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A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Functions of Forested Wetlands in the Mississippi Alluvial Valley

Elizabeth O. Murray and Charles V. Klimas

July 2013

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Elizabeth O. Murray and Charles V. Klimas

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Final report

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Abstract

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

This *Regional Guidebook* presents the HGM Approach for assessing the functions of most of the wetlands that occur in the Mississippi Alluvial Valley (MAV). It consolidates and extends the coverage provided by two previous guidebooks for the Delta Region of Arkansas and the Yazoo Basin of Mississippi.

The report begins with an overview of the HGM Approach and then classifies and characterizes the principal indentified MAV wetlands. Detailed HGM assessment models and protocols are presented for five of those wetland types, or subclasses, representing most of the forested wetlands in the region other than those associated with lakes and impoundments. The following wetland subclasses are treated in detail: Flat, Low-Gradient Riverine Backwater, Low-Gradient Riverine Overbank, Isolated Depression, and Connected Depression. The appendices provide field data collection forms and spreadsheets for making calculations.

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Contents

Abstract ii

Figures and Tables v

Preface vii

1 Introduction 1

2 Overview of the Hydrogeomorphic Approach 4

Hydrogeomorphic classification 4
Reference wetlands 4
Assessment models and functional indices 6
Assessment protocol 7

3 Characterization of Wetland Subclasses in the Mississippi Alluvial Valley 9

Reference domain 9
Climate 9
Geology and geomorphology 10
Pleistocene Terraces 12
Holocene Meander Belts 12
Hydrology 14
Western Lowlands 15
Arkansas Lowlands 16
St. Francis Basin 16
Yazoo Basin 17
Tensas Basin 17
Boeuf Basin 17
Soils 18
Vegetation 19
Alterations to environmental conditions 22
Land use and management 22
Hydrology 23
Definition and identification of the HGM classes and subclasses 24
Class: Flat 29
Class: Riverine 32
Class: Depression 37
Class: Fringe 41

4 Wetland Functions and Assessment Models 44

Function 1: Detain Floodwater 45
Function 2: Detain Precipitation 46
Function 3: Cycle Nutrients 48
Function 4: Export Organic Carbon 50

Function 5: Maintain Plant Communities 51
Function 6: Provide Habitat for Fish and Wildlife 54

5 Variables and Data Collection 57

V_{TRACT} - Wetland Tract 58
$V_{CONNECT}$ – Percent Connectivity 59
V_{CORE} – Percent Core 60
V_{FREQ} – Change in Flood Frequency 61
V_{POND} – Percent Ponded Area 62
V_{DUR} – Change in Flood Duration 64
V_{SOIL} - Soil Alteration 65
$V_{DWD\&S}$ – Downed Woody Debris Biomass and Snags 66
V_{LITTER} – Percent Litter 67
V_{STRATA} – Strata Present 68
$V_{TREESIZE}$ – Tree Size Classes 68
V_{COMP} – Vegetation Composition 70
V_{TBA} - Tree Basal Area 71

6 Assessment Protocol 72

Document the project purpose and characteristics 73
Screen for red flags 75
Define assessment objectives, identify regional wetland subclass(es) present, and identify assessment area boundaries 75
Collect field data 78
Apply assessment results 81

References 84

Appendix A: Preliminary Project Documentation 88

Appendix B: Field Data Sheets 89

Appendix C: Common and Scientific Names of Plant Species Referenced in Text and Data Sheets 94

Appendix D: Photos of Indicators used in the MAV HGM Data collection 97

Report Documentation Page

Figures and Tables

Figures

Figure 1. Example subindex graph for the Tree Density (V_{TDEN}) assessment variable for a particular wetland subclass. 7
Figure 2. The Mississippi Alluvial Valley reference domain. 9
Figure 3. Distribution of the major lowland basins and principal Quaternary deposits in the Mississippi Alluvial Valley as well as the deltaic plain and chenier plain deposits south of the Red River. 11
Figure 4. Principal geomorphic settings and features of the Mississippi Alluvial Valley. 12
Figure 5. Key to the wetland classes in the MAV. 25
Figure 6. Key to the wetland subclasses and community types in the MAV 26
Figure 7. Common landscape positions of wetland community types in the Flat Class. 30
Figure 8. Common landscape positions of wetland community types in the Riverine Class. 33
Figure 9. Common landscape positions of wetland community types in the Depression Class. 38
Figure 10. Common landscape positions of wetland community types in the Fringe Class. 41
Figure 11. Wetland subclasses (purple line indicates extent of "wetland tract") 58
Figure 12. Identification of "connected perimeter" (green line). 59
Figure 13. Identification of "core area." 60
Figure 14. Example application of geomorphic mapping and aerial photography to develop a preliminary wetland classification for a proposed project area. 74
Figure 15. Land cover. 76
Figure 16. Project area (in yellow) 76
Figure 17. Wetland subclasses (purple line indicates extent of the "wetland tract"). 76
Figure 18. WAAs. 76
Figure 19. Example sample distribution. Refer to Figure 18 for WAA designations. 79

Tables

Table 1. Hydrogeomorphic wetland classes. 5
Table 2. Potential regional wetland subclasses in relation to classification criteria. 6
Table 3. Composition and site affinities of common forest communities in the MAV 21
Table 4. Hydrogeomorphic Classification of Forested Wetlands in the MAV and Typical Geomorphic Settings of Community Types. 28
Table 5. Applicability of Variables by Regional Wetland Subclass 58
Table 6. Variable Sub Indices for V_{TRACT} 59
Table 7. Variable Sub Indices for $V_{CONNECT}$ 60
Table 8. Variable Sub Indices for V_{CORE} 61
Table 9. Variable Sub Indices for V_{POND} 63
Table 10. Variable Sub Indices for V_{SOIL} 66

Table 11. Variable Sub Indices for V_{LITTER} 68
Table 12. Variable Sub Indices for V_{STRATA} 69
Table 13. Variable Sub Indices for $V_{TREESIZE}$ 70
Table 14. Variable Sub Indices for V_{TBA} 71

Preface

In 2002, the US Army Engineer Research and Development Center (ERDC) published *A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Selected Regional Wetland Subclasses, Yazoo Basin, Lower Mississippi River Alluvial Valley*, (Smith and Klimas 2002). This was followed in 2004 by *A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Wetlands in the Delta Region of Arkansas, Lower Mississippi River Alluvial Valley* (Klimas et al. 2004, updated to Version 2.0 in 2011). This *Regional Guidebook* consolidates the two previously published guidebooks, and incorporates new sample data to extend coverage to all of the Mississippi Alluvial Valley (MAV) between the confluences of the Mississippi River with the Ohio River and the Red River. The current guidebook does not necessarily supersede those documents – users familiar with those earlier reports can continue to apply them within their regions of applicability if they prefer, and they will yield essentially the same results as this guidebook. However, this version is designed to be applied more quickly; it requires less data collection and provides simplified data input forms. This guidebook can also be used in parts of the MAV not covered by the previous guidebooks. This streamlined approach was originally developed for the Arkansas Delta Region by Sheehan and Murray (2011), based in part on earlier efforts to devise a more rapid HGM assessment approach by Tom Roberts (Tennessee Technological University).

The authors of this report are Research Ecologists with the Wetlands and Coastal Ecology Branch, Ecosystem Evaluation and Engineering Division, Environmental Laboratory, ERDC. However, much of the data collection, wetland classification, and model development were accomplished by groups of people who are credited as co-authors or advisors in the previous Mississippi and Arkansas guidebooks. Those guidebooks, in turn, were based in large part on an earlier document (*A Regional Guidebook for Assessing the Functions of Low Gradient, Riverine Wetlands of Western Kentucky* by Ainslie et al. 1999). The list of collaborators on all of these source documents is long, but major contributors included R.D. Smith, T. Foti, J. Pagan, H. Langston, W.B. Ainslie, and T. Roberts, in addition to the authors of this report. The work of all of these collaborators is included in this consolidated report, including portions of the text and

some figures that are taken directly from those earlier documents. However, they are not responsible for the modified and simplified version presented here.

Major funding for those various source documents was provided by Region 6 of the Environmental Protection Agency through programs administered by the Multi-Agency Wetland Planning Team of the State of Arkansas. Funding was also provided by the Corps of Engineers through research programs conducted by ERDC. The consolidated report and the field work to extend the guidebook coverage were funded by the Wetlands Regulatory Assistance Program (WRAP) and published by ERDC as part of the Hydrogeomorphic Assessment (HGM) Guidebook series. The ERDC WRAP Program Manager is Sally Yost.

This work was performed under the general supervision of Patrick O'Brien, Chief, Wetlands and Coastal Ecology Branch, Environmental Laboratory (EL); Dr. Edmond Russo, Chief, Ecosystem Evaluation and Engineering Division, EL; and Dr. Elizabeth C. Fleming, Director, EL.

COL Kevin J. Wilson was Commander of ERDC; Dr. Jeffery P. Holland was Director.

1 Introduction

The Hydrogeomorphic (HGM) Approach is a method for assessing the capacity of a wetland to perform ecological functions that are comparable to similar wetlands in a region. 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.

HGM assessments are conducted using methods that are developed for one or more wetland subclasses within a defined geographic region, such as a mountain range, river basin, or ecoregion. The wetland classification system and assessment approach for that region are published in a regional HGM guidebook, based on guidelines published in the National Action Plan (National Interagency Implementation Team 1996), which were developed cooperatively by the US Army Corps of Engineers (USACE), US Environmental Protection Agency (USEPA), US Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), Federal Highway Administration (FHWA), and US 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.

This report is a regional guidebook developed for assessing wetlands that commonly occur in the Mississippi Alluvial Valley (MAV), an area encompassing parts of six states between the confluence of the Ohio and Mississippi Rivers southward to the confluence of the Red and Mississippi Rivers. This guidebook describes the wetlands of that region and presents models and methods for assessing their functional integrity.

The wetland classification system, models and methods incorporated in this guidebook were originally developed by two separate groups of technical advisors (i.e., “Assessment Teams”) who worked on earlier guidebooks published for portions of the region. The two portions of the region covered

earlier were the Yazoo Basin in Mississippi (Smith and Klimas, 2002) and the Delta Region of Arkansas (Klimas et al. 2004; 2011). The 2004 Arkansas guidebook was structured to be consistent with the 2002 Yazoo Basin guidebook but included some refinements reflecting a more extensive reference dataset. The 2011 Arkansas guidebook incorporated some additional changes to how soil and hydrology variables are measured, based on user experience with the original version. In order to determine whether the model calibrations needed to be modified for the expanded region covered by this guidebook, additional reference data were collected in northeastern Louisiana, southeastern Missouri, and western Tennessee and Kentucky. Those data were compared to the existing assessment model calibration curves and species composition criteria, which were found to be applicable throughout the expanded region covered by the guidebook with only minor modifications. Consequently, this guidebook uses the 2011 Arkansas Delta guidebook as the basic template for all model variables and their calibration. The model structure and application methods also are consistent with the earlier guidebook, but have been simplified for easier application in the field based on a system developed by Sheehan and Murray (2011) in Arkansas. That system was reviewed and approved by members of the original Assessment Team; therefore, its adoption here is consistent with standard HGM procedure. Persons conducting assessments in the Arkansas or Mississippi portions of the MAV may wish to continue to use the older guidebooks for consistency with prior assessments or because they are familiar and comfortable with the methods. Otherwise, this version should provide similar results but is simpler to apply and is applicable over a larger area.

Note that the portion of the Lower Mississippi Valley south of the Red River is not included in this guidebook's area of applicability. That region, which consists mostly of the Atchafalaya Basin, is a distributary landscape that is geologically distinct from the alluvial valley segment of the Lower Mississippi Valley (Saucier 1994). Therefore, all of the Lower Mississippi Valley south of the Red River confluence is included in a separate Southeastern Coastal Plain HGM guidebook (Wilder et al. 2013).

Also excluded from this guidebook is the batture, which is the regional name for the land between the mainstem levees of the large rivers in the MAV. No reference data were collected from the batture during the development of this or any other HGM guidebook. An earlier study of the batture forests (Klimas 1988) found wetland communities with composition

and structure that were generally similar to the river-connected wetland subclasses described in this guidebook. However, most sites within the levee system are subject to periodic deep, high-velocity flows and extensive sediment redistribution events that are clearly influenced by the confining effects of the levee system. Therefore, users who choose to apply the models and reference data used here to batture sites should be aware that there are differences in fundamental processes between those areas and the reference sites used to develop this guidebook.

This guidebook adopts the perspective that the mainstem Mississippi River levee and related systemic flood-control features constructed in the 20th century are permanent, and constitute the "baseline condition" for the purposes of functional assessment.

The remainder of this report is organized in the following manner. Chapter 2 provides a brief overview of the major components of the HGM Approach. Chapter 3 characterizes the regional wetland subclasses in the MAV Region. 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. Appendix A presents preliminary project documentation and field sampling guidance. An example of field data sheets is presented in Appendix B; working versions that perform the required calculations must be downloaded from http://el.erdc.usace.army.mil/wetlands/guidebooks.cfm. Appendix C contains the common and scientific names of plant species referenced in the text and data sheets.

2 Overview of the Hydrogeomorphic Approach

The HGM approach incorporates consideration of (a) the HGM classification system, (b) the characteristics of reference wetlands, (c) assessment variables and assessment models from which functional indices are derived, and (d) assessment protocols.

Hydrogeomorphic classification

The HGM classification was developed specifically to support functional assessment (Brinson 1993a). It uses three criteria to group wetlands that function similarly: geomorphic setting, water source, and hydrodynamics. Geomorphic setting refers to the topography and landscape position of the wetland. Water source refers to the primary source of the water that sustains wetland characteristics, such as precipitation, floodwater, or groundwater. Hydrodynamics refers to the level of energy with which water moves through the wetland, and the direction of water movement.

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

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 be sensitive to common types of wetland impacts. In order to reduce variability, the classification criteria are applied at a regional scale to create regional wetland subclasses. Examples of potential regional subclasses are shown in Table 2.

Reference wetlands

Reference wetlands are sites selected to represent the range of variability that occurs within a regional wetland subclass as a result of natural processes (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).

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 river flow becomes the dominant water source. Additional water sources may be groundwater discharge and precipitation. Because tidal fringe wetlands are frequently flooded and water table elevations are controlled mainly by sea surface elevation, tidal fringe wetlands seldom dry for significant periods. Tidal fringe wetlands lose water by tidal exchange, by overland flow to tidal creek channels, and by evapotranspiration. Organic matter normally accumulates in higher elevation marsh areas where flooding is less frequent and the wetlands are isolated from shoreline wave erosion by intervening areas of low marsh or dunes. S*partina 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 down slope unidirectional water flow. Slope wetlands can occur in nearly flat landscapes if groundwater discharge is a dominant source to the wetland surface. Slope wetlands lose water primarily by saturated subsurface flows, surface flows, and by evapotranspiration. They may develop channels, but the channels serve only to convey water away from the slope wetland. Slope wetlands are distinguished from depression wetlands by the lack of a closed topographic depression and the predominance of the groundwater/interflow water source. Fens are a common example of slope wetlands.
Mineral Soil Flats	Mineral soil flats are most common on interfluves, extensive relic lake bottoms, or large alluvial terraces where the main source of water is precipitation. They receive virtually no groundwater discharge, which distinguishes them from depressions and slopes. Dominant hydrodynamics are vertical fluctuations. Mineral soil flats lose water by evapotranspiration, overland flow, and seepage to underlying groundwater. They are distinguished from flat non-wetland areas by their poor vertical drainage due to impermeable layers (e.g., hardpans), slow lateral drainage, and low hydraulic gradients. Pine flatwoods with hydric soils are an example of mineral soil flat wetlands.
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 standard wetlands are the subset of reference wetlands that function at a level that is characteristic of the least altered wetland sites in the least altered landscapes.

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 one or more characteristics or processes of the wetland ecosystem. Functional capacity is the ability of a wetland to perform a specific function in a manner comparable to that of reference standard wetlands. Application of assessment models results in a Functional Capacity Index (FCI) ranging from 0.0 to 1.0. Wetlands with an FCI of 1.0 perform the assessed function at a level that is characteristic of reference standard wetlands. A lower FCI indicates that the wetland is performing a function at a level below the level that is characteristic of reference standard wetlands.

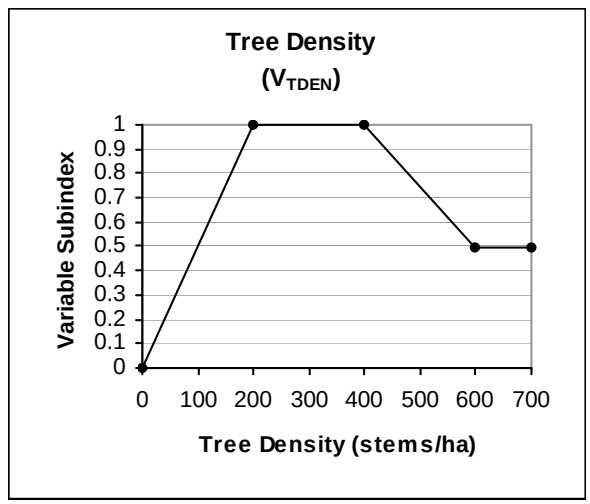
For example, the following equation (model) could be used to assess a function commonly of interest with regard to riverine wetlands: the capacity of the wetland to detain floodwater.

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

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

Each of the variables in the model is scaled against the range of values observed in the reference wetlands. The values, or metrics, are measures appropriate for characterizing the particular variable, such as percent cover for the V_{GVC} variable, or number of trees per hectare for the V_{TDEN} variable. 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. Figure 1 illustrates the relationship between metric values of tree density (V_{TDEN}) and the variable subindex for an example wetland subclass. As shown in the graph, tree densities of 200 to 400 stems/ha represent reference standard conditions, based on field studies, and a variable subindex of 1.0 is assigned for assessment models where tree density is a component. Where tree densities are higher or lower than those found in reference standard conditions, a lesser variable subindex value is assigned.

Figure 1. Example subindex graph for the Tree Density (V_{TDEN}) assessment variable for a particular wetland subclass.



Assessment protocol

All of the steps described in the preceding sections concern development of the assessment tools and the rationale used to produce this *Regional*

Guidebook. Although users of the guidebook should be familiar with this process, their primary concern will be the protocol for application of the assessment procedures. The assessment protocol is a defined set of tasks, along with specific instructions, that allows resource professionals to assess the functions of a particular wetland area. 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 field data. The final task is performing an analysis that involves calculation of functional indices. These steps are described in detail in Chapter 6, and the required data sheets, spreadsheets, and supporting digital spatial data are provided in the Appendices.

3 Characterization of Wetland Subclasses in the Mississippi Alluvial Valley

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 MAV, exclusive of the batture lands between the mainstem Mississippi River levees. The MAV is defined according to Saucier (1994), who distinguishes it from the Lower Mississippi Valley, which extends from the mouth of the Ohio River to the Gulf of Mexico, and includes the deltaic and chenier plain deposits in southern Louisiana. Saucier limits the MAV to that segment of the Lower Mississippi Valley that lies north of the head of the Atchafalaya River, which marks the upstream end of the deltaic plain from a geologic perspective. For the purposes of this guidebook, the southern boundary of the MAV is delimited by the meander belt of the Red River, which is confluent with the Mississippi at the same location as the Atchafalaya. Excluded from the MAV is Crowley's Ridge, a strip of Tertiary-age upland in northeastern Arkansas and southeastern Missouri. The area covered by the guidebook includes all other parts of Louisiana, Mississippi, Arkansas, Missouri, Tennessee and Kentucky that lie within the MAV (Figure 2).

Figure 2. The Mississippi Alluvial Valley reference domain.

Climate

The northern portion of the MAV has a humid temperate climate with about 48 inches of rain annually. The southern end of the valley is humid

subtropical, with 56 inches of rainfall on average. The distribution of precipitation is such that excess moisture is present in the winter and spring months, and frequent soil moisture deficits occur in the months of June through September.

The MAV has temperate winters and long, hot summers, with prevailing southerly winds that carry moisture from the Gulf Coast, creating high humidity levels and a high incidence of thunderstorms. Freezing temperatures reach much of the area for short periods in most years, and tornadoes and ice storms commonly occur (Brown et al. 1971, Southern Regional Climate Center 2012).

Geology and geomorphology

The most recent synthesis of the geologic history and major physiographic divisions within the MAV was by Saucier (1994). This guidebook relies primarily on his interpretations, and much of the following discussion is adapted directly from that publication.

Surface topography within the alluvial valley is defined by the characteristics of a deep alluvial fill that overlies coastal plain geologic formations and deeper Paleozoic and older rocks. The MAV is bounded on the east and west by exposures of the coastal plain sediments and by the Ouachita and Ozark mountains in Arkansas and Missouri. Remnant coastal plain deposits also form a narrow elongated upland “island,” Crowley’s Ridge, which is not considered to be part of the MAV. It extends more than 125 miles through southeastern Missouri and northeastern Arkansas, but is less than 10 miles wide on average. In places it rises as much as 250 feet above the elevation of the adjacent alluvial deposits of the MAV. There are various wetlands on Crowley’s Ridge, such as seeps and small stream bottoms, but they are discussed in a separate publication (Klimas et al. 2005), and are not included in this guidebook.

About half of the alluvial valley is made up of terraces that are remnants of multiple glacial outwash events during Wisconsin glacial cycles. Other Pleistocene terraces that were established between outwash episodes are composed primarily of meandering-river depositional features. Holocene (post-glacial) meander belt features make up nearly all of the remainder of the MAV. Each of these surfaces has unique features, and their distribution and varying elevations divide the MAV into six major sub-basins. Figure 3 illustrates the distribution of the major geomorphic settings and sub-basins

within the MAV, and Figure 4 presents a generalized view of the relative landscape positions of the principal deposits. The characteristics of those features and the major sub-basins are described in the following sections.

Figure 3. Distribution of the major lowland basins and principal Quaternary deposits in the Mississippi Alluvial Valley as well as the deltaic plain and chenier plain deposits south of the Red River (adapted from Saucier (1994)).

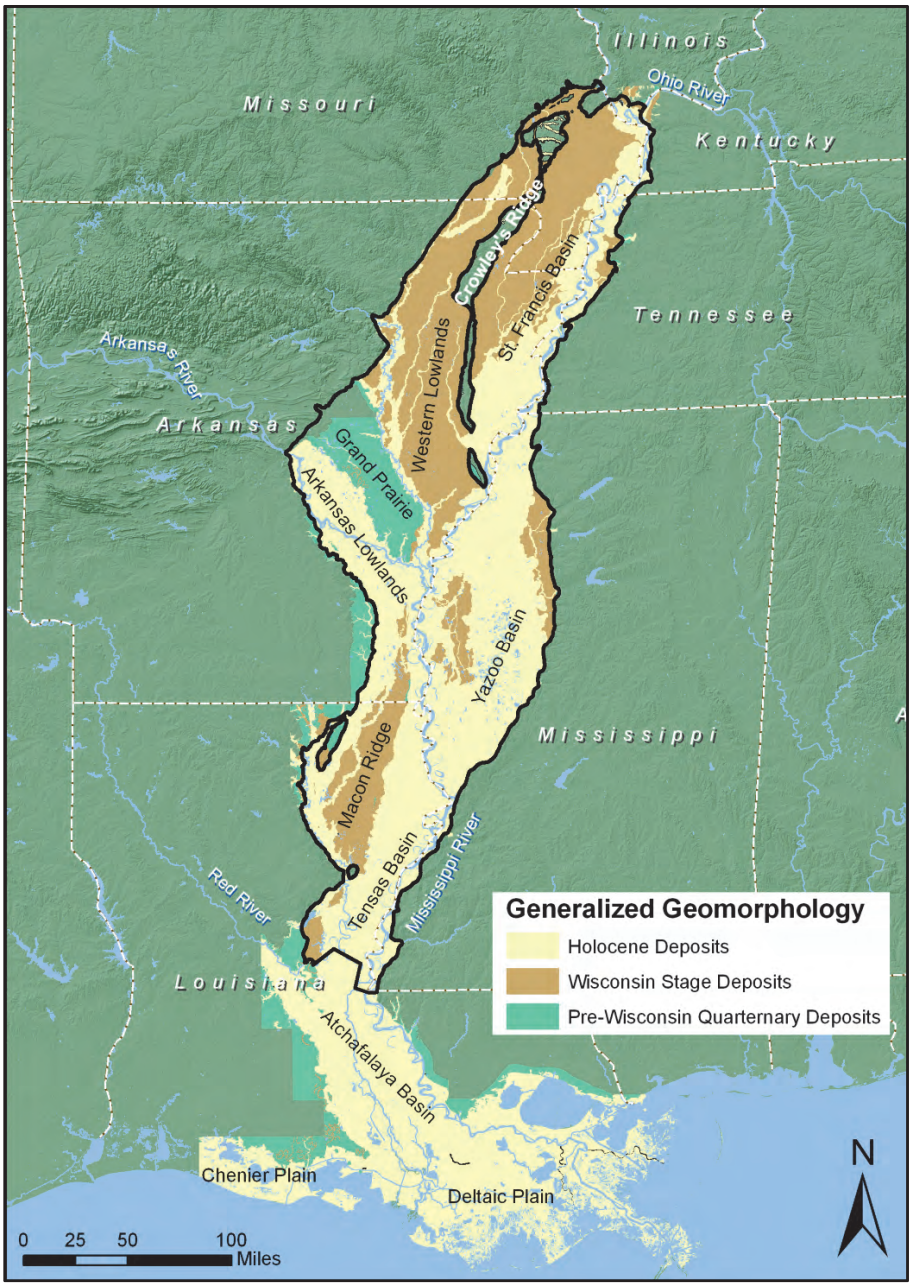
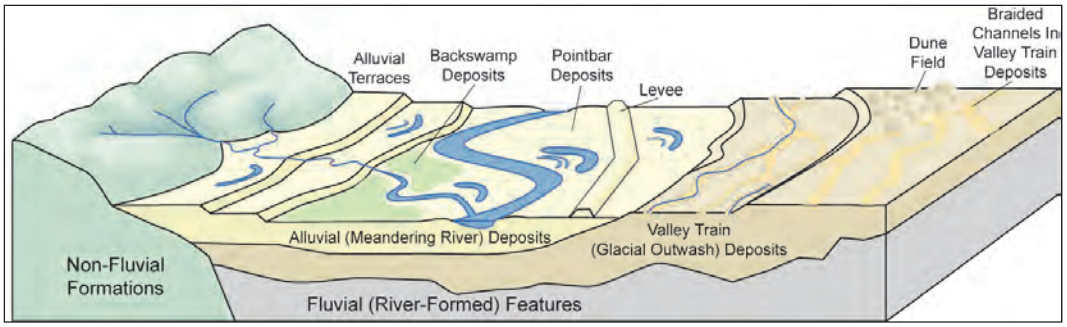


Figure 4. Principal geomorphic settings and features of the Mississippi Alluvial Valley.



Pleistocene Terraces

The northern third of the MAV – as well as Macon Ridge in Louisiana and southern Arkansas – consists primarily of Pleistocene deposits of glacial outwash that flushed into the Mississippi Valley during periods of waning Late Wisconsin continental glaciation. Sometimes called "valley train" terraces, they are composed of relatively unsorted, coarse materials deposited in a braided-stream environment, and capped with a veneer of fine-grained, well-sorted sediments deposited later by meandering streams. Valley train deposits usually occur in the form of multiple distinct terrace surfaces, with the oldest and highest being 30 feet or more above the modern floodplain. On the lower and younger terraces, the remnant outwash channels are often distinctly visible, and may carry smaller modern streams within them. Some of the valley train surfaces are covered with extensive dunefields made up of wind-blown sand and silt deflated from younger outwash channels and deposited on adjacent older surfaces.

In addition to the glacial outwash terraces, remnants of pre-Wisconsin Arkansas and Mississippi River meander belts also remain in the MAV as high terraces, primarily within Arkansas along the western valley wall, and as the extensive terrace peninsula known as the Grand Prairie (Figure 3). There are also much later, lower elevation Wisconsin-age alluvial terraces along the southern margin of the Grand Prairie and adjacent to the Cache River. All of the alluvial terraces are characterized by features typical of meandering streams, as described for Holocene meander belts, below, rather than the braided channel features found on valley train terraces.

Holocene Meander Belts

Point bars. Point bar deposits predominate within the Holocene meander belts in the MAV. They generally consist of relatively coarse-grained

materials (silts and sands) laid down on the inside (convex) bend of a meandering stream channel. The result is a characteristic pattern of low arcuate ridges separated by swales ("ridge and swale" or "meander scroll" topography). Point bar swales range from narrow and shallow to broad and deep, and usually are closed at each end to form depressions. The scale and depth of point bar swales depend on the depositional environment that formed the adjacent ridges and the degree of sedimentation within the swale since it formed.

Abandoned channels. These features are the result of cutoffs, where a stream abandons a channel segment, usually because migrating bendways intersect and channel flow moves through the neck. The typical sequence of events following a neck cutoff is that the upper and lower ends of the abandoned channel segment quickly fill with coarse sediments, creating an open oxbow lake. Usually, small connecting channels maintain a connection between the river and the lake, at least at high river stages, so river-borne fine-grained sediments gradually fill the abandoned channel segment. If this process is not interrupted, the lake eventually fills completely, the result being an arcuate swath of cohesive, impermeable clays within a better drained point bar deposit. Often, however, the river migrates away from the channel segment and the hydraulic connection is lost, or the connection is interrupted by later deposition of point bar or natural levee deposits. In either case, the filling process is dramatically slowed, and abandoned channel segments may persist as open lakes or depressions of various depths and dimensions.

Abandoned courses. An abandoned course is a stream channel segment left behind when a stream diverts flow to a new meander belt. Abandoned course segments can be hundreds of miles long, or only short segments may remain where the original course has been largely obliterated by subsequent stream activity. In some cases, the abandoned course is captured by smaller streams, which meander within the former channel and develop their own point bars and other features. Where the stream course is abandoned gradually, the remnant stream may fill the former channel with point bar deposits even as its flow declines. Thus, while abandoned channels often become depressions with fine-textured soils, abandoned courses are more likely to be fairly continuous with the point bar deposits of the original stream, or to become part of the meander belt of a smaller stream.

Natural levees. A natural levee forms where overbank flows result in deposition of relatively coarse sediments (sand and silt) adjacent to the stream channel. The material is deposited as a continuous sheet that thins with distance from the stream, resulting in a relatively high ridge along the bankline and a gradual backslope that becomes progressively more fine-grained with distance from the channel. Along the modern Mississippi River, natural levees rise about 4.5 m above the elevation of the adjacent floodplain and may extend for several kilometers or more from the channel. Natural levees formed by smaller streams or over short periods of time tend to be proportionately smaller, but the dimensions and composition of natural levee deposits are the product of various factors, including sediment sources and the specific mode of deposition.

Backswamps. As natural levees and point bars accrete sediments along active streams, a meander belt ridge forms that is higher than the adjacent land surfaces. Where alluvial ridges (or other elevated features such as uplands or terraces) are configured so as to form a basin between them, they collect runoff, pool floodwaters, and accumulate fine sediments. The resulting backswamp environments typically have substrates of massive clays, and are incompletely drained by small, sometimes anastomosing streams. They may include large areas that do not fully drain through channel systems but remain ponded well into the growing season. In much of the MAV, backswamp deposits are 12 m thick or more.

Hydrology

The dominant drainage feature of the MAV is the Mississippi River. The drainage area of the Mississippi River basin is approximately 3,227,000 sq km, which is about 41 percent of the land area of the continental United States (USACE 1973). Major floods on the lower Mississippi River usually originate in the Ohio River basin, and can crest in any month from January to May. High flows that originate in the upper Mississippi River system generally occur in late spring and early summer (Tuttle and Pinner 1982).

Groundwater also is a significant component of the hydrology of the MAV. The alluvial aquifer occupies coarse-grained deposits that originated as glacial outwash and from more recent alluvial activity. Generally, the surface of the alluvial aquifer is within 10 m of the land surface, and it is approximately 38 m thick. It is essentially continuous throughout the MAV. Where the top stratum is made up of coarse sediments or thinly veneered with fine sediments, the alluvial aquifer is recharged by surface

waters. Discharge is primarily to stream channels, which contribute to stream baseflow during low-flow periods (Saucier 1994, Terry et al. 1979).

All of the major elements of the drainage system and hydrology of the MAV have been modified to varying degrees in historic times. At the time of European settlement, major Mississippi River floods would have inundated about half of the MAV (Moore 1972). Much of the region also was subject to prolonged, extensive ponding following the winter wet season in virtually all years, localized short-term ponding following rains at any time of year, and extensive inundation within tributary floodbasins due to rainfall in headwater areas in most years. Engineering projects and agricultural activities have incrementally altered and continue to alter these various sources of wetland hydrology, as described in the Alterations to Environmental Conditions section, below.

The MAV is subdivided into six major lowland areas or basins, each of which is a distinct hydrologic unit draining southward (Figure 3). The basins are separated by Pleistocene terraces, Holocene meander belt ridges, or by Crowley's Ridge.

Western Lowlands

The Western Lowlands is the designation for the second-largest of the sub-basins in the MAV. It spans much of northeastern Arkansas and south-eastern Missouri, where it is bounded on the west and north by the Ozark escarpment, on the west and south by the Grand Prairie, and on the east by Crowley's Ridge.

Various streams enter the basin from the Ozark Plateau to the west, including the Black, Current, Spring, White, and Little Red Rivers. The Cache River and Bayou De View originate within the lowlands on the eastern side of the basin. All of these streams drain to the White River, which discharges to the Arkansas River.

All of the major streams in the basin are flanked by relatively narrow floodplains with recent (Holocene) landforms that are typical of meandering river systems, including poorly drained backswamps, better-drained point bars, and well-drained natural levees. Abandoned channel segments form crescent-shaped oxbow lakes and depressions. However, most of the Western Lowlands region is made up of much older Pleistocene valley train terraces that form five distinct surfaces in the Western Lowlands, with the

oldest and highest being 10m or more above the modern floodplain. On the lower and younger terraces, the remnant outwash channels are often distinctly visible, and may carry smaller modern streams within them. Some of the valley train surfaces are covered with extensive dunefields made up of wind-blown sands deflated from younger outwash channels and deposited on adjacent older surfaces.

Arkansas Lowlands

The Arkansas Lowlands area lies immediately north and east of the Arkansas River, and is bounded on the north by the Grand Prairie. It is the smallest of the major MAV sub-basins. Bayou Meto and Bayou Two Prairie are the only major streams in the basin.

All of the landforms in the Arkansas Lowlands are Holocene deposits of the Arkansas River. They are composed of features typical of meandering streams, such as point bar, backswamp, natural levee, and abandoned channel deposits.

St. Francis Basin

The St. Francis Basin is the northernmost lowland area in the MAV, extending through southeastern Missouri and northeastern Arkansas between Crowley's Ridge and the modern meander belt of the Mississippi River. The principal streams are the St. Francis, Tyronza, and Little Rivers, as well as Pemiscot Bayou.

The southern third of the basin, in Arkansas, is made up primarily of Holocene meander belt deposits of the Mississippi River, while the rest of the area is largely composed of valley train deposits. As in the Western Lowlands, there are multiple levels of valley train terraces in the St. Francis basin, but the lowest and most extensive levels are products of the most recent episodes of Pleistocene glacial meltwater moving down the valley, and many of the braided outwash channels are distinctly visible. Relict sand bars and wind-blown sand are also apparent on the surface of some valley train deposits, and there are numerous more recent features known as "sand blows" composed of previously buried outwash sands ejected during the New Madrid earthquakes of 1811 and 1812.

Yazoo Basin

The largest of the lowland areas in the MAV is located in northwestern Mississippi, where the area is bounded on the east by rolling uplands and on the west by the current meander belt of the Mississippi River. The majority of the area consists of multiple Holocene meander belts of the Mississippi River and extensive intervening backswamp environments. Limited areas of Pleistocene valley train also are present, but they are not as distinctly elevated above the Holocene deposits as they typically are in other basins.

All surface water discharge from the Yazoo Basin is through the Yazoo River, which enters the Mississippi River at the southern end of the basin. Most of that water originates in the uplands along the eastern flank of the basin and is carried to the Yazoo via the Coldwater, Yocona, Tallahatchie, and Yalobusha Rivers, as well as via several smaller streams. Interior drainage is provided by numerous small streams that discharge to Deer Creek, the Big Sunflower River, Steele Bayou, or Bogue Phalia, which then flow to the lower Yazoo River. The pattern of drainage within the basin is generally southward, but can be quite convoluted, reflecting the influence of the complex topography dominated by abandoned meander belts of the Mississippi River.

Tensas Basin

The Tensas Basin extends from near the mouth of the Arkansas River in eastern Arkansas to the mouth of the Red River in Louisiana. It is bounded by the current Mississippi River meander belt on the east and the outwash terraces of Macon Ridge on the west. All of the landforms in the basin are made up of Holocene meander belt deposits, primarily of Mississippi and Arkansas River origins. The Tensas River and Bayou Macon are the principal streams in the northern and central parts of the study area, and Black River drains the southern part, where it is formed from the confluence of the Tensas River with the Ouachita River which enters the basin from the west. Various smaller streams arise within the basin and flow to one of those major drainages.

Boeuf Basin

The Boeuf Basin is a narrow lowland that lies between Macon Ridge on the east and uplands on the west. Geologically, it is a continuation of the

Arkansas Lowlands, but is separated from them by the Arkansas River. It is made up of Holocene meander belt and backswamp deposits laid down by the Arkansas River when it flowed far to the south of its present location. It is named after the Boeuf River, but in Arkansas that stream flows entirely within the Macon Ridge uplands to the east before entering the lowlands in Louisiana. In Arkansas, the principal stream is Bayou Bartholomew, which flows within an abandoned course of the Arkansas River. The largest stream in the basin is the Ouachita River, which enters the western side of the basin near Monroe, Louisiana. It follows an abandoned Arkansas River channel as it collects the flow of all other drainages and exits the basin at Sicily Island near the southern terminus of Macon Ridge.

Soils

Parent materials of soils in the MAV are fluvial sediments. The alternating periods of meander belt development and glacial outwash deposition produced complex but characteristic landforms where sediments were sorted to varying degrees based on their mode and environment of deposition. The sorting process has produced textural and topographic gradients that are fairly consistent on a gross level and result in distinctive soils. Generally, within a Holocene meander belt, surface substrates grade from relatively coarse-textured, well-drained, higher elevation soils on natural levees directly adjacent to river channels through progressively finer textured, and less well-drained materials on levee backslopes and point bar deposits to very heavy clays in closed basins such as large swales and abandoned channels. Backswamp deposits between meander belts also are filled with heavy clays. Valley train deposits typically have a top stratum (upper 0.2–3 m) of fine-grained material (clays and silts) that blankets the underlying network of braided channels and interfluves. On older, higher valley train deposits, the top stratum contains considerable loess, and in some areas consists of sandy dunes. The lowest, most recent valley trains have surface soils that are derived primarily from Mississippi River flooding (Brown et al. 1971, Saucier 1994).

The gradient of increasingly fine soil textures from high-energy to low-energy environments of deposition (natural levees and point bars to abandoned channels and backswamps) implies increasing soil organic matter content, increasing cation exchange capacity, and decreasing permeability. However, all of these patterns are generalizations, and quite different conditions occur regularly. The nature of alluvial deposition varies between and within flood events, and laminated or localized

deposits of varying textures are common within a single general landform. Thus, natural levees dominated by coarse-textured sediments may contain strata with high clay content, and valley train surfaces that are usually fine-grained may have some soil units with high sand content. Point bar deposits, which typically have less organic matter incorporated into the surface soils than backswamps or abandoned channels, may actually contain more total organic matter on a volume basis due to the presence of large numbers of buried logs and other stream-transported organic material (Saucier 1994).

Within the Holocene meander belts, soils of older meander belts are likely to show greater A horizon development than soils in equivalent positions within younger meander belts (Autin et al. 1991). Similarly, older soils are likely to be more acidic and deeper, show less depositional stratification and more horizonation, and otherwise exhibit characteristics of advanced soil development not seen in soils of younger meander belts.

Individual soil series descriptions can be found at: http://soils.usda.gov/technical/classification/scfile/index.html.

Vegetation

Forests of the MAV are referred to as bottomland hardwoods, a term that incorporates a wide range of species and community types that can tolerate inundation or soil saturation for at least some portion of the growing season (Wharton et al. 1982).

Bottomland hardwood forests are among the most productive and diverse ecosystems in North America. Under presettlement conditions, they were essentially continuous throughout the Lower Mississippi Valley, and they interacted with the entire watershed, via floodwaters, to import, store, cycle, and export nutrients (Brinson et al. 1980, Wharton et al. 1982). Although these conditions have changed dramatically in modern times, the remaining forests still exist as a complex mosaic of community types that reflect variations in alluvial and hydrologic environments. Within-stand diversity varies from dominance by one or a few species to forests with a dozen or more overstory species, and diverse assemblages of understory, ground cover, and vine species (Putnam 1951, Wharton et al. 1982).

Most major overviews of bottomland hardwood forest ecology emphasize the relationship between plant community distribution and inundation,

usually assuming that floodplain surfaces that occupy different elevations in relation to a river channel reflect different flood frequency, depth, and duration (e.g., Brinson et al. 1981; Wharton et al. 1982). This leads to classification of forests in terms of hydrologic "zones," each zone having characteristic plant communities. Zonal characterization systems generally reference most sites to a presumed stream entrenchment process that leaves a stepwise sequence of terraces. However, zonal concepts have limited utility in much of the MAV where Pleistocene landforms and multiple abandoned Holocene meander belts dominate the landscape. In addition, features such as natural levees and abandoned channels, which may be rather minor components of some southeastern floodplains, often occupy large areas within the MAV. In much the same way, the general zonal models imply that the principal hydrologic controls on community composition are flood frequency, depth, and duration, as indicated by elevation relative to a stream channel. However, stream flooding is just one of many important sources of water in forested wetlands of the MAV, and factors such as ponding of precipitation and poor drainage may be more important than flooding effects in many landscape settings.

Despite the complexity of the landscape, plant communities do occur on recognizable combinations of site hydrology and geomorphology within the MAV. The synthesis documents of Putnam (1951) and Putnam et al. (1960) adopt a perspective that recognizes the unique terrain of the region, and summarize the principal combinations of lowland landscape setting, drainage characteristics, and flood environment as they influence plant community composition. Table 3 is based on that approach. However, the first two cover types in Table 3, where a variety of oak species are listed as commonly present, actually encompass a wide array of sites where species dominance patterns vary greatly.

Under natural conditions, forest stands within the MAV undergo change at various temporal and spatial scales. Primary succession occurs on recently deposited substrates, which include abandoned stream channels, point bars, crevasse splays, and abandoned beaver ponds. A sequential replacement of pioneer species with longer-lived, heavy-seeded species occurs over time, and usually involves changes in substrate elevation as additional sedimentation occurs. This pattern was common when stream channels migrated freely, but in historic times channel stabilization has reduced the creation of new substrates dramatically.

Table 3. Composition and site affinities of common forest communities in the MAV (after Putnam (1951)).

Forest Cover Type	Characteristic Species	Site Characteristics
Sweetgum - Water Oaks	*Liquidambar styraciflua* *Quercus nigra* *Quercus texana* *Quercus phellos* *Ulmus americana* *Celtis laevigata* *Fraxinus pennsylvanica*	In first bottoms except for deep sloughs, swamps, fronts, and poorest flats. Also on terrace flats.
White Oaks - Red Oaks - Other Hardwoods	*Quercus michauxii* *Quercus similis* *Quercus pagoda* *Quercus shumardii* *Quercus falcata* *Fraxinus americana* *Carya* spp. *Nyssa sylvatica* *Ulmus alata*	Fine, sandy loam and other well-drained soils on first bottom and terrace ridges.
Hackberry - Elm - Ash	*Celtis laevigata* *Ulmus americana* *Fraxinus pennsylvanica* *Carya aquatica* *Quercus phellos*	Low ridges, flats, and sloughs in first bottoms, terrace flats, and sloughs. Occasionally on new lands or fronts.
Overcup Oak - Water Hickory	*Quercus lyrata* *Carya aquatica*	Poorly drained flats, low ridges, sloughs, and backwater basins with tight soils.
Cottonwood	*Populus deltoides* *Carya illinoensis* *Platanus occidentalis* *Celtis laevigata*	Front land ridges and well-drained flats.
Willow	*Salix nigra*	Front land sloughs and low flats.
Riverfront Hardwoods	*Platanus occidentalis* *Carya illinoensis* *Fraxinus pennsylvanica* *Ulmus americana* *Celtis laevigata* *Acer saccharinum*	All front lands except deep sloughs and swamps.
Cypress - Tupelo	*Taxodium distichum* *Nyssa aquatica* *Nyssa sylvatica* var. *biflora*	Low, poorly drained flats, deep sloughs, and swamps in first bottoms and terraces.

The typical natural regeneration process in established forest stands is initiated by single tree-falls, periodic catastrophic damage from fire or windstorm, and inundation mortality due to blocked drainage or beaver dams. Small forest openings occur due to windthrow, disease, lightning

strikes, and similar influences that kill individual trees or small groups of trees (Dickson 1991). The resulting openings are rapidly colonized, but the composition of the colonizing trees may vary widely depending on factors such as existing advanced reproduction, seed rain from adjacent mature trees, and importation of seed by animals or floodwaters. Often, this pattern results in small, even-aged groves of trees, sometimes of a single species (Putnam et al. 1960).

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

Alterations to environmental conditions

The physical and biological environment of the MAV has been extensively altered by human activity. Isolation and stabilization of the Mississippi and Arkansas Rivers have effectively halted the large-scale channel migration and overbank sediment deposition processes that created and continually modified the Holocene landscapes of the alluvial valley. At the same time, sediment input to depressions and sub-basins within the area has increased manyfold in historic times due to erosion of uplands and agricultural fields (Kleiss 1996, Saucier 1994, Smith and Patrick 1991). The Mississippi River no longer overwhelms the landscape with floods that course through the basin, but it continues to influence large areas through backwater flooding. Patterns of land use and resource exploitation have had differential effects on the distribution and quality of remaining forest communities. Assessment of wetland functions in this highly modified landscape requires an understanding of the scope of the more influential changes that have taken place.

Land use and management

Natural levees, which commonly are the highest elevations in the landscape of the MAV and often are in direct proximity to water, have been the focus

of human settlement during both prehistoric and historic times (Saucier 1994). At the time of the first European explorations of the region in the 16th century, natural levees of the major rivers were extensively used for maize agriculture by Native Americans (Hudson 1997). By the time detailed surveys of the Mississippi River were first made in the 1880s, European settlers were farming nearly all of the natural levees adjacent to the river through the MAV (Mississippi River Commission 1881–1897). Lower terrain had not been similarly developed (Barry 1997).

In the last two decades of the 19th century, local flood control and drainage efforts began to have widespread effects in the region, and railroads were constructed in formerly remote areas. These changes allowed logging and agricultural development to proceed on a massive scale throughout the MAV. As the 20th century progressed, improvements to farming equipment and crops and the initiation of coordinated Federal flood control efforts allowed further conversion of forested land to agriculture. From an estimated original area of 9 to 10 million hectares, Lower Mississippi Valley forests had been reduced by about 50 percent by 1937, and 50 years later less than 25 percent of the original area remained forested (Smith et al. 1993). Much of the remaining forest is highly fragmented, with the greatest degree of fragmentation occurring on drier sites (such as natural levees), and the largest remaining tracts being in the wettest areas (Rudis 1995). Nearly all of the remaining forests within the basin have been harvested at least once, and many have been cut repeatedly and are in degraded condition due to past high-grading practices (Putnam 1951; Rudis and Birdsey 1986).

Hydrology

The hydrology of the MAV has been modified extensively and purposefully. Unconnected wetlands associated with the higher alluvial terraces (such as Grand Prairie) and with the valley train terraces were not subject to major river flooding in historic times, and they were readily drained with simple ditch systems and planted with row crops. The lowlands were far more difficult to convert to agricultural uses. By the mid-19th century, many individual plantations along the Mississippi River were protected with low levee systems, often built with slave labor, that were sufficient to exclude most floods, but not the periodic catastrophic event (Barry 1997). Additional drainage and levee building were accomplished under the provisions of the Federal Swamp Lands Act passed in 1849 and 1850 (Holder 1970), but the first truly extensive and effective efforts were undertaken in the late 19th

century and into the first few decades of the 20th century, when numerous local levee and drainage districts were created and funded by land taxes and the sale of bonds.

Despite the successes of the early drainage districts, their efforts could not overcome the effects of the Mississippi, Yazoo, Red, and Arkansas Rivers in flood stage; and periodic widespread destruction occurred (Barry 1997). A devastating flood in 1927 finally prompted Congress to direct the US Army Corps of Engineers to implement a comprehensive federal flood control plan for the entire Lower Mississippi Valley. The approach included construction of larger and stronger levees as well as various channel modifications, bank protection works, and other features. The multiple elements of this plan and its subsequent modifications collectively comprise the Mississippi River and Tributaries Project (MR&T), which is the largest flood-control project in the world (US Army Engineer Division, Mississippi Valley 1998).

Congress directed changes to the MR&T plan in the 1930s and 1940s that included the addition of cutoffs, tributary reservoirs, and an emphasis on maintenance of a stable, deep Mississippi River channel as a levee protection measure and a means of providing navigation benefits. In the 1950s, 1960s, and 1970s the project was expanded to include numerous tributary modifications, pump stations, harbor improvement projects, and lock and dam projects, as well as channel and levee projects throughout the system. During this last period, fish and wildlife considerations also became authorized project purposes. Meeting fish and wildlife objectives generally involved constructing water control structures within floodways and sump areas to allow habitat management for waterfowl (Moore 1972).

The cornerstone of the Federal flood-control effort in the Lower Mississippi Valley is the mainstem levee system, which is essentially continuous on the western side of the Mississippi River from Cape Girardeau, MO, to Venice, LA, about 16 km above the mouth of the river, except where tributaries enter. Levees also extend up the tributaries and they are used to create backwater areas that are used as water storage basins during major Mississippi River floods.

Definition and identification of the HGM classes and subclasses

Brinson (1993a) identified five wetland classes based on hydrogeomorphic criteria, as described in Chapter 2. Wetlands representing four of these

classes (Flat, Riverine, Depression, and Fringe wetlands) and a variety of subclasses occur within the MAV. However, categorical separation of these classes is sometimes difficult because of the complexity of the landscape and hydrology within the basin and because features of wetlands intergrade and overlap among types. Consequently, a set of specific criteria has been established to assist the user in assigning any particular wetland in the region to the appropriate class, subclass, and community type. These criteria are presented in the form of dichotomous keys in Figures 5 and 6. In addition, each wetland type identified in the keys is described in the following section, which also includes a series of block diagrams illustrating the major wetland types and their relationships to various landforms and man-made structures. These relationships also are summarized in Table 4.

Figure 5. Key to the wetland classes in the MAV.

Key to Wetland Classes in the Mississippi Alluvial Valley

1. Wetland is not within the 5-year floodplain of a stream **2**

1. Wetland is within the 5-year floodplain of a stream **3**

    2. Topography generally flat, principal water source is precipitation ..... **Flat**

    2. Topography is depressional, or within the 5-year floodplain of a stream **3**

3. Wetland is not in a topographic depression or impounded..... **Riverine**
3. Wetland is in a topographic depression, or impounded **4**

    4. 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**

    4. Wetland is in an impoundment or depression other than above **5**

5. Wetland is associated with a water body that has permanent water more than 2 m deep in most years ..... **Fringe**

5. Wetland is associated with a water body that is ephemeral or less than 2 m deep in most years ..... **Depression**

Figure 6. Key to the wetland subclasses and community types in the MAV (Sheet 1 of 2).

Key to Wetland Subclasses and Community Types in the Mississippi Alluvial Valley		
CLASS: FLAT	Subclass	Community Type
1. Soil reaction acid	Non-Alkali Flat (2)	
1. Soil reaction circum-neutral to alkaline (lake bed deposits)		
2. Vegetation dominated by graminoids		*wet tallgrass prairie*
2. Vegetation dominated by woody species		
2a. Vegetation dominated by pine		*pine flat*
2b. Vegetation dominated by post oak		*post oak flat*
2c. Vegetation dominated by hardwoods other than post oak		*hardwood flat*
3. Vegetation dominated by graminoids		*alkali wet prairie*
3. Vegetation dominated by post oak		*alkali post oak flat*
CLASS: RIVERINE	Subclass	Community Type
1. Wetland associated with low-gradient stream (Stream Orders > 6, or other alluvial streams)	3	
1. Wetland associated with mid-gradient stream (Stream Orders 4–6)	Mid-Gradient Riverine (2)	
2. Water source primarily overbank flooding or lateral saturation		*mid-gradient floodplain*
2. Water source primarily backwater flooding, wetland typically located at confluence of two streams		*mid-gradient backwater*
3. Wetland not an impoundment	Low-Gradient Riverine (5)	
3. Wetland an impoundment	Riverine Impounded (4)	
4. Wetland impounded by beaver		*beaver complex*
4. Wetland impounded for wildlife management (greentree reservoirs and moist soil units)		*managed wildlife impoundments*
5. Water source primarily overbank flooding (5-year zone) that falls with stream water levels, or lateral saturation from channel flow		*low-gradient overbank*
5. Water source primarily backwater flooding or overbank flows (5-year zone) that remain in the wetland due to impeded drainage after stream water levels fall		*low-gradient backwater*

Figure 6. (Sheet 2 of 2).

CLASS: DEPRESSION	Subclass	Community Type
1. Depression not subject to direct stream flooding during a 5-year event; precipitation, runoff, and groundwater are the dominant inflows.....2		
1. Depression has significant direct stream inflows and outflows relative to stored volume and/or is influenced by overbank or backwater flooding during a 5-year event 4		
2. Depression discharges water to surface channels, but has no significant surface inflows relative to discharge	Headwater Depression	*headwater swamp*
2. Depression has no significant direct surface outlet to a stream channel, or outflows are minor relative to stored volume	Unconnected Depression (3)	
3a. Precipitation-dominated depression in dunefields.....		*sandpond*
3b. Depressional feature in abandoned meander features (oxbows or swales) not subject to 5-year flood flows		*unconnected alluvial depression*
3c. Depressional feature in relict glacial outwash channel		*valley train pond*
4. Significant, perennial streamflow enters and leaves depression.....	Not Depression Class: see Riverine Class	
4. Depression not subject to perennial flow, but receives overbank or backwater flooding during 5-year events	Connected Depression	*floodplain depression*
CLASS: FRINGE	**Subclass**	**Community Type**
1. Wetland on the margin of a man-made reservoir	Reservoir Fringe	*reservoir shore*
1. Wetland on the margin of water body other than a reservoir.....2		
2. Water body subject to stream flooding during 5-year flood events	Connected Lacustrine Fringe	*connected lake margin*
2. Water body not subject to flooding during a 5-year event.....	Unconnected Lacustrine Fringe	*unconnected lake margin*

Some of the criteria that are used in the keys in Figures 5 and 6 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 the hydrologic models used to develop flood return interval maps generally include the 5-year return interval.

Table 4. Hydrogeomorphic Classification of Forested Wetlands in the MAV and Typical Geomorphic Settings of Community Types.

Wetland Classes, Subclasses, and Communities	Typical Geomorphic Setting
CLASS: FLAT	
SUBCLASS: ALKALI FLAT	
Alkali Post Oak Flat	Lacustrine sediments deposited in lake systems impounded by glacial outwash.
SUBCLASS: NON-ALKALI FLAT	
Hardwood Flat	Backswamp and point bar environments on Pleistocene and Holocene meander-belt topography, and on interfluves on valley trains.
Post Oak Flat	Pleistocene terraces.
CLASS: RIVERINE	
SUBCLASS: MID-GRADIENT RIVERINE	
Mid-Gradient Floodplain	Point bar and natural levee deposits within active meander belts of streams transitioning from uplands to alluvial plain, or dissecting terrace deposits.
Mid-Gradient Backwater	Backswamp and point bar deposits within active meander belts of mid-gradient streams near point of confluence with major alluvial river.
SUBCLASS: LOW-GRADIENT RIVERINE	
Low-Gradient Overbank	Point bar and natural levee deposits within active meander belts of alluvial streams.
Low-Gradient Backwater	Backswamp, point bar, and low-lying valley train deposits within and between both active and inactive meander belts of alluvial streams.
SUBCLASS: IMPOUNDED RIVERINE	
Beaver Complex	All flowing waters.
Wildlife Management Impoundment	Various settings.
CLASS: DEPRESSION	
SUBCLASS: HEADWATER DEPRESSION	
Headwater Swamp	In relict outwash channel, adjacent to scarp of a higher valley train terrace.
SUBCLASS: UNCONNECTED DEPRESSION	
Sand Pond	Eolian sand deposits (dunefields) on valley trains.
Valley Train Pond	Depressions atop buried braided outwash channels on valley trains.
Unconnected Alluvial Depression	Abandoned channels and large swales in former and current meander belts of larger rivers (including both Holocene and Pleistocene meander belt deposits).
SUBCLASS: CONNECTED DEPRESSION	
Floodplain Depression	Abandoned channels and large swales in former and current meander belts of larger rivers.
CLASS: FRINGE	
SUBCLASS: UNCONNECTED LACUSTRINE FRINGE	
Unconnected Lake Margin	Abandoned channels in meander belts and adjacent to man-made impoundments.
SUBCLASS: CONNECTED LACUSTRINE FRINGE	
Connected Lake Margin	Abandoned channels in meander belts and adjacent to man-made impoundments.

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.

The classification system addresses a major confounding aspect of overlap among wetland types that arises from the characteristic topographic variation within certain wetland types. Sites that function primarily as riverine wetlands and flats often incorporate small, shallow depressions, sometimes characterized as vernal pools and microdepressions. These features are regarded as normal components of the riverine and flat ecosystems, and are not separated into the Depression Class unless they meet specific criteria. Other significant criteria relating to classification are elaborated in the wetland descriptions in the following paragraphs.

The following sections briefly describe the classification system developed for this guidebook for wetlands in the MAV. All of the wetland types are described, but assessment models and supporting reference data were developed for only a subset of these types, as described in Chapter 4.

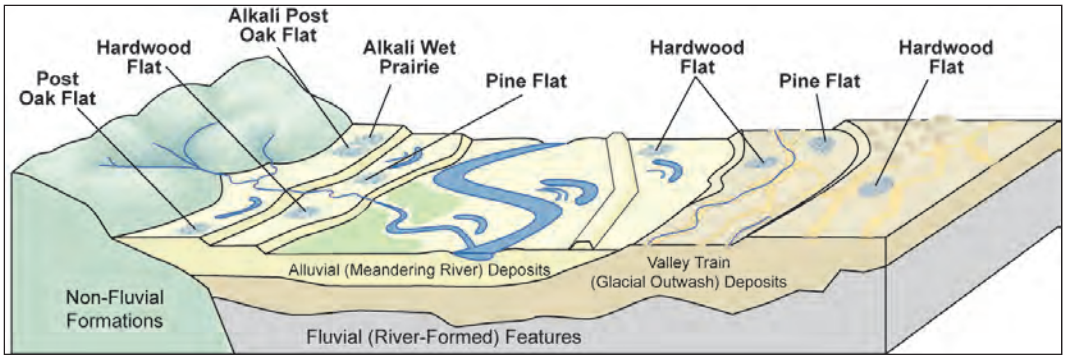
Class: Flat

Flats have little or no gradient, and the principal water source is precipitation. There is minimal overland flow into or out of the wetland except as saturated flow. Wetlands on flat areas that are subject to stream flooding during a 5-year event are classified as Riverine. Small ponded areas within flats are considered to be normal components of the Flat Class if they do not meet the criteria for the Depression Class. Sites are considered to be Slope wetlands rather than Flats if they have sufficient gradient to cause runoff in a single direction (however, slope wetlands are rare in the MAV), and as Slope or Depression wetlands if groundwater discharge is the principal water source within the wetland. There are two subclasses and six community types in the Flat Class, all of which occur within the MAV.

Figure 7 illustrates common landscape positions where wetlands in the Flat Class are found. See Figure 7 to identify land surfaces.

Subclass: alkali flat. Alkali flats (also called sodic or saline flats) have soils with high pH and high levels of sodium or magnesium salts in or near the surface layer. They typically have very poor drainage and a shallow

Figure 7. Common landscape positions of wetland community types in the Flat Class.



hardpan. The combination of impeded drainage and unusual soil chemistry restricts the potential plant communities, and provides habitats for certain rare species. The two community types in this subclass are separated based on predominant vegetation, but in fact probably represent a continuum of change in soil conditions, where the forested community occurs on soils with deeper hardpans than the prairie community. Most sites with alkali soils are believed to be former Pleistocene lake beds.

Alkali flats are not common in the MAV, and assessment models applicable to these types are not presented in this guidebook.

Community types. The following communities occur within the alkali flats subclass:

a. *Alkali post oak flat.* Alkali post oak flats occur on sites where the soils have extremely poor drainage and concentrations of salts accumulate near or on the soil surface. These sites are believed to have been occupied by shallow lakes during the Pleistocene. Repeated filling and drying of the lakes caused salts to accumulate, and today the ancient lakebeds are flats that support unique wetlands with characteristic plants that are tolerant of the high salt concentrations and impeded drainage conditions. In most cases, alkali flats are a mosaic of prairie and unvegetated “slick spots” on soils with salts at or very near the surface, while soils with less surface salt or somewhat better drainage support stunted post oak trees.

b. *Alkali wet prairie.* The ancient Pleistocene lake beds that support alkali post oak flats also support small areas of alkali wet prairie (also called saline prairie) where soil salinity is highest or drainage is

very poor. Where the salts accumulate on the surface, it is common to find a hard white or gray surface, termed a "slick spot." These areas may have salt crystals visible on the surface during dry periods, and they are largely devoid of vegetation. The perimeter of the slick spot often supports a crust of lichens, mosses, and liverworts. Beyond the slick spot edge, prairie species are able to colonize as the depth to the zone of concentrated salts increases, and stunted trees and shrubs occur on still deeper soils.

Subclass: non-alkali flat. Flats with neutral and acid soils can support a variety of community types. They are differentiated based on predominant vegetation types, which generally reflect drainage conditions. Fire history may also be an important factor in certain instances. These wetlands are widely distributed within the MAV, and provide habitat for numerous plant and animal species. 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 disconnected from streamflows by modern man-made levees, and these sites are now classified as flats.

This guidebook includes assessment models applicable to all of the forested non-alkali flats in the MAV. Assessment models were not developed for the wet tallgrass prairie type, for which few high quality reference sites could be located.

Community types: The following communities are found in non-alkali flats:

a. *Wet tallgrass prairie.* The wet tallgrass prairie community type typically occurs within broad basins or headwater draws that have poor drainage, or in minor swales within larger expanses of dry prairie. All of these sites tend to stay wet, with areas of standing surface water, through spring. They usually become extremely dry in late summer. Wet tallgrass prairie is dominated by typical prairie species such as big bluestem (*Andropogon gerardii*), little bluestem (*Andropogon scoparius*), Indian grass (*Sorghastrum nutans*), switch grass (*Panicum virgatum*), and numerous perennial forbs. However, it also includes wetland species such as beakrush (*Rhynchospora* spp.), marsh fleabane (*Pluchea foetida*), sundews

(*Drosera* spp.) and sphagnum moss (*Sphagnum* spp.). Fire is essential to maintain prairies — without fire, trees will gradually establish.

b. *Pine flat.* Pine flats, also called pine flatwoods, are common in the Coastal Plain, but in the MAV they are restricted to valley train deposits, on silt loam soils that are acid to strongly acid and with a high water table throughout the winter and spring. In the modern landscape, most of these sites have been dramatically altered by forest management, drainage, and by changes in fire frequency, timing, and intensity.

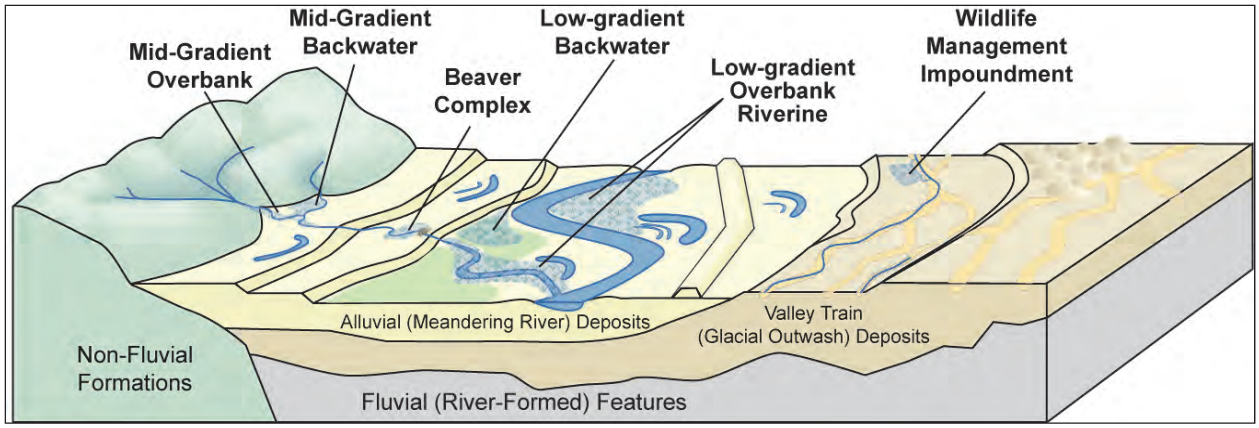
c. *Hardwood flat.* Hardwood flats occur on fairly level terrain that is not within the 5-year floodplain of stream systems, but that nevertheless remains wet throughout winter and spring due to rainfall that collects in small shallow pools. These pools often refill and remain wet for days or weeks following summer rains. Hardwood flats often are dominated by Nuttall oak (*Quercus texana*) in Holocene environments, and by water or willow oaks on older surfaces, where they are sometimes called oak flatwoods.

d. *Post oak flat.* Post oak flats occur on clay soils with poor drainage, generally on the margins of the Grand Prairie, where they may intergrade with hardwood flats, but are distinctively dominated by post oak or Delta post oak. These sites are saturated to the surface in the wet season and following rains, but become extremely dry and hard in summer. Mima (or pimple) mounds often are present, and contribute to the extensive ponding on these sites by impounding rainwater and impeding runoff. Tree growth tends to be very slow, although trees are not stunted as they are on alkali post oak flats.

Class: Riverine

Riverine wetlands are those areas directly flooded by streamflow, including backwater and overbank flow, at least once in five years on average (i.e., they are within the 5-year floodplain). Depressions and fringe wetlands that are within the 5-year floodplain are not included in the Riverine Class, but beaver ponds and wildlife management impoundments are usually considered to be riverine. Riverine wetlands encompass many different types of wetland communities; there are three subclasses and six community types in the Riverine Class in the MAV (Table 4, Figure 8).

Figure 8. Common landscape positions of wetland community types in the Riverine Class.



Subclass: mid-gradient riverine. Mid-gradient riverine wetlands are associated with streams (typically 4th – 6th order) that have significant floodplain development, but are upstream of the meandering portion of a stream system. They are important sources for input of organic material to the stream system. Mid-gradient systems are of limited distribution in the MAV, being restricted to sites transitional to the Coastal Plain, the Tertiary uplands flanking the upper part of the valley, and to some parts of the drainages flanking the Grand Prairie and Crowley's Ridge.

Due to the limited distribution of mid-gradient riverine systems in the MAV and consequent limited extent of potential reference wetlands for this subclass, no specific applicable assessment models have been developed for this guidebook.

Community types. The following community types occur within the mid-gradient riverine subclass:

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

b. *Mid-gradient backwater*. Mid-gradient backwater wetlands occur at the confluence of streams where high flows on the larger channel cause backwater flooding in the lower reaches of the mid-gradient tributary. They are sites where sediments accumulate rapidly, building natural levees and creating extensive backwater areas that drain slowly. Mid-gradient backwater systems tend to support plant communities that are more tolerant of flooding and sedimentation than the communities on most other mid-gradient floodplains. Species typical of adjacent hillslopes are not successful within the backwater zone, and some portions of the floodplain are occupied by species such as baldcypress (*Taxodium distichum*), that are more typical of lowland swamps.

Subclass: low-gradient riverine. Low-gradient riverine wetlands occur within the 5-year floodplain of meandering streams (usually 7th order or higher). They include a wide variety of community types, and have important functions related to habitat as well as sediment and water storage.

Community types. The following community types occur within the low-gradient riverine subclass:

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

gradient backwater community type. Many sites that were subject to backwater flooding in historic times are now protected by levees. Wetlands on these altered sites are classified as flats.

b. *Low-gradient overbank*. Low-gradient overbank wetlands occur on regularly flooded sites (1- to 5-year flood frequency zone) along or near streambanks and on bars and islands within channel systems. These sites are usually point bar deposits, often with a natural levee veneer. This type differs from the low-gradient backwater community type because floodwater usually moves through the overbank zone at moderate to high velocities, parallel to the channel. Sediments, nutrients, and other materials are exported downstream or imported from upstream sites differently than they are in backwater wetlands. Backwater sites may tend to accumulate fine sediments and organic material and to export dissolved materials in the water column. Overbank sites tend to be subject to scour or deep deposition of coarse sediments, and litter and other detritus may be completely swept from a site or accumulated in large debris piles. In-channel sandbars and riverfront areas usually are dominated by willows, sycamore (*Platanus occidentalis*), cottonwood, and similar pioneer species, while older and less exposed substrates support more diverse communities. In most cases, however, plant communities in the overbank flood zone tend to be dominated by species with broad tolerances for inundation, sedimentation, and high-velocity flows. Overbank sites sometimes include vernal pools, usually in the form of long, arched swales between the depositional ridges of meander-scroll topography, rather than the irregularly shaped pools typically found in backwater areas.

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

There are no HGM models specific to beaver complexes, but the recommended approach is to regard them as a fully functional component of any riverine system being assessed. Because the hydrological modifications and management techniques used in managed impoundments do not reflect the

patterns observed in reference systems, this guidebook does not include models designed specifically for application in those areas.

Community types. The following community types occur within the impounded riverine subclass:

a. *Beaver complex*. Beaver complexes were once nearly ubiquitous in the continental United States, but became relatively uncommon during the past two centuries following the near-extirpation of beaver. In their most common form, they consist of a series of impounded pools on flowing streams. Beavers cut trees for dams and food, and they have preferences for certain species (e.g., sweetgum (*Liquidambar styraciflua*)), 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 beavers reoccupy the area, the configuration changes again, the result being that systems with active beaver populations are in a constant state of flux.

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

Class: Depression

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

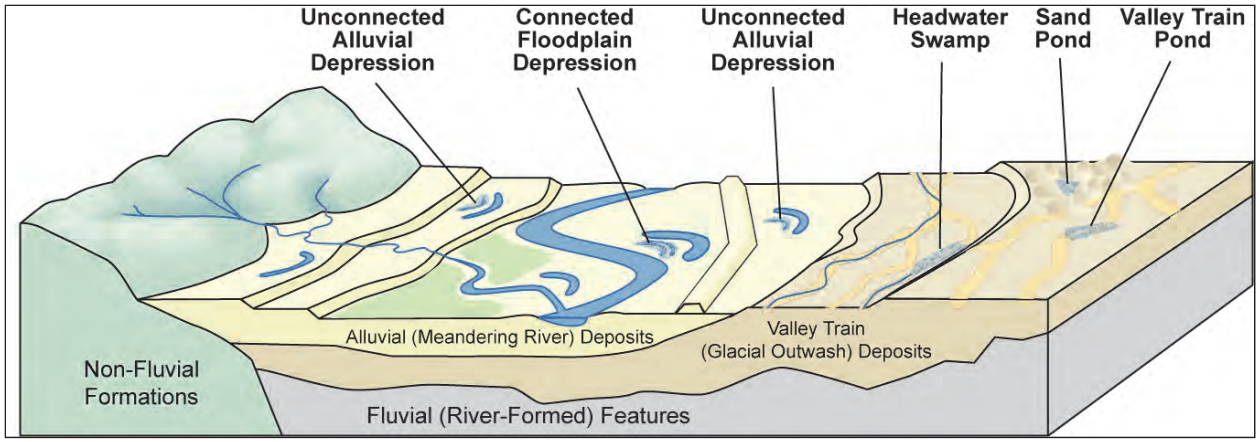
Depressions (both unconnected and connected) are distinguished from the ponded areas that occur within the Flat and Riverine Subclasses in several ways. Depressions tend to occur in abandoned channels, abandoned courses, and large point bar swales, while vernal pools within Flat and Riverine wetlands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

- Depressional soils may have one or both of the hydric soil indicators F2 (Loamy Gleyed Matrix) or A4 (Hydrogen Sulfide) (USDA NRCS 2010).
- Depressions are distinct, closed units with relatively abrupt transitions to flats, riverine wetlands, or uplands (as opposed to extensive riverine backwater zones).
- Vegetation in depressions is usually dominated by one or more of the following species: baldcypress, water tupelo (*Nyssa aquatica*), swamp privet (*Forestiera acuminata*), water elm (*Planera aquatica*), and buttonbush (*Cephalanthus occidentalis*). Many depressions are fringed (and some are dominated) by species such as overcup oak and water hickory.

In the MAV, there are three subclasses and five community types in the Depression Class (Table 4, Figure 9).

Subclass: headwater depression. Headwater depressions have one or more outlets that form the headwaters of perennial streams. They export materials such as nutrients and organic matter to downstream systems, and contribute to maintenance of stream baseflow. They differ from Connected Depressions in that they do not have a surface stream input; rather, they are fed by groundwater, precipitation, and/or local runoff.

Figure 9. Common landscape positions of wetland community types in the Depression Class.



Community type. The following community type occurs within the headwater depression subclass:

a. *Headwater swamp*. Few examples of this wetland type are known, but those that have been examined appear to be restricted to basins formed in ancient glacial outwash channels that receive groundwater from adjacent higher terraces. The nearly constant water supply into the depression creates swamp conditions, where baldcypress and water tupelo are the most common tree species. Few species are present in the understory, and herbaceous species grow primarily on stumps or from a zone of mosses on tree trunks at the level where water tends to stabilize during the growing season. The perimeter forest is dominated by typical lowland species, such as green ash, overcup oak, and Nuttall oak. All known examples of this wetland type are in Monroe or Phillips Counties in Arkansas – including the largest example – which is located at the Louisiana Purchase State Park.

Subclass: unconnected depression. Unconnected depressions are found in a variety of landscape settings. They are maintained by precipitation, runoff, and sometimes by groundwater. Some may have small (non-perennial) inflow and outlet channels, but they are not overwhelmed by floodwaters during 5-year events; therefore, the import or export of materials is not a significant function of these wetlands except during extreme events. Their disconnection from river systems may result in very different wildlife functions than those associated with connected depressions. For example, unconnected depressions may lack predatory fish

populations, and thereby provide vital habitat for certain invertebrate and amphibian species.

Community types. The following community types occur within the unconnected depressions subclass:

a. *Sand pond.* Sand ponds are depressions within dunefields on valley train terraces. The dunes are wind-blown accumulations of sediments that were deposited in waning glacial outwash channels, and date from 12,000 and 30,000 years before present. Individual dunes typically are 3 to 5 m high, and support upland forests or have been converted to agriculture. Numerous small, enclosed depressions are confined by the dunes, resulting in a poorly drained environment that ponds rainwater and possibly intercepts local groundwater for extended durations. As a result, distinctive, unconnected wetlands form that usually include swamp species such as baldcypress or water tupelo in the deepest interior areas, and successively less water-tolerant species around the perimeter of the depression. Many sand ponds, particularly those in the northern part of their distribution, contain the shrub species pondberry (*Lindera melissifolia*) and corkwood (*Leitneria floridana*), which do not commonly occur in any other habitat in the region.

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

c. *Valley train pond*. Valley train ponds are unconnected wetlands associated with glacial outwash ("valley train") deposits. They form in very shallow basins that are the remnants of ancient braided channel systems. Plant species in valley train ponds on the youngest outwash deposits (e.g., much of the St. Francis basin) are similar to those found in the alluvial depressions of active stream meander belts, such as baldcypress and water tupelo. Ancient sandbars within the valley train depressions may support species that are not commonly seen in swamps, but are more typical of sandy riverfront areas, such as sycamore and river birch. Older valley train deposits, where outwash channels are largely filled by stream backwater sediments, loess, or erosion from surrounding surfaces, have fewer, shallower ponds than younger surfaces, and tend to be dominated by species less tolerant of water such as willow and water oaks. Water sources for valley train ponds may include groundwater connections through the subsurface, sand-filled paleo-channel system, in addition to precipitation and local runoff.

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

Community type. The floodplain depression is the sole community type described within the connected depression subclass:

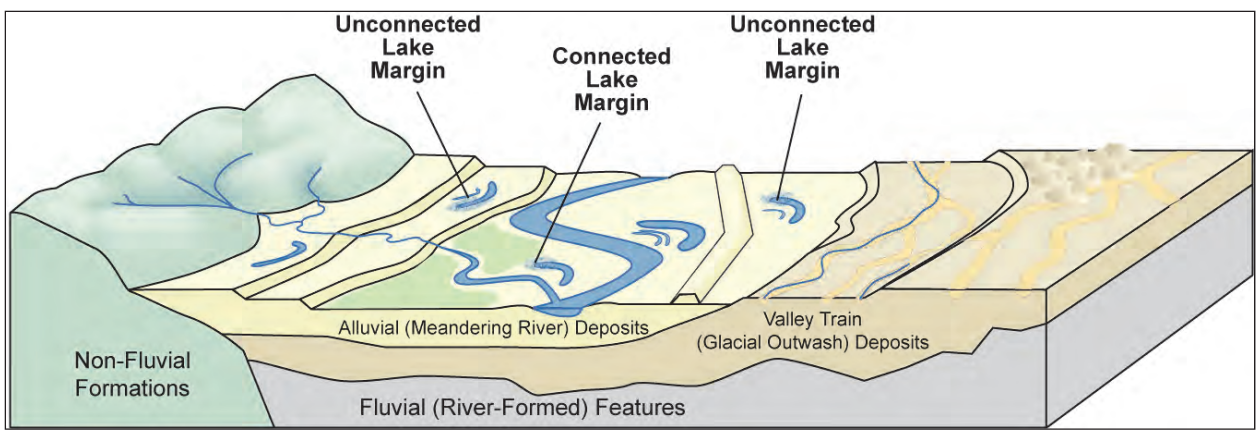
a. *Floodplain depression*. Floodplain depression wetlands are most commonly found in remnants of abandoned stream channels, or in broad swales left behind by migrating channels. They are usually near the river, and are flooded by the river during the more common (1- to 5-year) flood events, or are directly connected to perennial streams. They typically support swamp forests or shrub swamps in deeper water zones that remain flooded most of the time, and overcup oak-water hickory forests in areas that dry out in summer. Floodplain depression wetlands were once common in the MAV, but as effective flood-control works have been developed along major rivers, many depressions have become disconnected from stream systems and now function as unconnected alluvial depressions (discussed previously).

Class: Fringe

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

In the MAV, natural lakes occur mostly in the abandoned channels of large rivers (oxbows), but numerous man-made impoundments also support fringe wetlands. Typical examples include the baldcypress fringe common on oxbow lakes, or the black willow fringe that is often associated with borrow pits. There are three subclasses and three community types in the Fringe Class (Table 4, Figure 10). No assessment models have been developed for any of the Fringe wetland subclasses in the MAV, 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 10. Common landscape positions of wetland community types in the Fringe Class.



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

Community type. The reservoir shore is the sole community type described within the reservoir fringe subclass:

a. *Reservoir shore.* Man-made reservoirs include a wide array of features, such as large farm ponds, municipal water storage reservoirs, and state recreational lakes. In almost all cases, these lakes are managed specifically to modify natural patterns of water flow; therefore, their shoreline habitats are subjected to inundation at times and for durations not often found in nature. Steep reservoir shores usually support little perennial wetland vegetation other than a narrow fringe of cattails and rushes and 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 due to boat wakes, and similar impacts.

Subclass: connected lacustrine fringe. Fringe wetlands are considered to be "connected" to other aquatic systems if they become contiguous with riverflows during a 5-year flood event, or have perennial streams flowing into and out of them. This means that aquatic organisms can move freely between the river and the lake on a regular basis; and nutrients, sediments, and organic materials are routinely exchanged between the riverine and lake systems.

Community type: The connected lake margin is the sole community type described in the connected lacustrine fringe subclass:

a. *Connected lake margin.* Connected lake margin wetlands occur primarily in oxbow lakes near large rivers, where they are frequently inundated during floods (that is, they are within the 1- to 5-year flood frequency zone) or directly connected to perennial streams. Many lakes that would have met this criterion early in the 1900s have gradually been disconnected from riverflows due to the completion of large levees and other flood-protection works, and the wetlands in those lakes are now classified as unconnected lake margins. Connected lake margins differ from unconnected systems in that they routinely exchange nutrients, sediments, and aquatic organisms with the river system. Shoreline cypress-tupelo stands and fringe marshes are common, and the upper reaches of oxbow lakes often contain buttonbush swamps and expansive marsh systems. In addition to natural oxbows, there are man-made bodies

of water, such as borrow pits, which support connected fringe wetlands. Connected lake margin fringe wetlands are common along large rivers within the MAV.

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

Community type. The unconnected lake margin is the sole community type described in the unconnected lacustrine fringe subclass:

a. *Unconnected lake margin*. Unconnected lakes are lakes that are not within the portion of a floodplain that is inundated by a river on a regular basis (that is, they are not within the 1- to 5-year floodplain). They are similar in appearance to connected lake margins but are classified separately because they do not regularly exchange nutrients, sediments, or fish with river systems. Most are associated with oxbow lakes, where baldcypress wetlands normally form in a narrow band along the shoreline. Shallow filled areas in the upper and lower ends of the lake sometimes develop more extensive wetland complexes of willows, buttonbush, and marsh species.

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

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

4 Wetland Functions and Assessment Models

This *Guidebook* uses five sets of assessment models applicable to wetlands in the MAV. Only forested wetlands (or sites that could support forested wetlands) are intended to be assessed using these models. No rapid assessment models were developed for the Alkali Flat subclass, Headwater Depression subclass or the Mid-Gradient Riverine subclass, because relatively few examples of these wetlands exist in the MAV. None of the Fringe Class or Riverine Impounded subclass wetlands are addressed in the guidebook because impacts to these wetlands are likely to involve subtle changes in water level management, which are beyond the scope of a rapid assessment technique.

The MAV 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. For simplicity, the Non-Alkali Flat subclass will be referred to simply as the Flat subclass.

The output from the assessment models is a Functional Capacity Index (FCI) for each assessed function. This can be multiplied by some measure of affected area (usually hectares or acres) to generate Functional Capacity Units (FCU). Generally, FCUs are the most convenient basis for discussing and comparing among various potential impacts to wetlands, mitigation options, and similar potential actions affecting wetland functions.

The five wetland subclasses addressed with models in this guidebook are as follows:

1. Flat.
2. Low-Gradient Riverine Overbank.
3. Low-Gradient Riverine Backwater.
4. Unconnected Depression.
5. Connected Depression.

The following functions are assessed:

1. Detain Floodwater.
2. Detain Precipitation.

3. Cycle Nutrients.
4. Export Organic Carbon.
5. Maintain Plant Communities.
6. 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.

Function 1: Detain Floodwater

This function reflects the ability of wetlands to store, convey, and reduce the velocity of floodwater as it moves through a wetland. The potential effects of this reduction are damping of the downstream flood hydrograph, maintenance of post-flood base flow, and deposition of suspended sediments from the water column to the wetland. This function is assessed for the following regional wetland subclasses in the MAV: Low-Gradient Riverine Overbank, Low-Gradient Riverine Backwater, and Connected Depression. The recommended procedure for assessing this function involves estimation of "roughness" within the wetland, in addition to a change in flood frequency. A potential independent, quantitative measure for validating the functional index is the volume of water stored per unit area per unit time (m^3/ha/time), at a discharge equivalent to the average annual peak event.

The assessment model for the Detain Floodwater function includes the following assessment variables:

V_{FREQ} = change in flood return interval
$V_{DWD\&S}$ = down woody debris and snags
V_{STRATA} = number and top strata present
V_{TBA} = tree basal area

1. Flat.

Not Assessed

2. Low-Gradient Riverine Overbank.

$$FCI = V_{FREQ} \times \left[\frac{\left(V_{DWD\&S} + V_{STRATA} + V_{TBA} \right)}{3} \right]$$

3. Low-Gradient Riverine Backwater.

$$FCI = V_{FREQ} \times \left[\frac{\left(V_{DWD\&S} + V_{STRATA} + V_{TBA} \right)}{3} \right]$$

4. Unconnected Depression.

Not Assessed

5. Connected Depression.

$$FCI = V_{FREQ} \times \left[\frac{\left(V_{DWD\&S} + V_{STRATA} + V_{TBA} \right)}{3} \right]$$

Function 2: Detain Precipitation

This function is defined as the capacity of a wetland to prevent or slow runoff of rainfall to streams. This is accomplished chiefly by microdepressional storage, infiltration, and absorption by organic material and soils. Both floodprone (riverine) wetlands and nonflooded wetlands (flats) are assessed for this function. Depressional wetlands also perform a precipitation storage function, but are not assessed for that function within the MAV. Precipitation storage in depressions is related to local runoff to varying degrees, and it is difficult to consistently define source areas and available storage volumes in the context of a rapid field assessment. In contrast, precipitation storage in flats and riverine wetlands is more often a local effect related to microdepressional storage and infiltration capacity. Three wetland subclasses are assessed for the precipitation detention function in the MAV: Flat, Low-Gradient Riverine Overbank, and Low-Gradient Riverine Backwater.

The recommended procedure for assessing this function is estimation of available micro-depression storage and characterization of the extent of organic surface accumulations available to improve absorption and infiltration. A potential independent direct measure would be calculation

of onsite storage relative to runoff predicted by a storm hydrograph for a given rainfall event.

The assessment model for the Detain Precipitation function includes the following assessment variables:

V_{POND} = percent of area subject to ponding
V_{SOIL} = soil integrity
V_{LITTER} = percent cover of the litter layer

1. Flat.

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

2. Low-Gradient Riverine Overbank.

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

3. Low-Gradient Riverine Backwater.

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

4. Unconnected Depression.

Not Assessed

5. Connected Depression.

Not Assessed

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 soil integrity, V_{SOIL} and the percentage of the ground surface covered by litter V_{LITTER}.

Function 3: Cycle Nutrients

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. 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 five wetland subclasses.

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

The model for assessing the Cycle Nutrients function includes the following assessment variables:

V_{TBA} = tree basal area
V_{STRATA} = number and top strata present
$V_{TREESIZE}$ = number and top tree size present
V_{SOIL} = soil integrity
$V_{DWD\&S}$ = down woody debris and snags

The model can be expressed in a general form:

1. Flat.

$$FCI = \frac{\left[\frac{\left(V_{TBA} + V_{STRATA} + V_{TREESIZE}\right)}{3} + \frac{\left(V_{SOIL} + V_{DWD\&S}\right)}{2}\right]}{2}$$

2. Low-Gradient Riverine Overbank.

$$FCI = \frac{\left[\frac{\left(V_{TBA} + V_{STRATA} + V_{TREESIZE}\right)}{3} + \frac{\left(V_{SOIL} + V_{DWD\&S}\right)}{2}\right]}{2}$$

3. Low-Gradient Riverine Backwater.

$$FCI = \frac{\left[\frac{\left(V_{TBA} + V_{STRATA} + V_{TREESIZE}\right)}{3} + \frac{\left(V_{SOIL} + V_{DWD\&S}\right)}{2}\right]}{2}$$

4. Unconnected Depression.

$$FCI = \frac{\left[\frac{\left(V_{TBA} + V_{STRATA} + V_{TREESIZE}\right)}{3} + \frac{\left(V_{SOIL} + V_{DWD\&S}\right)}{2}\right]}{2}$$

5. Connected Depression.

$$FCI = \frac{\left[\frac{\left(V_{TBA} + V_{STRATA} + V_{TREESIZE}\right)}{3} + \frac{\left(V_{SOIL} + V_{DWD\&S}\right)}{2}\right]}{2}$$

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}, number and top strata present (V_{STRATA}), and the number of and top tree size classes present ($V_{TREESIZE}$). V_{STRATA} reflects varying levels of nutrient availability and turnover rates, with the aboveground 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. Down woody debris and snags $V_{DWD\&S}$ 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 soil alteration variable (where a high index is indicated by low alteration rates) represents a shorter-term storage compartment of largely decomposed, but nutrient-rich organics on the soil surface. All of these components are combined

here in a simple arithmetic model, which weights each element equally. Note that one detrital component, litter accumulation, is not used in this model. That is because it is a relatively transient component of the onsite nutrient capital, and may in fact be readily exported. Therefore, it is used as a nutrient-related assessment variable only in the carbon export function, discussed in the next section.

Function 4: Export Organic Carbon

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, and the occurrence of periodic flooding to assess the organic export function of a wetland. This function is assessed in wetlands that have outflow to streams, which includes three subclasses assessed by the rapid assessment: Low-Gradient Riverine Overbank, Low-Gradient Riverine Backwater, and Connected Depression. An independent quantitative measure of this function is the mass of carbon exported per unit area per unit time ($g/m^2/year$).

The model for assessing the Export Organic Carbon function includes the following assessment variables:

V_{FREQ} = change in frequency of flooding
V_{LITTER} = percent cover of the litter layer
$V_{DWD\&S}$ = down woody debris and snag biomass
V_{TBA} = tree basal area
V_{STRATA} = number and top strata present

1. Flat.

Not Assessed

2. Low-Gradient Riverine Overbank.

$$FCI = V_{FREQ} \times \frac{\left[\frac{(V_{TBA} + V_{STRATA})}{2} + \frac{(V_{LITTER} + V_{DWD\&S})}{2}\right]}{2}$$

3. Low-Gradient Riverine Backwater.

$$FCI = V_{FREQ} \times \frac{\left[\frac{\left(V_{TBA} + V_{STRATA}\right)}{2} + \frac{\left(V_{LITTER} + V_{DWD\&S}\right)}{2}\right]}{2}$$

4. Unconnected Depression.

Not Assessed

5. Connected Depression.

$$FCI = V_{FREQ} \times \frac{\left[\frac{\left(V_{TBA} + V_{STRATA}\right)}{2} + \frac{\left(V_{LITTER} + V_{DWD\&S}\right)}{2}\right]}{2}$$

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 and strata components (V_{TBA}, V_{STRATA}) 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, and woody debris (V_{LITTER}, $V_{DWD\&S}$). This model differs from the nutrient cycling model in that materials stored in the soil are not included due to their relative immobility, and flooding is a required component of this model, because the export function is largely dependent on inundation and continuity with stream flows (V_{FREQ}). 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 consequently is not included in other models where it may seem appropriate. However, it is included in this model because it represents the most mobile dead organic fraction in the wetland, and because it may be the only component of that fraction that is present in young or recently restored systems.

Function 5: Maintain Plant Communities

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. This function is assessed in all five subclasses in the MAV. 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, all such methods require extensive field sampling and data analysis conducted by ecologists familiar with the plant communities of the region.

The model for assessing the Maintain Plant Communities function includes the following assessment variables:

V_{TBA} = tree basal area
$V_{TREESIZE}$ = tree size classes
V_{COMP} = composition of tallest woody stratum
V_{SOIL} = soil integrity
V_{DUR} = change in growing season flood duration
V_{POND} = microdepressional ponding

1. Flat.

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

2. Low-Gradient Riverine Overbank.

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

3. Low-Gradient Riverine Backwater.

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

4. Unconnected Depression.

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

5. Connected Depression.

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

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 size classes (V_{TBA} and $V_{TREESIZE}$). Together these indicate whether the stand has a structure typical of a mature forest with "gap" regeneration processes in place. The second term of the expression (V_{COMP}) considers the species composition of the dominant stratum, 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 three specific site factors that may be crucial to plant community maintenance under certain conditions. V_{SOIL} is a simple indicator of the level of disturbance or integrity of the soil. As described in the section "Vegetation" in Chapter 3, plant communities of the MAV are strongly affiliated with particular soil types; these are the product of distinct alluvial processes. The V_{SOIL} variable allows recognition of sites where the native soils have been replaced or buried by sediments inappropriate to the site, or where the native soils have been damaged significantly, as by compaction. Periodic flooding is important to the composition and structure of lowland plant communities, and its occurrence is accounted for in the flood duration variable. Shifts in frequency are not likely to affect plant community

composition and structure as significantly as changes to flood duration and ponding, so only the latter two hydrologic variables are included in this model. Flood duration (V_{DUR}) has been shown to be a major factor affecting the health and composition of lowland forest trees, especially where flooding has been artificially extended into the growing season, in either spring or fall. 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 MAV.

Function 6: Provide Habitat for Fish and Wildlife

This function is defined as the ability of a wetland to support the fish and wildlife species that utilize wetlands during some part of their life cycles. 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 MAV depend on certain aspects of wetland structure and dynamics, such as periodic flooding or ponding, specific vegetation composition, and proximity to other habitats. This function is assessed in all five subclasses in the MAV. Potential independent, quantitative measures of this function are animal inventory approaches, which require extensive field data collection and analysis by ecologists experienced with such methods, as well as specific knowledge of the fauna and habitats of the region.

The model for assessing the Provide Habitat for Fish and Wildlife function includes the following assessment variables:

V_{FREQ} = change in frequency of flooding
V_{DUR} = change in growing season flood duration
V_{POND} = microdepressional ponding
V_{COMP} = tree composition
$V_{DWD\&S}$ = down woody debris and snags
V_{STRATA} = number and top strata present
V_{TBA} = tree basal area
V_{TRACT} = wetland tract size

$V_{CONNECT}$ = habitat connections
V_{CORE} = core area

1. Flat.

$$FCI = \left(V_{POND} \times \left[\frac{\left(V_{COMP} + V_{STRATA} + V_{DWD\&S} + V_{TBA} \right)}{4} \right] \times \left[\frac{\left(V_{TRACT} + V_{CONNECT} + V_{CORE} \right)}{3} \right] \right)^{1/3}$$

2. Low-Gradient Riverine Overbank.

$$FCI = \left(\left[\frac{\left(V_{FREQ} + V_{DUR} + V_{POND} \right)}{3} \right] \times \left[\frac{\left(V_{COMP} + V_{STRATA} + V_{DWD\&S} + V_{TBA} \right)}{4} \right] \times \left[\frac{\left(V_{TRACT} + V_{CONNECT} + V_{CORE} \right)}{3} \right] \right)^{1/3}$$

3. Low-Gradient Riverine Backwater.

$$FCI = \left(\left[\frac{\left(V_{FREQ} + V_{DUR} + V_{POND} \right)}{3} \right] \times \left[\frac{\left(V_{COMP} + V_{STRATA} + V_{DWD\&S} + V_{TBA} \right)}{4} \right] \times \left[\frac{\left(V_{TRACT} + V_{CONNECT} + V_{CORE} \right)}{3} \right] \right)^{1/3}$$

4. Unconnected Depression.

$$FCI = \left(\left[\frac{\left(V_{COMP} + V_{STRATA} + V_{DWD\&S} + V_{TBA} \right)}{4} \right] \times \left[\frac{\left(V_{TRACT} + V_{CONNECT} + V_{CORE} \right)}{3} \right] \right)^{1/2}$$

5. Connected Depression.

$$FCI = \left(\left[\frac{\left(V_{FREQ} + V_{DUR}\right)}{2} \right] \times \left[\frac{\left(V_{COMP} + V_{STRATA} + V_{DWD\&S} + V_{TBA}\right)}{4} \right] \times \left[\frac{\left(V_{TRACT} + V_{CONNECT} + V_{CORE}\right)}{3} \right] \right)^{1/3}$$

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}) and the periodic occurrence of temporary, isolated aquatic conditions (V_{POND}). The second expression includes four indicators of forest structure and diversity, specifically overstory basal area (V_{TBA}), composition (V_{COMP}), down woody debris and snag density ($V_{DWD\&S}$) and a measure of structural complexity and maturity (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. Three landscape-level variables are incorporated within the last term of the model to reflect the importance of habitat fragmentation and interhabitat continuity as considerations in determining habitat quality many wildlife species within the MAV: the size of the overall wetland complex independent of the boundaries of the assessment area (V_{TRACT}); the proportion of the assessment area that is buffered from surrounding land uses and edge effects (V_{CORE}); and the proportion of the assessment area boundary that is connected to other suitable habitats ($V_{CONNECT}$).

5 Variables and Data Collection

Information used to assess the functions of regional wetland subclasses in the MAV is collected at several different spatial scales, and entered into the data forms provided in Appendix A. Landscape-level variables that might be best addressed using maps or aerial photographs are listed first, followed by variables that are assessed after a walk-through of the entire Wetland Assessment Area (WAA) or estimated at representative points within the WAA. Previous HGM guidebooks for the region used a more intensive sampling approach to collect variable values.

Note that different wetland subclasses use different subsets of the assessment variables, and the ranges of values offered for these variables change depending on the subclass chosen in the top Site Information section of the data sheet (Appendix B). Thus, it is imperative that the subclass is selected prior to printing out the data sheets for the field. Table 5 indicates which variables are used for each subclass assessment. Any variables not required for assessment will have "Not Used" next to them in the data sheet once a subclass is selected, so the user doesn't spend time in the field trying to collect them. Species names used in the data sheets are provided in Appendix C, and pictures of several indicators are included in Appendix D.

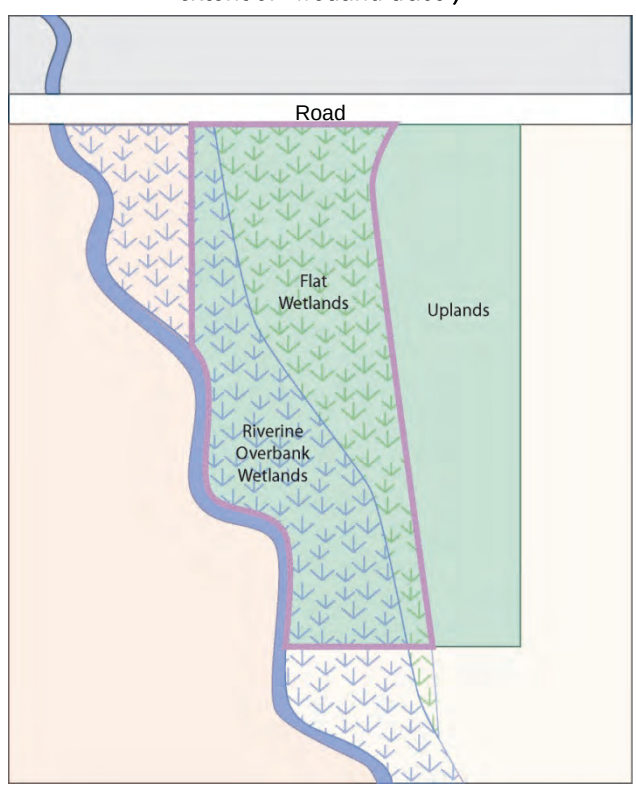
The procedure for conducting an assessment requires only one tool, a specialized 10-factor basal area measuring prism. All other variables are estimated visually and assigned a subindex score based on ranges of values. Directions for estimating and entering data for each variable are presented below. Some of these procedures are identical to those used in the previous HGM guidebooks published for the region, but most are simplified. However, the subindex values generated by the simplified field procedures are based on the same extensive reference data set as the more complicated, previously published procedures. Additional reference site samples were collected and included to allow the extension of this guidebook to the entire MAV. Therefore, the use of data ranges will yield subindex values that are similar or identical to those calculated using the previous, more labor-intensive field sampling procedures.

Table 5. Applicability of Variables by Regional Wetland Subclass

Variable Code	Variable Name	Flat	Riverine Backwater	Riverine Overbank	Unconnected Depression	Connected Depression
V_{TRACT}	Tract Size	+	+	+	+	+
$V_{CONNECT}$	Percent Connectivity	+	+	+	+	+
V_{CORE}	Percent Core	+	+	+	+	+
V_{FREQ}	Change in Flood Frequency	Not Used	+	+	Not Used	+
V_{POND}	Percent Ponding	+	+	+	Not Used	Not Used
V_{DUR}	Change in Flood Duration	Not Used	+	+	Not Used	+
V_{SOIL}	Soil Alteration	+	+	+	+	+
$V_{DWD\&S}$	Downed Woody Debris and Snags	+	+	+	+	+
V_{LITTER}	Percent Litter	+	+	+	Not Used	+
V_{STRATA}	Strata Present	+	+	+	+	+
$V_{TREESIZE}$	Tree Size Classes	+	+	+	+	+
V_{COMP}	Vegetation Composition	+	+	+	+	+
V_{TBA}	Tree Basal Area	+	+	+	+	+

The variables and methods are described below in the order they appear in the data sheets. Note that although this guidebook employs metric units, there is an option to "Select for English Units" on the data input calculator and field data sheets that will allow the entire assessment to be conducted and summarized in English units.

Figure 11. Wetland subclasses (purple line indicates extent of "wetland tract")



V_{TRACT} - Wetland Tract

This variable is defined as the area of contiguous forested wetland that includes the WAA (Figure 11). Adjacent wetlands need not be in the same regional subclass as the assessment area to be part of the wetland tract.

Determine the approximate size of the wetland tract using the following procedure:

1. Measure the size in hectares of the forested wetland area that is contiguous and directly accessible to any wildlife utilizing the WAA (including the WAA itself). Use topographic maps, aerial photography, GIS, field reconnaissance or another appropriate method.
2. Select the range of values on the data sheet that includes the forested wetland area in hectares. The variable subindex (VSI) will be calculated automatically based on reference data as shown in Table 6.

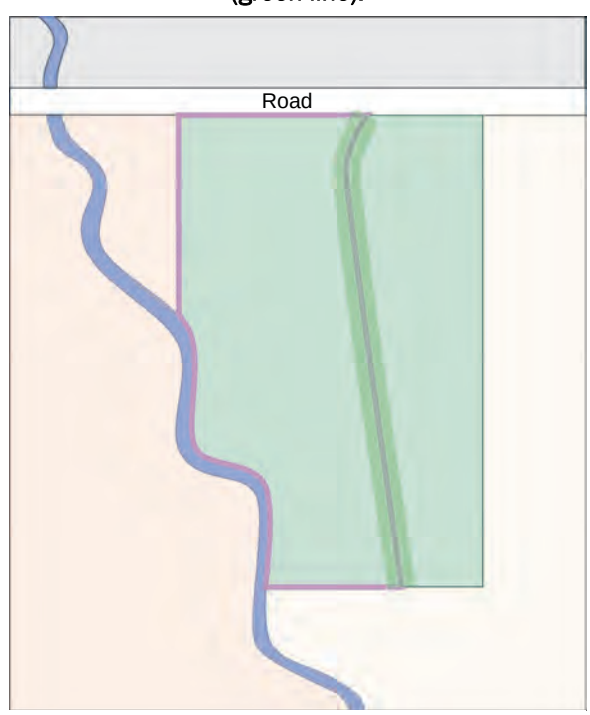
Table 6. Variable Sub Indices for V_{TRACT}

VSI	1.0	0.7	0.4	0.1
V_{TRACT} Range	3000 ha or more	1750-3000 ha	500-1750 ha	Less than 500 ha

$V_{CONNECT}$ – Percent Connectivity

This variable is defined as the proportion of the perimeter of a forested wetland tract that is connected to suitable wildlife habitat such as upland forests or other wetlands vegetated with native species, including recovering harvested areas (Figure 12). Agricultural fields, orchards, pastures dominated by non-native species, mined areas, and developed areas are examples of unsuitable habitats, regardless of whether they meet the criteria for federally jurisdictional wetlands or not. Note that because this is a landscape-level variable, the "tract" is not limited to the WAA under consideration, but includes all contiguous forested wetlands (Figure 12).

Figure 12. Identification of "connected perimeter" (green line).



The percentage of the forested wetland tract boundary that is "connected" is used to quantify this variable. Note that the "tract" is not limited to the WAA under consideration, but includes all contiguous forested

wetlands. An adjacent habitat is considered connected if it is within 0.5 km (0.31 mile) of the boundary of the forested wetland tract. Measure it using the following procedure:

1. Determine the length of the forested wetland tract boundary. Use field reconnaissance, topographic maps, aerial photography, Geographic Information System (GIS), or another suitable method or tool.
2. Measure the length of the forested wetland tract boundary that is within 0.5 km (0.31 mile) of suitable habitats like those described previously.
3. Divide the length of connected forested wetland tract boundary by the length of the total forested wetland tract boundary, and then multiply by 100. The resulting number is the percent of the wetland tract boundary that is connected.
4. Select the range of values on the data sheet that includes the percent connectivity. The variable subindex will be calculated automatically based on reference data, as shown in Table 7.

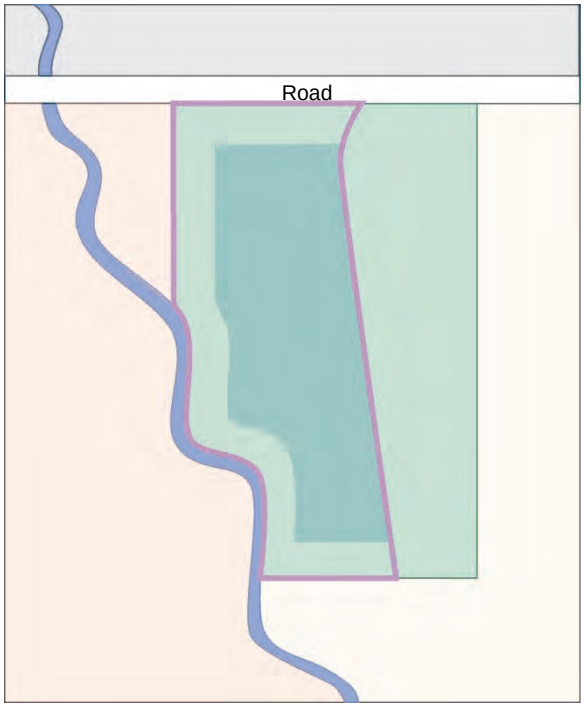
Table 7. Variable Sub Indices for $V_{CONNECT}$

VSI	1.0	0.7	0.4	0.1
$V_{CONNECT}$ Range	20% or more	10-19%	1-9%	0%

V_{CORE} – Percent Core

This variable is defined as the portion of a wetland tract that lies to the inside of a 100-m (330-ft) buffer interior of the boundary of the entire forested area (Figure 13). The percentage of a wetland tract that lies to the inside of this 100-m (330-ft) buffer zone is the metric used to quantify this variable. Note that the tract is not limited to the WAA under consideration, but includes all contiguous forested wetlands. Determine the value of this metric using the following procedure:

Figure 13. Identification of "core area."



1. On a map or photo, draw a continuous line 100 m inside the boundary of the entire contiguous forested area.
2. Calculate the size of the wetland tract that lies inside this line. This is the core area.
3. Divide the size of the core area by size of the wetland tract and multiply by 100. The resulting number is the percent of the wetland tract that is the core area.
4. Select the range of values on the data sheet that includes the forested wetland area in hectares. The variable subindex will be calculated automatically based on reference data, as shown in Table 8.

Table 8. Variable Sub Indices for V_{CORE}

VSI	1.0	0.7	0.4	0.1
V_{CORE} Range	20% or more	10-19%	1-9%	0%

V_{FREQ} – Change in Flood Frequency

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 effort. This variable is only assessed for river-connected subclasses (riverine and connected depression subclasses).

1. After walking the entire WAA, and completing a reconnaissance of the surrounding areas, check all documentation check-boxes that best describe the WAA. Condition categories and documentation are as follows (VSIs based on reference data are shown in parentheses):

- Natural flood return interval (VSI=1.0).

    - No artificial levees, spoil piles or other obstructions to water entering the site from the adjacent stream
    - No stream channelization
    - No lateral cutting or bank erosion of stream
    - No channel downcutting
    - Gauge data
    - Local knowledge

- Moderately impacted return interval (1-3 year change in return interval) (VSI=0.5).

    - Artificial levees or other obstructions present, but overbank flooding persists
    - <50% of stream reach channelization
    - Moderate lateral cutting or bank erosion of stream
    - Moderate channel downcutting
    - Gauge data
    - Local knowledge

- Severely impacted return interval (>3 year change in return interval) (VSI=0.1).

    - Artificial levees or other obstructions significant
    - >50% of stream reach channelization
    - Severe lateral cutting or bank erosion of stream
    - Severe channel downcutting
    - Gauge data
    - Local knowledge

2. Select the return interval choice (natural, moderately impacted, or severely impacted) on the data sheet that includes the preponderance of documentation boxes checked in step 1. The variable subindex will be calculated automatically, as described above.

V_{POND} – Percent Ponded Area

Percent 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 percent 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. Select the range of values on the data sheet that includes the percent of ponded area. The variable subindex will be calculated automatically based on reference data (Table 9), and the geomorphic surface selected in the Site Information section of the data sheet. Geomorphic surfaces can be identified using the maps developed by Saucier (1994), which are available at http://lmvmapping.erdc.usace.army.mil.

Table 9. Variable Sub Indices for V_{POND}

VSI		1.0	0.7	0.4	0.1
V_{POND} Range	Flat – Holocene	50-85%	30-50% or 85-90%	20-30% or > 90%	<20%
	Flat – Pleistocene Alluvial Terrace	25-60%	15-25% or 60-80%	5-15% or >80%	<5%
	Flat – Pleistocene Valley Train	30-80%	20-30% or 80-90%	10-20% or >90%	<10%
	Riverine Backwater	20-70%	15-20% or 70-85%	5-15% or >85%	<5%
	Riverine Overbank	0-40%	40-70%	>70%	N/A

V_{DUR} – Change in Flood Duration

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. The V_{DUR} variable is intended to reflect changes in function that result from changes in growing season hydrology. Increases or decreases in growing season flood durations are assumed to cause reduced function relative to the pre-impact condition for the Maintain Plant Communities and Provide Wildlife Habitat functions.

Changes in flood duration are grouped into three condition categories: natural flood duration, moderately impacted flood duration (1-3 week change in flood duration) and severely impacted flood duration. As with the flood frequency variable, a series of field observations are made, and a majority of documentation indicators in a condition category indicate the appropriate condition choice.

1. After walking the entire WAA and completing a reconnaissance of the surrounding areas, check all documentation boxes that best describe the WAA, and select the best supported condition.

- Natural flood duration (VSI=1.0).
    - No artificial obstructions prevent drainage of the WAA (e.g., roads, blocked culverts)
    - No basal swelling (Appendix D1). Note that basal swelling differs from the natural flaring or buttressing that is common on certain lowland species such as elms and baldcypress. Basal swelling principally affects oaks and is expressed as a distinct swollen zone along the lower portion of the trunk, sometimes larger than the area immediately below it. If in doubt as to the reason for any observed trunk swelling, do not use this indicator.
    - No tip dieback (Appendix D2). Note that the tip dieback is common on lowland trees and should be used as indicator of water stress only when it is extensive and clearly reflects declining tree health.
    - No ditches promote the drainage of the WAA

- No ditches bring additional water to the WAA
- Local knowledge

- Moderately impacted flood duration (1-3 week change in flood duration) (VSI=0.5).

  - Artificial obstructions present, but removable, or only partially affect drainage
  - Basal swelling limited to area immediately around (within 10 meters) of an obvious obstruction (e.g., blocked culvert) but not found throughout the WAA.
  - Tip dieback limited to area immediately around (within 10 meters) of an obvious obstruction (e.g., blocked culvert) but not found throughout the WAA.
  - Some ditching promotes the drainage of the WAA
  - Ditches add some water to the WAA
  - Local knowledge

- Severely impacted flood duration (>3 week change in duration) (VSI=0.1).

  - Artificial obstructions significantly prevent drainage of WAA
  - Extensive basal swelling throughout WAA
  - Extensive tip dieback throughout WAA
  - Extensive ditching promotes the drainage of the WAA
  - Ditches add excessive water to the WAA
  - Local knowledge

2. Select the flood duration choice (natural, moderately impacted, or severely impacted) on the data sheet that includes the preponderance of documentation boxes checked in step 1. The variable subindex will be calculated automatically as described above.

V_{SOIL} - Soil Alteration

This variable is measured as the percent of the assessment area with altered soils. Altered soils exhibit evidence of fill, excavation, compaction, bedding, land-leveling, or ripping. Normal tilling is not considered to constitute soil alteration for the purposes of this assessment. Measure soil alteration with the following procedure:

1. As part of the reconnaissance walkover of the entire WAA, estimate the percentage of the site in which the soils have been altered. In particular, look for evidence of excavation fill, severe compaction, bedding, or agricultural activities.
2. Select the range of values on the data sheet that includes the percent area of altered soils. The variable subindex will be calculated automatically based on reference data as shown in Table 10.

Table 10. Variable Sub Indices for V_{SOIL}

VSI	1.0	0.7	0.3	0.0
V_{SOIL} Range	5% or less	6-50%	51-80%	more than 80%

$V_{DWD\&S}$ – Downed Woody Debris Biomass and Snags

Woody debris is an important habitat and nutrient cycling component of forests. In a functioning wetland forest, there are multiple size classes of standing and downed dead wood: standing snags and stumps, fallen logs (>3” in diameter), fallen branches (1-3” in diameter), and twigs (<1” in diameter). These break down over different lengths of time to release carbon back to the soil, where it can be cycled into living biomass.

1. This variable is evaluated in multiple plots located within the WAA and entered on the Plot Data Sheet (see Chapter 5, Assessment Protocol, for plot sampling instructions). For each plot, check all documentation checkboxes that best describe the WAA. Condition categories and documentation are as follows:

- Natural amount of down woody debris and snags present (VSI=1.0).
    - All classes of woody debris (snags, logs, branches, twigs) are present in expected amounts (10-25% cover combined, Appendix D3a)
    - No indication that water stress has increased woody debris or snags
    - No indication that the site has been recently cleared of woody debris
    - Any excessive woody debris is caused by temporary tornado or ice damage
    - Woody debris temporarily absent due to controlled burn

- Moderately impacted amount of woody debris and snags, but likely to recover (VSI=0.5).

    - No snags, but mature trees present
    - Woody debris cleared for nonpermanent shift in use, such as agroforestry
    - Excessive woody debris from logging operations

- Severely impacted amount of woody debris and snags, not likely to recover (VSI=0.1)

    - No snags or trees present
    - Woody debris cleared for permanent shift in use
    - Excessive woody debris (>25% cover) and snags due to unresolved water stress (Appendix D3c)

2. Select the down woody debris choice (natural, moderately impacted, or severely impacted) on the data sheet that includes the preponderance of documentation boxes checked in step 1. The variable subindex will be calculated automatically, as described above.

V_{LITTER} – Percent Litter

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 accounted for in the woody debris variable above. It also excludes organic material sufficiently decayed to be included in the soil O horizon. The percent cover of litter is determined as follows:

1. This variable is evaluated in multiple plots located within the WAA and entered on the Plot Data Sheet (see Chapter 5, Assessment Protocol, for plot sampling instructions). For each plot, estimate the percentage of the ground surface that is covered by litter.
2. Select the range of values on the data sheet that includes the percent area of covered by litter. The variable subindex will be calculated in the green cell automatically based on reference data, as shown in Table 11.

Table 11. Variable Sub Indices for V_{LITTER}

VSI		1.0	0.7	0.4	0.1
V_{LITTER} Range	Flat	90% or more	60-89%	30-59%	less than 30%
	Riverine Backwater	50% or more	35-49%	10-34%	less than 10%
	Riverine Overbank	90% or more	70-89%	10-69%	less than 10%
	Unconnected Depression	N/A	N/A	N/A	N/A
	Connected Depression	50% or more	35-49%	10-34%	less than 10%

V_{STRATA} – Strata Present

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

1. This variable is evaluated in multiple plots located within the WAA and entered on the Plot Data Sheet (see Chapter 5, Assessment Protocol, for plot sampling instructions). For each plot, identify which of the following vegetation layers are present and account for at least 10 percent cover, on average, throughout the site. Check all checkboxes on the data sheet that apply:

- Trees (greater than or equal to 10 cm dbh).
- Shrubs and Saplings (shrubs and saplings less than 10 cm dbh but at least 4.5 ft tall).
- Ground cover (woody plants less than 4.5 ft tall and herbaceous vegetation).

2. The variable subindex will be calculated automatically based on the number of strata, and the top stratum present, based on reference data (e.g., a single stratum of trees will have a higher variable subindex than a single stratum of groundcover), as shown in Table 12.

$V_{TREESIZE}$ – Tree Size Classes

The number of tree size classes indicates the maturity and complexity of the forest. Even-aged stands are often recovering from clearcut forestry practices. Uneven-aged stands with some larger trees represent mature

Table 12. Variable Sub Indices for V_{STRATA}

Top Stratum	Top Stratum Partial VSI		Number of Strata	Number of Strata Partial VSI	
	Riverine Subclasses	Flats / Depressions Subclasses		Riverine Subclasses	Flats / Depressions Subclasses
Tree	1.0	1.0	3	1.0	1.0
Sapling and Shrubs	0.4	0.4	2	0.7	1.0 / 0.7*
Ground Cover	0.2	0.2	1	0.3	0.7 / 0.3*
No Veg	0.0	0.0	0	0.0	0.0
VSI = (Top Stratum Partial VSI + Number of Strata partial VSI) / 2					

* First number is partial VSI if trees are the top stratum, second number is partial VSI otherwise

forests where single trees die and leave gaps, allowing younger trees to replace them. Since the rapid assessment procedure does not require tree DBHs or density to be measured, this variable is intended to indicate the complexity of the forest. It complements – rather than replaces – the Tree Basal Area variable, which indicates biomass, but doesn't distinguish between small trees very close to the point measured and much larger trees further away. Estimate the tree age complexity of the WAA using the following procedure:

1. This variable is evaluated in multiple plots located within the WAA and entered on the Plot Data Sheet (see Chapter 5, Assessment Protocol, for plot sampling instructions). For each plot, identify which of the following tree size classes are present and account for at least 10 percent cover. It should be possible to visually estimate the class that a given tree belongs in. Check all boxes that apply:

- 10-25 cm dbh
- 25.1-50 cm dbh
- 50.1-75 cm dbh
- >75 cm dbh

2. The variable subindex will be calculated automatically based on the number of tree classes and the top tree class present, based on reference data as presented in Table 13.

Table 13. Variable Sub Indices for $V_{TREESIZE}$

Top Size Class (DBH)	Top Size Class Partial VSI			Number of Size Classes	Number of Size Classes Partial VSI		
	Riverine	Flats	Depressions		Riverine	Flats	Depressions
>75 cm	1.0	1.0	1.0	4	1.0	1.0	1.0
50.1 - 75 cm	0.8	1.0	1.0	3	0.8	1.0	1.0
25.1 - 50 cm	0.6	0.8	0.7	2	0.5	0.8	0.7
10 - 25 cm	0.3	0.4	0.3	1	0.3	0.5	0.3
No trees	0.0	0.0	0.0	0	0.0	0.0	0.0
VSI = (Top Stratum Partial VSI + Number of Strata partial VSI) / 2							

V_{COMP} – Vegetation Composition

This variable represents the species composition of the tallest woody stratum present in the assessment area, and the exotics present anywhere on the WAA. The tallest stratum 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. The species lists in the calculator enumerate the scientific names of the relevant species. However, the “Check for Common Names” box may be selected, and the lists will be generated using common names instead. Measure the composition variable using the following procedure:

1. This variable is evaluated in multiple plots located within the WAA and entered on the Plot Data Sheet (see Chapter 5, Assessment Protocol, for plot sampling instructions). For each plot, 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 tree stratum does not have at least 20 percent cover, determine the tallest woody stratum with at least 10 percent total cover, and use it as the tallest stratum.
2. Within the tallest stratum, identify the dominant species based on percent cover using the 50/20 rule (US Army Corps of Engineers 1992): rank species in descending order of percent cover and identify dominants by summing relative dominance in descending order until 50 percent is exceeded; additional species with 20 percent relative dominance should also be included. Check these species on the data sheet within composition groups 1, 2, and 3. Accurate identification of woody species is critical for determining the dominant species in each plot. In most cases, the principal

dominant species are apparent and field calculations using the 50/20 rule will not be necessary.

3. Check all species in group 4 within the WAA, regardless of whether they are dominants, or which strata they are in.
4. The variable subindex is calculated automatically by creating a weighted average with the following weights: Group 1, 1.0; Group 2, 0.66; Group 3, 0.33; Group 4, 0.

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). This variable is evaluated in multiple plots located within the WAA and entered on the Plot Data Sheet (see Chapter 5, Assessment Protocol, for plot sampling instructions). In each plot, stand at the plot center and measure tree basal area using the following procedure:

1. Use a basal area wedge prism (or other basal area estimation tool) as directed to tally eligible tree stems. Basal area prisms are available in various Basal Area Factors, and in both SI (metric) and non-SI (English) versions. Some are inappropriate for use in collecting the data needed here, because they are intended to be used for large-diameter trees in areas with little understory. The non-SI 10-factor prism works well in forests of the MAV, and it is readily available.
2. Select the range of values on the data sheet that includes the tree tally counted in Step 1. The variable subindex will be calculated automatically based on reference data as shown in Table 14.

Table 14. Variable Sub Indices for V_{TBA}

VSI		1.0	0.7	0.4	0.1
V_{TBA} Tree Count Range	Flat	>10	7-10	1-6	0
	Riverine Backwater	>10	7-10	1-6	0
	Riverine Overbank	>14	9-14	1-8	0
	Unconnected Depression	>14	9-14	1-8	0
	Connected Depression	>14	9-14	1-8	0

6 Assessment Protocol

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 MAV. 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 represent existing conditions at the project site, while data for the post-project assessment are normally based on a prediction of the conditions that can reasonably be expected to exist following proposed project impacts. A well-documented set of assumptions should be provided with the assessment to support the predicted post-project conditions used in making an assessment.

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

A series of tasks are required to assess regional wetland subclasses in the MAV 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

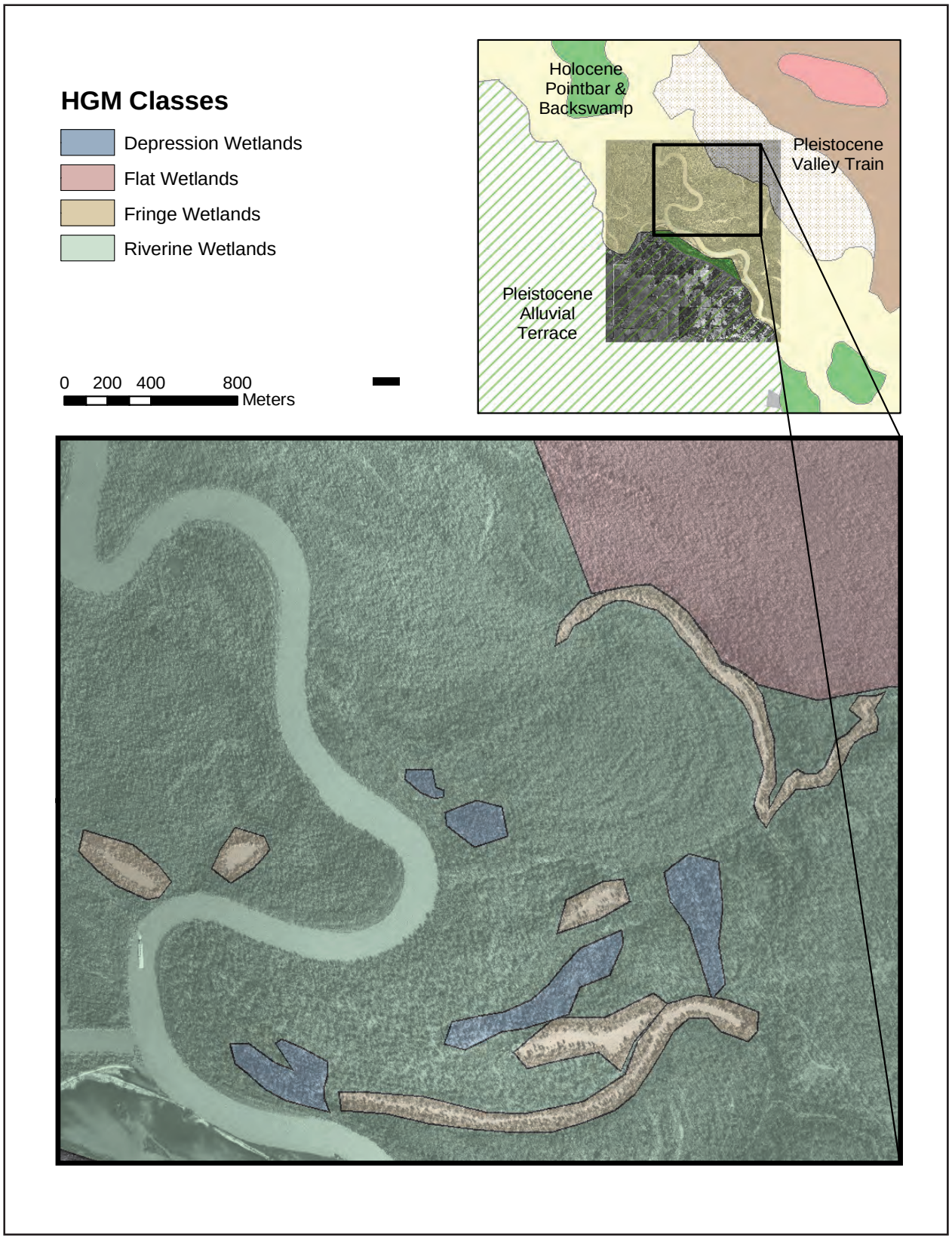
Data Sheet A1 in Appendix A (Site or Project Information and Assessment Documentation) provides a checklist of information needed to conduct a complete assessment, and serves as a cover sheet for all compiled assessment maps, drawings, data sheets, and other information. It requires the assignment of a project name, identification of personnel involved in the assessment, and attachment of supporting information and documentation. The first step in this process is to develop a narrative explanation of the project, with supporting maps and graphics. This should include a description of the project purpose and project area features, which can include information on location, climate, surficial geology, geomorphic setting, surface and groundwater hydrology, vegetation, soils, land use, existing cultural alteration, proposed impacts, and any other characteristics and processes that have the potential to influence how wetlands at the project area perform functions. The accompanying maps and drawings should indicate the locations of the project area boundaries, jurisdictional wetlands, wetland assessment areas (described 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 may be useful in characterizing a project area:

- Aerial photographs
- Topographic maps
- Geomorphic maps (Saucier 1994)
- County soil survey
- National Wetland Inventory maps
- Chapter 3 of this *Regional Guidebook*

For large projects or complex landscapes, it is usually beneficial to use aerial photos and geomorphic information to develop a preliminary classification of wetlands for the project area and vicinity prior to going to the field. Figure 14 illustrates this process for a typical MAV lowland wetland complex. The rough wetland map can then be taken to the field to refine and revise the identification of wetland subclasses.

Figure 14. Example application of geomorphic mapping and aerial photography to develop a preliminary wetland classification for a proposed project area.



The final map should be attached to the completed Site or Project Description sheet.

Screen for red flags

Screening for red flag features helps determine whether the wetlands or other natural resources around the project area require special consideration or attention that may preempt or postpone 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.

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

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

- Compare several wetlands as part of an alternatives analysis.
- Identify specific actions that can be taken to minimize project impacts.
- Document baseline conditions at a wetland site.
- Determine mitigation requirements.
- Determine mitigation success.
- 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.

Figures 15 through 18 present a simplified project scenario to illustrate the steps used to designate the boundaries of Wetland Assessment Areas (WAA), each of which will require a separate HGM assessment. Figure 15 illustrates a land cover map for a hypothetical project area. Figure 16 shows the project area (in yellow) superimposed on the land cover map. To determine the boundaries of the WAAs, first use the Keys to Wetland Classes and Subclasses (Figures 5 and 6) and identify the wetland subclasses within and contiguous to the project area (Figure 17). Overlay the project area

Figure 15. Land cover.

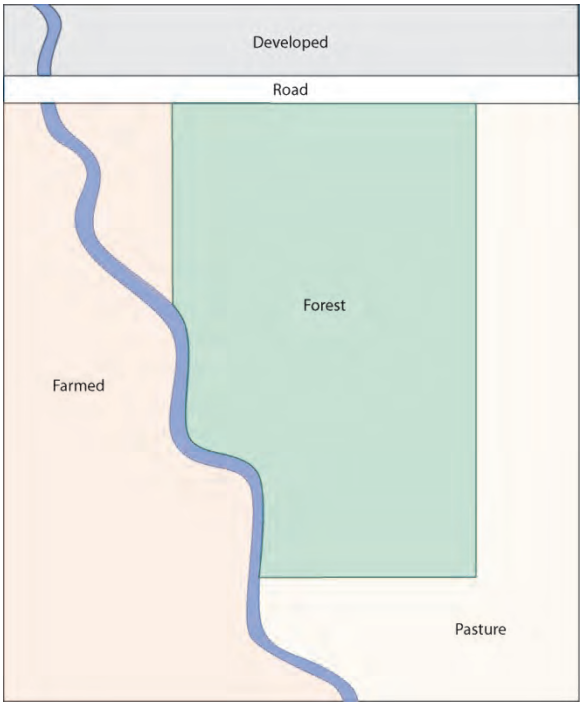


Figure 16. Project area (in yellow).

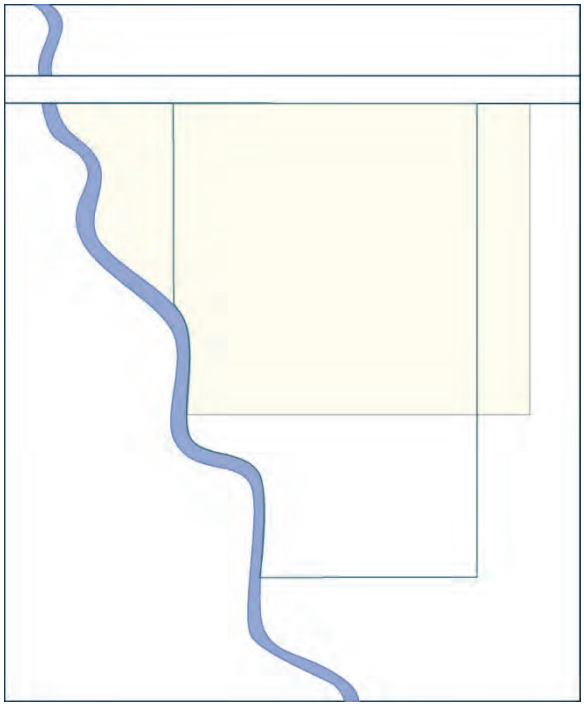


Figure 17. Wetland subclasses (purple line indicates extent of the "wetland tract").

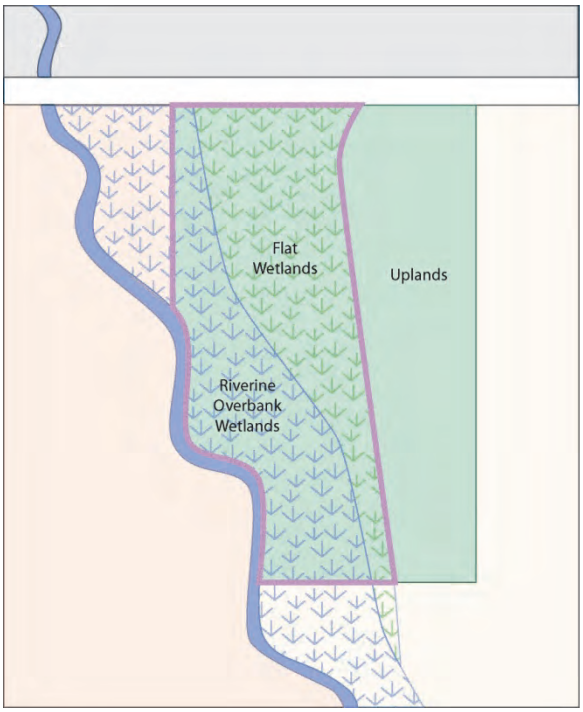
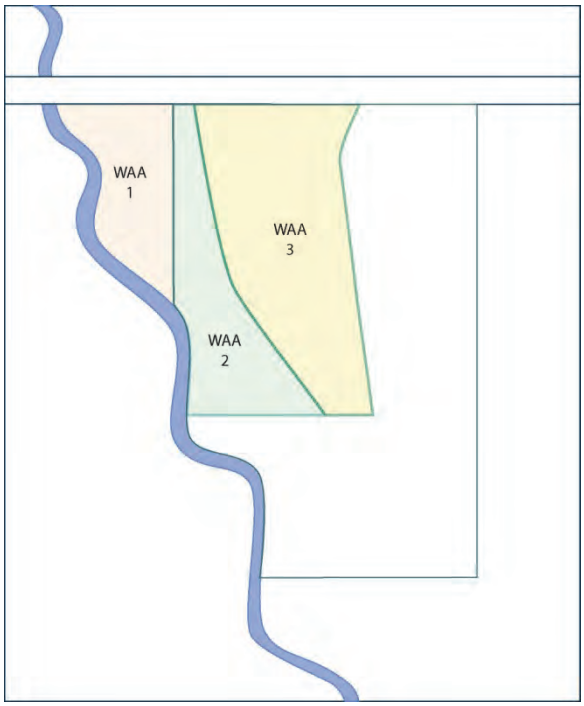


Figure 18. WAAs.



boundary and the wetland subclass boundaries to identify the WAAs for which data will be collected (Figure 18). Attach these maps, photos, and drawings to the Documentation Sheet (Appendix A) and assign an identifying number to each WAA, specifying the subclass it belongs to, and calculating the area in hectares or acres.

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

At least three situations can be identified that necessitate defining and assessing multiple WAAs within a project area. The first situation occurs when widely separated areas of wetlands belonging to the same regional subclass occur in the project area. Such 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 17, 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 18, where the area designated as Riverine Overbank Wetlands in Figure 17 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 MAV, 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, the following WAAs may be defined: cleared land, early successional sites, and mature forests.

However, users 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 data 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

Chapter 5 (Variables and Data Collection) describes how to make the observations and estimates needed to complete the assessment, and the data sheets provide prompts for use in the field. When all the data are entered into the data sheet and calculator, a summary at the end presents the variable subindices and the Functional Capacity Indices (FCIs) for each function; the variable subindices and the FCIs are calculated using the models previously described. Functional Capacity Units (FCUs) are then calculated by multiplying the FCIs by the WAA area in hectares. Depending on the site (Project Site or Mitigation Site) and timing (Before Project or After Project) the user selected from drop down menus at the top of the sheet, a message appears above the table of FCIs and FCUs instructing the user which section of the Mitigation Sufficiency Calculator the results should be entered into. This is only necessary to do if the results are being used to determine a mitigation need. An error message of “Check Data” indicates that a vital piece of information is missing from the data entry, and the FCIs cannot be calculated without it. It should be noted that although FCIs are unitless, FCUs are in the area unit used, so it is important to know whether the default hectares are used, or the English units (acres). The units used will display in the Wetland Size data entry space, and the FCUs match whichever unit is shown there.

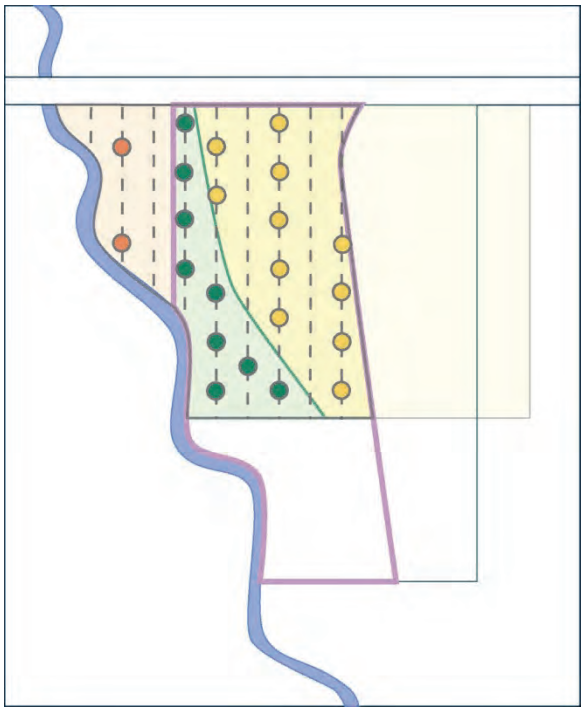
The data sheets provided in Appendix B are organized to facilitate data collection at each of the several spatial scales of interest. For example, the first group of variables (Site and WAA Field Data Sheet) contains information about landscape scale or WAA-scale characteristics collected using aerial photographs, maps, and hydrologic information regarding each WAA and vicinity, or collected during a walking reconnaissance of the WAA. Data collected for these variables are entered directly on the Data Sheets, 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 the Plot Data Sheet, which is two pages long. Additional copies of the Plot Data Sheet are completed for each plot sampled within the WAA.

All of the data sheets shown in Appendix B are printouts from the MAV Data Sheets and Calculator (the Calculator), a single spreadsheet that allows raw data entry; the spreadsheet automatically calculates variable subindices, FCIs, and FCUs. Printouts of the Data Sheets from the spreadsheet must be printed out and taken to the field, and then the raw data may be entered in the same form in the Excel spreadsheet, so that automated calculations occur.

All data from each of the Plot Data Sheets are compiled automatically by the Calculator. These summarized data are then used by the Calculator to automatically determine the Functional Capacity of the wetland being assessed and reported in the Summary section of the MAV Data Sheets and FCI Calculator, once the Subclass is selected and raw data are entered.

Figure 19. Example sample distribution. Refer to Figure 18 for WAA designations.



The sampling procedures for conducting an assessment require few tools, but a specialized basal area estimation or measurement tool, reference materials for plant identification, and this guidebook will be necessary. Generally, all measurements should be taken in metric units (although English unit equivalents may be selected on the spreadsheet before the data are entered). Plots should be approximately 0.04 ha in diameter (a tenth of an acre), but the data collected within plots are not area dependent, so plot boundaries can be visually estimated. The most efficient approach is to establish a center point and make estimates in a circle around that point that has a radius of approximately 10m. A typical layout for the establishment of sample plots and transects in the hypothetical WAAs is shown in Figure 19. 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 in representative locations are probably adequate to characterize the WAA.

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 differentially emphasize or exclude any of these local conditions, but should represent the site as a whole. Therefore, on large sites the best approach often is a simple systematic plot layout, where evenly spaced parallel transects are established (using a compass and pacing) and sample plots are distributed at regular paced intervals along those transects. For example, a 12-ha tract, measuring about 345 m on each side, might be sampled using two transects spaced 100 m apart (and 50 m from the tract edge), with plots at 75-m intervals along each transect (starting 25 m from the tract edge). This would result in eight sampled plot locations, which should be adequate for a relatively diverse 12-ha forested wetland area. In Figure 19, 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, and sample at intervals along alternate transects (see WAA 3 in Figure 19). Continue until the entire site has been sampled at a low plot density, then review the data and determine whether 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 remains high, then return to the alternate, unsampled transects and continue sampling until the data set is representative of the site as a whole, as indicated by a leveling off of the dominant species list and basal area values. Other variables may level off more quickly or slowly than tree composition and basal area, but these two factors are

generally good indicators, 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 19, 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 the Site, the WAA Data Sheet, and the multiple copies of the Plot Data Sheet is compiled automatically by the Calculator in the Data Summary. These summarized data are then used by the Calculator to automatically determine the Functional Capacity of the wetland being assessed on the FCI/FCU Calculation Summary tab of the Calculator for each WAA.

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 Calculator is a particularly useful tool for testing various scenarios and proposed actions — it allows 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 the user to recognize when a particular function is being maximized to the detriment of other functions, as might occur when 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 unconnected depressions. Conversely, unconnected depressions are more likely to support endemic species than are river-connected systems. These types of comparisons may be particularly important where a proposed action will result in a change of subclass. When a levee, for example, will convert a riverine wetland to a flat, it is helpful to be able to recognize that certain import and export functions will no longer occur.

Users of this guidebook 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. For example, most of the reference standard conditions identified in the field were mature forests with high species diversity, and typically the riverine and flats subclasses were dominated by a variety of oak species while the depressional subclasses were dominated by baldcypress and overcup oak. Sites that deviate from these reference conditions may produce low scores for some functions. However, there are situations where deviation from the reference standard condition is appropriate, and should be recognized as such. In most of these cases, alternative reference standards have been identified in the discussions of assessment variables (e.g., cottonwood or willow dominating on new substrates is recognized as an appropriate V_{COMP} condition). In other instances, however, professional judgment in the field is essential to proper application of the models. For example, some depression sites with near-permanent flooding are dominated by buttonbush. Where this occurs because of water control structures or impeded drainage due to roads, it should be recognized as having arrested functional status, at least for some functions. However, where the same situation occurs because of beaver

activity or changes in channel courses, the buttonbush swamp should be recognized as a functional component of a larger wetland complex, and the V_{COMP} weighting system can be adjusted accordingly. Another potential way to deal with beaver in the modern landscape is to adopt the perspective that beaver complexes are fully functional but transient components of riverine wetland systems for all functions. At the same time, if beaver are not present (even in an area where they would normally be expected to occur), the resulting riverine wetland can be assessed using the models, but the overall 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. Note, however, that normal, noncatastrophic disturbances to wetlands (i.e., tree mortality causing small openings) are accounted for in the reference data used in this guidebook.

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

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Appendix A: Preliminary Project Documentation

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 Sheets and assessment summaries

Appendix B: Field Data Sheets

Please note that the data sheets will vary slightly depending on the HGM subclass being assessed. Please print data sheets directly from the calculator after selecting a subclass. This appendix is for illustrative purposes only.

v. 9-30-12

Mississippi Alluvial Valley HGM
Site and WAA Field Data Sheet And Calculator

Team: UTM Easting:
Project Name: UTM Northing:
Location: Sampling Date:
WAA Number: Wetland size (ha):
Wetland Subclass: Low-Gradient Riverine Backwater ☐ Select for English Units
Geomorphology (only used for Flats Subclass):
Site and Timing: Clear Form

Landscape Variables - Using aerial photographs and maps, fill out the following:

V_{TRACT} - Tract Size: The WAA is part of a forested wetland tract at least:

○ 3000 ha or more ○ 1750-3000 ha ○ 500-1750 ha ○ <500 ha

$V_{CONNECT}$ - Connectivity: Percent of WAA Perimeter within .5 km of natural communities

○ 20% or more ○ 10-19% ○ 1-9% ○ 0%

V_{CORE} - Core: percent of the WAA at least 100-m from the forest edge

○ 20% or more ○ 10-19% ○ 1-9% ○ 0%

WAA Variables - Conduct a walking survey of the site to fill out the following:

V_{FREQ} - Change in Flood Frequency - Change in flood frequency from natural conditions

○ Natural return Interval
- ☐ No artificial levees, spoil piles or other obstructions
- ☐ No channelization ☐ No lateral cutting or bank erosion
- ☐ No channel downcutting ☐ Gauge Data ☐ Local Knowledge

○ Moderately impacted return interval (1-3 year change in return interval)
- ☐ Artificial levees or other obstruction present, but overbank flooding persists
- ☐ <50% of reach channelized ☐ Moderate lateral cutting or bank erosion
- ☐ Moderate channel downcutting ☐ Gauge Data ☐ Local Knowledge

○ Severely impacted return interval (> 3 year change)
- ☐ Artificial levees or other obstruction significant
- ☐ >50% of reach channelized ☐ Severe lateral cutting or bank erosion
- ☐ Severe channel downcutting ☐ Gauge Data ☐ Local Knowledge

V_{POND} - Ponding - Percent of WAA subject to ponding after precipitation

○ 20-70% ○ 15-20% or 70-85% ○ 5-15% or >85% ○ <5%

Site and WAA Field Data Sheet And Calculator Page 2

Team: _____ UTM Easting: _____
Project Name: _____ UTM Northing: _____
Location: _____ Sampling Date: _____
WAA Number: _____ Wetland size (ha): _____
Wetland Subclass: Low-Gradient Riverine Backwater
Geomorphology (only used for Flats Subclass): _____
Site and Timing: _____

V_{DUR} - Change in Flood Duration in the Growing Season

○ Natural flood duration

- ☐ No artificial obstructions prevent drainage of WAA (eg, roads, blocked culvert, etc.)
- ☐ No basal swelling
- ☐ No tip die back
- ☐ No ditches promote drainage of WAA
- ☐ No ditches bring additional water to WAA
- ☐ Local knowledge

○ Moderately impacted flood duration (1-3 week change in flood duration)

- ☐ Artificial obstruction present, but removable or only partially affecting drainage
- ☐ Limited localized basal swelling
- ☐ Limited, localized tip dieback
- ☐ Some ditching promotes drainage of WAA
- ☐ Ditches add some water to WAA
- ☐ Local knowledge

○ Severely impacted flood duration (> 3 week change in flood duration)

- ☐ Artificial obstruction significantly prevent drainage of WAA
- ☐ Extensive basal swelling in WAA
- ☐ Extensive tip dieback in WAA
- ☐ Extensive ditching promotes drainage of WAA
- ☐ Ditches add excessive water to WAA
- ☐ Local knowledge

V_{SOIL} - Soil integrity - Percent of the soil altered by fill, excavation, bedding or compaction

○ 5% or less ○ 6-50% ○ 51-80% ○ >80%

Notes:

v. 9-30-12

Mississippi Alluvial Valley HGM
Plot Data Sheet

Team: _____ UTM Easting: _____
Project Name: _____ UTM Northing: _____
Location: _____ Sampling Date: _____
WAA Number: _____ Wetland size (ha): _____ Plot Number: _____

Wetland Subclass: Low-Gradient Riverine Backwater ☐ Select for English Units

Geomorphology (only used for Flats Subclass):

Site and Timing: Clear Form

Plot Variables -Complete the information for the following variables within one or more representative 0.04-ha (0.1-acre) plot(s) within the WAA (separate data sheet each plot)

$V_{DWD\&S}$ - Down Woody Debris and Snags

○ Natural amount of down woody debris and snags present:
- ☐ All classes of woody debris (snags, logs, branches, twigs) in expected amounts.
- ☐ No indication that water stress has increased woody debris or snags.
- ☐ No indications that the site has been recent cleared of woody debris.
- ☐ Any excessive woody debris from temporary tornado or ice damage.
- ☐ Woody debris temporarily absent due to controlled burn.

○ Moderately impacted amount of woody debris and snags, but likely to recover.
- ☐ No snags, but mature trees present
- ☐ Woody debris cleared for non-permanent change of use, such as agroforestry.
- ☐ Excessive woody debris from logging.

○ Severely impacted amount of woody debris and snags, not likely to recover
- ☐ No snags or trees present
- ☐ Woody debris cleared for permanent shift in use.
- ☐ Excessive woody debris and snags due to unresolved water stress

V_{LITTER} - Litter - Percent cover

○ 50% or more ○ 35-49% ○ 10-34% ○ <10%

V_{STRATA} - Strata Present - select all that apply

- ☐ Trees
- ☐ Saplings and Shrubs
- ☐ Ground Cover

Number of Strata:
Top Stratum:

$V_{TREESIZE}$ - Tree Size Classes - select all that apply

- ☐ 10-25 cm dbh
- ☐ 25.1-50 cm dbh
- ☐ 50.1 - 75 cm dbh
- ☐ > 75 cm dbh

Plot Field Data Sheet Page 2

Team: _____ UTM Easting: _____
Project Name: _____ UTM Northing: _____
Location: _____ Sampling Date: _____
WAA Number: _____ 0 and size (ha): _____
Wetland Subclass: Low-Gradient Riverine Backwater
Geomorphology (only used for Flats Subclass): _____
Site and Timing: _____

V_{COMP} - Vegetation Composition (Check all **dominant species** in the tallest stratum--use 50/20 rule. Check all exotics and invasives, including non-dominants, in all strata)

☐ Check for Common Names

Group 1 = 1.00	Group 2 = 0.66	Groups 3 = 0.33
☐ *Carya aquatica*	☐ *Acer drummondii*	☐ *Carpinus caroliniana*
☐ *Nyssa aquatica*	☐ *Acer negundo*	☐ *Cornus drummondii*
☐ *Quercus lyrata*	☐ *Acer rubrum*	☐ *Cornus foemina*
☐ *Quercus texana*	☐ *Carya illinoensis*	☐ *Crategus spp.*
☐ *Quercus pagoda*	☐ *Celtis laevigata*	☐ *Forestiera acuminata*
☐ *Quercus phellos*	☐ *Diospyros virginiana*	☐ *Ilex decidua*
☐ *Taxodium distichum*	☐ *Fraxinus pennsylvanica*	☐ *Planera aquatica*
☐ —	☐ *Gleditsia aquatica*	☐ —
☐ —	☐ *Liquidambar styraciflua*	☐ —
☐ —	☐ *Quercus michauxii*	☐ —
☐ —	☐ *Quercus palustris*	☐
☐ —	☐ *Salix nigra*	☐
☐	☐ *Ulmus americana*	**If the site is completely unvegetated, choose an unlabelled box in Group 4 to force Vegetation Composition to 0.**
☐	☐ *Ulmus crassifolia*	
	☐	
	☐	

Group 4 (Exotics) = 0.0 Select any present in all strata

☐ *Alternanthera philoxeroides*	☐ *Baccharis halimifolia*	☐ *Eichhornia crassipes*
☐ *Ligustrum sinense*	☐ *Lonicera japonica*	☐ *Microstegium vimineum*
☐ *Phragmites australis*	☐ *Pueraria montana*	☐ *Sapium sebiferum*
☐	☐	☐

0 Species in Group 1	0 Species in Group 2	0 Species in Group 3	0 Species in Group 4

Center Variables - Measure from a center point:

V_{TBA} - Tree Basal Area - Number of trees counted from a point using a #10 prism

○ >10 ○ 7-10 ○ 1-6 ○ 0

Notes:

Appendix C: Common and Scientific Names of Plant Species Referenced in Text and Data Sheets

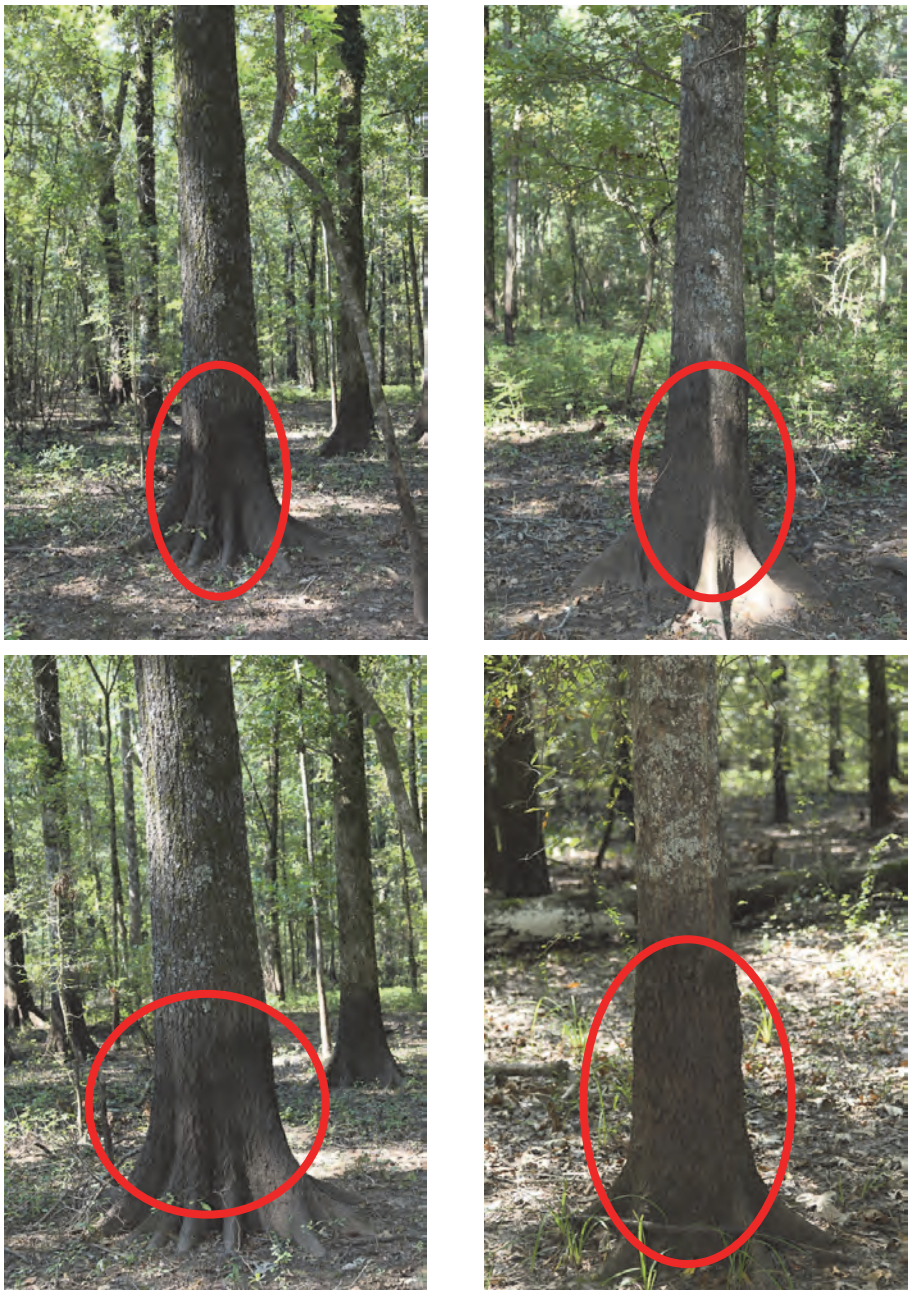
Scientific Name	Common Name
Acer drummondii	Swamp red maple
Acer negundo	Box elder
Acer saccharinum	Silver maple
Alternanthera philoxeroides	Alligator weed
Amorpha fruticosa	Leadplant
Asimina triloba	Paw-paw
Baccharis halimifolia	Baccharis
Betula nigra	River birch
Callicarpa americana	Beautyberry Car
Carpinus caroliniana	Ironwood
Carya aquatica	Water hickory
Carya cordiformis	Bitternut hickory
Carya illinoensis	Pecan
Carya laciniosa	Shellbark hickory
Carya ovata	Shagbark hickory
Carya tomentosa	Mockernut hickory
Catalpa speciosa	Catalpa
Celtis laevigata	Sugarberry
Cephalanthus occidentalis	Buttonbush
Cornus drummondii	Smooth dogwood
Cornus florida	Flowering dogwood
Cornus foemina	Swamp dogwood
Crataegus spp.	Hawthorn
Diospyros virginiana	Persimmon
Eichornia crassipes	Water hyacinth
Forestiera acuminata	Swamp privet
Fraxinus americana	White ash
Fraxinus pennsylvanica	Green ash
Gleditsia aquatica	Water locust
Gleditsia triacanthos	Honey locust

Scientific Name	Common Name
Hibiscus spp.	Hibiscus
Ilex decidua	Deciduous holly
Itea virginica	Virginia willow
Leitneria floridana	Corkwood
Ligustrum sinense	Japanese privet
Ligustrum spp.	Common privet
Lindera melissifolia	Pondberry
Liquidambar styraciflua	Sweetgum
Lonicera japonica	Japanese honeysuckle
Microstegium vimineum	Japanese stiltgrass
Morus rubra	Red mulberry
Nyssa aquatica	Water tupelo
Nyssa sylvatica	Blackgum
Phragmites australis	Common reed
Pinus taeda	Loblolly pine
Planera aquatica	Water elm
Platanus occidentalis	Sycamore
Populus deltoides	Eastern cottonwood
Populus heterophylla	Swamp cottonwood
Prunus angustifolia	Chickasaw plum
Prunus serotina	Black cherry
Pueraria montana	Kudzu
Quercus acutissima	Sawtooth oak
Quercus falcata	Southern red oak
Quercus lyrata	Overcup oak
Quercus macrocarpa	Bur oak
Quercus michauxii	Cow oak
Quercus nigra	Water oak
Quercus texana	Nuttall oak
Quercus pagoda	Cherrybark oak
Quercus palustris	Pin oak
Quercus phellos	Willow oak
Quercus shumardii	Shumard oak
Quercus similis	Delta post oak
Quercus stellata	Post oak
Quercus velutina	Black oak

Scientific Name	Common Name
Rubus spp.	Blackberry
Salix nigra	Black willow
Sambucus canadensis	Elderberry
Styrax americana	Storax
Taxodium distichum	Baldcypress
Triadica sebifera	Chinese tallow tree
Ulmus alata	Winged elm
Ulmus americana	American elm
Ulmus crassifolia	Cedar elm
Ulmus rubra	Slippery elm
Vaccinium spp.	Blueberry
	(concluded)

Appendix D: Photos of Indicators used in the MAV HGM Data collection

D1: Basal Swelling



Examples of basal swelling (adapted from Sheehan and Murray 2011, photo by Mike Wintroath).

D2: Tip Dieback

Red circles show tip dieback (adapted from Sheehan and Murray 2011, photo by Mike Wintroath).

D3: Woody Debris

a. Low amount of WD -0% to 10%

b. Medium amount of WD - 10% to 25%

c. High amount of WD - 25% to 100% (adapted from Sheehan and Murray 2011, photo by Mike Wintroath).

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

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1. REPORT DATE *(DD-MM-YYYY)*
July 2013

2. REPORT TYPE
Final report

3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE
A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Functions of Forested Wetlands in the Mississippi Alluvial Valley

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
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5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
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3909 Halls Ferry Road, Vicksburg, MS 39180-6199

8. PERFORMING ORGANIZATION REPORT NUMBER
ERDC/EL TR-13-14

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Headquarters, U.S. Army Corps of Engineers
Washington, DC 20314-1000

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

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

13. SUPPLEMENTARY NOTES

14. ABSTRACT:

The Hydrogeomorphic (HGM) Approach is a method for developing and applying indices for the site-specific assessment of wetland functions. The HGM Approach was initially designed to be used in the context of the Clean Water Act Section 404 Regulatory Program permit review process to analyze project alternatives, minimize impacts, assess unavoidable impacts, determine mitigation requirements, and monitor the success of compensatory mitigation. However, a variety of other potential uses have been identified, including the design of wetland restoration projects, and management of wetlands. This Regional Guidebook presents the HGM Approach for assessing the functions of most of the wetlands that occur in the Mississippi Alluvial Valley (MAV). It consolidates and extends the coverage provided by two previous guidebooks for the Delta Region of Arkansas and the Yazoo Basin of Mississippi.

The report begins with an overview of the HGM Approach and then classifies and characterizes the principal indentified MAV wetlands. Detailed HGM assessment models and protocols are presented for five of those wetland types, or subclasses, representing most of the forested wetlands in the region other than those associated with lakes and impoundments. The following wetland subclasses are treated in detail: Flat, Low-Gradient Riverine Backwater, Low-Gradient Riverine Overbank, Isolated Depression, and Connected Depression. The appendices provide field data collection forms and spreadsheets for making calculations.

15. SUBJECT TERMS
Wetlands
Mississippi Alluvial Valley (MAV)
HGM
Functional Assessment
Hydrogeomorphic
Bottomland Hardwoods

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON Elizabeth Murray**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			**19b. TELEPHONE NUMBER** *(include area code)*
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED		108	925-212-1359

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