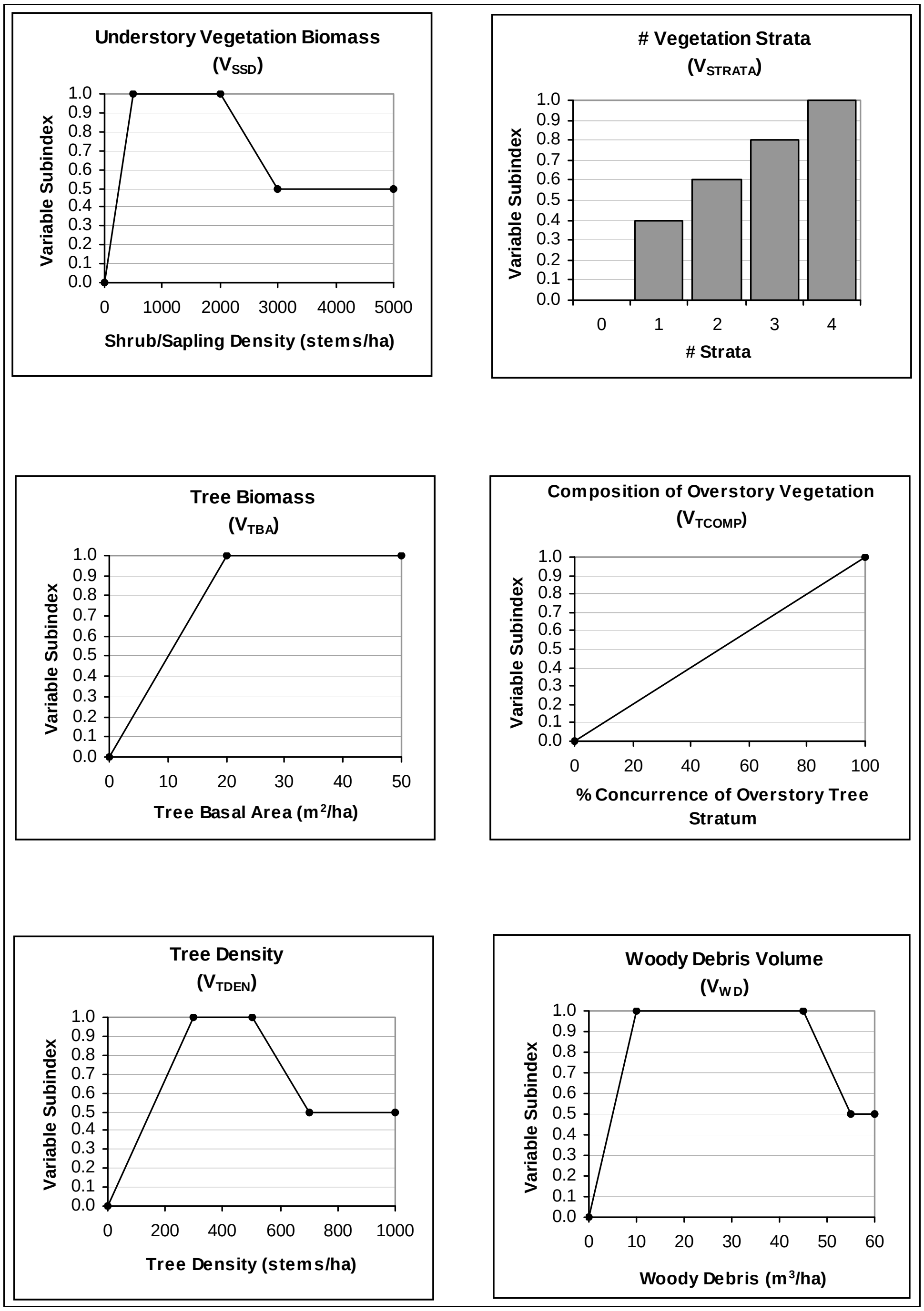

Figure 14. (Sheet 3 of 3)

Subclass: Mid-Gradient Riverine

All functions are assessed for this subclass using the general form of each assessment model presented in Chapter 4. Figure 15 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. Detain Floodwater

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

b. Detain Precipitation

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

c. Cycle Nutrients

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

d. Export Organic Carbon

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

e. Maintain Plant Communities

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

f. Provide Habitat for Fish and Wildlife

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

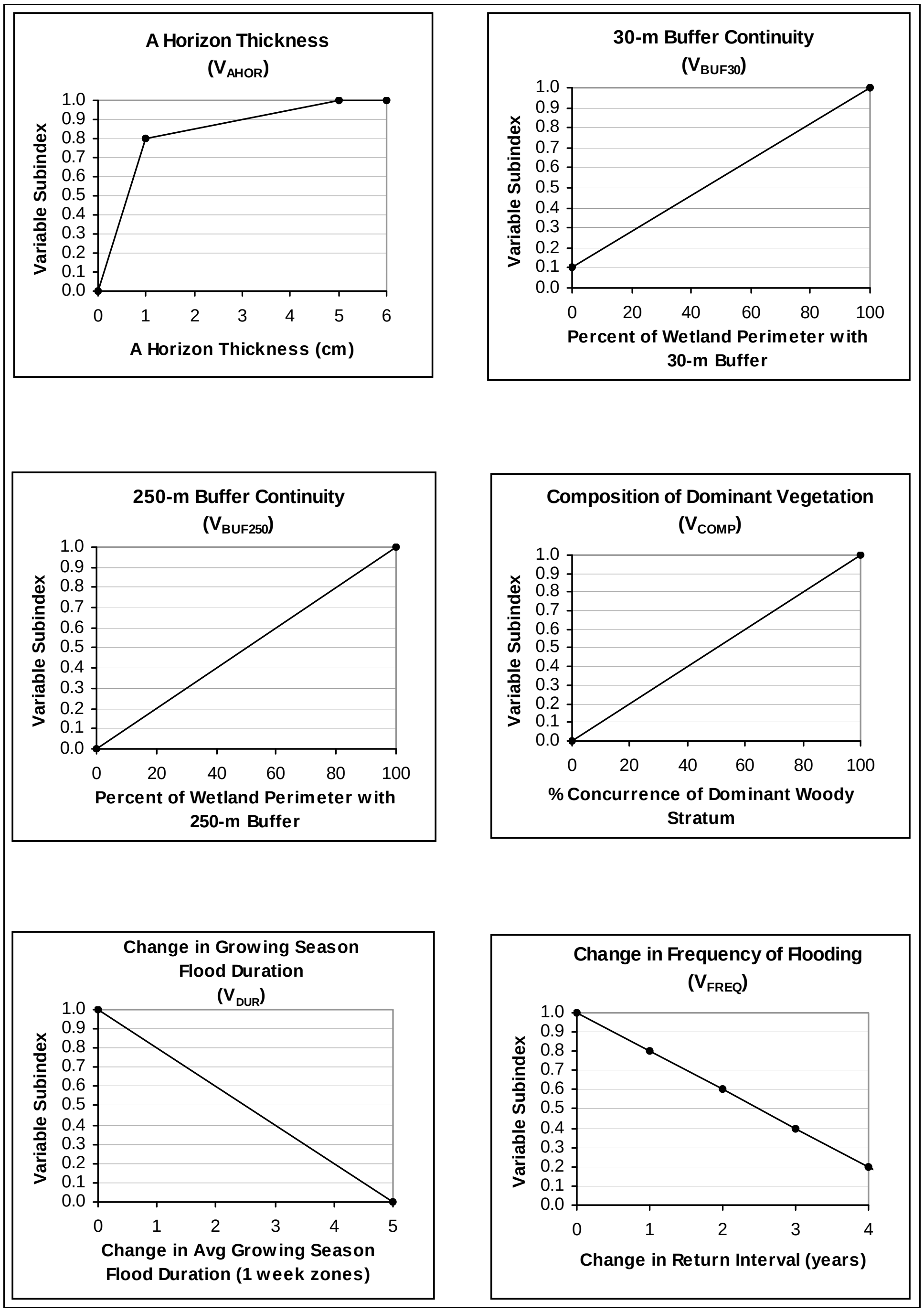

Figure 15. Subindex curves for Mid-gradient Riverine wetlands (Sheet 1 of 4)

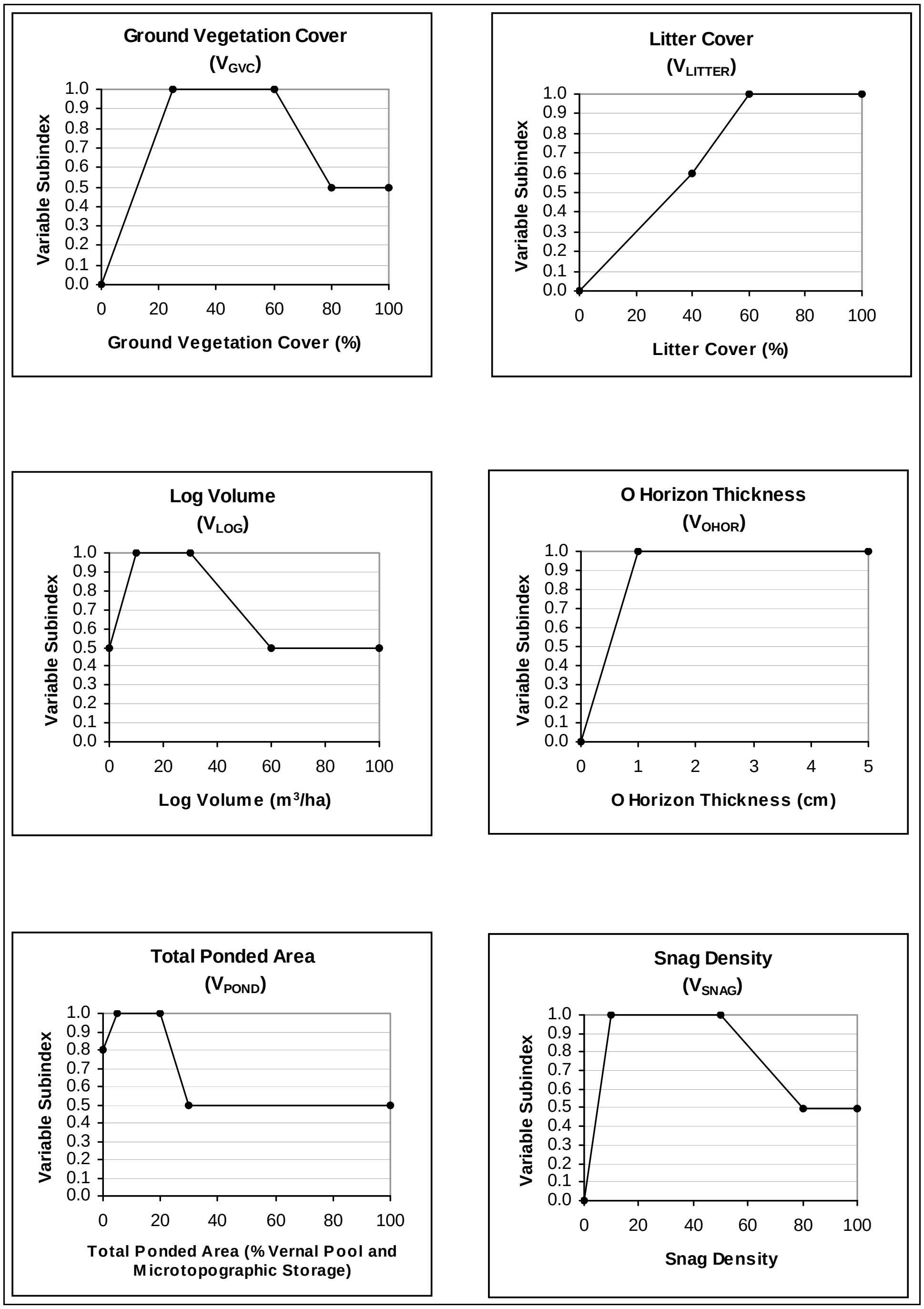

Figure 15. (Sheet 2 of 4)

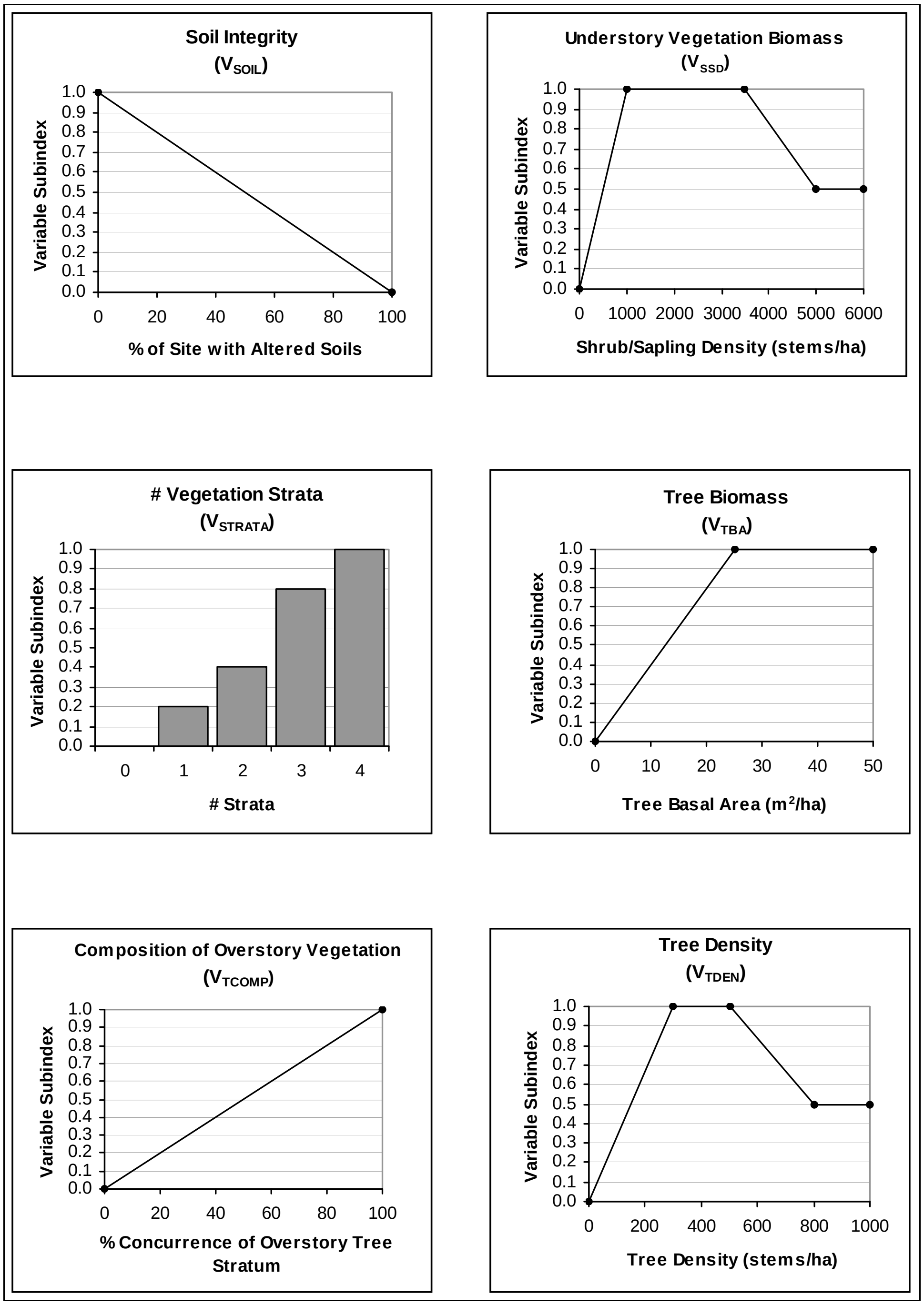

Figure 15. (Sheet 3 of 4)

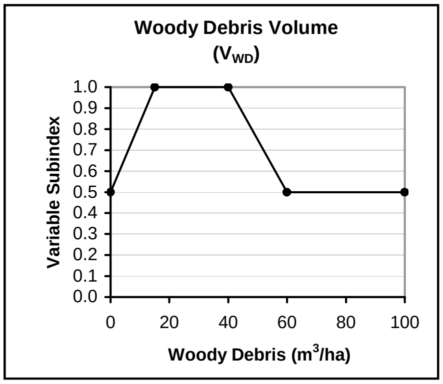

Figure 15. (Sheet 4 of 4)

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 16 provides the relationship between the variable metrics and the subindex for each of the assessment variables based on the riverine overbank reference data.

a. *Detain Floodwater*.

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

b. *Detain Precipitation.*

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

c. *Cycle Nutrients.*

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

d. *Export Organic Carbon.*

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

e. Maintain Plant Communities.

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

f. Provide Habitat for Fish and Wildlife.

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

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 17 provides the relationship between the variable metrics and the subindex for each of the assessment variables based on the riverine backwater reference data.

a. Detain Floodwater.

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

b. Detain Precipitation.

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

c. Cycle Nutrients.

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

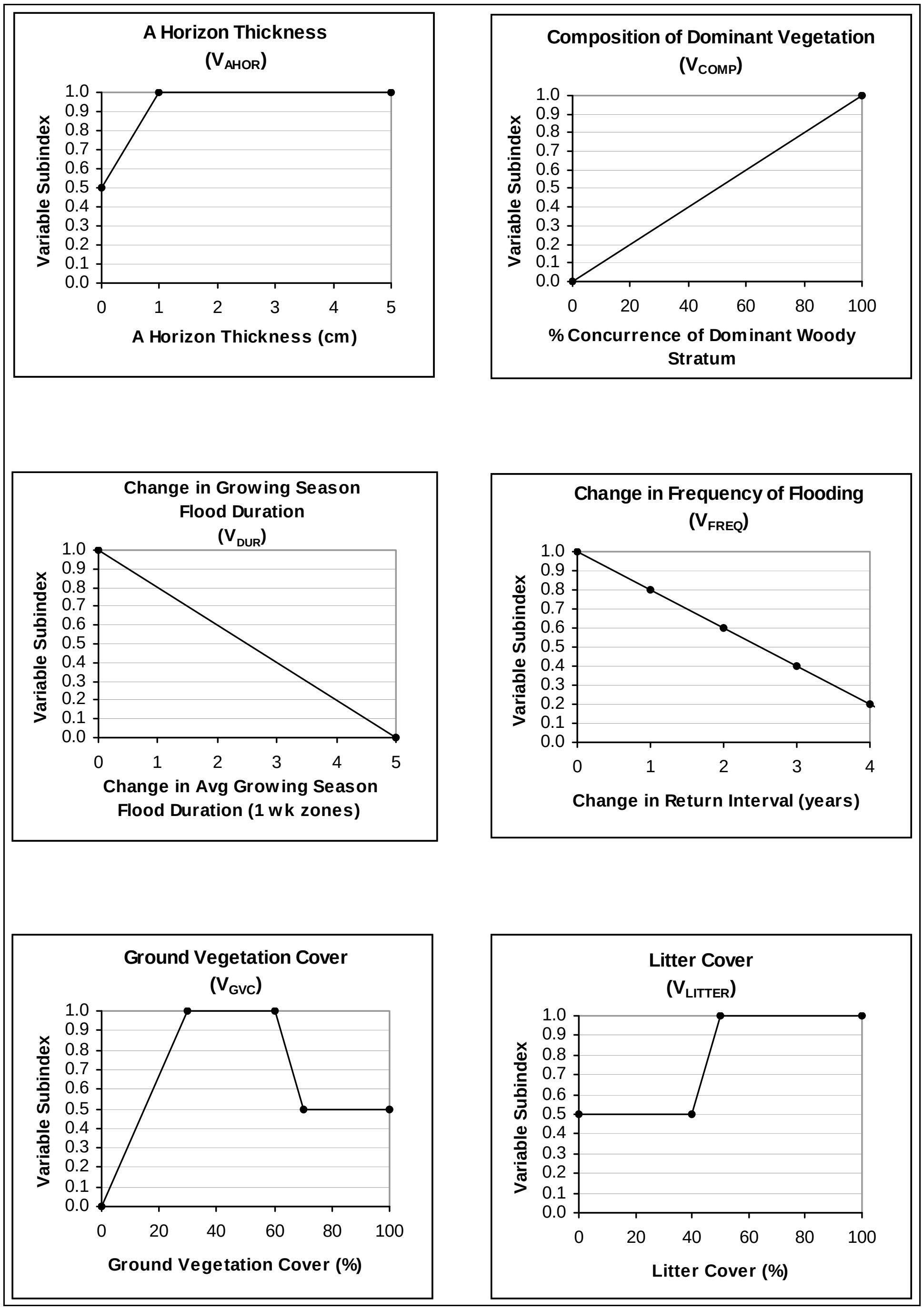

Figure 16. Subindex graphs for Low-Gradient Riverine Overbank wetlands (Sheet 1 of 3)

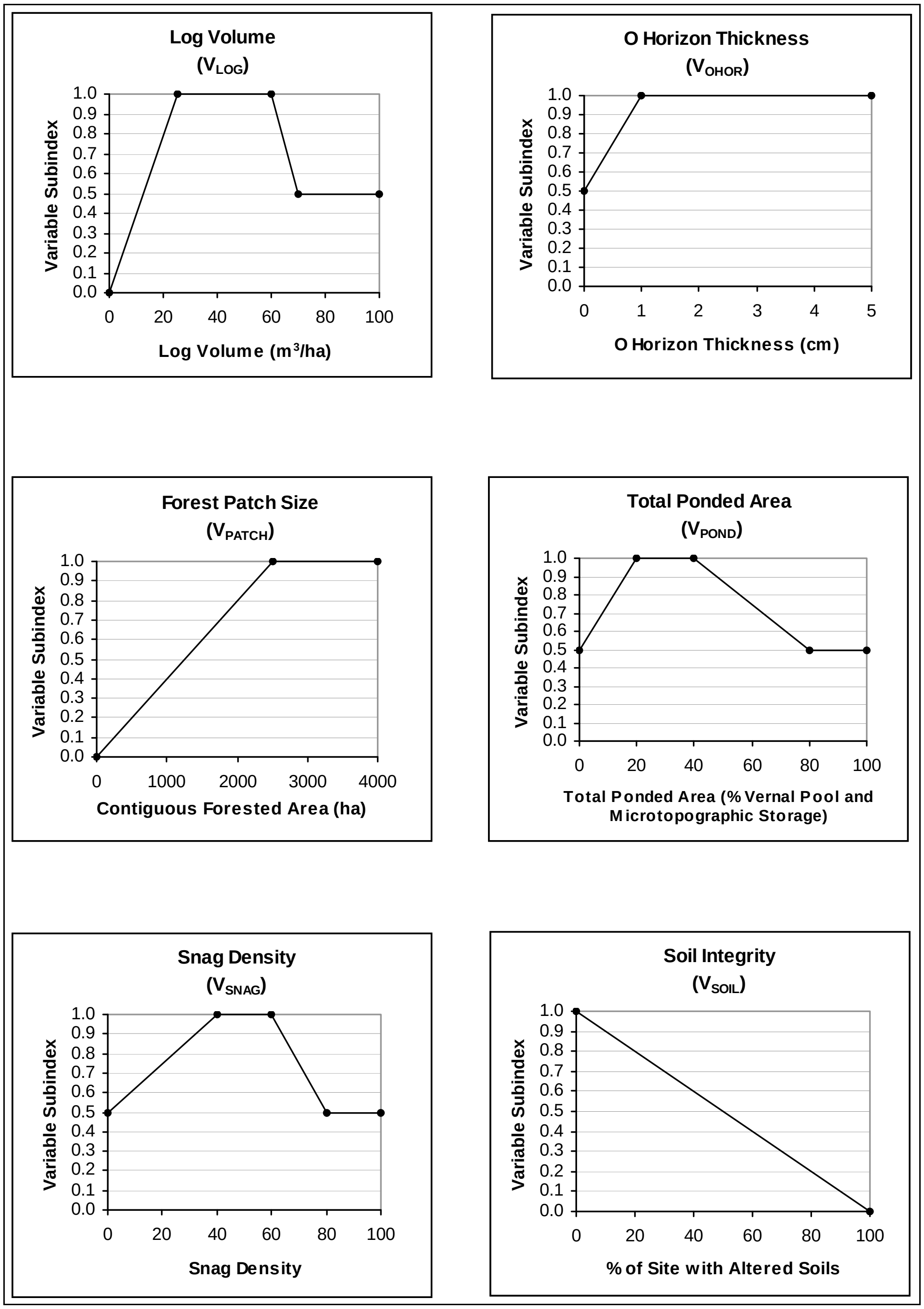

Figure 16. (Sheet 2 of 3)

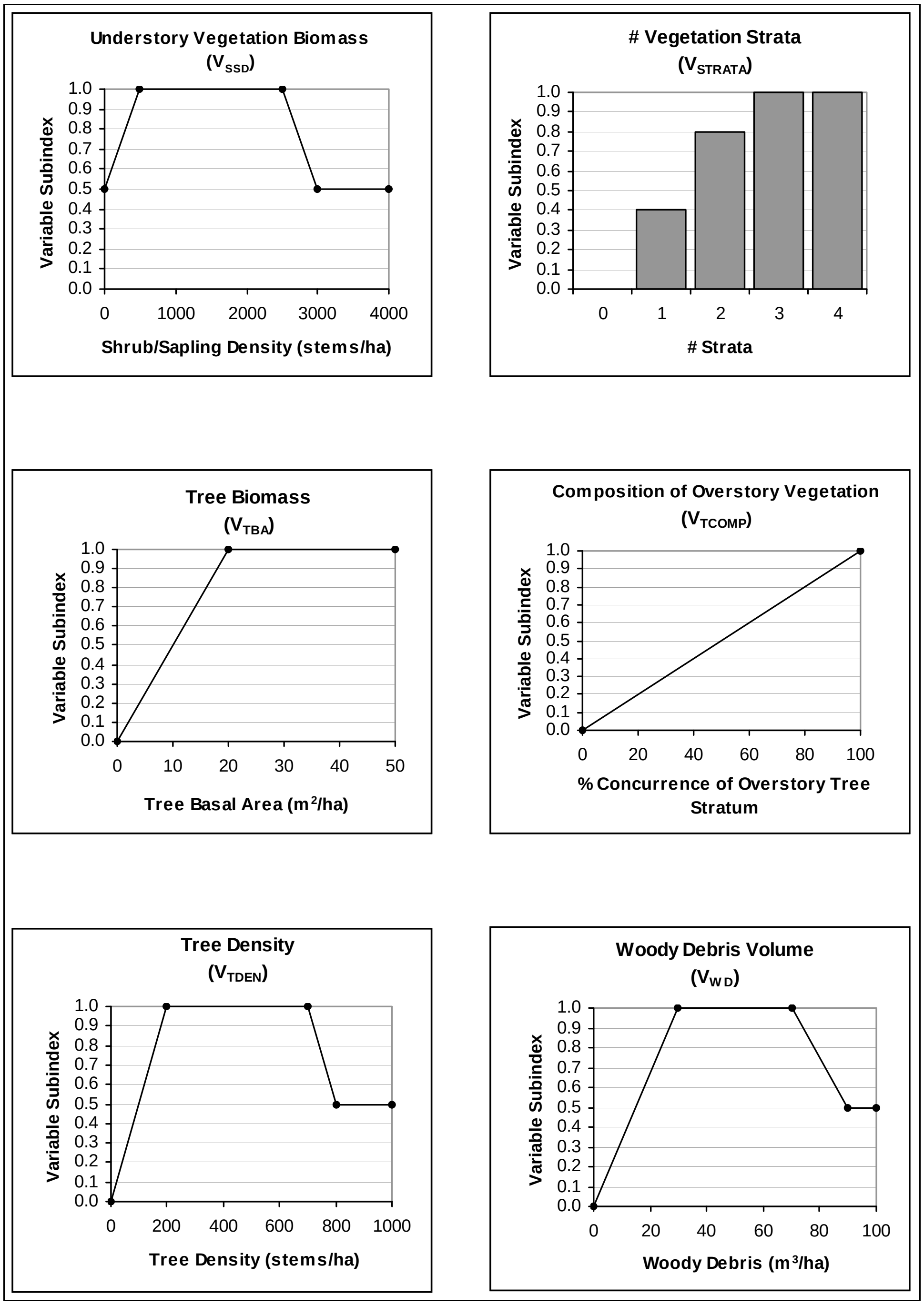

Figure 16. (Sheet 3 of 3)

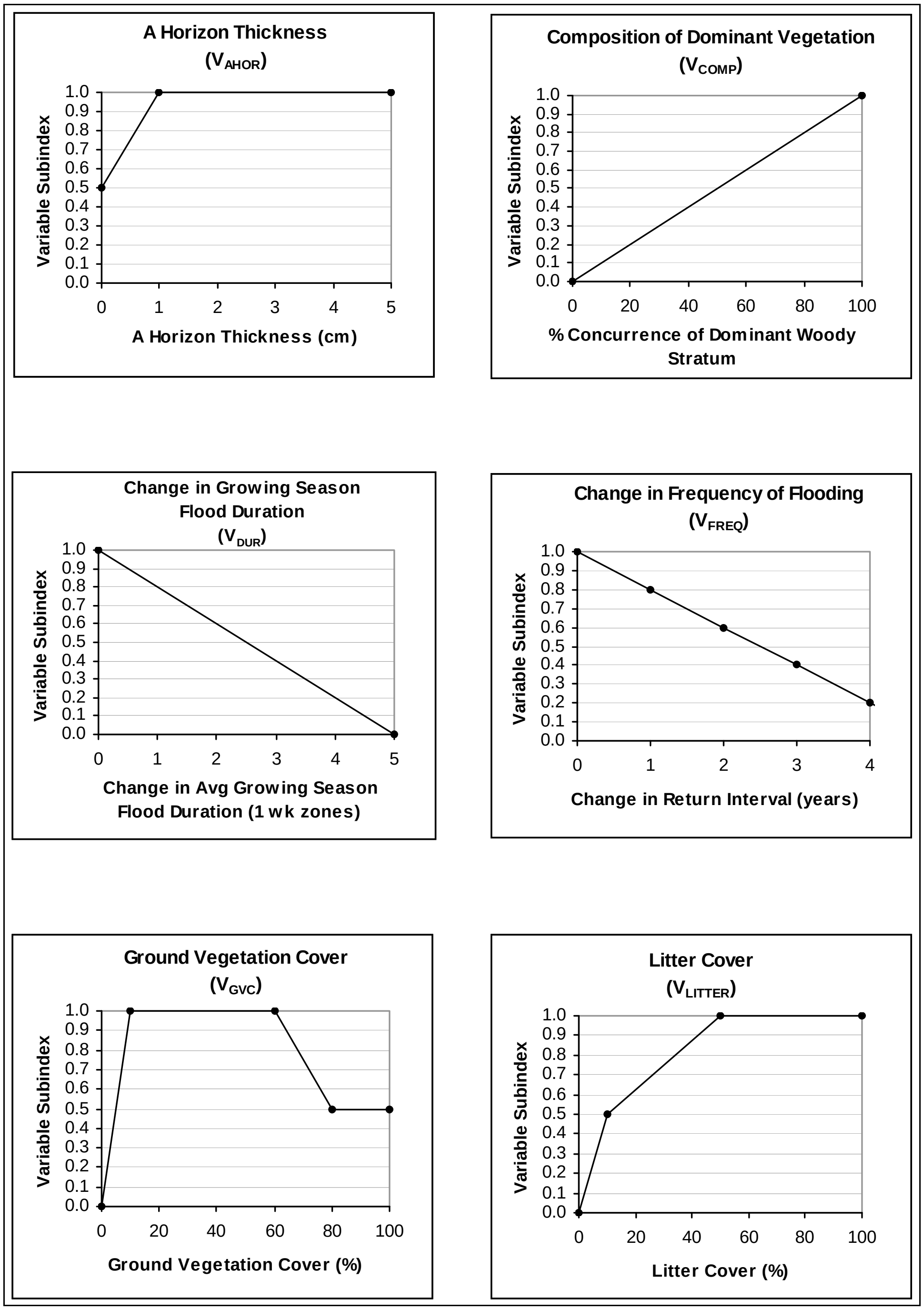

Figure 17. Subindex graphs for Low-Gradient Riverine Backwater wetlands (Sheet 1 of 3)

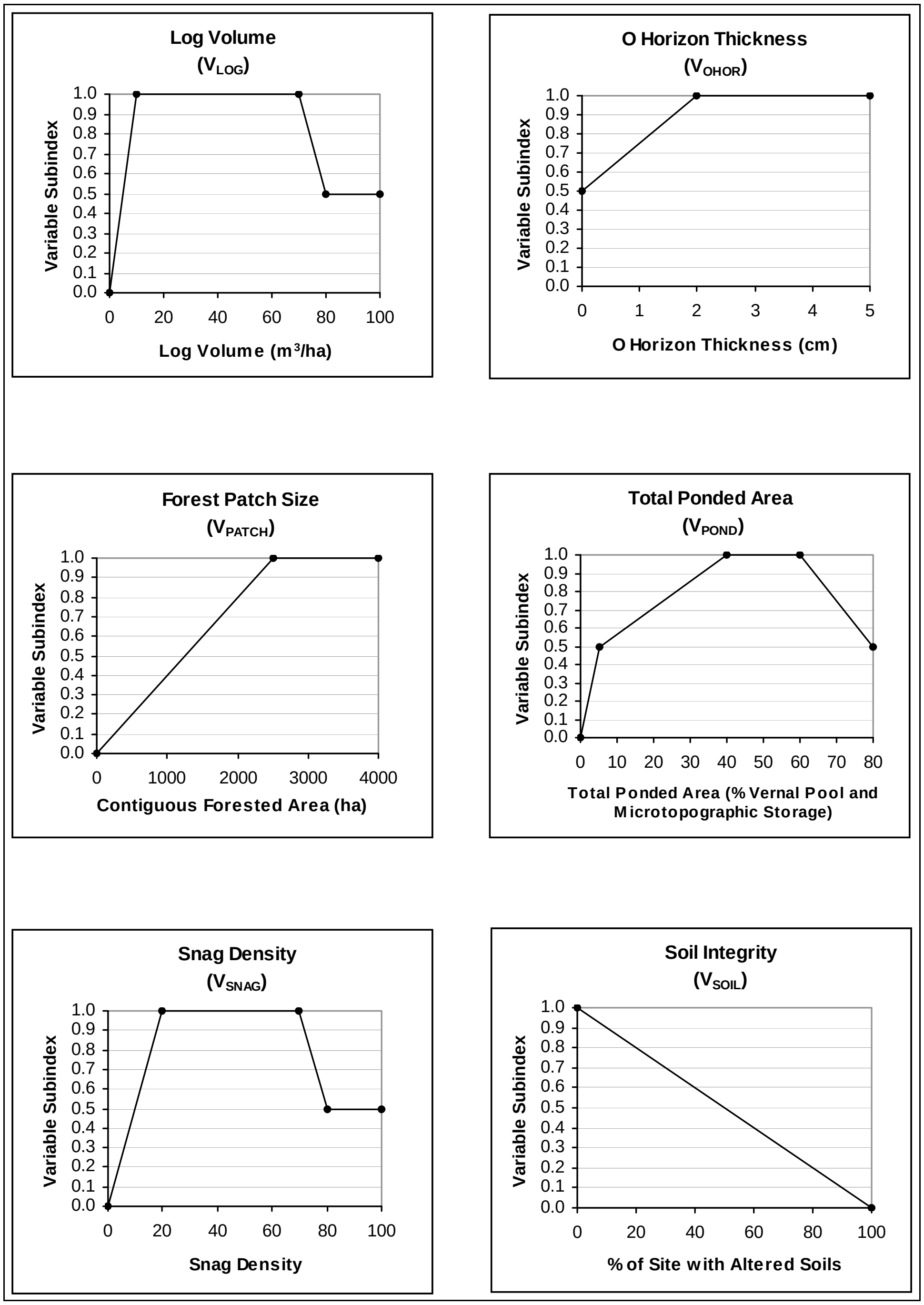

Figure 17. (Sheet 2 of 3)

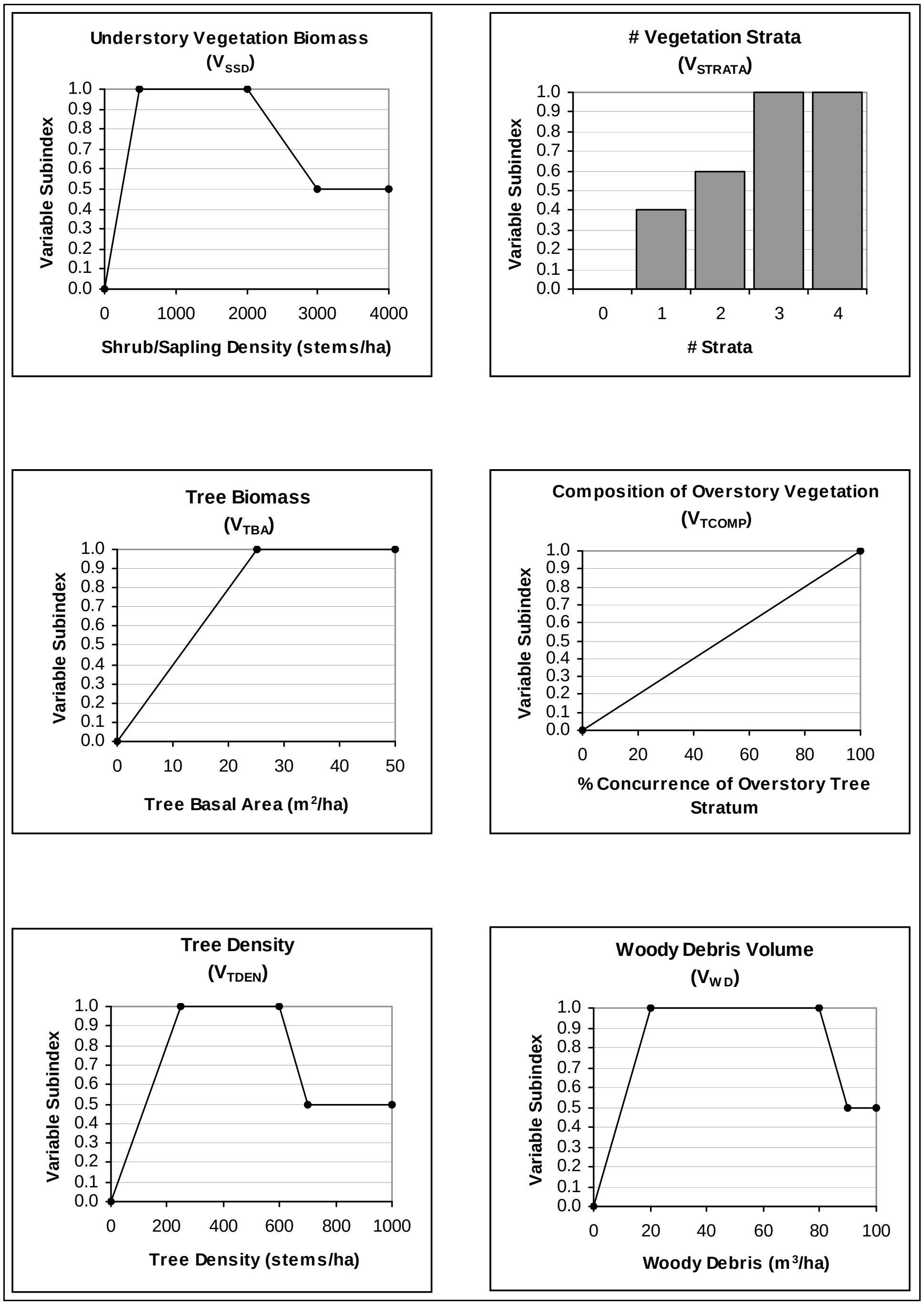

Figure 17. (Sheet 3 of 3)

d. *Export Organic Carbon.*

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

e. *Maintain Plant Communities.*

$$FCI = \left(\left\{ \frac{\left[\frac{(V_{TBA} + V_{TDEN})}{2} + V_{COMP}\right]}{2} \right\} \times \left[\frac{(V_{SOIL} + V_{DUR} + V_{POND})}{3} \right] \right)^{1/2} \quad (28)$$

f. *Provide Habitat for Fish and Wildlife*

$$FCI = \left\{ \left[\frac{(V_{FREQ} + V_{DUR} + V_{POND})}{3}\right] \times \left[\frac{(V_{TCOMP} + V_{STRATA} + V_{SNAG} + V_{TBA})}{4}\right] \times \left[\frac{(V_{LOG} + V_{OHOR})}{2}\right] \times V_{PATCH} \right\}^{1/4} \quad (29)$$

Subclass: Unconnected Depression

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

a. *Detain Floodwater*. Not assessed.

b. *Detain Precipitation*. Not assessed.

c. *Cycle Nutrients.*

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

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

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

d. *Export Organic Carbon*. Not assessed.

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

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

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

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

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

$$FCI = \left\{ \left[\frac{(V_{T\,COMP} + V_{STRATA} + V_{SNAG} + V_{TBA})}{4} \right] \times \left[\frac{(V_{LOG} + V_{OHOR})}{2} \right] \times \left[\frac{(V_{BUF\,30} + V_{BUF\,250})}{2} \right] \right\}^{1/3} \tag{34}$$

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

$$FCI = \left\{ \left[\frac{(V_{T\,COMP} + V_{STRATA} + V_{SNAG} + V_{TBA})}{4} \right] \times \left[\frac{(V_{BUF\,30} + V_{BUF\,250})}{2} \right] \right\}^{1/2} \tag{35}$$

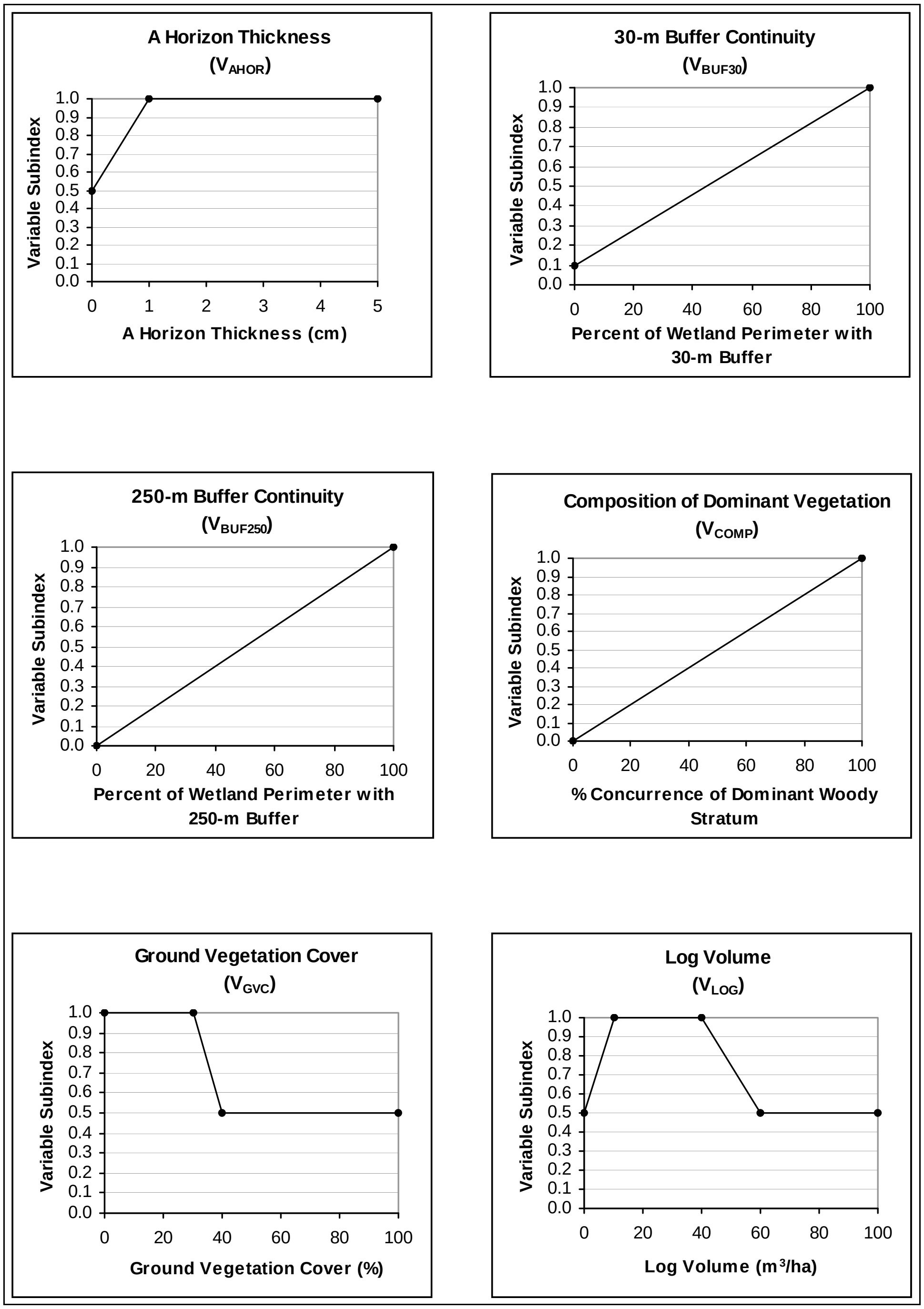

Figure 18. Subindex graphs for Unconnected Depression wetlands (Sheet 1 of 3)

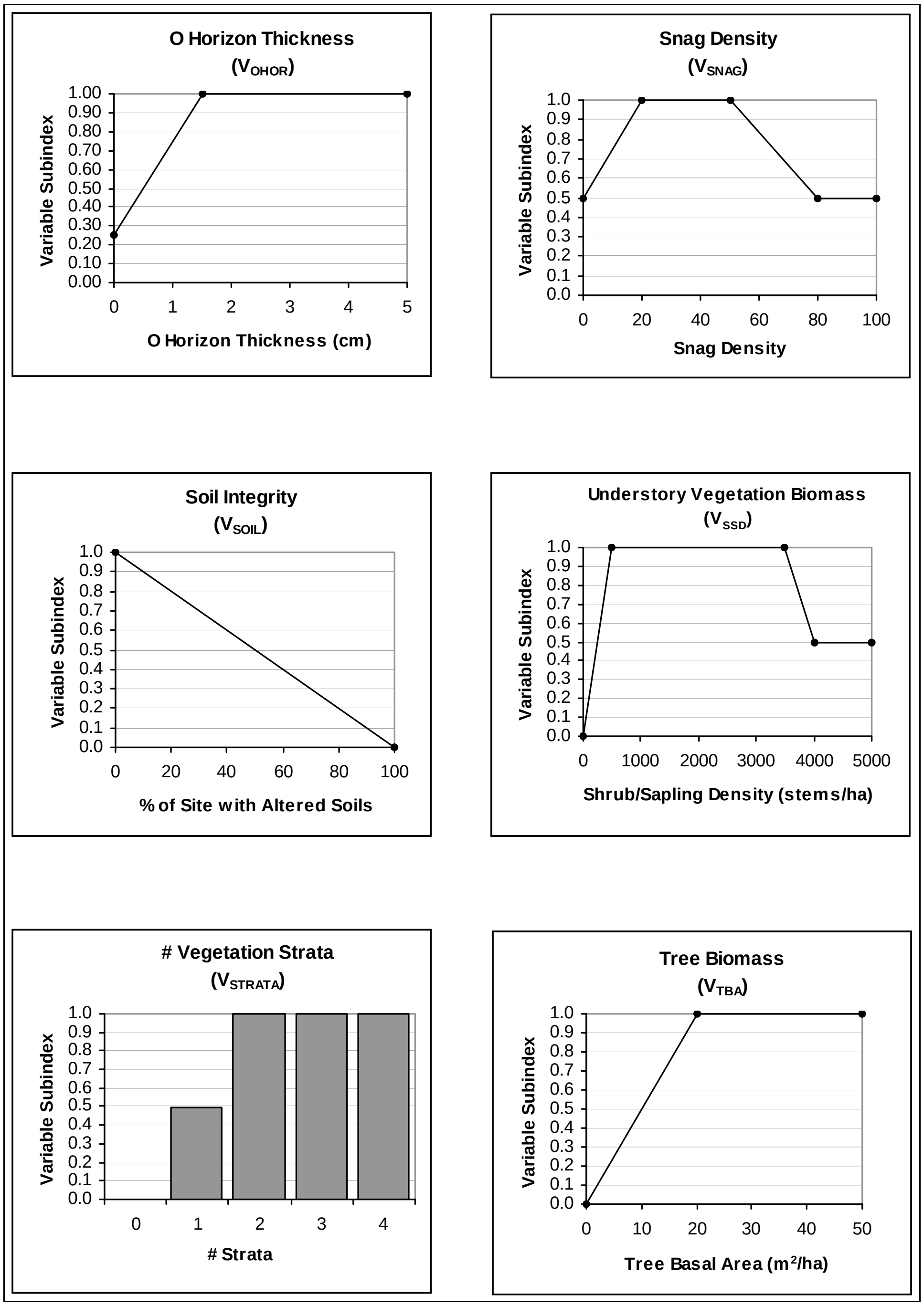

Figure 18. (Sheet 2 of 3)

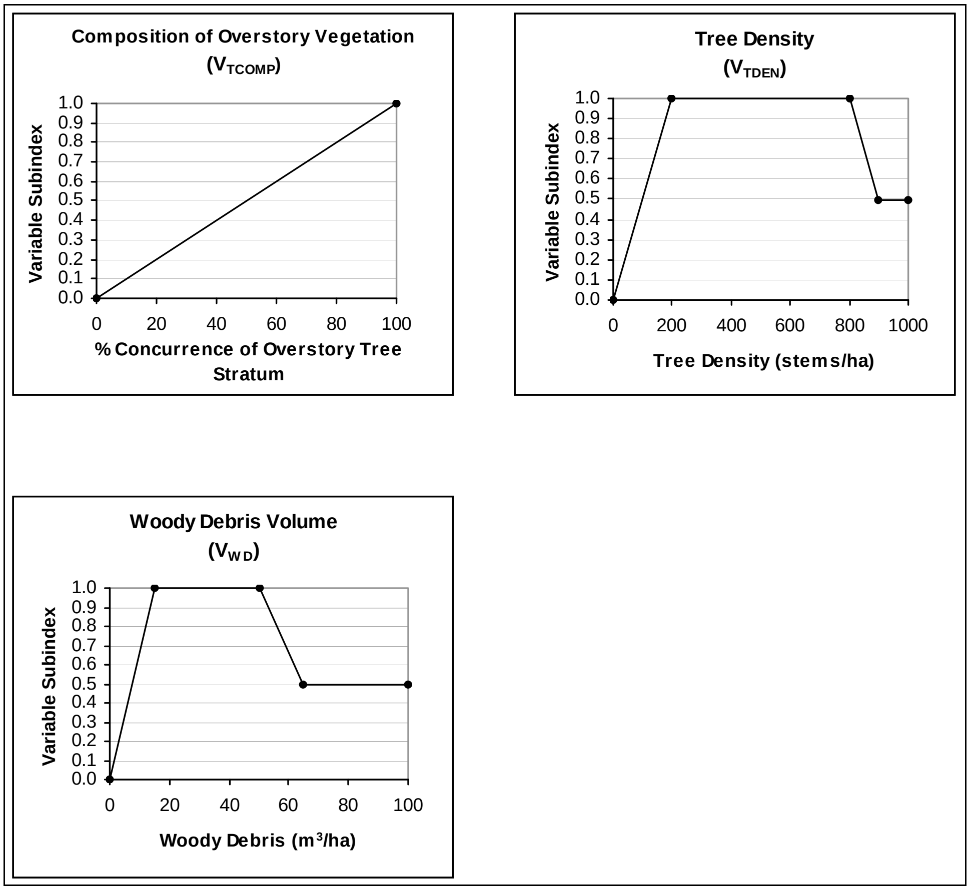

Figure 18. (Sheet 3 of 3)

Subclass: Connected Depression

Five functions are assessed for this subclass as follows. Some of the models have been modified from the general model form presented in Chapter 4. Figure 19 provides the relationship between the variable metrics and the sub-index for each of the assessment variables based on the connected depression reference data.

a. Detain Floodwater.

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

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

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

b. *Detain Precipitation*. Not assessed.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

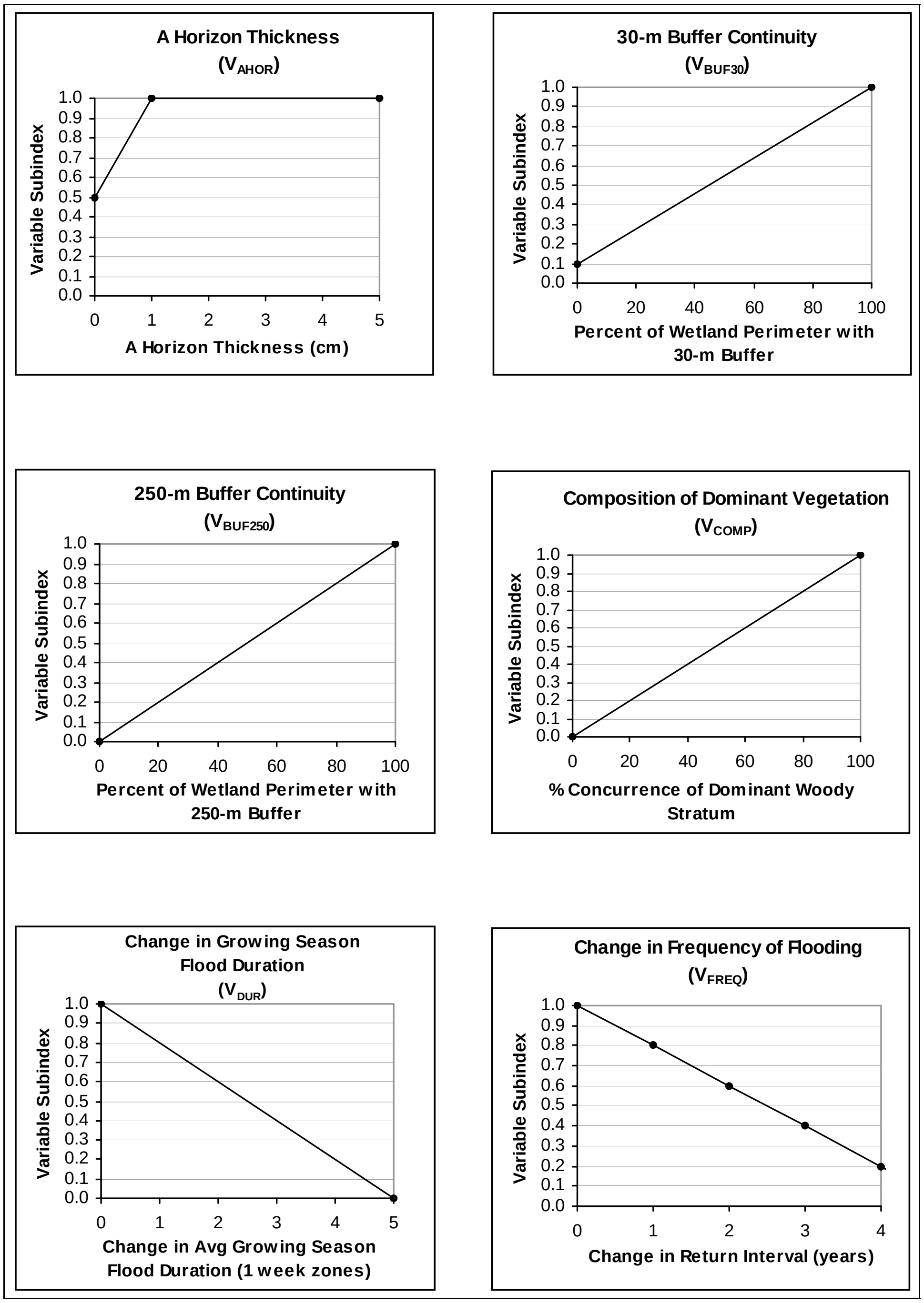

Figure 19. Subindex graphs for Connected Depression wetlands (Sheet 1 of 3)

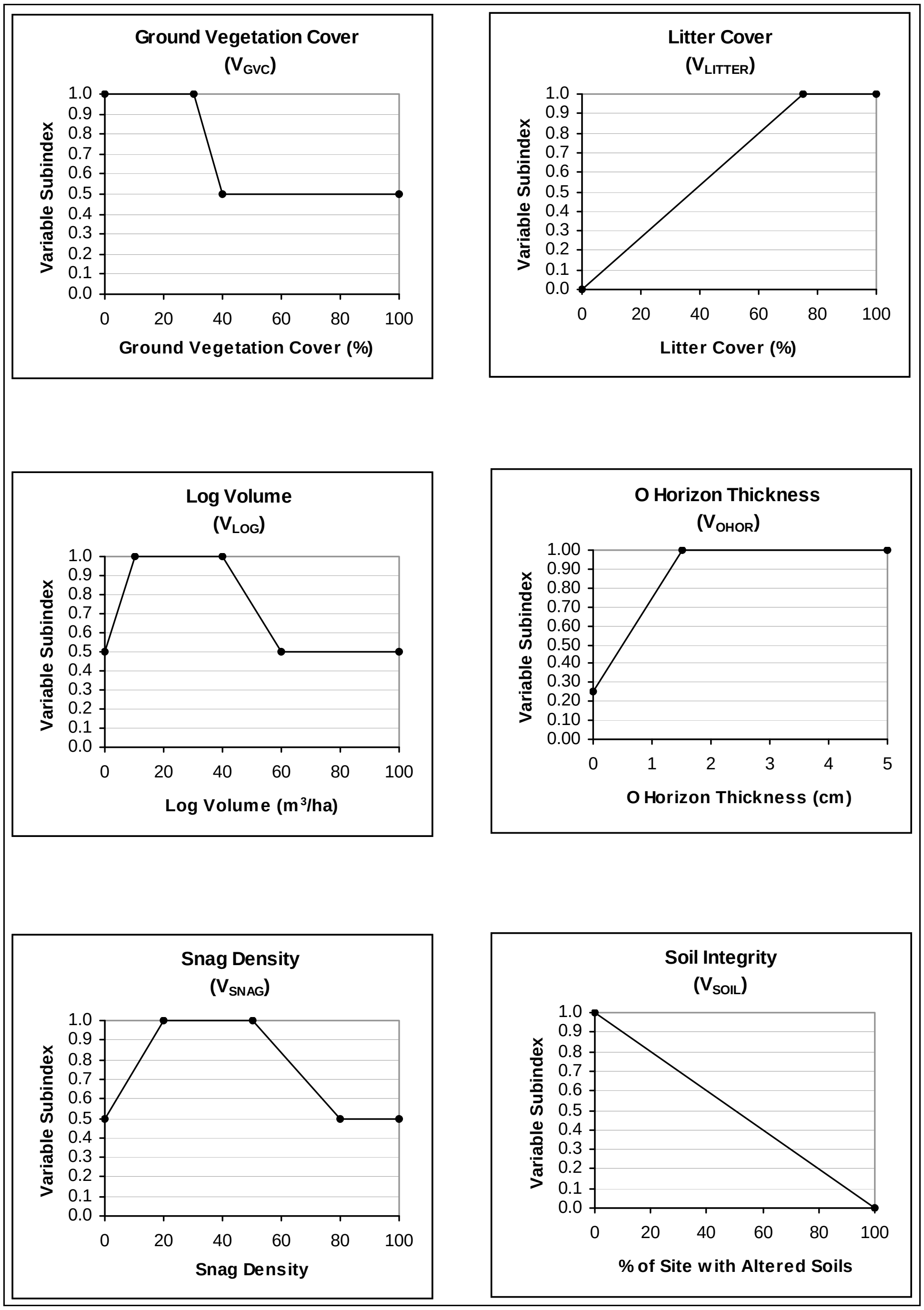

Figure 19. (Sheet 2 of 3)

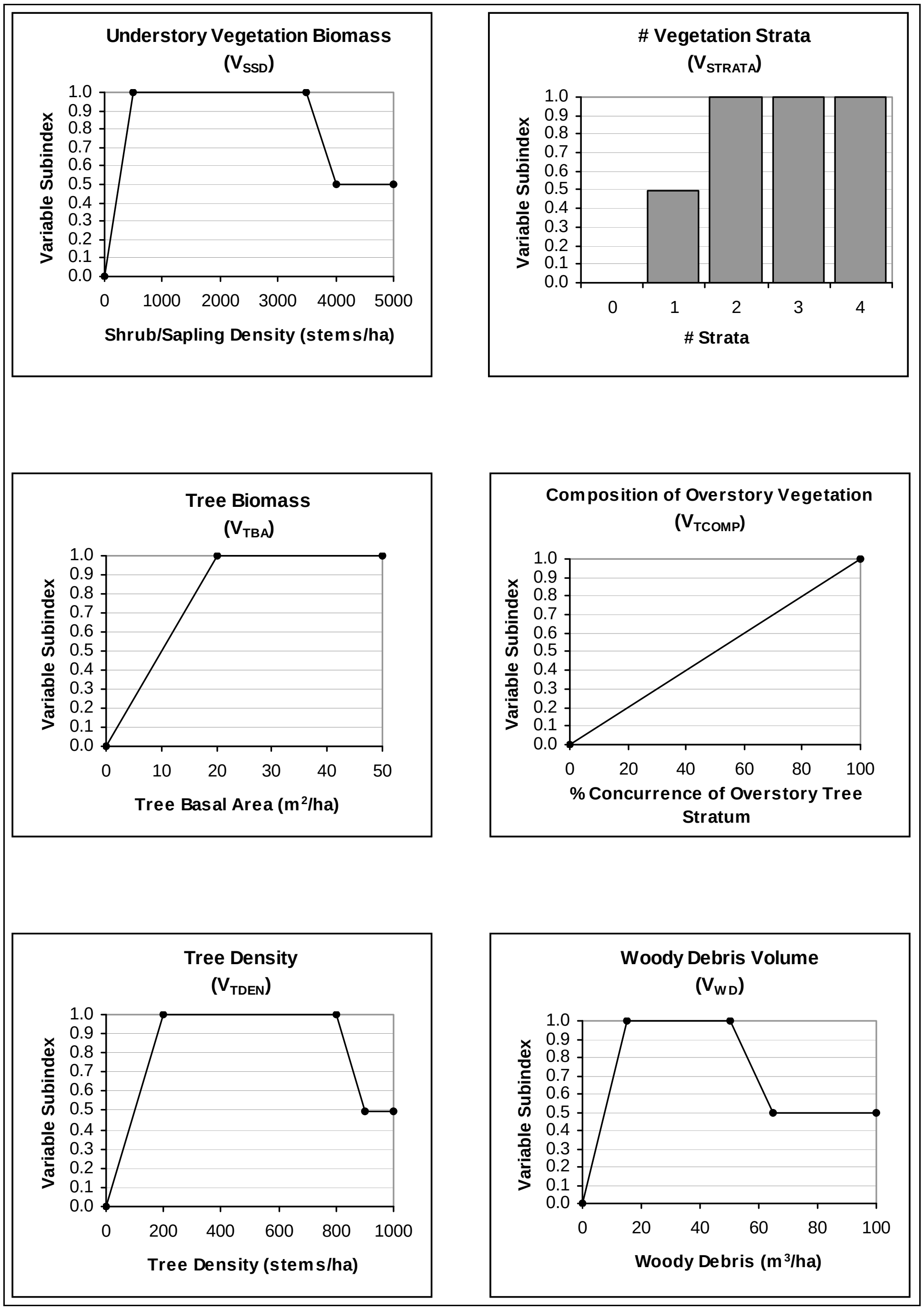

Figure 19. (Sheet 3 of 3)

6 Assessment Protocol

Introduction

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

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

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

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

- Document the project purpose and characteristics.
- Screen for red flags.
- Define assessment objectives and identify regional wetland subclass(es) present and assessment area boundaries.
- Collect field data.
- Analyze field data.
- Document assessment results.
- Apply assessment results.

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

Document the Project Purpose and Characteristics

Data Form A1 (Site or Project Information and Assessment 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 and identification of personnel involved in the assessment. Supporting information and documentation are to be attached to this form. 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 (WAA) (to be discussed later in this chapter), proposed impacts, roads, ditches, buildings, streams, soil types, plant communities, threatened or endangered species habitats, and other important features.

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

- Aerial photographs.
- Topographic maps.
- Geomorphic maps.
- County soil survey.
- National Wetland Inventory maps.
- Flood frequency maps.
- Chapter 3 of this Regional Guidebook.

For large projects or complex landscapes, it is usually a good idea to use aerial photos, flood maps, and geomorphic information to develop a preliminary classification of wetlands for the project area and vicinity prior to going to the field. Figure 20 illustrates this process for a typical lowland wetland complex. The rough wetland map can then be taken to the field to refine and revise the identification of wetland subclasses.

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

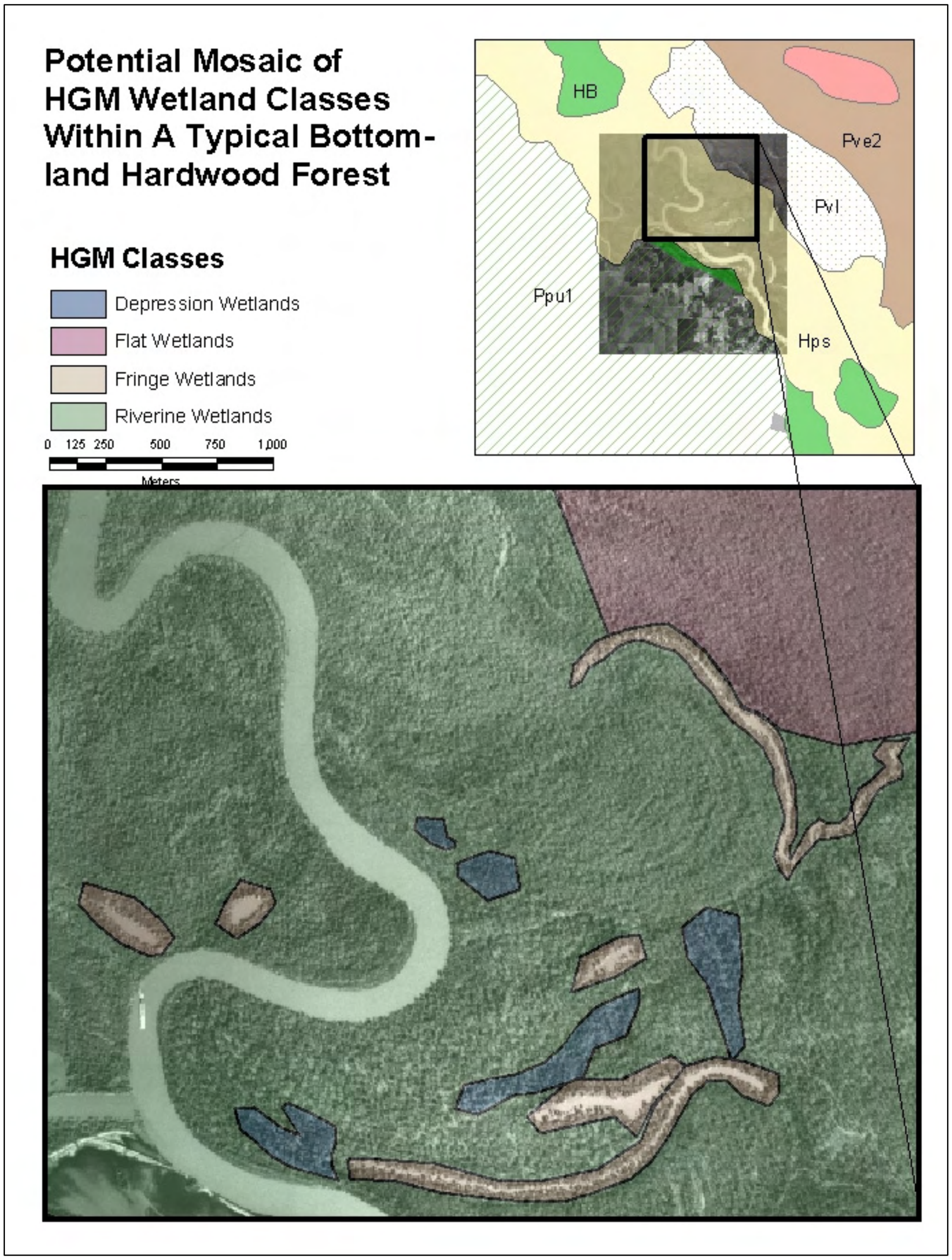

Figure 20. Example application of geomorphic mapping and aerial photography to develop a preliminary wetland classification for a proposed project area

Screen for Red Flags

Red flags are features in the vicinity of the project area to which special recognition or protection has been assigned on the basis of objective criteria (Table 5). Many red flag features, based on national criteria or programs, are similar from region to region. Other red flag features are based on regional or local criteria. Screening for red flag features determines if the wetlands or other natural resources around the project area require special consideration or attention that may preempt or postpone conducting a wetland assessment. For example, if a proposed project has the potential to adversely affect threatened or endangered species, an assessment may be unnecessary since the project may be denied or modified based on the impacts to the protected species alone.

Table 5
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 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) or Resource Conservation and Recovery Act (RCRA)	I
Areas providing Critical Habitat for Species of Special Concern	C
Areas covered under the Farmland Protection Act	K
Floodplains, floodways, or floodprone areas	J
Areas with structures/artifacts of historic or archeological significance	G
Areas protected under the Land and Water Conservation Fund Act	K
National Wildlife Refuges and special management areas	C
Areas identified in the North American Waterfowl Management Plan	C, F
Areas identified as significant under the Ramsar Treaty	H
Areas supporting rare or unique plant communities	C, H
Areas designated as Sole Source Groundwater Aquifers	I, L, M
Areas protected by the Safe Drinking Water Act	E, I, L
City, County, State, and National Parks	B, D, H, L
Areas supporting threatened or endangered species	C, F, H, I
Areas with unique geological features	H
Areas protected by the Wild and Scenic Rivers Act or Wilderness Act	D
State wetland mitigation banks	M

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

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

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

- Compare several wetlands as part of an alternatives analysis.
- Identify specific actions that can be taken to minimize project impacts.
- Document baseline conditions at a wetland site.
- Determine mitigation requirements.
- Determine mitigation success.
- 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 21 through 24 present a simplified project scenario to illustrate the steps used to designate the boundaries of WAAs, each of which will require a separate HGM assessment. Figure 21 illustrates a land cover map for a hypothetical project area. Figure 22 shows the project area (in yellow) superimposed on the land cover map. To determine the boundaries of the WAAs, first use the Key to Wetland Classes (Figure 11) and the wetland subclass descriptions (Table 4) to identify the wetland subclasses within and contiguous to the project area (Figure 23). Overlay the project area boundary and the wetland subclass boundaries to identify the WAAs for which data will be collected (Figure 24). Attach these maps, photos, and drawings to Data Form A1 and complete the first three columns of the table on Data Form A1 by assigning an identifying number to each WAA, specifying the subclass it belongs to, and calculating the area (ha).

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

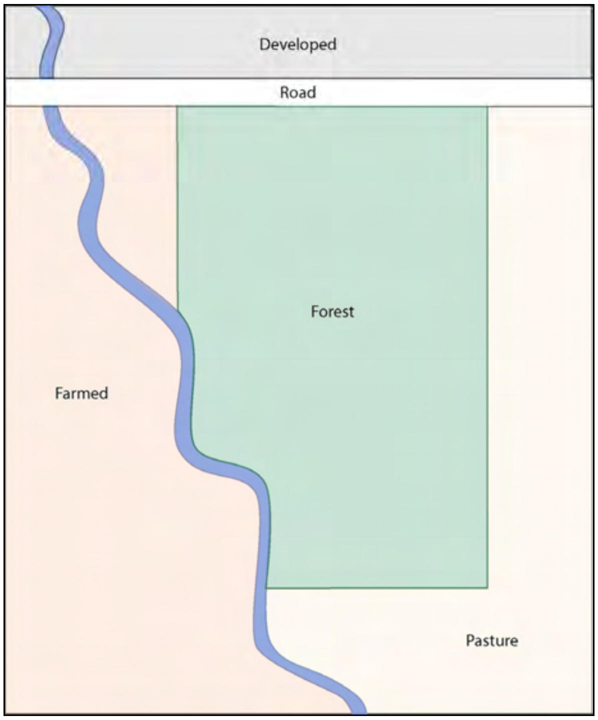

Figure 21. Land cover

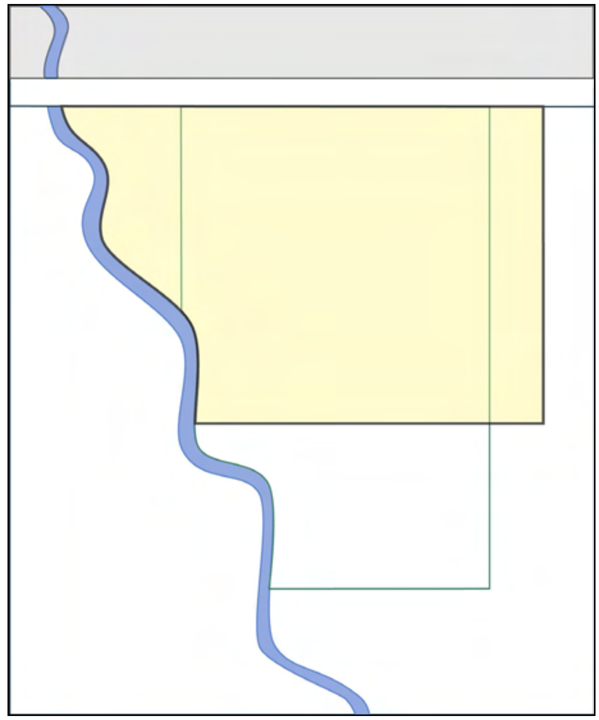

Figure 22. Project area (in yellow)

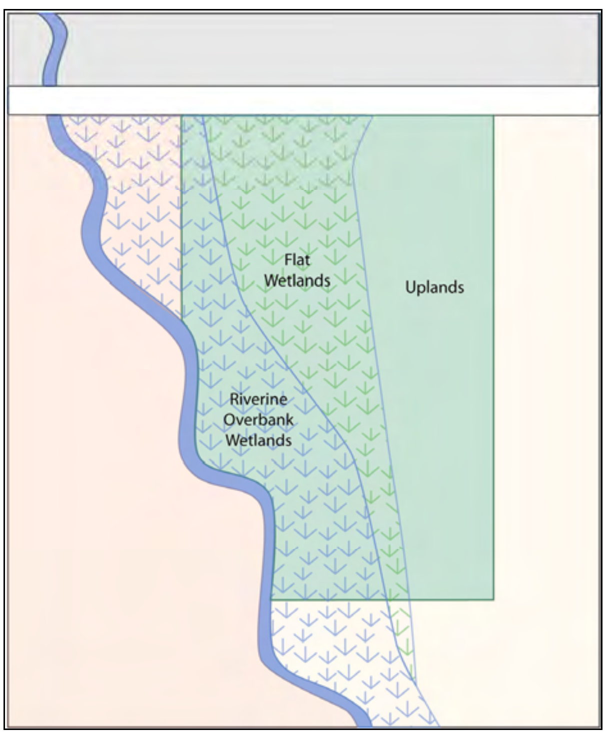

Figure 23. Wetland subclasses. Birds-foot symbols indicate extent of wetlands

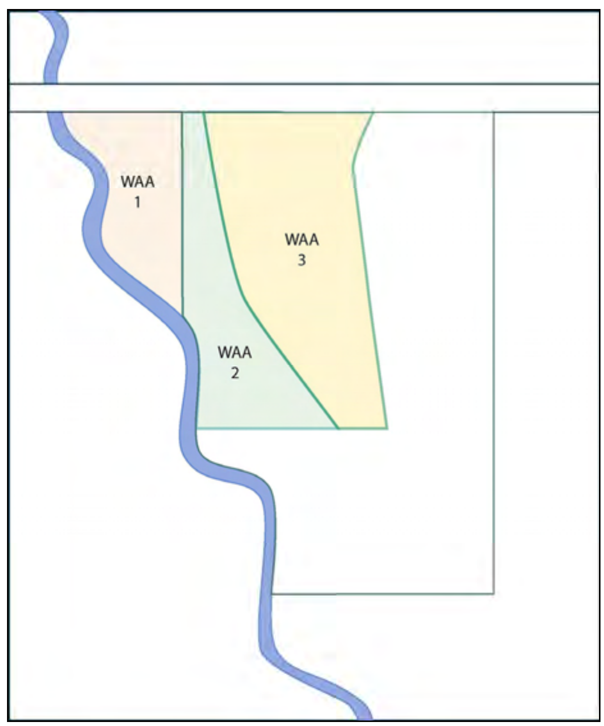

Figure 24. WAAs

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 noncontiguous wetlands must be designated as separate WAAs because the assessment process includes consideration of the size and isolation of individual wetland units. The second situation occurs where more than one regional wetland subclass occurs within a project area, as illustrated in Figure 23, 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 24, where the area designated as Riverine Overbank Wetlands in Figure 23 is further subdivided into two WAAs based on land use and vegetation cover. The farmed area clearly will have different characteristics from those of the forested wetland, and they will be assessed separately (though using the same models and reference data).

In the Arkansas Valley Region of Arkansas, the most common scenarios requiring designation of multiple WAAs 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, separate WAAs that are cleared land, early successional sites, and mature forests may be defined. However, one should be cautious about splitting a project area into many WAAs based on relatively minor differences, such as local variation due to canopy gaps and edge effects. The reference curves used in this document (Chapter 5) incorporate such variation, and splitting areas into numerous WAAs based on subtle differences will not materially change the outcome of the assessment. It will, however, greatly increase the sampling and analysis requirements. Field experience in the region should provide a sense of the range of variability that typically occurs, and is sufficient to make reasonable decisions in defining multiple WAAs.

Collect Field Data

Information on the variables used to assess the functions of regional wetland subclasses in the Arkansas Valley 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 previously, the Project Information 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 WAAs 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 6). Use the Data Forms checklist in Appendix A2 to determine how many of each form are needed, then make copies of the required forms, which are provided in Appendix B.

Table 6
Applicability of Assessment Variables by Regional Wetland Subclass

Variable Code	Flat	Mid-Gradient Riverine Floodplain	Low-Gradient Riverine Overbank	Low-Gradient Riverine Backwater	Unconnected Depression	Connected Depression
V_{AHOR}	+	+	+	+	*	*
V_{BUF30}	not used	+	not used	not used	+	+
V_{BUF250}	not used	+	not used	not used	+	+
V_{COMP}	+	+	+	+	+	+
V_{DUR}	not used	+	+	+	not used	+
V_{FREQ}	not used	+	+	+	not used	+
V_{GVC}	+	+	+	+	*	*
V_{LITTER}	+	+	+	+	not used	*
V_{LOG}	+	+	+	+	*	*
V_{OHOR}	+	+	+	+	*	*
V_{PATCH}	+	not used	+	+	not used	not used
V_{POND}	+	+	+	+	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 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.

The sampling procedures for conducting an assessment require few tools, but certain tapes, a shovel, specialized basal area estimation or measurement tools, reference materials, and an assortment of other items listed in Appendix A2 will be needed. Generally, all measurements should be taken in metric units (although non-SI equivalents are indicated for most sampling criteria such as plot sizes). Collecting data in non-SI 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 a non-SI 10-factor prism, which is an appropriate size for use in the forests of the Arkansas Valley Region. A conversion factor is built into the data form to make the needed adjustments to the recorded field data. The second instance involves use of a diameter tape for basal area measurement, which is an alternative approach to the prism method. Because non-SI diameter-breast-high (dbh) tapes are more widely available than SI tapes, the summarization spreadsheets provided in Appendix D are able to accept either non-SI or SI units as input data.

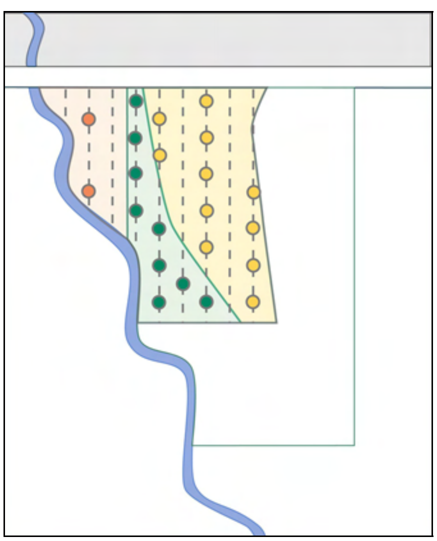

Figure 25. Example sample distribution. Refer to Figure 24 for WAA designations

A typical layout for the establishment of sample plots and transects in the hypothetical WAAs is shown in Figure 25. As in defining the WAA, there are elements of subjectivity and practicality in determining the number of sample locations for collecting plot-based and transect-based site-specific data. The exact numbers and locations of the plots and transects are dictated by the size and heterogeneity of the WAA. If the WAA is relatively small (i.e., less than 2–3 acres, or about a hectare) and homogeneous with respect to the characteristics and processes that influence wetland function, then three or four 0.04-ha plots, with associated nested transects and subplots in representative locations, are probably adequate to characterize the WAA. Experience has shown that the time required to complete an assessment of an area that size is 2–4 hours, depending primarily on the experience of the assessment team. However, as the size and heterogeneity of the WAA increase, more sample plots are required to represent the site accurately. 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 emphasize or exclude any of these local conditions differentially, but to represent the site as a whole. Therefore, on large sites the best approach often is a simple systematic plot layout, where evenly spaced parallel transects are established (using a compass and pacing) and sample plots are distributed at regular paced intervals along those transects. For example, a 12-ha tract, measuring about 345 m on each side, might be sampled using two transects spaced 100 m apart (and 50 m from the tract edge), with plots at 75-m intervals along each transect (starting 25 m from the tract edge). This would result in eight sampled plot locations, which should be adequate for a relatively diverse 12-ha forested wetland area. In Figure 25, 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 previously, and sample at intervals along alternate transects (see WAA 3 in Figure 25). 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 new dominant species no longer being encountered, and has the average basal area for the site changed markedly with the addition of recent samples? If not, there is probably no need to add further samples to the set. If overstory structure and composition variability remain high, then return to the alternate, unsampled transects and continue sampling until the data set is representative of the site as a whole, as indicated by a leveling off of the dominant species list and basal area values. Other variables may level off more quickly or slowly than tree composition and basal area; but these two factors are generally good indicators, and correspond well to the overall suite of characteristics of interest within a particular WAA. 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 25, this is illustrated by the sample distribution in WAA 1, which is a farmed area where few variables are likely to be measurable, or at least will vary little from plot to plot. In this case, every other plot location is sampled along every other transect.

The information on Data Form 1 (Appendix B) 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 FCI values and Functional Capacity Units (FCUs) 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 that follow. 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 follow. Where plot and point samples are required, refer to the plot layout diagram in Figure 26. 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 6, but the data forms in Appendix B indicate which variables are pertinent to each subclass. The data forms also provide brief summaries of the methods used to assess each variable, but the user should read through these more detailed descriptions and have them available in the field for reference as necessary.

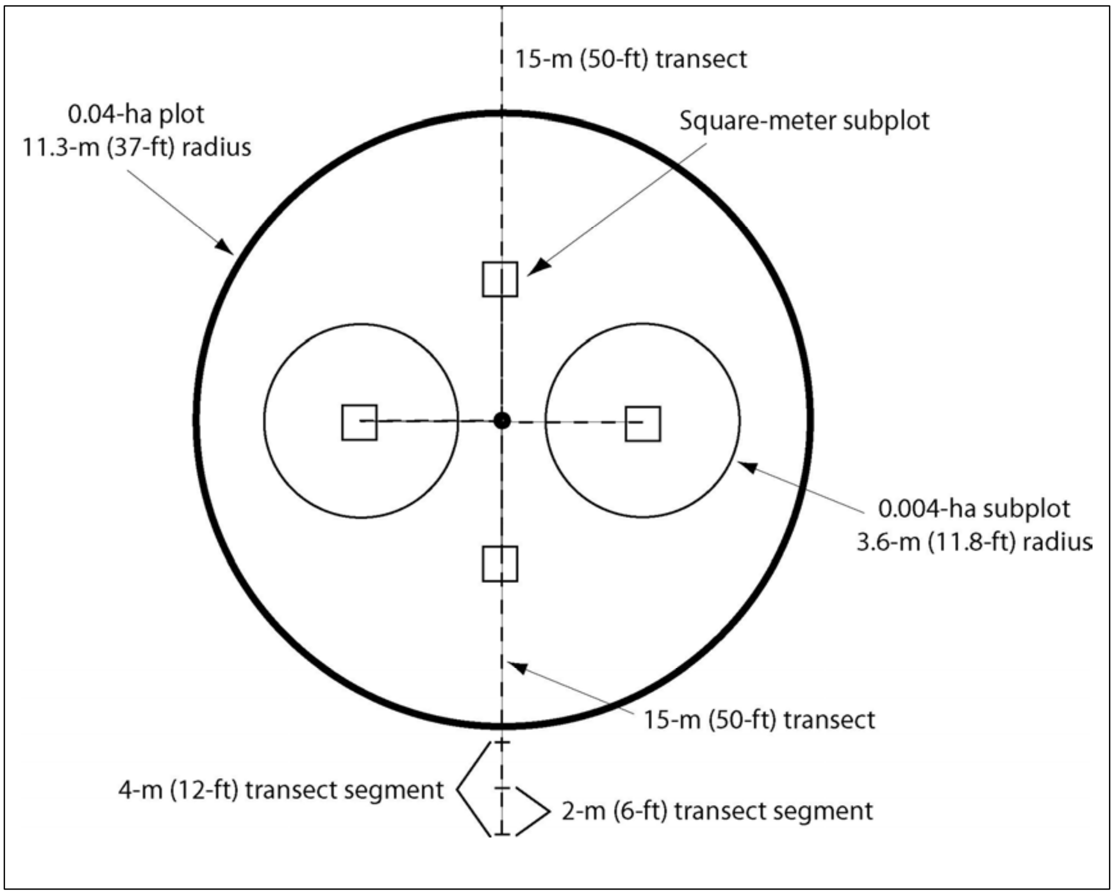

Figure 26. Layout of plots and transects for field sampling.

V_{AHOR} – A Horizon Organic Accumulation

This variable represents total mass of organic matter in the A soil horizon, 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 Soil Conservation Service 1993). In practice, the HGM models using this variable are concerned with the storage of organic matter, so for these 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 following procedure.

1. Establish sample points by selecting two or more locations within the 0.04-ha circular plot that are representative of the range of micro-topographic conditions in the plot, or select two or more of the four 1-m^2 subplots established for litter and ground cover estimation. Dig a hole (25 cm or 10 in. deep is usually adequate) and measure the thickness of the A horizon. Record measurements in centimeters on Data Form 2, and calculate the average value for the plot as indicated on that form.

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

V_{BUF30} – Percent of Perimeter Bounded by 30-m Buffer

This variable describes the percentage of the wetland perimeter bounded by a 30-m buffer that provides contiguous habitat with appropriate characteristics to meet the “general use” habitat needs (basking, feeding, limited nesting, and hibernation) of many reptiles and amphibians. Note that the buffer can consist of any community type that is usually “drier” than the depression 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 following discussion, the potential buffer area is assumed to completely surround wetlands in depressions. However, for wetlands along mid-gradient streams the variable is approached differently. The width and depth of mid-gradient streams are likely to represent a barrier to movement or exposure to predators for many of the species of greatest interest with regard to this variable. Therefore, for mid-gradient riverine wetlands, buffer widths are calculated for only that side of the stream where the wetland is present.

Determine the value of this metric using the following procedure, and refer to Figure 27 as needed.

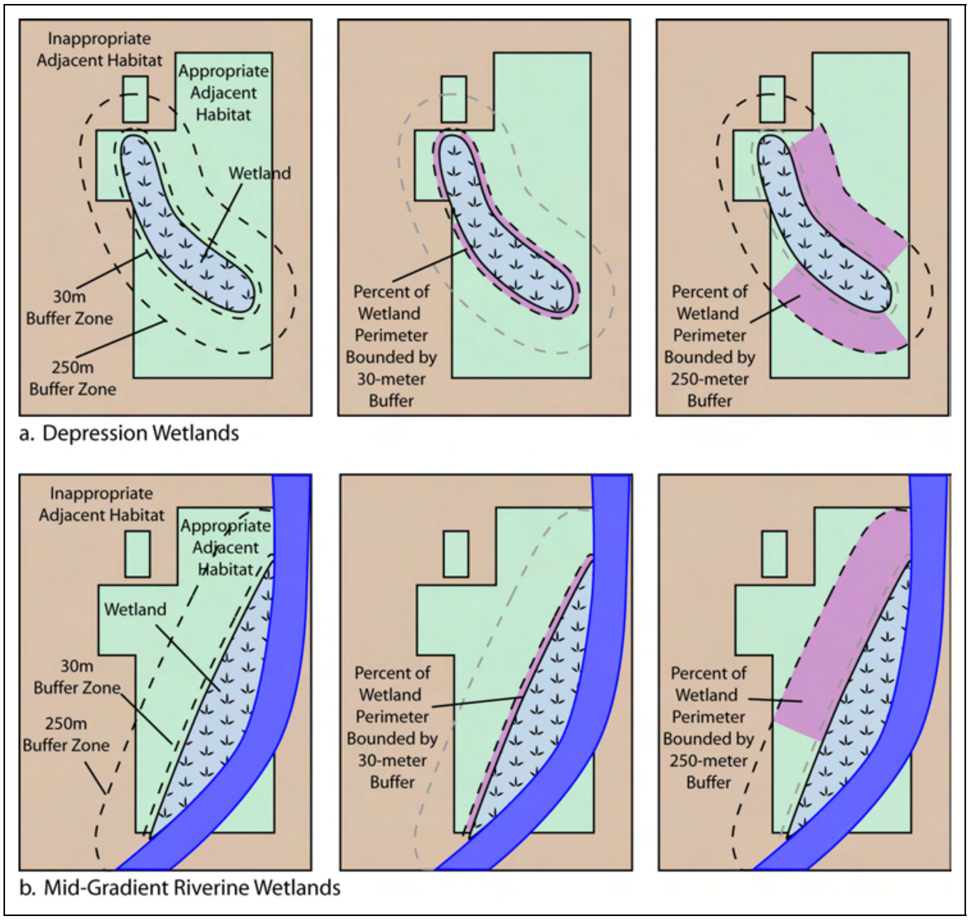

Figure 27. Measurement of buffer characteristics

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

2. Draw a second line 30 m outside the wetland boundary line. This defines the outer limit of the 30-m buffer zone (Figure 27a).

3. Identify and mark the boundaries of the appropriate habitats within the buffer zone. If the boundary of appropriate habitat intersects the boundary of the 30-m buffer, draw a line perpendicular to the wetland boundary to determine where along the perimeter the full 30-m buffer ends. Areas of appropriate habitat that are not contiguous with the wetland boundary will not be considered in this metric (Figure 27a).

4. Visually estimate the percentage of the wetland perimeter bounded by a full 30-m buffer. This is actually measured as a lineal percentage. Consider the wetland outline to be a clock face. In Figure 27a, the full 30-m buffer runs from roughly 12:15 to 9:30, and then again from 10:00 to 11:45 or 11/12 = 92 percent. Record that percentage on Data Form 1 in the box at the right-hand side of the V_{BUF30} row, and transfer the same number to the right-hand side of the V_{BUF30} row on Data Form 3.

5. For mid-gradient riverine wetlands, use the same approach, but restrict the procedure to the same side of the stream where the wetland occurs (Figure 27b). In the example shown in Figure 27b, the continuity of the 30-m buffer is 100 percent.

V_{BUF250} – Percent of Perimeter Bounded by 250-m Buffer

This variable describes the percentage of the wetland perimeter bounded by a 250-m buffer that provides contiguous habitat with appropriate characteristics to meet nesting, hibernation, and other habitat needs of a broad suite of reptiles and amphibians. Note that the buffer can consist of any community type that is usually drier than the depression 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 following discussion, the potential buffer area is assumed to completely surround wetlands in depressions. However, for wetlands along mid-gradient streams the variable is approached differently. The width and depth of mid-gradient streams are likely to represent a barrier to movement or exposure to predators for many of the species of greatest interest with regard to this variable. Therefore, for mid-gradient riverine wetlands, buffer widths are calculated for only that side of the stream where the wetland is present.

Determine the value of this metric using the following procedure, and refer to Figure 27 as needed.

1. On a map or photo, draw a continuous line separating the depression WAA 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 27a).

3. Identify and mark the boundaries of the appropriate habitats within the buffer zone. If the boundary of appropriate habitat intersects the boundary of the 250-m buffer, draw a line perpendicular to the wetland boundary to determine where along the perimeter the full 250-m buffer ends. Areas of appropriate habitat that are not contiguous with the wetland boundary will not be considered in this metric (Figure 27a).

4. Visually estimate the percentage of the wetland perimeter bounded by a full 250-m buffer. This is actually measured as a lineal percentage. Consider the wetland outline to be a clock face. In Figure 27a, the full 250-m buffer runs from roughly 1:15 to 5:00 and then again from 6:00 to 8:30, or 6.25/12 = 52 percent. Record that percentage on Data Form 1 in

the box at the right-hand side of the V_{BUF250} row, and transfer the same number to the right-hand side of the V_{BUF250} row on Data Form 3.

5. For mid-gradient riverine wetlands, use the same approach, but restrict the procedure to the same side of the stream where the wetland occurs (Figure 27b). In the example shown in Figure 27b, the continuity of the 250-m buffer is approximately 70 percent.

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 following procedure:

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

2. If the tree stratum has at least 20 percent cover, then the value for V_{COMP} will be the same as the value for V_{TCOMP}. In this case, skip the remaining steps and simply enter the V_{TCOMP} value (see V_{TCOMP} discussion) 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:[1] 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.

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[1] Memorandum from Headquarters, U.S. Army Corps of Engineers, 6 March 1992, Subject: Clarification and Interpretation of the 1987 Manual. http://www.nww.usace.army.mil/html/offices/op/rf/wetdelww/clarif_87_man.pdf

5. Record the percent concurrence value in the box at the right-hand side of the V_{COMP} row on Data Form 2.

6. 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.

V_{DUR} – Change in Growing Season Flood Duration

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

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

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

1. Determine the change in growing season flood duration by comparing the preproject and postproject flood durations.

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

V_{FREQ} – Change in Frequency of Flooding

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

1. Determine the change in recurrence interval by comparing the preproject and postproject flood frequencies. For the preproject condition, the recurrence interval can be determined or estimated using one of the following information sources:

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

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

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

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

Note that the number of possible changes in return interval varies depending on the starting flood frequency. This is due in part to the classification of the flood frequencies: any area flooded more frequently than once a year is grouped with the 1-year return interval group, and everything flooded less frequently than every 5 years is no longer classified as riverine, and therefore the frequency variable no longer applies. As Figure 28 illustrates, the maximum of four zone changes is possible only for wetlands starting in the 1- or 5-year return interval categories (blue and red). This maximum change leads to a 0.2 variable subindex. In contrast, if the starting return interval is 3 years, a maximum of two zone changes is possible in either direction (green line), leading to a potential subindex of 0.6. A subindex of 0.0 occurs only if the change in frequency extends beyond the 5-year return interval required in the definition of riverine wetlands.

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 following procedure:

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 26. 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.

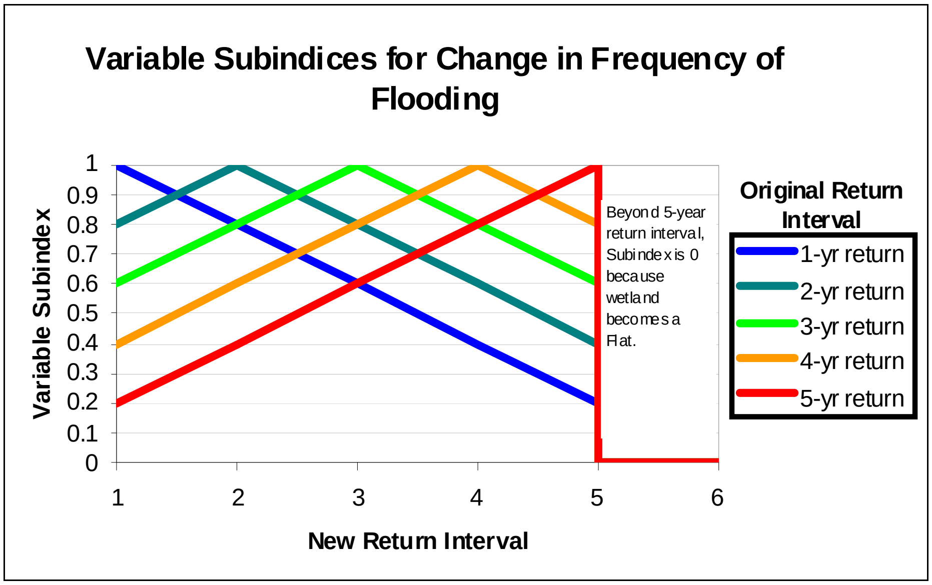

Figure 28. Potential variable subindices for different starting return interval frequencies

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). It also excludes organic material sufficiently decayed to be included in the estimate of O horizon thickness (see V_{OHOR} discussion). 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 following procedure:

1. Visually estimate the proportion of the ground surface covered by litter in each of the four 1-m^2 subplots (the same subplots established for estimating ground vegetation cover, Figure 26). 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}) section later in this chapter.

V_{OHOR} – O Horizon Organic Accumulation

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

Thickness of the O soil horizon is the metric used to quantify this variable. Measure it using the following procedure:

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

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

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

V_{PATCH} – Forest Patch Size

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

Determine the size of the forested patch using the following procedure:

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, geographic information system, field reconnaissance, or another appropriate method.

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

V_{POND} – Total Ponded Area

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

Estimate total ponded area using the following procedure:

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

2. Report the percent of the assessment area subject to ponding on Data Form 1 in the box on the right-hand side of the V_{POND} row, and transfer that value to the V_{POND} box on Data Form 3. Note that, in the case of the Flats subclass, Data Form 3 also requires identification of the geomorphic surface on which the WAA 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. 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 WAA to one of three possible surfaces:

    - *High terraces of the Arkansas River and nonalluvial flats*. Surfaces identified as Pleistocene terraces (map symbol "Ptu" on Saucier and Snead 1989 and map symbol "Qt" on Haley 1993) and wetlands found on nonalluvial flats make up this category. Most sites potentially containing large nonalluvial flats have been recently mapped by the Arkansas Multi-Agency Wetland Planning Team (2005). Where terraces of the Arkansas River are of uncertain age, but are clearly high above the modern floodplain, they should be included in this category.

    - *Recent alluvium on all streams and low terraces of the Arkansas River*. This category includes surfaces identified as recent alluvium (map symbol "Hal" on Saucier and Snead 1989, and "Qal" on Haley 1993). Generally, the historic floodplains of all streams as well as the first and second terraces of the Arkansas River are included in this category, but not terraces of tributary streams.

    - *Tributary terraces*. Tributary streams to the Arkansas River may or may not have terraces, and they are usually included within the broad mapping units for Holocene Alluvium on Saucier and Snead (1989) and Haley (1993), which also include more recent alluvium. More detailed mapping of tributary features can be found in Smith (1986a, 1986b) and Smith and Breland (2004). Generally, any distinct terraces noted along tributaries in the field should be included in this category.

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 following procedure:

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

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

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

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

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

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

V_{SSD} – Shrub-Sapling Density

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

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 26). Record the number of stems in each 0.004-ha subplot in the spaces provided in the V_{SSD} row on Data Form 2.

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

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

V_{STRATA} – Number of Vegetation Strata

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

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

   - Canopy (trees greater than or equal to 10 cm dbh in the canopy layer)
   - Subcanopy (trees greater than or equal to 10 cm dbh below the canopy layer — recognize this layer if it is distinctly different from a higher, more mature canopy)
   - Understory (shrubs and saplings less than 10 cm dbh but at least 1.4 m (4.5 ft tall))
   - Ground cover (woody plants less than 1.4 m (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 following procedure:

1. Use a basal area wedge prism (or other basal area estimation tool) as directed to tally eligible tree stems, and enter the tally in the indicated space on the V_{TBA} line on Data Form 3. Basal area prisms are available in various Basal Area Factors, and in both SI and non-SI 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 non-SI 10-factor prism works well for these purposes, 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 non-SI 10-factor prism, multiply the number of stems tallied by 25. Enter the total basal area figure in the right-hand box on the V_{TBA} row on Data Form 2.

3. Transfer the total basal area as a plot value to the V_{TBA} row on Data Form 3. Average all 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 measure tree diameters directly in the 0.04-ha plot, rather than use a plotless (e.g., wedge prism) estimation method. The difference between the two methods is likely to be insignificant at the level of resolution employed in the HGM assessment. However, if 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. Or the direct measurement approach may be used to facilitate more rigorous data collection, particularly if the relative contribution of each tree species to the total basal area of the WAA is important. Therefore, an alternative field form is provided in Appendix C1 that can be used to record the species and diameter of every tree within the 0.04-ha plot. Basal area can be calculated by hand on that data form or on the spreadsheet provided in Appendix D1. The spreadsheet will also indicate the basal area of each tree so the individual tree values for each species can be summed if the total basal area by species is needed. This can be used simply to provide more detailed documentation of the assessment process or to improve the rigor of the estimates for the V_{TCOMP} variable. Tree counts directly from the basal area sheets can also be used instead of the field counts that are the recommended method for deriving the V_{TDEN} variable.

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

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

1. Using a metric (cm) diameter tape, 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 previously.

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

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

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

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

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

V_{TCOMP} – Tree Composition

The tree composition variable is intended to represent the pattern of dominance among tree species in the forest canopy. V_{TCOMP} is calculated if the total canopy cover of trees (living woody stems ≥ 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 (Headquarters, U.S. Army Corps of Engineers, 1992). This requires ranking species in descending order of percent cover, summing relative dominance in descending order until 50 percent is exceeded. Additional species with 20 percent relative dominance should also be included as dominants. Accurate identification of woody species is critical for determining the dominant species in each plot. Sampling during the dormant season may require proficiency in recognizing plant form, bark, and dead or dormant plant parts. Users who do not feel confident in identifying trees and shrubs should get help.

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

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

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

V_{TDEN} – Tree Density

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

1. Count the number of tree stems within the 0.04-ha plot (note: this is not the same as the stem count taken with the basal area wedge prism to determine V_{TBA}). Determine carefully 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 in the following text (Brown 1974; Brown et al. 1982).

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 15.24-m (50-ft) east-west transects, originating at the 0.04-ha plot center point (Figure 26).

2. Count the number of nonliving stems in Size Class 1 (small) (greater than or equal to 0.6 cm (0.25 in.) and less than 2.5 cm (1 in.) that intersect a vertical plane above a 2-m (6-ft) segment of each 15.24-m (50-ft) transect. This can be any 2-m (6-ft) segment, as long as it is consistently placed. Figure 26 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 (1 in.) and less than 7.6 cm (3 in.) that intersect the plane above a 4-m (12-ft) segment of each 15.24-m (50-ft) transect. This can be any 4-m (12-ft) segment, as long as it is consistently placed. Figure 26 illustrates it as placed at the end furthest from the plot center point, overlapping with the 2-m (6-ft) transect segment. Record the number of Size Class 2 stems from each transect in the spaces provided on the V_{WD} (Size Class 2) line on Data Form 2.

4. Measure and record the diameter of nonliving stems in Size Class 3 (large) (greater than or equal to 7.6 cm (3 in.) that intersect the plane above the entire length of the 15.24-m (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.

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

Analyze Field Data

The analysis of field data requires three steps.

1. 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 in Chapter 5.

2. The second step is to insert the variable subindices into the appropriate assessment models in Chapter 5 and calculate the FCI for each assessed function.

3. Finally, the FCI is multiplied by the area of the WAA (ha) to calculate FCUs for each assessed function.

However, all of these calculations can be carried out automatically by entering the Data Form 3 summary data (right-hand boxes) and the area (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 noninundated conditions and a simpler version for situations where ground-level variables are not assessed because of standing water. Use the spreadsheet for inundated conditions if any of the plots are under water. Alternatively, separate WAAs can be established for inundated and noninundated subsections of the depression.

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

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

Document Assessment Results

Once all of the data collection, summarization, and analysis steps have been completed, it is important to assemble all pertinent documentation. Appendix A1 is a cover sheet that, when completed, identifies the assembled maps, drawings, project description, Data Forms, and summary sheets (including spreadsheet printouts) that are attached to document the assessment. It is highly recommended that this documentation step be completed.

Apply Assessment Results

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

Note that the assessment procedure does not produce a single grand index of function; rather each function is separately assessed and scored, resulting in a set of functional index scores and functional units. How these are used in any particular analysis depends on the objectives of the analysis. In the case of an impact assessment, it may be reasonable to focus on the function that is most detrimentally affected. In cases where certain resources are particular regional priorities, the assessment may 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 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.

Special Issues in Applying the Assessment Results

Users of this document must recognize that not all situations can be anticipated or accounted for in developing a rapid assessment method. In particular, users must be able to adapt the material presented here to special or unique situations encountered in the field. Most of the reference sites were relatively mature, diverse, and structurally complex hardwood stands. However, 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 drainage impeded by 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 WAA is not penalized either way. Other situations that require special consideration include areas affected by fire, sites damaged by ice storms, and similar occurrences. Fire, in particular, can cause dramatic short-term changes in many of the indicators measured to assess function, such as ground cover, woody debris, and litter accumulation. Note, however, that normal, non-catastrophic disturbances to wetlands (i.e., tree mortality causing small openings) are accounted for in the reference data used in this guidebook.

Another potential consideration in the application of the assessment models presented here concerns the projection of future conditions. This may be particularly important in determining the rate at which functional status will improve as a result of restoration actions intended to offset impacts to jurisdictional wetlands. The graphs in Figure 29 represent general recovery trajectories for forested hardwood wetlands within the Arkansas Valley 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 FCIs 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 confuse 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.

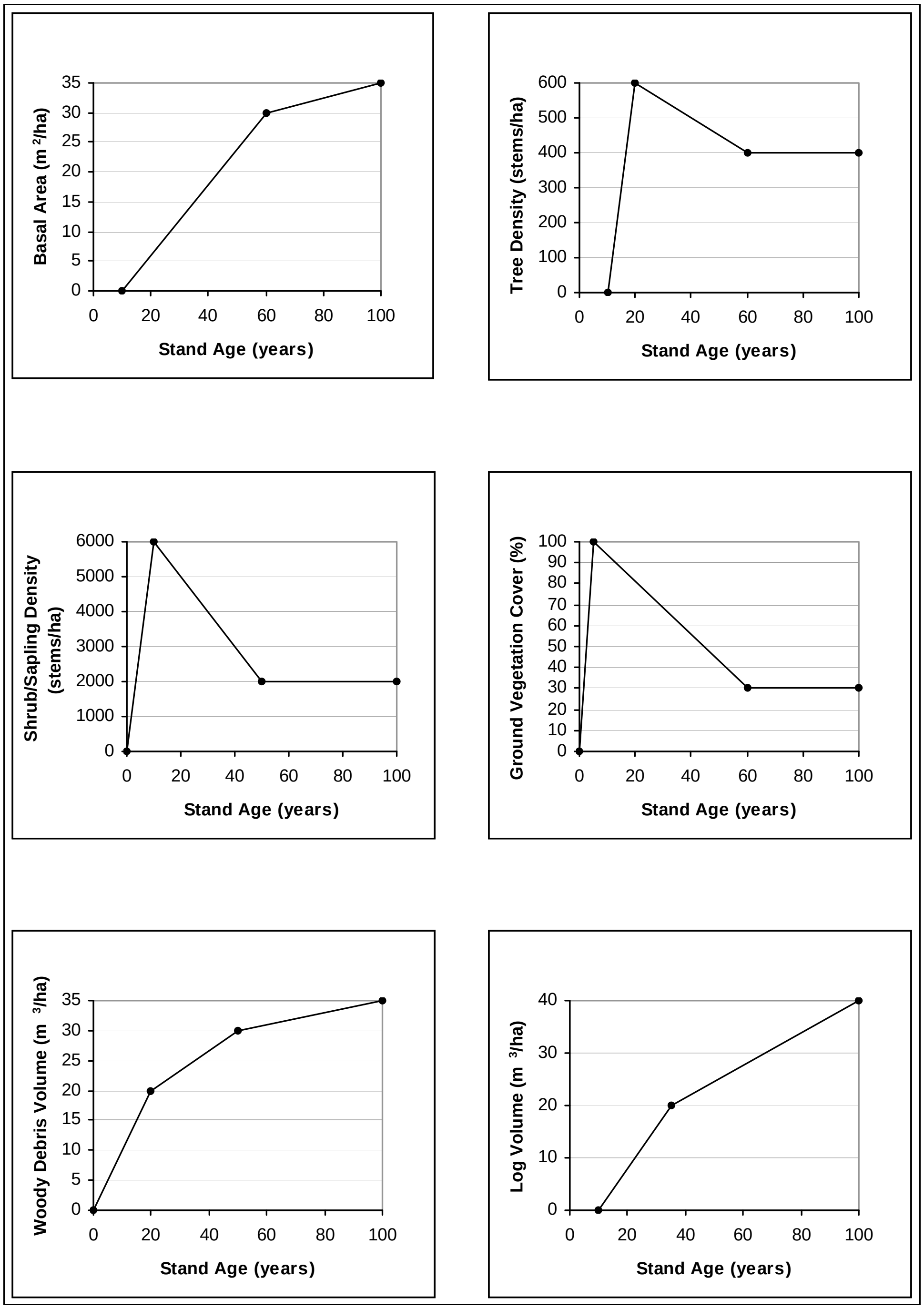

Figure 29. Projected recovery trajectories for selected assessment variables (Continued)

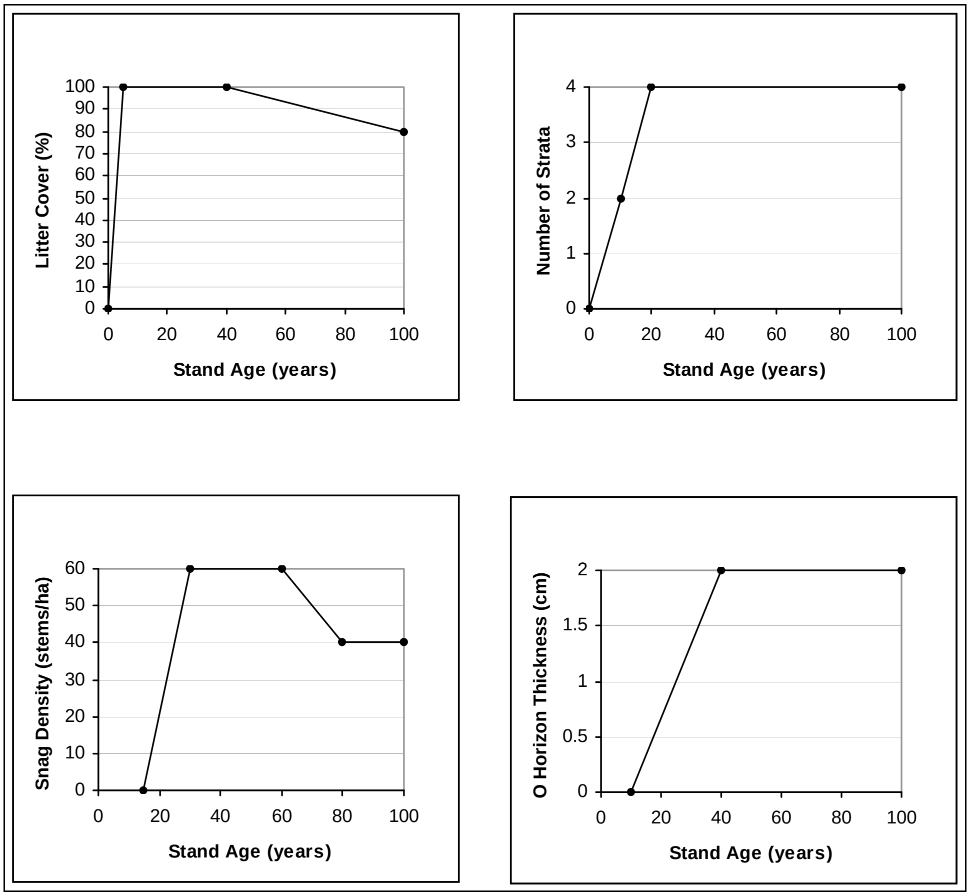

Figure 29. (Concluded)

Note also that the graphs in Figure 29 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.

Often, the methods and assumptions presented in this guidebook must be adapted to particular situations, and the user can do so as long as all revisions and new assumptions are fully documented. One situation where case-by-case adaptation is likely to be needed concerns greentree reservoirs. As currently configured, the assessment models assume that greentrees within riverine wetlands will remain riverine (i.e., the impounding levees will not be an impediment to the exchange of floodwater, fish, and organic material between the forest and the stream system). In fact, this may be the case for some situations where the greentree is actually part of a larger flood-control unit, or it is filled by closing gates in a stream channel rather than pumping. But where the greentree actually is an off-channel impoundment, and does not interact with the stream system, it should probably be viewed as having lost the river-connection component of the export, flood detention, and fish habitat functions. Most other wildlife functions remain, however (indeed, the point of greentree reservoirs is to maximize waterfowl use).

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Appendix A
Preliminary Project Documentation and Field Sampling Guidance

Contents

Please reproduce these forms locally as needed.

APPENDIX A1

SITE or PROJECT INFORMATION and ASSESSMENT DOCUMENTATION

(Complete one form for entire site or project area)

Date: ______________________________________

Project/Site Name: ___________________________

Person(s) involved in assessment:

Field ____

____

Computations/summarization/quality control ____

____

The following checked items are attached:

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

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

_____ Other pertinent documentation (describe): ______________________________________

____

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

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

Alternative Field and Summarization Forms Attached:

_______ Basal Area (DATA FORM C1)

_______ Log and Woody Debris (DATA FORM C2)

Page 1 of 1 plus attachments

APPENDIX A2

FIELD ASSESSMENT PREPARATION CHECKLIST

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

FIELD GEAR REQUIRED	COMMENTS
DISTANCE TAPE (preferably metric, at least 50 ft or 20 m) AND ANCHOR PIN	Minimum of 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 non-SI 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 in. deep. A water bottle is recommended if conditions are dry, to help distinguish soil colors (organic-stained soils must be distinguished from mineral soil).
MISCELLANEOUS SUGGESTED GEAR	You'll need clipboards and pencils, and extra data forms are highly recommended. Flagging may be helpful for establishing plot centers and boundaries, at least until the assessment team is comfortable with the field procedures. A camera and GPS unit will improve documentation of the assessment and are highly recommended. Record position and take a representative photo at each plot location. Field copies of aerial photos and topo maps may be important if multiple Wetland Assessment Areas must be established and recognized in the field.

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APPENDIX A2

DATA FORMS

Print the following data forms (Data Forms 1, 2, and 3 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 will also need Form C1 to calculate basal area. Both forms are located in Appendix C.	Multiple copies (same number as Data Form 2 sets)

PAGE 2 OF 2

APPENDIX A3

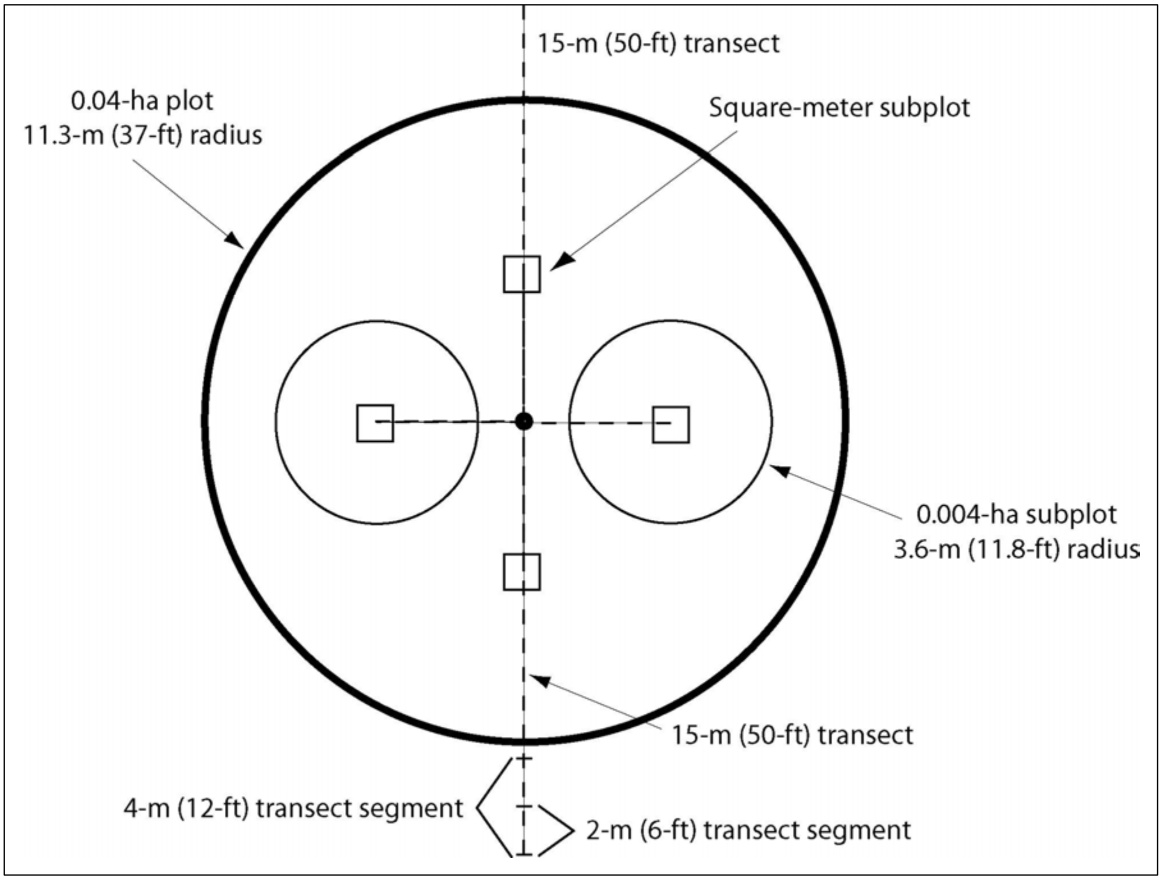

Figure A1. Layout of plots and transects for field sampling.

Appendix B
Field Data Forms

Contents

Appendix B1
Field Data Forms for Nonalkali 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 WETLAND ASSESSMENT AREA LEVEL DATA COLLECTION

SUBCLASS: NONALKALI FLAT WETLANDS
WAA # ___________
PLOT # ___________

Complete one copy of this form for each Wetland Assessment Area

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

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
V_{PATCH} Forest patch size	From aerial photos or field reconnaissance, estimate the size of the forested area that is contiguous to the WAA and accessible to wildlife (including the WAA itself, if it is forested). Include both upland and wetland forests. Record the area at right – if it exceeds 2500 ha, enter "2500."	Size of the forested tract = _______ ha
Geomorphic surface (used to determine appropriate V_{POND} entry on spreadsheet)	CHECK ONE: High terraces of the Arkansas River (map symbol Qt) and nonalluvial flats All recent alluvium (map symbol Qal) and low terraces (Qt) of the Arkansas River Terraces of tributaries to the Arkansas River (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 1.4 m (4.5 ft) tall) **Ground cover** (woody plants < 1.4 m (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 = ____

PAGE 1 OF 1

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

SUBCLASS: NONALKALI FLAT WETLANDS
WAA # ___________
PLOT # ___________

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

OBSERVATIONS FROM THE CENTER POINT

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

OBSERVATIONS WITHIN A 0.04-HA PLOT

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

V_{TDEN} Tree density	Count the number of trees (dbh ≥ 10 cm). Multiply by 25 to calculate stems/ha	# trees tallied = ______ x 25 =	tree density per ha ______
V_{SNAG} Snag density	Count the number of snags (standing dead trees at least 1.4 m (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

PAGE 1 OF 3

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

SUBCLASS: NONALKALI FLAT WETLANDS
WAA # ___________
PLOT # ___________

OBSERVATIONS WITHIN A 0.04-HA PLOT

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

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

PAGE 2 OF 3

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

SUBCLASS: NONALKALI FLAT WETLANDS
WAA # ___________
PLOT # ___________

OBSERVATIONS WITHIN TWO 0.004-HA PLOTS

From the center point, 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 = _____ $\times$ 125 = ______	Understory stems/ha = ________

OBSERVATIONS WITHIN 4 SUBPLOTS 1-m X 1-m SQUARE

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

V_{LITTER} Litter cover	Estimate the percent of the plot area covered by undecomposed litter. Average the results of the four subplots.	Subplot 1 = ____% Subplot 2 = ____% Subplot 3 = ____% Subplot 4 = ____%	Average litter cover = _____%
V_{GVC} Ground vegetation cover	Estimate the percent cover of all herbaceous plants and woody plants < 1.4 m (4.5 ft) tall. Average the results of the four subplots.	Subplot 1 = ____% Subplot 2 = ____% Subplot 3 = ____% Subplot 4 = ____%	Average ground veg cover = _______%

OBSERVATIONS ALONG TRANSECTS

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

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

PAGE 3 OF 3

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

SUBCLASS: NONALKALI 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:	High terrace or nonalluvial flat ____ Low terrace or recent alluvium ____ Tributary terrace ____
V_{STRATA}	Number of vegetation strata	____ strata
V_{SOIL}	Percent of the wetland assessment area with culturally unaltered soils	_______ %

Transfer the plot data below from Data Form 2 and average all values									
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	**AVERAGES**
V_{TBA}									BA = _____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

PAGE 1 OF 1

Appendix B2
Field Data Forms for Mid-Gradient Riverine Wetlands

Data Form	Number of Pages	Title
1	2	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 (2 pages) – TRACT AND WETLAND ASSESSMENT AREA LEVEL DATA COLLECTION

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

Complete one copy of this form for each Wetland Assessment Area

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

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

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

PAGE 1 OF 2

DATA FORM 1 (2 pages) – TRACT AND WETLAND ASSESSMENT AREA LEVEL DATA COLLECTION

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

Geomorphic surface (used to determine appropriate V_{POND} entry on spreadsheet)	CHECK ONE:	High terraces of the Arkansas River (map symbol Qt) and nonalluvial flats	______
		All recent alluvium (map symbol Qal) and low terraces (Qt) of the Arkansas River	_______
		Terraces of tributaries to the Arkansas River (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 1.4 m (4.5 ft) tall) **Ground cover** (woody plants < 1.4 m (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 = ____

PAGE 2 OF 2

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

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

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

OBSERVATIONS FROM THE CENTER POINT

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

OBSERVATIONS WITHIN A 0.04-HA PLOT

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

V_{TDEN} Tree density	Count the number of trees (dbh ≥ 10 cm). Multiply by 25 to calculate stems/ha	# trees tallied = ______ x 25 =	tree density per ha ______
V_{SNAG} Snag density	Count the number of snags (standing dead trees at least 1.4 m (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

PAGE 1 OF 3

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

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

OBSERVATIONS WITHIN A 0.04-HA PLOT

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

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

PAGE 2 OF 3

<u>DATA FORM 2 (3 pages) – PLOT-LEVEL DATA COLLECTION</u>

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

OBSERVATIONS WITHIN TWO 0.004-HA PLOTS

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

V_{LITTER} Litter cover	Estimate the percent of the plot area covered by undecomposed litter. Average the results of the four subplots.	Subplot 1 = ____% Subplot 2 = ____% Subplot 3 = ____% Subplot 4 = ____%	Average litter cover = _____%
V_{GVC} Ground vegetation cover	Estimate the percent cover of all herbaceous plants and woody plants < 1.4 m (4.5 ft) tall. Average the results of the four subplots.	Subplot 1 = ____% Subplot 2 = ____% Subplot 3 = ____% Subplot 4 = ____%	Average ground veg cover = _______%

OBSERVATIONS ALONG TRANSECTS

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

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

PAGE 3 OF 3

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}	Change in flood recurrence interval (0-5)								________years
V_{DUR}	Change in flood duration (0-5)								_______weeks
V_{POND}	Percent of the wetland assessment area that ponds water								_______ %
Geomorphic surface (used to determine appropriate V_{POND} entry on spreadsheet - from Data Form 1)				CHECK ONE:					High terrace or nonalluvial flat ____ Low terrace or recent alluvium ____ Tributary terrace ____
V_{STRATA}	Number of vegetation strata								____ strata
V_{SOIL}	Percent of the wetland assessment area with culturally unaltered soils								_______ %
Transfer the plot data below from Data Form 2 and average all values									
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	**AVERAGES**
V_{TBA}									BA = _____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

PAGE 1 OF 1

Appendix B3
Field Data Forms for Low-Gradient Riverine Overbank Wetlands

Data Form	Number of Pages	Title
1	2	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.		

<u>DATA FORM 1 (2 pages) – TRACT AND WETLAND ASSESSMENT AREA LEVEL DATA COLLECTION</u>

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

Complete one copy of this form for each Wetland Assessment Area

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

<table>
<tr><th>HGM Variable Addressed</th><th colspan="2">Procedure (see Chapter 6 for details)</th><th>Indicator Value</th></tr>
<tr><td>V_{PATCH}
Forest patch size</td><td colspan="2">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."</td><td>Size of the forested tract = ________ ha</td></tr>
<tr><td>V_{FREQ}
Change in flood frequency</td><td>Determine (or estimate) the frequency of flooding from streams for sites within the 5-year floodplain for both pre-project and post-project conditions. Enter 0 if this is not an assessment involving hydrologic alteration.</td><td>A. Pre-project flood return interval = _____
(1 = annual flooding, 5 = once in 5 years)

B. Post-project flood return interval = ________</td><td>A minus B =
____

(absolute value; ignore minus signs)
(range = 0 to 5)</td></tr>
<tr><td>V_{DUR}
Change in flood duration</td><td>Determine (or estimate) the duration of continuous flooding from streams (longest single event) during the growing season for sites within the 5-year floodplain for both pre-project and post-project conditions. Enter 0 if this is not an assessment involving hydrologic alteration.</td><td>A. Pre-project growing season flood duration (weeks of continuous growing season flooding, on average) =
_____

B. Post-project growing season flood duration (weeks of continuous growing season flooding, on average) =
________</td><td>A minus B =
____

(absolute value; ignore minus signs)
(range = 0 to 5 –enter 5 if change is 5 or greater)</td></tr>
<tr><td>Geomorphic surface (used to determine appropriate V_{POND} entry on spreadsheet)</td><td colspan="3">CHECK ONE:

High terraces of the Arkansas River (map symbol Qt) and nonalluvial flats _______

All recent alluvium (map symbol Qal) and low terraces (Qt) of the Arkansas River ________

Terraces of tributaries to the Arkansas River (map codes beginning with H or Qal) ________</td></tr>
</table>

PAGE 1 OF 2

DATA FORM 1 (2 pages) – TRACT AND WETLAND ASSESSMENT AREA LEVEL DATA COLLECTION

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

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

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
V_{POND} Percentage of the site capable of ponding water	Estimate the area likely to be ponded following extended rainfall. This includes both large vernal pool sites (swales) and microdepressions such as those left by trees that have blown over and uprooted.	% of site likely to pond = _________
V_{STRATA} Number of vegetation strata present	Vegetation layers are counted as present in the following categories if they account for at least 10% cover over the observed area. **Canopy** (trees ≥ 10 cm dbh that are in the canopy layer) **Subcanopy** (trees ≥ 10 cm dbh that are below the canopy layer) **Understory** (shrubs and saplings < 10 cm dbh but at least 1.4 m (4.5 ft) tall) **Ground cover** (woody plants < 1.4 m (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 = ____

PAGE 2 OF 2

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

OBSERVATIONS FROM THE CENTER POINT

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

OBSERVATIONS WITHIN A 0.04-HA PLOT

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

V_{TDEN} Tree density	Count the number of trees (dbh ≥ 10 cm). Multiply by 25 to calculate stems/ha	# trees tallied = ______ x 25 =	tree density per ha ______
V_{SNAG} Snag density	Count the number of snags (standing dead trees at least 1.4 m (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

PAGE 1 OF 3

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 suppression, high-grading, or other disturbances	**C:** Uncommon, minor, or shrub species in reference standard sites, but may dominate in degraded systems
Acer saccharinum	*Carpinus caroliniana*	*Cretaegus* spp.
Carya cordiformis	*Celtis laevigata*	*Ilex opaca*
Platanus occidentalis	*Fraxinus pennsylvanica*	*Ulmus alata*
Populus deltoides	*Liquidambar styraciflua*	
Quercus michauxii	*Quercus nigra*	
Quercus macrocarpa	*Ulmus americana*	
Salix nigra	*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 = _____ %		

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

PAGE 2 OF 3

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

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

OBSERVATIONS WITHIN TWO 0.004-HA PLOTS

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

V_{LITTER} Litter cover	Estimate the percent of the plot area covered by undecomposed litter. Average the results of the four subplots.	Subplot 1 = ____% Subplot 2 = ____% Subplot 3 = ____% Subplot 4 = ____%	Average litter cover = _____%
V_{GVC} Ground vegetation cover	Estimate the percent cover of all herbaceous plants and woody plants < 1.4 m (4.5 ft) tall. Average the results of the four subplots.	Subplot 1 = ____% Subplot 2 = ____% Subplot 3 = ____% Subplot 4 = ____%	Average ground veg cover = _______%

OBSERVATIONS ALONG TRANSECTS

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

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

PAGE 3 OF 3

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}	Change in flood recurrence interval (0-5)	_________years
V_{DUR}	Change in flood duration (0-5)	________weeks
V_{POND}	Percent of the wetland assessment area that ponds water	________ %
Geomorphic surface (used to determine appropriate V_{POND} entry on spreadsheet - from Data Form 1)	CHECK ONE:	High terrace or nonalluvial flat ____ Low terrace or recent alluvium ____ Tributary terrace ____
V_{STRATA}	Number of vegetation strata	____ strata
V_{SOIL}	Percent of the wetland assessment area with culturally unaltered soils	________ %

Transfer the plot data below from Data Form 2 and average all values									
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	**AVERAGES**
V_{TBA}									BA = _____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

PAGE 1 OF 1

Appendix B4
Field Data Forms for Low-Gradient Riverine Backwater Wetlands

Data Form	Number of Pages	Title
1	2	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 (2 pages) – TRACT AND WETLAND ASSESSMENT AREA LEVEL DATA COLLECTION

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

Complete one copy of this form for each Wetland Assessment Area

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

<table>
<tr><th>HGM Variable Addressed</th><th colspan="2">Procedure (see Chapter 6 for details)</th><th>Indicator Value</th></tr>
<tr><td>V_{PATCH}
Forest patch size</td><td colspan="2">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."</td><td>Size of the forested tract = _______ ha</td></tr>
<tr><td>V_{FREQ}
Change in flood frequency</td><td>Determine (or estimate) the frequency of flooding from streams for sites within the 5-year floodplain for both pre-project and post-project conditions. Enter 0 if this is not an assessment involving hydrologic alteration.</td><td>A. Pre-project flood return interval = _____
(1 = annual flooding, 5 = once in 5 years)

B. Post-project flood return interval = _______</td><td>A minus B = _______

(absolute value; ignore minus signs) (range = 0 to 5)</td></tr>
<tr><td>V_{DUR}
Change in flood duration</td><td>Determine (or estimate) the duration of continuous flooding from streams (longest single event) during the growing season for sites within the 5-year floodplain for both pre-project and post-project conditions. Enter 0 if this is not an assessment involving hydrologic alteration.</td><td>A. Pre-project growing season flood duration (weeks of continuous growing season flooding, on average) = _____

B. Post-project growing season flood duration (weeks of continuous growing season flooding, on average) = _______</td><td>A minus B = ______

(absolute value; ignore minus signs) (range = 0 to 5 –enter 5 if change is 5 or greater)</td></tr>
<tr><td>Geomorphic surface (used to determine appropriate V_{POND} entry on spreadsheet)</td><td>CHECK ONE:</td><td colspan="2">High terraces of the Arkansas River (map symbol Qt) and nonalluvial flats ______

All recent alluvium (map symbol Qal) and low terraces (Qt) of the Arkansas River _______

Terraces of tributaries to the Arkansas River (map codes beginning with H or Qal) _______</td></tr>
</table>

PAGE 1 OF 2

DATA FORM 1 (2 pages) – TRACT AND WETLAND ASSESSMENT LEVEL DATA COLLECTION

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

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

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
V_{POND} Percentage of the site capable of ponding water	Estimate the area likely to be ponded following extended rainfall. This includes both large vernal pool sites (swales) and microdepressions such as those left by trees that have blown over and uprooted.	% of site likely to pond = _________
V_{STRATA} Number of vegetation strata present	Vegetation layers are counted as present in the following categories if they account for at least 10% cover over the observed area. **Canopy** (trees ≥ 10 cm dbh that are in the canopy layer) **Subcanopy** (trees ≥ 10 cm dbh that are below the canopy layer) **Understory** (shrubs and saplings < 10 cm dbh but at least 1.4 m (4.5 ft) tall) **Ground cover** (woody plants < 1.4 m (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 = _____

PAGE 2 OF 2

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

OBSERVATIONS FROM THE CENTER POINT

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

OBSERVATIONS WITHIN A 0.04-HA PLOT

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

V_{TDEN} Tree density	Count the number of trees (dbh ≥ 10 cm). Multiply by 25 to calculate stems/ha	# trees tallied = ______ x 25 =	tree density per ha _____
V_{SNAG} Snag density	Count the number of snags (standing dead trees at least 1.4 m (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 1 (2 pages) – TRACT AND WETLAND ASSESSMENT LEVEL DATA COLLECTION

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 suppression, high-grading, or other disturbances	**C:** Uncommon, minor, or shrub species in reference standard sites, but may dominate in degraded systems
Carya aquatica	*Acer negundo*	*Carpinus caroliniana*
Diospyros virginiana	*Acer rubrum*	*Crataegus* spp.
Fraxinus pennsylvanica	*Ulmus americana*	*Ilex opaca*
Liquidambar styraciflua		*Ulmus crassifolia*
Nyssa aquatica		
Quercus lyrata		
Quercus macrocarpa		
Quercus nuttallii		
Quercus phellos		
Taxodium distichum		
Calculations		
Using the dominant species circled in Columns A, B, and C above, calculate percent concurrence according to the following formula: {[(1.0 * number of circled dominants in Column A) + (0.66 * number of circled dominants in Column B) + (0.33 * number of circled dominants in Column C)] / total number of circled dominants in all columns} × 100 = _____ %		

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

PAGE 2 OF 3

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

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

OBSERVATIONS WITHIN TWO 0.004-HA PLOTS

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

V_{LITTER} Litter cover	Estimate the percent of the plot area covered by undecomposed litter. Average the results of the four subplots.	Subplot 1 = ____% Subplot 2 = ____% Subplot 3 = ____% Subplot 4 = ____%	Average litter cover = _____%
V_{GVC} Ground vegetation cover	Estimate the percent cover of all herbaceous plants and woody plants < 1.4 m (4.5 ft) tall. Average the results of the four subplots.	Subplot 1 = ____% Subplot 2 = ____% Subplot 3 = ____% Subplot 4 = ____%	Average ground veg cover = _______%

OBSERVATIONS ALONG TRANSECTS

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

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

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

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

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}	Change in flood recurrence interval (0-5)	_________years
V_{DUR}	Change in flood duration (0-5)	________weeks
V_{POND}	Percent of the wetland assessment area that ponds water	________ %
Geomorphic surface (used to determine appropriate V_{POND} entry on spreadsheet - from Data Form 1)	CHECK ONE:	High terrace or non-alluvial flat ____ Low terrace or recent alluvium ____ Tributary terrace ____
V_{STRATA}	Number of vegetation strata	____ strata
V_{SOIL}	Percent of the wetland assessment area with culturally unaltered soils	________ %

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

	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	**AVERAGES**
V_{TBA}									BA = ______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

PAGE 1 OF 1

Appendix B5
Field Data Forms for Unconnected Depression Wetlands

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

DATA FORM 1 (1 page) – TRACT AND WETLAND ASSESSMENT AREA LEVEL DATA COLLECTION

SUBCLASS: UNCONNECTED DEPRESSION WETLANDS
WAA # ___________
PLOT # ___________

Complete one copy of this form for each Wetland Assessment Area

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

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
V_{BUF30} Percent contiguous 30-m buffer	On a map or photo, outline a 30-m-wide buffer area 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 1.4 m (4.5 ft) tall) **Ground cover** (woody plants < 1.4 m (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 = ____

PAGE 1 OF 1

SUBCLASS: UNCONNECTED DEPRESSION WETLANDS
WAA # ___________
PLOT # ___________

PROCEDURE

Establish a plot center, assign a plot number (above), and complete the following three data sheets as directed. Repeat with new sets of plot data sheets as needed, assigning a new plot number to each set. See Chapter 6 for sampling details and guidance regarding the number of plots required. Generally, small areas should be represented by at least four plots. For large areas, establish plot centers at paced distances along evenly spaced transects. (NOTE: shaded variables are not used if they cannot be accurately assessed due to inundation.)

OBSERVATIONS FROM THE CENTER POINT

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

OBSERVATIONS WITHIN A 0.04-HA PLOT

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

V_{TDEN} Tree density	Count the number of trees (dbh ≥ 10 cm). Multiply by 25 to calculate stems/ha	# trees tallied = ______ x 25 =	tree density per ha ______
V_{SNAG} Snag density	Count the number of snags (standing dead trees at least 1.4 m (4.5 ft) tall and dbh ≥ 10 cm). Multiply by 25 to calculate snags/ha	# snags tallied = _______ x 25 =	snag density/ha _______
V_{OHOR} Thickness of the O horizon	Select two or more points within the plot that are representative of the range of microtopography within the plot as a whole. Dig a hole and measure the thickness of the O horizon (organic accumulation on the soil surface, excluding fresh litter, but including surface root mats if present) and the thickness of the A horizon (mineral soil with incorporated organic matter, indicated by distinct darkening relative to lower horizons)	Thickness of O horizon measurements (cm): ____ ____ ____	Average thickness of O horizon =_____ cm
V_{AHOR} Thickness of the A horizon		Thickness of A horizon measurements (cm): ____ ____ ____	Average thickness of A horizon = _____ cm

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

SUBCLASS: UNCONNECTED DEPRESSION WETLANDS
WAA # ___________
PLOT # ___________

OBSERVATIONS WITHIN A 0.04-HA PLOT

Field Procedure	
(1) If tree cover is ≥ 20%, use the 50/20 rule and circle the dominant trees in Columns A and B below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.	
(2) If tree cover is < 20%, identify the next tallest woody stratum with at least 10% cover. Use the 50/20 rule and circle the dominants in the next tallest woody stratum in Columns A and B below (based on estimates of % cover by species): If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.	
A: Common dominants in reference standard sites	**B:** Species commonly present in reference standard sites, but dominance generally indicates heavy selective harvest, land abandonment, or other disturbances
Carya aquatica	*Acer saccharinum*
Fraxinus spp.	*Cephalanthus occidentalis*
Nyssa aquatica	*Liquidambar styraciflua*
Quercus lyrata	*Salix nigra*
Taxodium distichum	
Calculations	
Using the dominant species circled in Columns A and B above, calculate percent concurrence according to the following formula: {[(1.0 * number of circled dominants in Column A) + (0.66 * number of circled dominants in Column B) / total number of circled dominants in all columns} × 100 = _____ %	

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

PAGE 2 OF 3

SUBCLASS: UNCONNECTED DEPRESSION WETLANDS
WAA # ___________
PLOT # ___________

OBSERVATIONS WITHIN TWO 0.004-HA PLOTS

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

V_{LITTER} Litter cover	Estimate the percent of the plot area covered by undecomposed litter. Average the results of the four subplots.	Subplot 1 = ____% Subplot 2 = ____% Subplot 3 = ____% Subplot 4 = ____%	Average litter cover = _____%
V_{GVC} Ground vegetation cover	Estimate the percent cover of all herbaceous plants and woody plants < 1.4 m (4.5 ft) tall. Average the results of the four subplots.	Subplot 1 = ____% Subplot 2 = ____% Subplot 3 = ____% Subplot 4 = ____%	Average ground veg cover = _______%

OBSERVATIONS ALONG TRANSECTS

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

PAGE 3 OF 3

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

SUBCLASS: UNCONNECTED DEPRESSION WETLANDS
WAA # ___________
PLOT # ___________

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 unaltered soils								________ %
Transfer the plot data below from Data Form 2 and average all values									
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	**AVERAGES**
V_{TBA}									BA = _____m^2/ha
V_{TDEN}									density = ___stems/ha
V_{SNAG}									density = ___stems/ha
V_{TCOMP}									concurrence = _______ %
V_{COMP}									concurrence = _______ %
V_{SSD}									density = ___stems/ha
V_{GVC}									cover = _______ %
V_{LITTER}									cover = _______ %
V_{OHOR}									thickness = ______ cm
V_{AHOR}									thickness = ______ cm
Use the Woody Debris Calculator spreadsheet (or the worksheet in Appendix C) to generate log and woody debris volume based on the transect data on Data Form 2. Enter those values below and average.									
V_{LOG}									log volume = _____ m^3/ha
V_{WD}									wd volume = _____ m^3/ha

PAGE 1 OF 1

Appendix B6
Field Data Forms for Connected Depression Wetlands

Data Form	Number of Pages	Title
1	2	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 (2 pages) – TRACT AND WETLAND ASSESSMENT AREA LEVEL DATA COLLECTION

SUBCLASS: CONNECTED DEPRESSION WETLANDS
WAA # ___________
PLOT # ___________

Complete one copy of this form for each Wetland Assessment Area

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

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

PAGE 1 OF 2

<u>**DATA FORM 1 (2 pages) – TRACT AND WETLAND ASSESSMENT AREA LEVEL DATA COLLECTION**</u>

SUBCLASS: CONNECTED DEPRESSION WETLANDS
WAA # ___________
PLOT # ___________

Walk the entire assessment area and develop estimates of the following indicators. For large or highly variable assessment areas, establish a series of transects across the area and make estimates along each transect, then average them for the area. (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 1.4 m (4.5 ft) tall) **Ground cover** (woody plants < 1.4 m (4.5 ft) tall, and herbaceous vegetation)	Number of strata present = ______
V_{SOIL} Soil Integrity	Estimate the percentage of the site that has significantly altered soils. Normal farm tillage is not considered a significant alteration in this case, but fill, land leveling that removes surface horizons, and compacted areas such as roads are counted.	Percent of site with altered soils = ____

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

SUBCLASS: CONNECTED DEPRESSION WETLANDS
WAA # ___________
PLOT # ___________

PROCEDURE

Establish a plot center, assign a plot number (above), and complete the following three data sheets as directed. Repeat with new sets of plot data sheets as needed, assigning a new plot number to each set. See Chapter 6 for sampling details and guidance regarding the number of plots required. Generally, small areas should be represented by at least four plots. For large areas, establish plot centers at paced distances along evenly spaced transects. (NOTE: shaded variables are not used if they cannot be accurately assessed due to inundation.)

OBSERVATIONS FROM THE CENTER POINT

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

OBSERVATIONS WITHIN A 0.04-HA PLOT

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

V_{TDEN} Tree density	Count the number of trees (dbh ≥ 10 cm). Multiply by 25 to calculate stems/ha	# trees tallied = ______ x 25 =	tree density per ha ______
V_{SNAG} Snag density	Count the number of snags (standing dead trees at least 1.4 m (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

PAGE 1 OF 3

<u>**DATA FORM 2 (3 pages) - PLOT-LEVEL DATA COLLECTION**</u>

SUBCLASS: CONNECTED DEPRESSION WETLANDS
WAA # ___________
PLOT # ___________

OBSERVATIONS WITHIN A 0.04-HA PLOT

<table>
<tr><th colspan="2">Field Procedure</th></tr>
<tr><td colspan="2">(1) If tree cover is ≥ 20%, use the 50/20 rule and circle the dominant trees in Columns A and B below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.</td></tr>
<tr><td colspan="2">(2) If tree cover is < 20%, identify the next tallest woody stratum with at least 10% cover. Use the 50/20 rule and circle the dominants in the next tallest woody stratum in Columns A and B below (based on estimates of % cover by species): If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.</td></tr>
<tr><td>A: Common dominants in reference standard sites</td><td>B: Species commonly present in reference standard sites, but dominance generally indicates heavy selective harvest, land abandonment, or other disturbances</td></tr>
<tr><td>Carya aquatica</td><td>Acer saccharinum</td></tr>
<tr><td>Fraxinus spp.</td><td>Cephalanthus occidentalis</td></tr>
<tr><td>Nyssa aquatica</td><td>Liquidambar styraciflua</td></tr>
<tr><td>Quercus lyrata</td><td></td></tr>
<tr><td>Taxodium distichum</td><td></td></tr>
<tr><th colspan="2">Calculations</th></tr>
<tr><td colspan="2">Using the dominant species circled in Columns A and B above, calculate percent concurrence according to the following formula:

{[(1.0 * number of circled dominants in Column A) + (0.66 * number of circled dominants in Column B)] / total number of circled dominants in all columns} × 100 = _____ %</td></tr>
</table>

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

PAGE 2 OF 3

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

SUBCLASS: CONNECTED DEPRESSION WETLANDS
WAA # ___________
PLOT # ___________

OBSERVATIONS WITHIN TWO 0.004-HA PLOTS

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

V_{LITTER} Litter cover	Estimate the percent of the plot area covered by undecomposed litter. Average the results of the four subplots.	Subplot 1 = ____% Subplot 2 = ____% Subplot 3 = ____% Subplot 4 = ____%	Average litter cover = _____%
V_{GVC} Ground vegetation cover	Estimate the percent cover of all herbaceous plants and woody plants < 1.4 m (4.5 ft) tall. Average the results of the four subplots.	Subplot 1 = ____% Subplot 2 = ____% Subplot 3 = ____% Subplot 4 = ____%	Average ground veg cover = _______%

OBSERVATIONS ALONG TRANSECTS

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

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

PAGE 3 OF 3

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}	Change in flood recurrence interval (0-5)	________years
V_{DUR}	Change in flood duration (0-5)	_______weeks
V_{STRATA}	Number of vegetation strata	____ strata
V_{SOIL}	Percent of the wetland assessment area with culturally unaltered soils	_______ %

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

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

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

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

PAGE 1 OF 1

Appendix C
Alternate Field Forms

Contents

Please reproduce these forms locally as needed.

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

SUBCLASS: ______________________
WAA # ___________
PLOT # ___________

If you are not using a basal area prism or similar tool to estimate tree basal area for the V_{TBA} variable, but instead are measuring individual tree diameters, use the form below to record tree diameters within each 0.04-ha plot. Follow the directions to summarize these data in terms of m^2/ha at the plot level, or use the spreadsheet provided in Appendix D, then enter the calculated value for each plot in the appropriate spaces on Appendix B Data Form 3. 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 3 in the V_{TBA} row as a plot value

PAGE 1 OF 1

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 in.) measured along Transect 1 and Transect 2 into the table below. Multiply each diameter measurement by 0.3937, and then square the result. Sum all results, then multiply that sum by 0.2657 to get large woody debris volume (m^3/ha).

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

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

SUBCLASS: ______________________
WAA # ___________
PLOT # ___________

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

PAGE 2 OF 2

Appendix D
Spreadsheets

Contents

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

Basal Area (V_{TBA}) Calculator
(Version of 12/2001)

Use one of the forms below (depending on whether tree diameters were measured in centimeters or inches) to calculate total basal area (m^2/ha) for a plot. Transfer the Total Plot Basal Area value (located in red cell) to the V_{TBA} line on Data Form 3 (Wetland Assessment Area Data Summary). Delete values from all green input cells and repeat data entry as needed for additional plots. (Note: Recording of species codes is optional. Users may want to include species associated with individual tree diameters to assist in determining dominance for V_{TCOMP} 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	Size Class 1	Size Class 2 No. of Stems/ 3.65 m Transect		Size Class 2	Size Class 2
	Transect 1	Transect 2	Total Stem Count	tons/acre	Transect 1	Transect 2	Total Stem Count	tons/acre
Plot 1			0	0.0			0	0.0
Plot 2			0	0.0			0	0.0
Plot 3			0	0.0			0	0.0
Plot 4			0	0.0			0	0.0
Plot 5			0	0.0			0	0.0

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

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

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

	Size Class 3 Sum of Stem Diameter^2 (in) Transect 1	Size Class 3 Sum of Stem Diameter^2 (in) Transect 2	Size Class 3 Total Diameter^2 (in)	Size Class 3 tons/acre	Size Class 3 ft^3/acre
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 Flat Regional Subclass
in the Arkansas Valley Region
(Version of 2/2007)

Project:	**example**		
WAA#	1	**Area of the WAA (ha):**	**10**

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}	1	cm	0.800
V_{BUF30}	N/A	%	N/A
V_{BUF250}	N/A	%	N/A
V_{COMP}	50	%	0.500
V_{DUR}	N/A	%	N/A
V_{FREQ}	N/A	years	N/A
V_{GVC}	50	%	1.000
V_{LITTER}	50	%	1.000
V_{LOG}	50	m^3 / ha	0.500
V_{OHOR}	1	cm	1.000
V_{PATCH}	3000	ha	1.000
V_{POND} (Low Terrace)	25	%	1.000
V_{POND} (High Terrace)		%	
V_{POND} (Tributary Terrace)		%	
V_{SNAG}	50	stems / ha	1.000
V_{SOIL}	50	%	0.500
V_{SSD}	500	stems / ha	1.000
V_{STRATA}	4	# layers	1.000
V_{TBA}	50	m^2 / ha	1.000
V_{TCOMP}	50	%	0.500
V_{TDEN}	500	stems / ha	1.000
V_{WD}	50	m^3 / ha	0.750

Function	Functional Capacity Index (FCI)	Functional Capacity Units (FCU)
Detain Floodwater	N/A	N/A
Detain Precipitation	1.000	10.000
Biogeochemical Cycling	0.944	9.438
Export Organic Carbon	N/A	N/A
Maintain Plant Communities	0.750	7.500
Provide Wildlife Habitat	0.900	9.001

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

Appendix E
Spatial Data

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

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

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

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

Common Name	Scientific Name
American elm	*Ulmus americana*
American holly	*Ilex opaca*
baldcypress	*Taxodium distichum*
beautyberry	*Callicarpa americana*
beech	*Fagus grandifolia*
big bluestem	*Andropogon gerardi*
bitternut hickory	*Carya cordiformis*
black cherry	*Prunus serotina*
black hickory	*Carya texana*
black oak	*Quercus velutina*
black willow	*Salix nigra*
blackberry	*Rubus* spp.
blackgum	*Nyssa sylvatica*
blackjack oak	*Quercus marilandica*
blueberry	*Vaccinium* spp.
box elder	*Acer negundo*
Bur oak	*Quercus macrocarpa*
buttonbush	*Cephalanthus occidentalis*
catalpa	*Catalpa speciosa*
cedar elm	*Ulmus crassifolia*
cherrybark oak	*Quercus pagoda*
chickasaw plum	*Prunus angustifolia*
cinnamon fern	*Osmunda cinnamomea*
common privet	*Ligustrum* spp.
cow oak	*Quercus michauxii*
cucumber magnolia	*Magnolia accuminata*
deciduous holly	*Ilex decidua*
eastern cottonwood	*Populus deltoides*

elderberry	*Sambucus canadensis*
flowering dogwood	*Cornus florida*
green ash	*Fraxinus pennsylvanica*
hawthorn	*Crataegus* spp.
hibiscus	*Hibiscus* spp.
highbush blueberry	*Vaccinium arboreum*
honey locust	*Gleditsia triacanthos*
indiangrass	*Sorghastrum nutans*
ironwood	*Carpinus caroliniana*
leadplant	*Amorpha fruticosa*
little bluestem	*Andropogon scoparius*
loblolly pine	*Pinus taeda*
mockernut hickory	*Carya tomentosa*
netted chain fern	*Woodwardia areolata*
northern red oak	*Quercus rubra*
Nuttall oak	*Quercus nuttallii*
overcup oak	*Quercus lyrata*
paw-paw	*Asimina triloba*
pecan	*Carya illinoensis*
persimmon	*Diospyros virginiana*
pin oak	*Quercus palustris*
pondberry	*Lindera melissifolia*
post oak	*Quercus stellata*
red maple	*Acer rubrum*
red mulberry	*Morus rubra*
river birch	*Betula nigra*
royal fern	*Osmunda regalis*
shagbark hickory	*Carya ovata*
shellbark hickory	*Carya laciniosa*
shortleaf pine	*Pinus echinata*
Shumard oak	*Quercus shumardii*
silver maple	*Acer saccharinum*
smooth dogwood	*Cornus drummondii*
southern red oak	*Quercus falcata*
spicebush	*Lindera benzoin*
storax	*Styrax americana*
sugar maple	*Acer saccharum*
sugarberry	*Celtis laevigata*
swamp cottonwood	*Populus heterophylla*
swamp dogwood	*Cornus foemina*
swamp privet	*Forestiera acuminata*
swamp red maple	*Acer drummondii*
sweetgum	*Liquidambar styraciflua*
switchgrass	*Panicum virgatum*
sycamore	*Platanus occidentalis*
umbrella magnolia	*Magnolia tripetala*
Virginia willow	*Itea virginica*

water elm	*Planera aquatica*
water hickory	*Carya aquatica*
water locust	*Gleditsia aquatica*
water oak	*Quercus nigra*
water tupelo	*Nyssa aquatica*
willow oak	*Quercus phellos*
winged elm	*Ulmus alata*
witch hazel	*Hamamelis virginiana*
witch hazel	*Hamamelis vernalis*

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14. ABSTRACT

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

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Wetland classification
Wetland function
Wetland restoration