ERDC/EL TR-04-3

Environmental Laboratory

US Army Corps of Engineers®
Engineer Research and Development Center

Ecosystem Management and Restoration Research Program

A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Depressional Wetlands in Peninsular Florida

Chris V. Noble, Rhonda Evans, Marti McGuire,
Katherine Trott, Mary Davis, and Ellis J. Clairain, Jr.

May 2004

Ecosystem Management and
Restoration Research Program

ERDC/EL TR-04-3
May 2004

A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Depressional Wetlands in Peninsular Florida

Chris V. Noble, Ellis J. Clairain, Jr.

Environmental Laboratory
U.S. Army Engineer Research and Development Center
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Rhonda Evans

U.S. Environmental Protection Agency, Region IV
Sam Nunn Atlanta Federal Center
61 Forsyth Street, SW
Atlanta, GA 30303-8960

Marti McGuire

Florida Department of Environmental Protection
2600 Blair Stone Road
Tallahassee, FL 32399-2400

Katherine Trott

Headquarters, U.S. Army Corps of Engineers
441 G Street NW
Washington, DC 20314-1000

Mary Davis

National Wildlife Federation
1313 West Peachtree
Atlanta, GA 30309

Final report

Prepared for U.S. Army Corps of Engineers
Washington, DC 20314-1000

Under Work Unit 32958

ABSTRACT: The Hydrogeomophic (HGM) Approach is a method for developing functional indices and the protocols used to apply these indices to the assessment of wetland functions at a site-specific scale. The HGM Approach was initially designed to be used in the context of the Clean Water Act Section 404 Regulatory Program permit review 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.

This report uses the HGM Approach to develop a Regional Guidebook to (a) characterize the Depressional Wetlands in Peninsular Florida, (b) provide the rationale used to select functions for the herbaceous and cypress dome subclasses, (c) provide the rationale used to select model variables and metrics, (d) provide the rationale used to develop assessment models, (e) provide data from reference wetlands and document its use in calibrating model variables and assessment models, and (f) outline the necessary protocols for applying the functional indices to the assessment of wetland functions.

Corps of Engineers Research Report Summary, May 2004

Assessing Wetland Functions

A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Depressional Wetlands in Peninsular Florida (ERDC/EL TR-04-3)

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

RESEARCH OBJECTIVE: The objective of this research was to develop a Regional Guidebook for applying the Hydrogeomorphic Approach to depressional wetlands in peninsular Florida in the context of the 404 Regulatory Program.

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

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

About the Authors: Mr. Chris V. Noble is a Soils Scientist, and Dr. Ellis J. Clarain, Jr., is a Research Biologist in the Environmental Laboratory, U.S. Army Engineer Research and Development Center (ERDC). Ms. Rhonda Evans is a Wetland Specialist in the Environmental Protection Agency. Ms. Marti McGuire is an Environmental Scientist in the Florida Department of Environmental Protection. Ms. Katharine Trott is a Senior Project Manager in the Headquarters, U.S. Army Corps of Engineers. Dr. Mary Davis is a Wetland Ecologist in the National Wildlife Federation. Point of Contact at ERDC is Mr. Noble at 601-634-3482, or Mr. Glenn G. Rhett, 601-634-3717, Director, Ecosystem Management and Restoration Research Program.

Contents

List of Figures

List of Tables

Preface

This Regional Guidebook was authorized by Headquarters, U.S. Army Corps of Engineers (HQUSACE), as part of the Ecosystem Management and Restoration Research Program (EMRRP). It is published as an Operational Draft for field testing for a 2-year period. Comments should be submitted via the Internet at the following address: *http://www.wes.army.mil/el/wetlands/hgmhp.html*.

Written comments should be addressed to:

Department of the Army
Research and Development Center
CEERD-EE-W
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

The work was performed under Work Unit 32958, "Technical Development of HGM," for which Dr. Ellis J. Clairain, Jr., Environmental Laboratory (EL), Vicksburg, MS, U.S. Army Engineer Research and Development Center (ERDC), was the Principal Investigator. Mr. Dave Mathis, CERD-C, was the EMRRP Coordinator at the Directorate of Research and Development, HQUSACE; Mr. David L. Shepp, CECW-EW, served as the EMRRP Technical Monitor's Representative; Mr. Glenn G. Rhett, EL, was the EMRRP Program Manager; and Dr. Clairain was the Task Area Manager.

This report was prepared by Mr. Chris V. Noble, EL; Ms. Rhonda Evans, U.S. Environmental Protection Agency (EPA) Region IV; Ms. Marti McGuire, Florida Department of Environmental Protection; Ms. Katherine Trott, HQUSACE; Dr. Mary Davis, National Wildlife Federation; and Dr. Clairain.

The authors wish to acknowledge the efforts of the following people, without whom this document would not have been possible: Jim Beever, Florida Game and Freshwater Fish Commission; Boyd Gunsalus and Steve Krupa, South Florida Water Management District; Ken Liudahl and Gene Fults, U.S. Department of Agriculture Natural Resources Conservation Service; Monica Folk, Nature Conservancy, Kissimmee, FL; Stuart Santos, U.S. Army Engineer District, Jacksonville, who attended the workshop and provided a great deal of thoughtful and constructive insight into the development of these models; Rhonda DuBois and Jeff Lin, Jaya Corporation, Huntsville, AL, who assisted with data analysis; Mike DelCharco, Taylor Engineering, Jacksonville, FL, and Eric Fleming, USDA National Resources Conservation Service, who contributed to the hydrology portions of the guidebook; and Beth Burger, U.S. Environmental Protection Agency, and Christina Uranowski, Tarpon Springs, FL, for their diligence in the field during the field data collection when they collected much of the information for this Guidebook.

This work took place under the general supervision of Dr. Morris Mauney, Jr., Chief, Wetlands and Coastal Ecology Branch; Dr. David J. Tazik, Chief, Ecosystem Evaluation and Engineering Division; and Dr. Elizabeth C. Fleming, Acting Director, EL.

COL James R. Rowan, EN, was Commander and Executive Director of ERDC. Dr. James R. Houston was Director.

1 Introduction

Background

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

On 16 August 1996 a National Action Plan to Implement the Hydrogeomorphic Approach (NAP) was published (*Federal Register* 1997). The NAP was developed cooperatively by a National Interagency Implementation Team consisting of the U.S. Army Corps of Engineers (USACE), U.S. Environmental Protection Agency (USEPA), National Resources Conservation Service (NRCS), Federal Highways Administration (FHWA), and U.S. Fish and Wildlife Service (USFWS). Publication of the NAP was designed to outline a strategy and promote the development of Regional Guidebooks for assessing the functions of regional wetland subclasses using the HGM Approach; to solicit the cooperation and participation of Federal, State, and local agencies, academia, and the private sector in this effort; and to update the status of Regional Guidebook development.

The sequence of tasks necessary to develop a Regional Guidebook outlined in the NAP was used to develop this Regional Guidebook (see the section, “Development Phase”). An initial workshop was held in Miami, FL, on 8-11 May 1995. The workshop was attended by hydrologists, biogeochemists, soil scientists, wildlife biologists, and plant ecologists from the public, private, and academic sectors with extensive knowledge of the depressional wetland ecosystem. Based on the results of the workshop, two regional wetland subclasses were defined and characterized, a reference domain was defined, wetland functions were selected, model variables were identified, and conceptual assessment models were developed. Subsequently, fieldwork was conducted to collect data from reference wetlands. These data were used to revise and calibrate the conceptual assessment models. A draft version of this Regional Guidebook was then subjected to several rounds of peer review and revised into the present guidebook.

Objectives

The objectives of this Regional Guidebook are to (a) characterize the Depressional Wetlands in Peninsular Florida, (b) provide the rationale used to select functions for the Herbaceous and Cypress Dome Subclasses, (c) provide the rationale used to select model variables and metrics, (d) provide the rationale used to develop assessment models, (e) provide data from reference wetlands and document its use in calibrating model variables and assessment models, and (f) outline the necessary protocols for applying the functional indices to the assessment of wetland functions.

Scope

This guidebook is organized in the following manner. Chapter 1 provides the background, objectives, and organization of the guidebook. Chapter 2 provides a brief overview of the major components of the HGM Approach and the development and application phases required to implement the approach. Chapter 3 characterizes the Herbaceous and Cypress Dome Subclasses in the Peninsular Depressional Wetlands in terms of geographical extent, climate, geomorphic setting, hydrology, vegetation, soils, and other factors that influence wetland function. Chapter 4 discusses each of the wetland functions, model variables, and function indices. This discussion includes a definition of the function; a quantitative, independent measure of the function for the purposes of validation; a description of the wetland ecosystem and landscape characteristics that influence the function; a definition and description of model variables used to represent these characteristics in the assessment model; a discussion of the assessment model used to derive the functional index; and an explanation of the rationale used to calibrate the index with reference wetland data. Chapter 5 outlines the steps of the assessment protocol for conducting a functional assessment of Depressional Wetlands in Peninsular Florida. Appendix A presents a Glossary. Appendix B summarizes functions, assessment models, variables, and variable measures, and includes copies of the field data forms needed to collect field data. Appendix B also provides expanded discussions on how to measure selected assessment variables. Appendix C summarizes how to determine soil texture by feel and percent foliage cover, lists species found, and presents photos of the dominant species.

While it is possible to assess the functions of Depressional Wetlands in Peninsular Florida using only the information contained in Chapter 5 and Appendix B, it is suggested that potential users familiarize themselves with the information in Chapters 2-4 prior to conducting an assessment.

2 Overview of the Hydrogeomorphic Approach

As indicated in Chapter 1, the HGM Approach is a collection of concepts and methods for developing functional indices and subsequently using them to assess the capacity of a wetland to perform functions relative to similar wetlands in a region. The HGM Approach includes four integral components: (a) the HGM classification, (b) reference wetlands, (c) assessment models/functional indices, and (d) assessment protocols. During the development phase of the HGM Approach, these four components are integrated in a Regional Guidebook for assessing the functions of a regional wetland subclass. Subsequently, during the application phase, end users, following the assessment protocols outlined in the Regional Guidebook, assess the functional capacity of selected wetlands. Each of the components of the HGM Approach and the development and application phases are discussed in this chapter. More extensive discussions can be found in Brinson (1993; 1995a,b); Brinson et al. (1995, 1996, 1998); Hauer and Smith (1998); Smith (2001); Smith and Wakeley (2001); Smith et al. (1995); and Wakeley and Smith (2001).

Hydrogeomorphic Classification

Wetland ecosystems share a number of features including relatively long periods of inundation or saturation, hydrophytic vegetation, and hydric soils. In spite of these common attributes, wetlands occur under a wide range of climatic, geologic, and physiographic situations and exhibit a wide variety of physical, chemical, and biological characteristics and processes (Cowardin et al. 1979; Ferren et al. 1996a,b,c; Mitsch and Gosselink 2000; Semeniuk 1987). The variability of wetlands makes it challenging to develop assessment methods that are both accurate (i.e., sensitive to significant changes in function) and practical (i.e., can be completed in the relative short time frame available for conducting assessments). Existing “generic” methods designed to assess multiple wetland types throughout the United States are relatively rapid, but lack the resolution necessary to detect significant changes in function. However, one way to achieve an appropriate level of resolution within the available time frame is to reduce the level of variability exhibited by the wetlands being considered (Smith et al. 1995).

The HGM Classification was developed specifically to accomplish this task (Brinson 1993). It identifies groups of wetlands that function similarly using three criteria that fundamentally influence how wetlands function: geomorphic setting, water source, and hydrodynamics. Geomorphic setting refers to the landform and position of the wetland in the landscape. Water source refers to the primary water source in the wetland such as precipitation, overbank floodwater, or ground water. Hydrodynamics refers to the level of energy and the direction that water moves in the wetland. Based on these three classification criteria, any number of "functional" wetland groups can be identified at different spatial or temporal scales. For example, at a continental scale, Brinson (1993) identified five hydrogeomorphic wetland classes. These were later expanded to the seven classes described in Table 1 (Smith et al. 1995). In many cases, the level of variability in wetlands encompassed by a continental scale hydrogeomorphic class is still too great to allow development of assessment models that can be rapidly applied while being sensitive enough to detect changes in function at a level of resolution appropriate to 404 review process. For example, at a continental geographic scale the depression class includes wetland ecosystems in different regions as diverse as California vernal pools (Zedler 1987), prairie potholes in North and South Dakota (Hubbard 1988; Kantrud et al. 1989), playa lakes in the high plains of Texas (Bolen et al. 1989), kettles in New England, and cypress domes in Florida (Ewel 1984; Kurz and Wagner 1953).

To reduce both inter- and intraregional variability, the three classification criteria are applied at a smaller, regional geographic scale to identify regional wetland subclasses. In many parts of the country, existing wetland classifications can serve as a starting point for identifying these regional subclasses (Ferren et al. 1996a,b,c; Golet and Larson 1974; Stewart and Kantrud 1971; Wharton et al. 1982). Regional subclasses, like the continental classes, are distinguished on the basis of geomorphic setting, water source, and hydrodynamics. In addition, certain ecosystem or landscape characteristics may also be useful for distinguishing regional subclasses in certain regions. For example, depressional subclasses might be based on water source (i.e., groundwater versus surface water), or the degree of connection between the wetland and other surface waters (i.e., the flow of surface water in or out of the depression through defined channels). Tidal fringe subclasses might be based on salinity gradients (Shafer and Yozzo 1998). Slope subclasses might be based on the degree of slope, landscape position, the source of water (i.e., throughflow versus groundwater), or other factors. Riverine subclasses might be based on water source, position in the watershed, stream order, watershed size, channel gradient, or floodplain width. Examples of potential regional subclasses are shown in Table 2, Smith et al. (1995), and Rheinhardt et al. (1997).

Regional Guidebooks include a thorough characterization of the regional wetland subclass in terms of its geomorphic setting, water sources, hydrodynamics, vegetation, soil, and other features that were taken into consideration during the classification process.

Table 1
Hydrogeomorphic Wetland Classes at the Continental Scale

HGM Wetland Class	Definition
Depression	Depression wetlands occur in topographic depressions (i.e., closed elevation contours) that allow the accumulation of surface water. Depression wetlands may have any combination of inlets and outlets or lack them completely. Potential water sources are precipitation, overland flow, streams, or groundwater/interflow 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 range from diurnal to seasonal. Depression wetlands may lose water through evapotranspiration, intermittent or perennial outlets, or recharge to groundwater. Prairie potholes, playa lakes, vernal pools, and cypress domes are common examples of depressional wetlands.
Tidal Fringe	Tidal fringe wetlands occur along coasts and estuaries and are under the influence of sea level. They intergrade landward with riverine wetlands where tidal current diminishes and riverflow becomes the dominant water source. Additional water sources may be groundwater discharge and precipitation. The interface between the tidal fringe and riverine classes is where bidirectional flows from tides dominate over unidirectional flows controlled by floodplain slope of riverine wetlands. Because tidal fringe wetlands frequently flood 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. *Spartina alterniflora* salt marshes are a common example of tidal fringe wetlands.
Lacustrine Fringe	Lacustrine fringe wetlands are adjacent to lakes where the water elevation of the lake maintains the water table in the wetland. In some cases, these wetlands consist of a floating mat attached to land. Additional sources of water are precipitation and groundwater discharge, the latter dominating where lacustrine fringe wetlands intergrade with uplands or slope uplands. Surface water flow is bidirectional, usually controlled by water-level fluctuations resulting from wind or seiche. Lacustrine wetlands lose water by flow returning to the lake after flooding and evaporation. 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 sites with saturated overflow with no channel formation. They normally occur on sloping land ranging from slight to steep. The predominant source of water is groundwater or interflow discharging at the land surface. Precipitation is often a secondary contributing source of water. Hydrodynamics are dominated by downslope unidirectional water flow. Slope wetlands can occur in nearly flat landscapes if groundwater discharge is a dominant source to the wetland surface. Slope wetlands lose water primarily by saturated subsurface flows and by evapo-transpiration. Slope wetlands may develop channels, but the channels serve only to convey water away from the slope wetland. Slope wetlands are distinguished from depressional 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 floodplain 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 upland areas by their poor vertical drainage due to impermeable layers (e.g., hardpans), slow lateral drainage, and low hydraulic gradients. Mineral soil flats that accumulate peat can eventually become organic soil flats. They typically occur in relatively humid climates. 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 the 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 flow from the channel or subsurface hydraulic connections between the stream channel and wetlands. 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 flats, 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 (for losing streams), and evaporation. Peat may accumulate in off-channel depressions (oxbows) that have become isolated from riverine processes and subjected to long periods of saturation from groundwater sources. Bottomland hardwoods on floodplains are an example of riverine wetlands.

Table 2 Potential Regional Wetland Subclasses in Relation to Geomorphic Setting, Dominant Water Source, and Hydrodynamics				
Geomorphic Setting	Dominant Water Source	Dominant Hydrodynamics	Potential Regional Wetland Subclasses	
			Eastern USA	Western USA/Alaska
Depression	Groundwater or interflow	Vertical	Prairie potholes 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 forest	Riparian wetlands

Reference Wetlands

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

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

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

Table 3
Reference Wetland Terms and Definitions

Term	Definition
Reference domain	The geographic area from which reference wetlands representing the regional wetland subclass are selected (Smith et al. 1995).
Reference wetlands	A group of wetlands that encompass the known range of variability in the regional wetland subclass resulting from natural processes and disturbance and from human alterations.
Reference standard wetlands	The subset of reference wetlands that perform a representative suite of functions at a level that is both sustainable and characteristic of the least human altered wetland sites in the least human altered landscapes. By definition, the functional capacity index for all functions in reference standard wetlands is assigned a 1.0.
Reference standard wetland variable condition	The range of conditions exhibited by model variables in reference standard wetlands. By definition, reference standard conditions receive a variable subindex score of 1.0.
Site potential (mitigation project context)	The highest level of function possible, given local constraints of disturbance history, land use, or other factors. Site potential may be less than or equal to the levels of function in reference standard wetlands of the regional wetland subclass.
Project target (mitigation project context)	The level of function identified or negotiated for a restoration or creation project.
Project standards (mitigation context)	Performance criteria and/or specifications used to guide the restoration or creation activities toward the project target. Project standards should specify reasonable contingency measures if the project is not being achieved.

Assessment Models and Functional Indices

In the HGM Approach, an assessment model is a simple representation of a function performed by a wetland ecosystem. It defines the relationship between one or more characteristics or processes of the wetland ecosystem. Functional capacity is simply the ability of a wetland to perform a function compared to the level of performance in reference standard wetlands.

Model variables represent the characteristics of the wetland ecosystem and surrounding landscape that influence the capacity of a wetland ecosystem to perform a function. Model variables are ecological quantities that consist of five components (Schneider 1994): (a) a name, (b) a symbol, (c) a measure of the variable and procedural statements for quantifying or qualifying the measure directly or calculating it from other measures, (d) a set of variables (i.e., numbers, categories, or numerical estimates (Leibowitz and Hyman 1997)) that are generated by applying the procedural statement, and (e) units on the appropriate measurement scale. Table 4 provides several examples.

Table 4
Components of a Model Variable

Name (Symbol)	Measure / Procedural Statement	Resulting Values	Units (Scale)
Substrate Disturbance ($V_{DISTURB}$)	The alteration of the soils by activities such as addition of fill material, soil oxidation, rock plowing, or removal of sediment.	present absent	unitless (nominal scale)
Presence of Ditches (V_{DITCH})	The presence of ditches within a certain distance of the wetland	1.0 0.8 0.3	unitless (interval scale)
Cover of Woody Vegetation (V_{WOODY})	The average percent areal cover of leaves and stems of shrubs and trees (> 1 m).	0 to >100	percent

Model variables occur in a variety of states or conditions in reference wetlands. The state or condition of the variable is denoted by the value of the measure of the variable. For example, percent herbaceous groundcover, the measure of the percent cover of herbaceous vegetation, could be large or small. Based on its condition (i.e., value of the metric), model variables are assigned a variable subindex. When the condition of a variable is within the range of conditions exhibited by reference standard wetlands, a variable subindex of 1.0 is assigned. As the condition deflects from the reference standard condition (i.e., the range of conditions within which the variable occurs in reference standard wetlands), the variable subindex is assigned based on the defined relationship between model variable condition and functional capacity. As the condition of a variable deviates from the conditions exhibited in reference standard wetlands, it receives a progressively lower subindex reflecting its decreasing contribution to functional capacity. In some cases, the variable subindex drops to zero. For example, when the percent cover of herbaceous groundcover is 40 percent or greater, the subindex for percent herbaceous groundcover is one. As the percent cover falls below 40 percent, the variable subindex score decreases on a linear scale to zero.

Model variables are combined in an assessment model to produce a Functional Capacity Index (FCI) that ranges from 0.0 to 1.0. The FCI is a measure of the functional capacity of a wetland relative to reference standard wetlands in the reference domain. Wetlands with an FCI of 1.0 perform the function at a level characteristic of reference standard wetlands. As the FCI decreases, it indicates that the capacity of the wetland to perform the function is less than that characteristic of reference standard wetlands.

Assessment Protocol

The final component of the HGM Approach is the assessment protocol. The assessment protocol is a series of tasks, along with specific instructions, that allow the end user to assess the functions of a particular wetland area using the functional indices in the Regional Guidebook. The first task is characterization, which involves describing the wetland ecosystem and the surrounding landscape, describing the proposed project and its potential impacts, and identifying the wetland areas to be assessed. The second task is collecting the field data for model variables. The final task is analysis, which involves calculation of functional indices.

Development Phase

The Development Phase of the HGM Approach is ideally carried out by an interdisciplinary team of experts known as the “Assessment Team,” or “A-Team.” The product of the Development Phase is a Regional Guidebook for assessing the functions of a specific regional wetland subclass (Figure 1). In developing a Regional Guidebook, the A-Team will complete the following major tasks. After organization and training, the first task of the A-Team is to

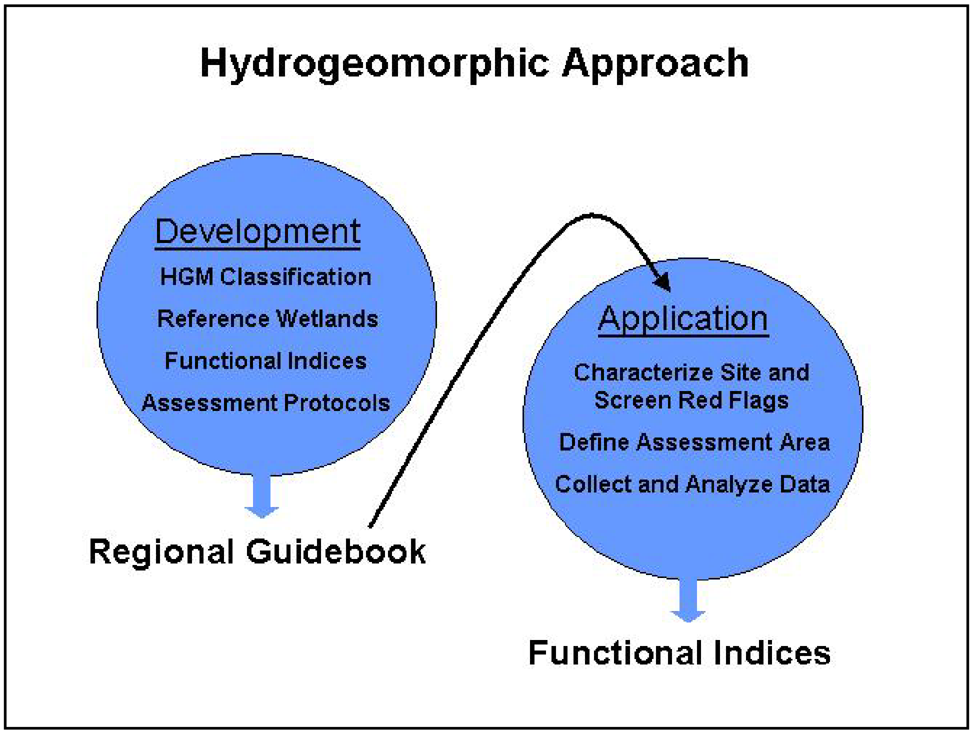


Figure 1. Development and application phases of the HGM Approach

classify the wetlands within the region of interest into regional wetland subclasses using the principles and criteria of the HGM Classification (Brinson 1993; Smith et al. 1995). Next, focusing on the specific regional wetland subclasses selected, the A-Team develops an ecological characterization or functional profile of the subclass. The A-Team then identifies the important wetland functions, conceptualizes assessment models, identifies model variables to represent the characteristics and processes that influence each function, and defines metrics for quantifying model variables. Next, reference wetlands are identified to represent the range of variability exhibited by the regional subclass. Field data are then collected from the reference wetlands and used to calibrate model variables and verify the conceptual assessment models. Finally, the A-Team develops the assessment protocols necessary for regulators, managers, consultants, and other end users to apply the indices to the assessment of wetland functions. The following list provides the detailed steps involved in this general sequence:

Task 1: Organize the A-Team.
- A. Identify A-Team members.
- B. Train A-Team in the HGM Approach.

Task 2: Select and Characterize Regional Wetland Subclasses.
- A. Identify/prioritize wetland subclasses.
- B. Select regional wetland subclass and define reference domain.
- C. Initiate literature review.
- D. Develop preliminary characterization of regional wetland subclasses.
- E. Identify and define wetland functions.

Task 3: Select Model Variables and Metrics and Construct Conceptual Assessment Models.

A. Review existing assessment models.
B. Identify model variables and metrics.
C. Define initial relationship between model variables and functional capacity.
D. Construct conceptual assessment models for deriving FCIs.
E. Complete Precalibrated Draft Regional Guidebook (PDRG).

Task 4: Conduct Peer Review of PDRG.

A. Distribute PDRG to peer reviewers.
B. Conduct interdisciplinary, interagency workshop of PDRG.
C. Revise PDRG to reflect peer review recommendations.
D. Distribute revised PDRG to peer reviewers for comment.
E. Incorporate final comments from peer reviewers on revisions into PDRG.

Task 5: Identify and Collect Data from Reference Wetlands.

A. Identify reference wetland field sites.
B. Collect data from reference wetland field sites.
C. Analyze reference wetland data.

Task 6: Calibrate and Field Test Assessment Models.

A. Calibrate model variables using reference wetland data.
B. Verify and validate (optional) assessment models.
C. Field test assessment models for repeatability and accuracy.
D. Revise PDRG based on calibration, verification, validation (optional), and field testing results into a Calibrated Draft Regional Guidebook (CDRG).

Task 7: Conduct Peer Review and Field Test of CDRG.

A. Distribute CDRG to peer reviewers.
B. Field test CDRG.
C. Revise CDRG to reflect peer review and field test recommendations.
D. Distribute CDRG to peer reviewers for final comment on revisions.
E. Incorporate peer reviewers' final comments on revisions.
F. Publish Operational Draft Regional Guidebook (ODRG).

Task 8: Technology Transfer.

A. Train end users in the use of the ODRG.
B. Provide continuing technical assistance to end users of the ODRG.

Application Phase

The Application Phase involves two steps. The first is using the assessment protocols outlined in the Regional Guidebook to carry out the following tasks (Figure 1).

a. Define assessment objectives.

b. Characterize the project site.

c. Screen for red flags.

d. Define the Wetland Assessment Area.

e. Collect field data.

f. Analyze field data.

The second step involves applying the results of the assessment, the FCI, to the appropriate decision-making process of the permit review sequence, such as alternatives analysis, minimization, assessment of unavoidable impacts, determination of compensatory mitigation, design and monitoring of mitigation, comparison of wetland management alternatives or results, determination of restoration potential, or identification of acquisition or mitigation sites.

3 Characterization of Cypress and Herbaceous Depressions in Peninsular Florida

Depressional wetlands in peninsular Florida cover a wide range of vegetative types. Two of the most extensive and significant are herbaceous depressions and cypress domes. These two types are scattered throughout Florida Subtropical Fruit, Truck Crop, and Range Major Land Resource Areas (MLRA) (U.S. Department of Agriculture (USDA) 1981). Both types of depressions occur as generally round or oval lows 0.3 to 20 ha (0.7 to 50 acres) in size as part of the larger flatwoods-slough-depressional landscape. The significance of the loss of depressional wetlands in Florida is not specifically recorded. Wetlands historically occupied 30 percent of the Florida landscape (Dahl 2000). Due to their prevalence and significant development pressures, 46 percent of the wetland acreage was lost in Florida by 1980 (Dahl 2000).

Regional Wetland Subclass and Reference Domain

This Regional Guidebook was developed to assess the functions of two subclasses of freshwater depressions in peninsular Florida: Cypress Domes and Herbaceous Marsh Depressional Wetlands. The subclasses are visually distinguished primarily by vegetation, but Cypress Domes typically have a longer hydroperiod. Depressional wetlands in Florida have many functional similarities (Table 5). Subsurface water flow is typically unidirectional; the soils are poorly

Table 5
Distinguishing Features of Cypress Domes and Herbaceous Depressions

Features	Cypress Domes	Herbaceous Depressions
Soils	Mineral and organic	Mineral
Average annual water levels	30 cm (12 in.)	30 cm (12 in.)
Duration of inundation	6 – 10 months	1 – 7 months

or very poorly drained. They are primarily precipitation driven, but the surficial aquifers play an important role in their function. Seasonal high water tables in the surficial aquifers maintain the water levels necessary to support wetland communities, and the wetland recharges the surficial aquifers during dry periods.

According to Smith et al. (1995), the reference domain is the geographic area occupied by the reference wetland sites. The reference domain for this guidebook is peninsular Florida from the Everglades north to the boundary of Land Resource Region U (USDA 1981) (Figure 2). The model variables are calibrated based on reference wetland sites located in Charlotte, Collier, Flagler, Hernando, Highlands, Osceola, Hillsborough, Indian River, Martin, Palm Beach, Pasco, Pinellas, Polk, Putnam, St. Johns, St. Lucie, and Volusia counties.

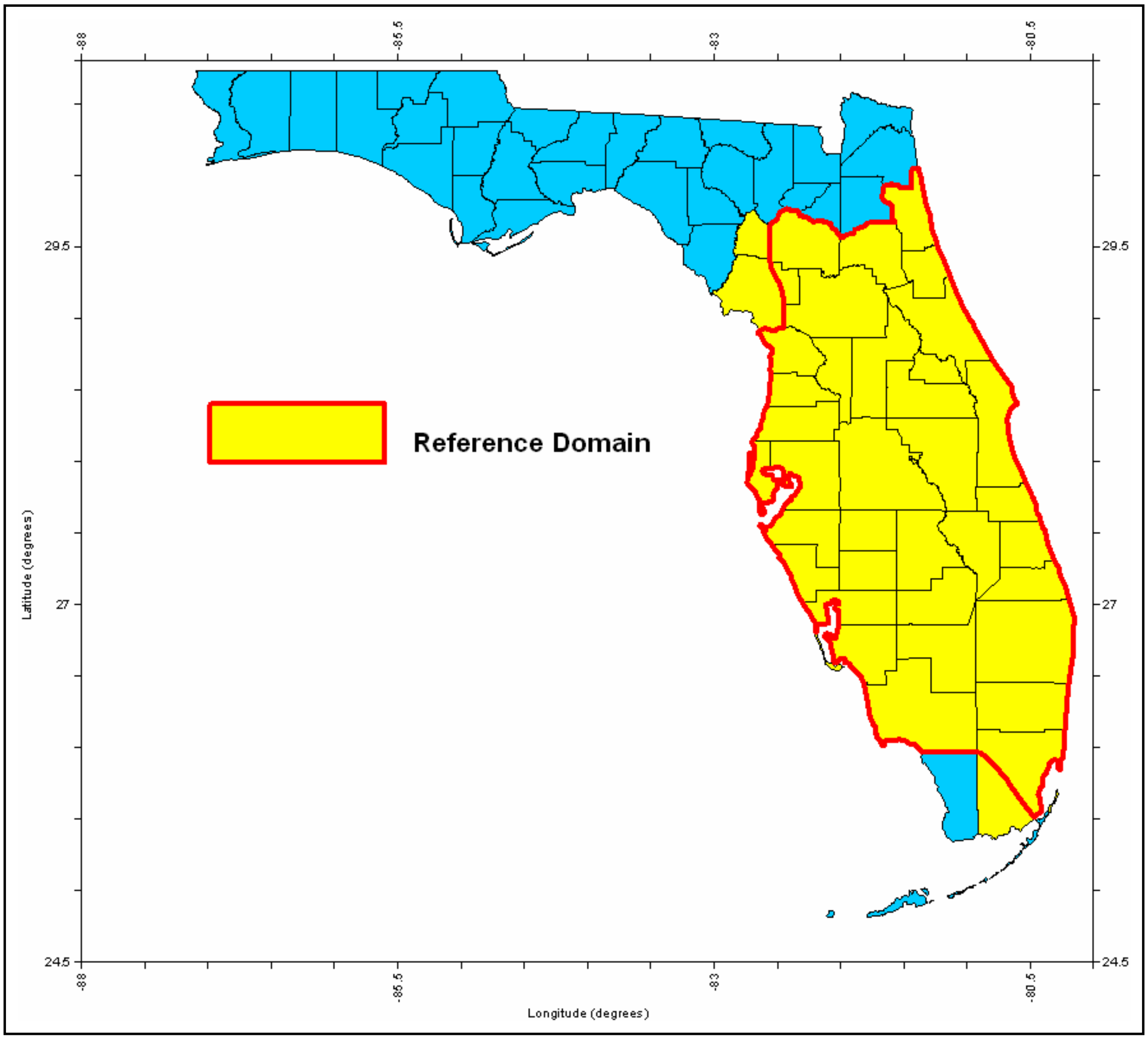


Figure 2. Reference domain for Cypress Dome and Herbaceous Marsh depressional wetlands

However, the functional models in this guidebook may apply to Cypress Domes and Herbaceous Marsh Depressions outside of the reference domain. Application of these models to depressional wetlands outside of peninsular Florida is at the discretion of the user.

Description of the Regional Wetland Subclass

Depressional wetlands are not unique to Florida but do make up a substantial portion of the wetland landscape. Cypress domes and herbaceous marshes are generally round, shallow depressions 0.3 to 1 m (1 to 3 ft) deep in a larger landscape of dry flatwoods, hydric flatwoods, sloughs, and depressions (Figure 3). Both cypress domes and herbaceous depressions may be closed depressions with no surface outlet, or connected to form a chain or outlet to larger drainageways

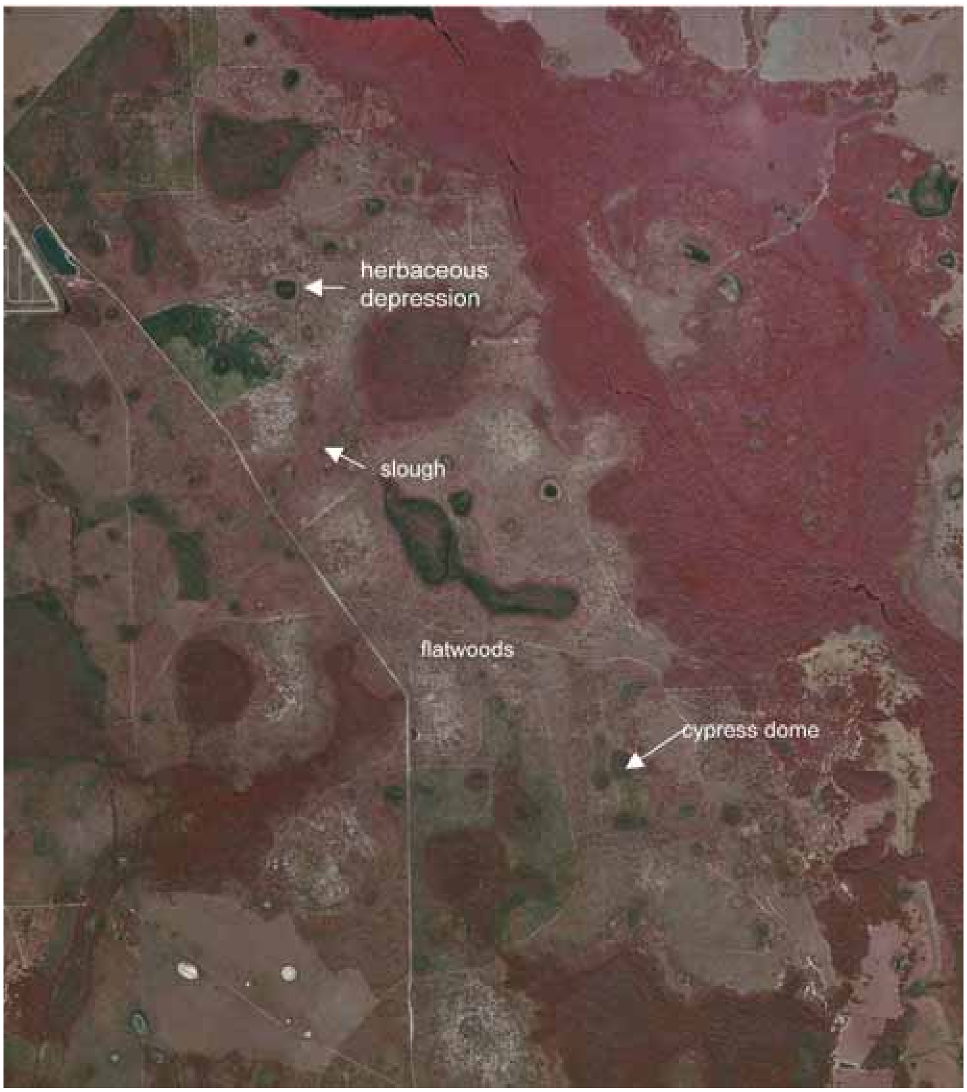


Figure 3. Aerial photograph of typical flatwoods-depression-slough landscape within the reference domain

or creeks. Fire is extremely important and is thought to be primarily responsible for the characteristic dome shape of cypress domes. Fires are most frequent in the shallow marsh or outermost zone and have a greater impact on this zone because it dries first. The cypress zone has a longer hydroperiod and is more likely to be wet during a fire.

Fire will impact or even kill trees on the outer edge of the cypress zone while the inner trees will not be affected, allowing them to grow taller, giving the wetland the characteristic dome shape (Figure 4). While fire may reach the interior of a cypress dome only once a century, it will impact the shallow marsh zone every 3 to 5 years in a natural setting.

Figure 4. Typical cypress dome illustrating the classic dome shape

Soils

Cypress domes and herbaceous depressions contain a wide variety of soils. These include soils with a sand texture greater than 2 m (80 in.) thick to soils with loamy sand surface and a restrictive sandy clay loam subsurface at 40 cm (16 in.). While cypress domes can have a soil of any texture, they are more likely than herbaceous depressions to have a thick organic soil.

Geomorphic setting

Depressional wetlands that occur as part of the larger flatwoods-slough-depression landscape are often part of a larger wetland system as well. The low relief of this wetland-upland system can make regulatory wetland identification especially difficult. Some depressional wetlands are adjacent to other wetlands of different subclasses (i.e., wet flats or slough). Other types of wetlands should be separated from the Cypress Dome or Herbaceous Depression for the application of this assessment method. Many of the depressional wetlands described in these subclasses are ringed by a collar of *Serenoa repens* (saw palmetto) separating the subclass from the surrounding landscape communities (Figure 5).

Figure 5. Typical herbaceous marsh with *Serenoa repens* (saw palmetto) at the upland wetland boundary, a shallow marsh, and deep marsh zones

Climate

The climate of peninsular Florida is subtropical with long, hot, humid summers and mild winters. The area typically has a summer rainy season with 60 percent of the rainfall during the months of June through September. Typically depressional wetlands fill with water during the summer rainy season and dry during the winter dry season. However storm events bringing 25 cm (10 in.) or more of rainfall can occur any month of the year. The average annual rainfall is 127 to 152 cm (50 to 60 in.) (Carlisle and Watts 1995). The major source of rainfall is thunderstorms, although winter cold fronts and hurricanes can contribute significantly in some years. Drought periods are common as well. During prolonged drought periods upland vegetative species will often invade the upper zones of depressional wetlands, but do not dominate. These plants are usually replaced by native wetland species when rainfall returns to more normal conditions unless other disturbances or impacts are present.

Water sources and hydrodynamics

Rainfall governs the water depth in cypress domes and marsh depressions, adding to surface water by throughfall and runoff and slowing infiltration by raising water tables in surrounding areas and limiting evaporation.

Evapotranspiration and infiltration are equally important in the export of water. Surface water outflow is significant only for connected depressions and only when the water level in the depression reaches sufficient depth to reach the height of the outlet. Cypress domes and herbaceous depressions will recharge the surficial aquifer during dry periods when the water table falls below the water level in the depression. During wet periods the surficial water table will discharge into the same wetland. Typically this recharge/discharge cycle occurs once a year, but can occur several times in a year depending on storm events. Infiltration is radially outward, controlled by surrounding water tables, and is related to wetland size and depth of the aquifer. Infiltration rates increase as the size of the wetland increases and as the water table falls. Surface water is closely coupled to groundwater in the underlying water table aquifer.

Biological profile

No wildlife species are known to live only in cypress domes or herbaceous depressions. However, a great many species use these isolated or connected wetlands during a portion of their life cycle. Insect diversity, while less than in riverine wetlands, is still significant and often forms the basis for the food chain in and around the greater wetland-upland landscape ecosystem. Because cypress domes and herbaceous depressional wetlands are not continuously inundated with water, they do not support a fish population. While the wet-dry cycle of cypress domes and herbaceous depressions is detrimental to fish populations, it is ideal for amphibians and reptiles. Many birds use cypress domes and herbaceous depressions for feeding and resting. Cypress tree canopies as well as tree cavities are used for nesting. Birds are more abundant in cypress domes than in the adjacent upland during migration as well as during the hot summer months (Harris and Mulholland 1983). Semiaquatic mammals such as otter and mink also use depressional wetlands. Other species that are more associated with uplands, like wild turkey, deer, and black bear, will also use cypress domes as a food source and cover during dry periods.

Disturbance

The importance of small isolated wetlands as hydrologic buffers for the region cannot be overemphasized, especially with the dramatic decrease in wetlands as urbanization alters runoff patterns and lowers water tables. Small wetlands have an even greater capacity for groundwater recharge than large wetlands since the rate of groundwater loss is directly correlated to the shoreline length per unit area (Millar 1971).

The most common disturbances to cypress domes and herbaceous depressions are surface drainage, subsurface drainage, extended hydroperiods, fire exclusion, logging in cypress domes, filling, excavation, excessive grazing, and rooting by wild hogs.

The characteristic structure and function of natural isolated wetlands are dependent on relative long-term environmental stability. Since most cypress dome and herbaceous depressions are relatively shallow, the lowering of the water table of 0.3 m (1 ft) would cause significant areas to be without surface water. As the hydroperiod decreases, upland species become dominant, beginning in the shallow marsh zone and moving inward toward the center of the wetland if the impact is severe.

Logging has had a major impact on most cypress domes. Nearly all swamps in Florida were logged between 1880 and 1950 (Ewel 1990). In some wetlands the second-growth timber has been harvested as well. In some instances entire cypress domes have been clear cut and chipped for landscape mulch. Even with regeneration of cypress trees after logging, the occurrence of large, even stands of trees reduces cover and nesting cavities. Clear-cutting drastically reduces hydroperiod by increasing evapotranspiration by as much as 90 percent (Riekerk and Korhnak 2000).

Cypress domes

Cypress dome depressional wetlands are generally round, closed or connected lows in the generally flat landscape. The soils are often, but not always, organic. When organic soils occur, they are thickest near the center of the wetland, which usually has the longest period of inundation. These wetlands typically have a wet meadow zone (Stewart and Kantrud 1971) immediately down slope of the upland wetland boundary. The boundary is often marked with a ring of saw palmetto. The wet meadow has the shortest period of inundation and in dry years may be saturated only to the soil surface. This zone is also the first to be invaded by upland species as a result of drainage. Cypress domes are often destroyed during clearing of upland vegetation around the wetland. The cypress zone is inside the wet meadow zone and would correspond to the shallow marsh zone. This zone is dominated by pond cypress with little understory vegetation and is nearly always inundated for several months during the year. Some cypress domes have a deep marsh zone inside the cypress zone. This zone is open of tree canopy giving the wetland a doughnut appearance. The deep marsh, when present, has the longest period of inundation. Species that can be found in this zone are common rush (*Juncus effuses* L.), denseflower knotweed (*Polygonum densiflorum*), bladderwort, and other obligate vegetation. Other species that can be found in cypress domes include red maple (*Acer rubrum*), common buttonbush (*Cephalanthus occidentalis*), wax myrtle (*Myrica cerifera*), swamp tupelo (*Nyssa biflora*), swamp bay (*Persea palustris*), slash pine (*Pinus elliottii*), dahoon holly (*Ilex cassine*), swamp fern (*Blechnum serrulatum*), cinnamon fern (*Osmunda cinnamomea*), royal fern (*Osmunda regalis*), and Virginia chainfern (*Woodwardia virginica*).

Wildlife species that often use cypress domes include deer (*Odocoileus virginianus*), raccoons (*Procyon lotor*), river otter (*Lutra canadensis*), barred owl (*Strix varia*), pileated woodpecker (*Dryocopus pileatus*), wood ducks (*Aix *sponsa*), frogs, turtles, bald eagles (*Haliaeetus leucocephalus*), black bear (*Ursus americanus*), and a variety of water snakes.

Herbaceous marsh

Herbaceous marsh depressional wetlands are similar in size and shape and occupy the same position on the landscape as cypress domes. The obvious difference is that cypress trees do not dominate marsh depressions. The lack of a cypress tree canopy increases the exposure to the sun so that marsh depressions have a much higher evaporation rate than cypress domes. In general marsh depressions are not as deep and have shorter hydroperiods than cypress domes. Soils are commonly sandy or sandy loam, but organic surfaces are not uncommon in the interiormost portions of the wetland. Marsh depressions generally have vegetative zones that would correlate with the zones described by Stewart and Kantrud in the classic publication *Classification of Natural Ponds and Lakes in the Glaciated Prairie Region*. The only exception is that many marsh depressional wetlands in Florida do not have a low prairie zone, but transition directly from the upland flatwoods into the wet meadow zone. The first wetland zone adjacent to the upland is the wet meadow zone also referred to as the *Hypericum* zone (Winchester et. al. 1985) because of the dominance of St. John's wort in this zone. The wet meadow zone is typically about 30 cm (12 in.) deep. The next zone inward is the shallow marsh or *Panicum-Rhynchospora* zone. This zone is dominated by maidencane and rush. The shallow marsh is approximately 40 to 50 cm (16 to 20 in.) deep. The deep marsh or mixed emergent zone is the third vegetative zone toward the center of the depressional marsh. This zone is dominated by pickerelweed (*Pontederia cordata*). The deep marsh zone is about 36 to 50 cm (14 to 20 in.) deep. One or more of the zones described is always found in natural wetlands in the sequence of wet meadow, shallow marsh, and deep marsh. The zones are usually continuous, but in rare cases a zone will only partially extend around the entire wetland. A permanent open-water zone does occur at the innermost portion of some wetlands, but none were sampled as part of this guidebook. However, created or restored wetlands often lack one or more zones or the zones will not form concentric rings.

Many of the same wildlife species that use cypress domes also use marsh depressions. A variety of frogs, snakes, turtles, and American alligator (*Alligator mississippiensis*) can be found in marsh depressions. Many species of waterfowl such as herons, egrets, bitterns, ibis, rails, limpkins, and wood stork (*Mycteria americana*) are often seen using marsh depressions for feeding.

4 Wetland Functions and Assessment Models

Overview

The following functions are performed by Cypress Domes and Herbaceous Depressional Wetlands in Peninsular Florida:

a. Surface Water Storage.

b. Subsurface Water Storage.

c. Biogeochemical Processes.

d. Characteristic Plant Community.

e. Wildlife Habitat.

The following sequence is used to present and discuss each of these functions:

a. *Definition:* defines the function and identifies an independent quantitative measure that can be used to validate the functional index.

b. *Rationale for selecting the function*: provides the rationale for why a function was selected and discusses onsite and offsite effects that may occur as a result of lost functional capacity.

c. *Characteristics and processes that influence the function*: describes the characteristics and processes of the wetland and the surrounding landscape that influence the function and lay the groundwork for the description of model variables.

d. *Description of model variables*: defines and discusses model variables and describes how each model variable is measured.

e. *Functional Capacity Index*: describes the assessment model from which the FCI is derived and discusses how model variables interact to influence functional capacity.

Function 1: Surface Water Storage

Definition

The function Surface Water Storage is defined as the capacity of the depressional wetland to store water above the soil surface. The annual water budget of depressional wetlands is under the influence of precipitation and through the interception of the groundwater table. Storm runoff is collected and stored temporarily in wetland basins. Temporary storage is lost to evapotranspiration or to groundwater. Storage alters the amount and timing of runoff from a catchment into streams and recharge to groundwater. Surface water adds soil moisture to the unsaturated zone and interacts with long-term groundwater and water elevations within depressional wetlands largely under the control of groundwater. This function is affected by both evapotranspiration and groundwater properties of the local area. Surface water has a significant effect on biogeochemical cycling and in particular has a very strong effect on vegetation and invertebrate and vertebrate populations. Potential independent, quantitative measures for validating the functional index include data of catchment precipitation, depression storage, evapotranspiration, water table elevations, and vertical hydraulic gradient.

Rationale for selecting the function

Performance of the function Surface Water Storage permits the wetland to retain surface water inputs for a sufficient period of time to develop other wetland characteristics (e.g., hydric soils, hydrophytic vegetation). In peninsular Florida, the principal source of water that results in the temporary or seasonal ponding of depressional wetlands is precipitation. Loss of water that has been dynamically stored occurs through evapotranspiration or recharge to groundwater. Groundwater recharge is controlled by the hydraulic conductivity of the soil. Cypress domes and herbaceous depressions of peninsular Florida generally occur in unconsolidated sands. Thus, hydraulic conductivity is generally high, leading to rapid draining as the water table recedes.

Surface Water Storage also has a significant effect on elemental cycling in the wetland. Prolonged saturation leads to anaerobic soil conditions and initiates chemical reactions that are highly dependent upon the redox capacity of the soil (Mausbauch and Richardson 1994). The oxygen concentration in wetland soils greatly affects the redox potential and the chemical cycling properties of elements and compounds, particularly nutrients. This function also has a very significant impact on invertebrate and vertebrate populations. Some invertebrates (e.g., midges) have very rapid life cycles and are highly adapted to ephemeral wetlands. On the other hand, many species (e.g., dragonflies) have much longer life histories and require ponded water conditions virtually throughout the year (Merritt and Cummins 1996). Likewise, many of the vertebrates that are obligatorily associated with aquatic environments (e.g., turtle) require long periods of static water storage (Mitsch and Gosselink 2000).

Characteristics and processes that influence the function

The characteristics and processes that influence the capacity of a depressional wetland to store water are from both natural and anthropogenic origins. Climate, landscape-scale geomorphic characteristics, and characteristics of the soil within and around the wetland are factors established largely by natural processes. Anthropogenic alterations of a wetland (e.g., tilling, cattle grazing, logging) also influence the way a wetland stores surface waters. Such effects may take the form of the dominant land use in and near the wetland and whether the wetland has been hydrologically modified through ditching or the placement of tile under the wetland to drain it.

Climatic conditions in peninsular Florida are generally characterized by hot, wet summers and warm, dry winters. Summer thunderstorms are the dominant source of water that is stored for this function. However, storm events bringing 25 cm (10 in.) of rain or more can occur any month of the year. Thus, the water table is affected over a large geographic area, raising the water table for an entire region. The majority of the water budget of these wetland types is controlled by precipitation sources.

The soil properties of cypress domes and herbaceous depressions are highly variable. Theoretically, at two ends of a continuum, sand permits high hydrologic conductivity and the rapid loss of dynamic waters to groundwater. In contrast, depressions may be lined with clay loam or organic soils that restrict hydrologic conductivity and result in stored waters above the groundwater table. Hence, for the former, storage is controlled by outputs through groundwater seepage and evapotranspiration, while storage is controlled for the latter almost exclusively by evapotranspiration.

In addition to geomorphic and climatic processes, human activities may also have a profound effect on the storage of water within a depressional wetland. Modifications to the upland, wetland edge, or directly to the wetland may greatly affect the receipt and retention of water. Land use changes such as soil compaction, cultivation, roads, urban development, and changes in evapotranspiration that result from grazing or logging are modifications that directly affect this function. Many depressional wetlands and/or the lands surrounding them are either grazed or cultivated, depending on dominant landform and characteristics that favor one land use type over another.

Ditching and/or tiling for the purpose of draining the wetland and putting it into crop, pasture, or sod production have modified many depressional wetlands. Such modifications so significantly affect the ability of the wetland to retain surface water that many such wetlands lose their wetland characteristics.

Description of model variables

Wetland Volume (V_{WETVOL}). This variable is defined as a change in the wetland volume. Wetlands store a certain volume of water based on the size and depth of the wetland. Changes to the volume, usually by placing fill material into the wetland or excavating and removing soil material from the wetland, will change the volume of the wetland. This variable is determined using the following procedure:

a. If no excavation or fill activity has occurred, then the variable subindex is 1.0. If fill or excavation activity has occurred, then estimate the volume of the fill material or the excavation and determine the difference in volume.

b. Using geographic information system (GIS), planimeter, global positioning system (GPS), or other means, measure the diameter of the wetland along the longest and shortest axis. Average these two diameters and use half of this averaged diameter for the radius of the wetland.

c. Measure the depth of the wetland.

d. Using the formula for a cone for circular depressional wetlands, determine the volume of the wetland.

e. Measure the area and thickness of the fill material or the area and depth of the excavation. Using the appropriate volume calculations, determine the volume of the fill or excavation. Examples of this calculation can be found in Appendix C.

f. Determine the percent of the fill or excavation of the wetland or Wetland Assessment Area (WAA).

g. Using Figure 6, determine the variable subindex for the change in wetland volume.

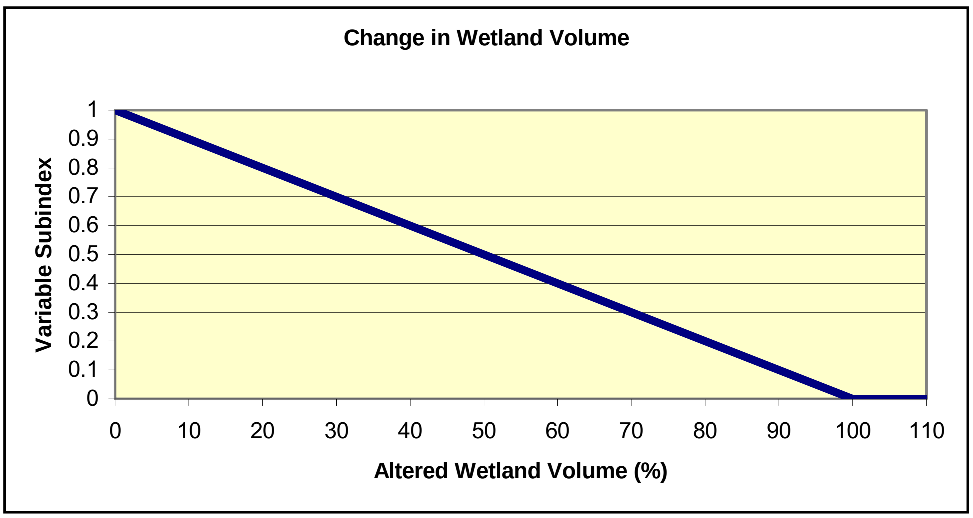


Figure 6. Relationship between change in wetland volume and functional capacity

In peninsular Florida reference sites, percent change in wetland volume ranged from 0 to 60 percent. Based on data from reference standard sites, a variable subindex of 1.0 is assigned to sites that had no change in wetland volume (i.e., no fill or excavation). As the percent of alteration increases above zero percent, a linearly decreasing subindex score down to zero is assigned for wetlands with 100 percent or greater alteration in the percent of alteration.

Change in Catchment Size (V_{CATCH}). This variable is defined as the percent change in the size of the wetland catchment or basin. Many impacts to the wetland can alter the water moving down slope on the soil surface or shallow subsurface into the wetland (i.e., ditching, diversions, detention areas, parking lots, roads, etc.). The intent of this variable is to assess the change in the amount of water diverted away from the wetland or prevented from entering the wetland. This variable is determined with the following procedure.

a. Using aerial photographs or topographic maps, determine the size of the catchment basin.

b. If the size of the catchment is unchanged, the subindex score would be 1.0.

c. If the size of the catchment has been changed, determine the percent change before and after the impacts.

d. Using Figure 7, determine the subindex score for change in catchment size.

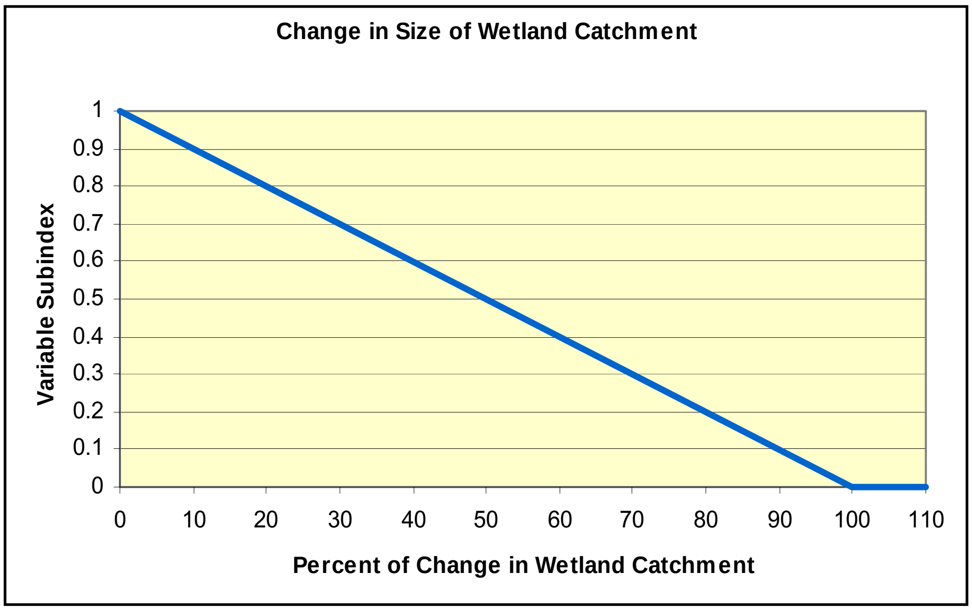


Figure 7. Relationship between the change in the size of wetland catchment and functional capacity, Function 1

In peninsular Florida reference sites, percent change in the size of the wetland catchment ranged from 0 to 99 percent. Based on data from reference standard wetland sites, catchment size had no change. As the percentage of catchment size changes above zero percent, a linearly decreasing subindex score down to 0.0 is assigned for wetlands at 100 percent change in catchment size. This is based on the assumption that as the size of the wetland catchment decreases, the amount of water entering the wetland is proportionately reduced and is not available to be stored by the wetland.

Upland Land Use (V_{UPUSE}). This variable is defined as the surface water runoff from the wetland catchment into the wetland. With increased disturbance and increased impervious surface surrounding the wetland, more surface water enters the wetland than under reference standard conditions. Burned natural areas should not receive an increased score. Determine the subindex score for this variable using the following procedure:

a. Using recent aerial photographs and GIS technology and verifying during field reconnaissance, determine the percent of the catchment that has the land uses listed in Table 6.

b. Using data from the local soil survey, determine the hydrologic group for the soils present in the catchment.

c. Using Table 6, modified from NRCS Technical Release 55 (TR-55) (USDA 1986), determine the curve number for the catchment.

d. Determine a weighted average runoff score for the upland catchment. Examples can be found in Appendix C.

Table 6
Runoff Curve Numbers, Function 1

Cover Type	Hydrologic Soil Groups			
	A	B	C	D
Open space (pasture, lawns, parks, golf courses, cemeteries):				
Poor condition (grass cover <50%)	68	79	86	89
Fair condition (grass cover 50% to 75%)	49	69	79	84
Good condition (grass cover >75%)	39	61	74	80
Impervious areas (parking lots, roofs, driveways, etc.)	98	98	98	98
Gravel	76	85	89	91
Urban districts:				
Commercial and business (85% cover)	89	92	94	95
Industrial (72% cover)	81	88	91	93
Residential districts by average lot size:				
1/8 acre or less (town houses and apartments) (65% cover)	77	85	90	92
1/4 acre (38% cover)	61	75	83	87
1/3 acre (30% cover)	57	72	81	86
1/2 acre (25% cover)	54	70	80	85
1 acre (20% cover)	51	68	79	84
2 acres (12% cover)	46	65	77	82
Newly graded areas (no vegetation or pavement)	77	85	90	92
Fallow crop areas (poor)	76	85	90	93
Fallow crop areas (good)	74	83	88	90
Row crops	70	80	86	90
Small grain	64	75	83	87
Groves and orchards				
<50% ground cover	57	73	82	86
50% to 75% ground cover	43	65	76	82
>75% cover	32	58	72	79
Forest and native range				
<50% ground cover	45	66	77	83
50% to 75% ground cover	36	60	73	79
>75% ground cover	30	55	70	77

e. Verify during field reconnaissance.

f. Using Figure 8, determine the subindex score for upland runoff.

In peninsular Florida, reference standard wetlands were surrounded by native flatwoods, sand pine scrub, or sloughs within the catchment (Figure 9). All of these vegetative types have a runoff score of 80 or less and would receive a subindex score of 1.0 (Figure 8). As runoff increases, the amount of water entering the wetland increases and the subindex decreases linearly to zero.

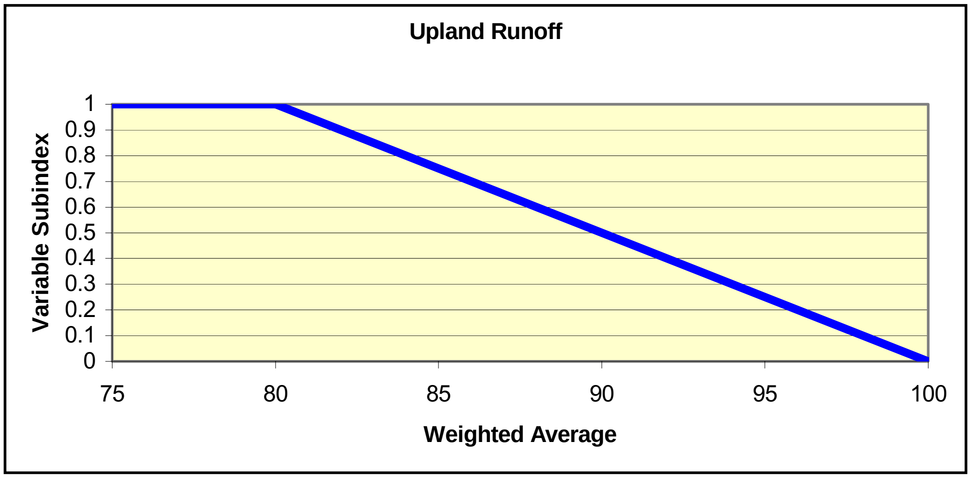


Figure 8. Relationship between upland runoff and functional capacity, Function 1

Figure 9. Pasture grass in good condition (>75 percent cover) on upland surrounding herbaceous wetland and cypress dome on soils in hydrologic group D

Surface Outlet (V_{SUROUT}). This variable is defined as the effectiveness of a drainage ditch at removing surface water from the wetland. Measure this variable using the following procedure:

a. Using recent aerial photographs and verifying during field reconnaissance, determine if any drainage ditches occur within the catchment or 100 m (330 ft) from it, whichever is less. If no drainage ditches occur within or 100 m from the catchment, then the subindex score for this variable would be 1.0.

b. If one or more ditches occur within or 100 m from the wetland, examine the ditch(es) to determine if they are maintained and free of obstructions. If the ditch is overgrown with trees or brush, has a water control structure within the ditch, is not connected to an outlet (i.e., stream or larger canal system), or is otherwise not maintained, the variable subindex would be 1.0. If the ditch is maintained and free of obstructions, measure the depth of the ditch and record on the field data sheet.

c. If the elevation of the bottom of the ditch is above the lowest point in the wetland, then the variable subindex would be 1.0 (Figure 10).

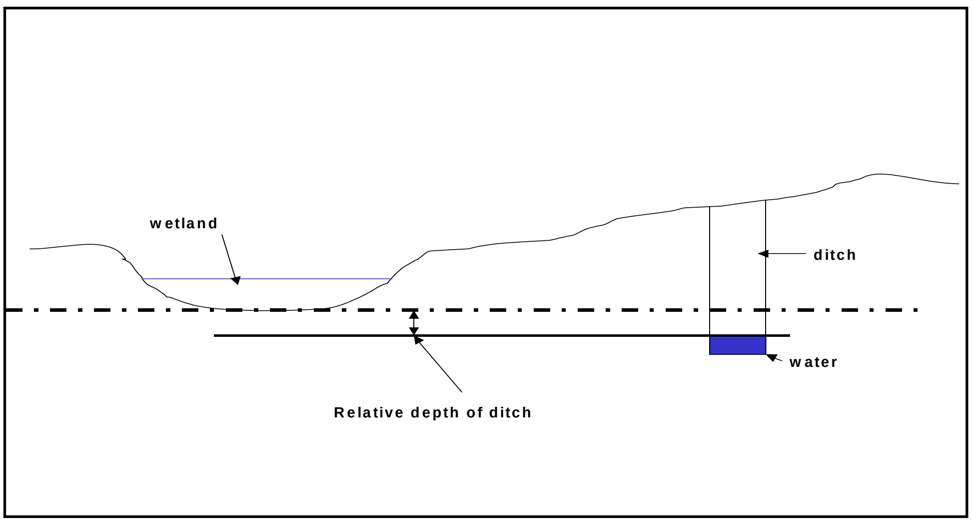


Figure 10. Relationship of the wetland landscape and relative ditch depth

d. If the elevation of the bottom of the ditch is lower than the lowest point in the wetland, determine the difference in elevation between the bottom of the ditch and the lowest point in the wetland.

e. Using the local NRCS County Soil Survey determine the dominant soil series between the wetland and the ditch and record on the field data sheet.

f. Using Table 7 select a profile characteristics category for the soil series between the ditch and the wetland. Determine the effective depth of the ditch in centimeters, which is the difference in elevation between the bottom of the ditch and the lowest point or elevation in the wetland.

Table 7 **Lateral Effects of Ditches, m (ft), for Selected Soil Profile Characteristics in Florida, Function 1**										
	Effective Depth of Ditch, cm									
Profile Characteristics	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**150**	**200**	**250**
Soils with spodic horizon	7 (23)	9 (28)	13 (43)	29 (94)	34 (112)	40 (130)	45 (149)	68 (223)	72 (238)	86 (281)
Soils without a spodic horizon, but with an argillic horizon	41 (134)	47 (153)	52 (170)	56 (185)	60 (197)	63 (208)	67 (220)	70 (229)	70 (229)	75 (245)
Soils with neither a spodic or an argillic horizon	54 (178)	56 (183)	62 (202)	67 (220)	72 (235)	75 (247)	78 (257)	92 (303)	92 (303)	100 (329)
Note: First distance is in meters followed by feet in parenthesis.										

g. Determine the percent of the wetland that is within the impact distance of the ditch using Figure 11. Determine the variable subindex score for Surface Outlet using Figure 12 and enter on the field data sheet.

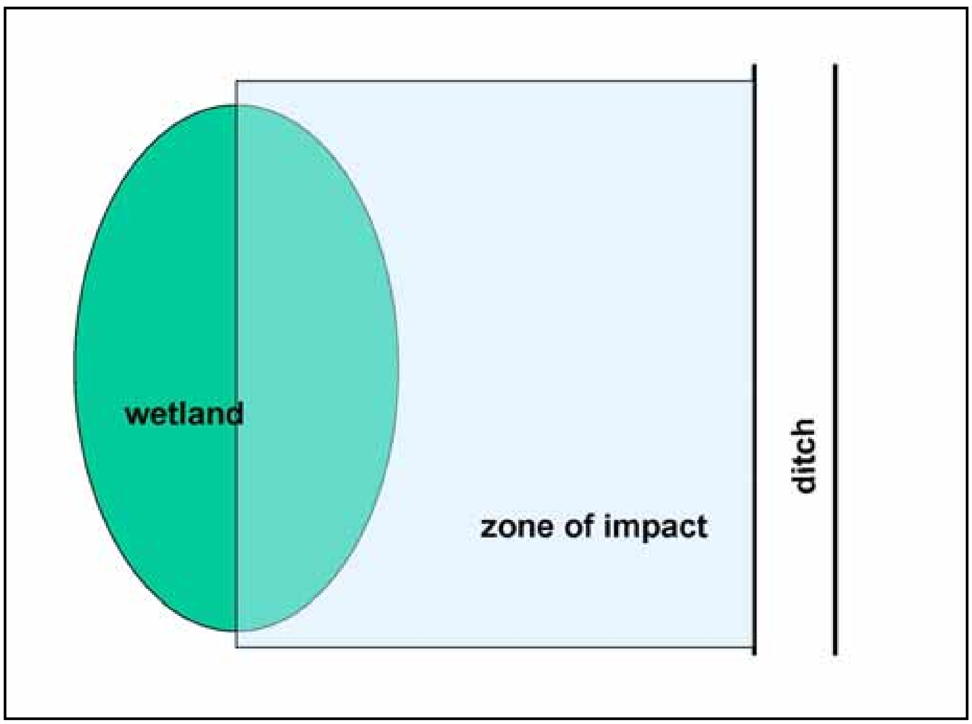


Figure 11. Fifty percent of the wetland is within the zone of impact and would receive a variable subindex score of 0.5, Functions 1 and 3

In peninsular Florida reference depressional wetlands, the impact of ditches on surface water storage ranged from zero to 85 percent. Based on data from reference standard sites, a variable subindex of 1.0 is assigned to sites outside the impact zone. As the percent of the wetland within the zone of impact increases above zero, the subindex score decreases linearly to zero when 100 percent of the

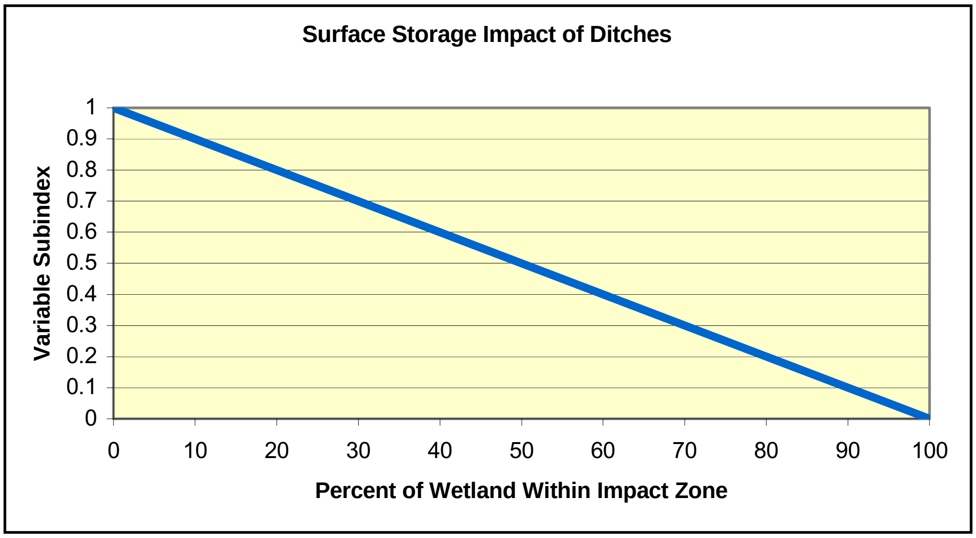


Figure 12. Relationship between lateral impact of ditches and functional capacity, surface storage impact, Function 1

wetland is within the zone of impact. This is based on the assumption that the relationship between surface water storage and impact by a drainage ditch is linear. This assumption could be validated using the independent, quantitative measures of function in the definition of the function.

Cypress Canopy (V_{CANOPY}). This variable represents the total cover of cypress trees in the cypress tree zone, and is defined as the average percent cover of cypress trees along selected transects within the cypress tree zone of cypress domes.

Percent cover of cypress trees is used to quantify this variable. Measure it using the following procedure:

a. Using the step point procedure described in the section "Collect Field Data" in Chapter 5, estimate the percent cover of cypress trees with the cypress zone along the selected transects.

b. Average the percent cover of cypress trees along all transects.

c. Report cypress tree cover as a percent between 0 and 100.

d. Using Figure 13, determine the subindex score for the percent cover of cypress trees in the cypress tree zone.

In Cypress Dome Reference Wetlands the percent cover of cypress trees ranged from 17 to 48 percent. Based on the data from reference standard sites, a variable subindex score of 1.0 would be assigned when the percent cover of cypress trees is between 40 and 100 percent (Figure 14). Zero percent cover of cypress trees, while not measured, would indicate severely altered conditions.

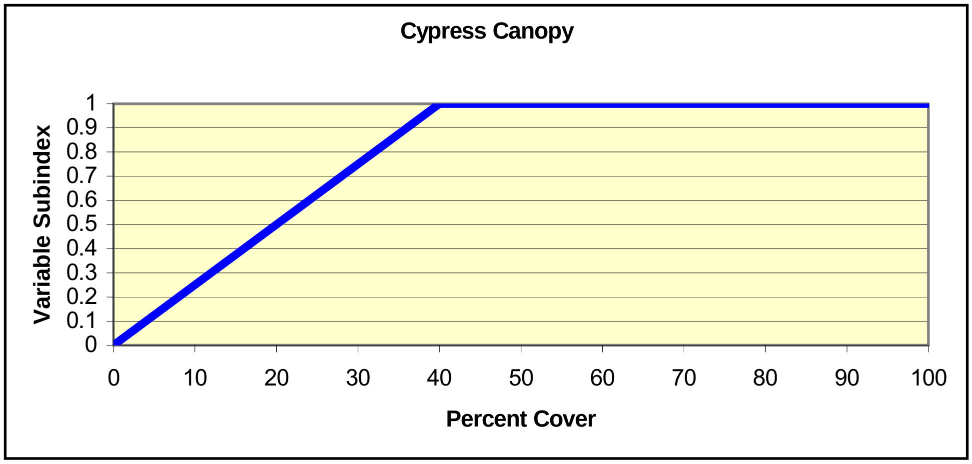


Figure 13. Relationship between cypress canopy cover and functional capacity, Function 1

Figure 14. Reference standard condition of cypress tree cover

As percent cover of cypress trees decreases below 40 percent, a linearly decreasing subindex score down to zero is assigned at 0 percent cover of cypress trees. This is based on the assumption that the decrease in cypress tree cover indicates an increase in the amount of evapotranspiration (Heimburg 1984). The rate at which the subindex decreases and the selection of zero as variable sub-index end point at zero percent cover are based on the assumption that the relationship between percent cover of cypress trees and increased evapotranspiration is linear. These assumptions could be validated using the independent quantitative measures of function in the definition of the function.

Functional Capacity Index

The assessment models for calculating the FCI are as follows:

a. For Herbaceous Depressional Wetlands:

$$FCI = \left\{ V_{WETVOL} \times \left[\frac{\left(\frac{V_{CATCH} + V_{UPUSE}}{2} \right) + V_{SUROUT}}{2} \right] \right\}^{1/2} \quad (1)$$

b. For Cypress Dome Depressional Wetlands:

$$FCI = \left\{ V_{WETVOL} \times \left[\frac{\left(\frac{V_{CATCH} + V_{UPUSE}}{2} \right) + \left(\frac{V_{SUROUT} + V_{CANOPY}}{2} \right)}{2} \right] \right\}^{1/2} \quad (2)$$

In the models, the capacity of depressional wetlands to store surface water focuses on three characteristics. The first is the effect of the wetland to hold water (V_{WETVOL}) and alteration of this capacity by fill or excavation activities. The second is the combination of the surrounding upland (V_{CATCH} and V_{UPUSE}) to supply the wetland with water through runoff and shallow groundwater. The third is the effect of ditches (V_{SUROUT}) and for Cypress Dome Wetlands the effect of cypress trees on the rate of evapotranspiration (V_{CANOPY}). Cypress trees transpire less water than is evaporated from a depression that is open to the sunlight. These two variables are averaged to prevent overweighting the significance of the other variables. V_{SUROUT} is kept separate to keep variables representing water flowing into the wetland (V_{CATCH} and V_{UPUSE}) separate from variables representing water flowing out or away from the wetland (V_{SUROUT}) and for cypress domes (V_{CANOPY}). These two parts are averaged and imply that the inflow of water has equal weight with the outflow of water.

The two parts of the equations are averaged using a geometric mean based on the assumption that V_{WETVOL} is as important as the combination of the other variables in relation to surface water storage. In other words, if the wetland is completely filled, then the subindex score for V_{WETVOL} would be 0.0 and the functional capacity for surface water storage would be zero as well.

Function 2: Subsurface Water Storage

Definition

The function Subsurface Water Storage is defined as the capacity of the depressional wetland to store water at and below the soil surface. The annual water budget of depressional wetlands is under the influence of precipitation and through the interception of the groundwater table. Storm runoff is collected and stored temporarily in wetland basins. Temporary storage is lost to evapotranspiration and to groundwater. Storage alters the amount and timing of runoff from a catchment into streams and recharge to groundwater. Subsurface water maintains soil moisture and interacts with long-term groundwater. This function is affected by both evapotranspiration and groundwater properties of the local area. Subsurface water has significant effect on biogeochemical cycling, vegetation, and invertebrate populations. While subsurface and surface water storage are connected during the wettest part of the year in most years, subsurface water has a longer impact to the wetland. Subsurface water storage may not be impacted even if surface water has been eliminated. In addition, during natural drought cycles subsurface water storage may be the only hydrologic function present to maintain wetland characteristics. Potential independent, quantitative measures for validating the functional index include data of catchment precipitation, depression storage, evapotranspiration, water table elevations, and vertical hydraulic gradient.

Rationale for selecting the function

Performance of the function Subsurface Water Storage permits the wetland to retain subsurface water inputs for a sufficient period of time to develop other wetland characteristics (e.g., hydric soils, hydrophytic vegetation). In peninsular Florida, the principal source of water that results in the temporary storage of water in the soil of depressional wetlands is precipitation. Loss of water that has been dynamically stored occurs through evapotranspiration of recharge to groundwater. Groundwater recharge is controlled by the hydraulic conductivity of the soil. Cypress domes and herbaceous depressions of peninsular Florida generally occur in unconsolidated sands. Thus, hydraulic conductivity is generally high, leading to rapid draining of subsurface water as the water table recedes.

Subsurface Water Storage also has a significant effect on elemental cycling in the wetland. Prolonged saturation leads to anaerobic soil conditions and initiates chemical reactions that are highly dependent upon the redox capacity of the soil (Mausbauch and Richardson 1994). The oxygen concentration in wetland soils greatly affects the redox potential and the chemical cycling properties of elements and compounds, particularly nutrients. This function also has a very significant impact on invertebrate and vertebrate populations. Some invertebrates (e.g., midges) have very rapid life cycles and are highly adapted to ephemeral wetlands.

Characteristics and processes that influence the function

The characteristics and processes that influence the capacity of a depressional wetland to store water are from both natural and anthropogenic origins. Climate, landscape-scale geomorphic characteristics, and characteristics of the soil within and around the wetland are factors largely established by natural processes. Anthropogenic alterations of a wetland (e.g., tilling, cattle grazing, logging) also influence the way a wetland stores subsurface water. Such effects may take the form of the dominant land use in and near the wetland and whether the wetland has been hydrologically modified through ditching or the placement of tile under the wetland to drain it.

Climatic conditions in peninsular Florida are generally characterized by hot, wet summers and warm, dry winters. Summer thunderstorms are the dominant water source that is stored for this function. However, storm events bringing 25 cm (10 in.) of rain or more can occur any month of the year. Thus, the water table is affected over a large geographic area, raising the water table for an entire region. The majority of the water budget of these wetland types is controlled by precipitation sources.

The soil properties of cypress domes and herbaceous depressions are highly variable. Theoretically, at one end of a continuum, sand permits high hydrologic conductivity and the rapid loss of dynamic waters to groundwater. In contrast, depressions may be lined with clay loam or organic soils that restrict hydrologic conductivity and result in stored waters above the groundwater table. Hence, for the former, storage is controlled by outputs through groundwater seepage and evapotranspiration, while storage is controlled for the latter almost exclusively by evapotranspiration.

In addition to geomorphic and climatic processes, human activities may also have a profound effect on the storage of water within a depressional wetland. Modifications to the upland, wetland edge, or directly to the wetland may greatly affect the receipt and retention of water. Land use changes, such as soil compaction, cultivation, roads, urban development, and changes in evapotranspiration that result from grazing or logging are modifications that directly affect this function. Many depressional wetlands and/or the lands surrounding them are either grazed or cultivated, depending on dominant landform and characteristics that favor one land use type over another.

Ditching and/or tiling for the purpose of draining the wetland and putting it into crop, pasture, or sod production have modified many depressional wetlands. Such modifications so significantly affect the ability of the wetland to retain surface water that many such wetlands lose their wetland characteristics.

Description of model variables

Subsurface Outlet (V_{SUBOUT}). This variable is defined as the effective drainage of ditches on the subsurface water storage of the wetland. Measure this variable using the following procedure:

a. Using recent aerial photographs and verifying during field reconnaissance, determine if any drainage ditches occur within or 300 m (1,000 ft) of the catchment, whichever is less. If no drainage ditches occur within or 300 m from the catchment, then the subindex score for this variable would be 1.0.

b. If one or more ditches occur within or 300 m from the catchment, examine the ditch(es) to determine if they are maintained and free of obstructions. If the ditch is overgrown with trees or brush, has a water control structure within the ditch, is not connected to an outlet (i.e., stream or larger canal system), or is otherwise not maintained, the variable subindex would be 1.0. If the ditch is maintained and free of obstructions, measure the depth of the ditch.

c. Determine the difference in elevation between the bottom of the ditch and the lowest point in the wetland (Figure 15).

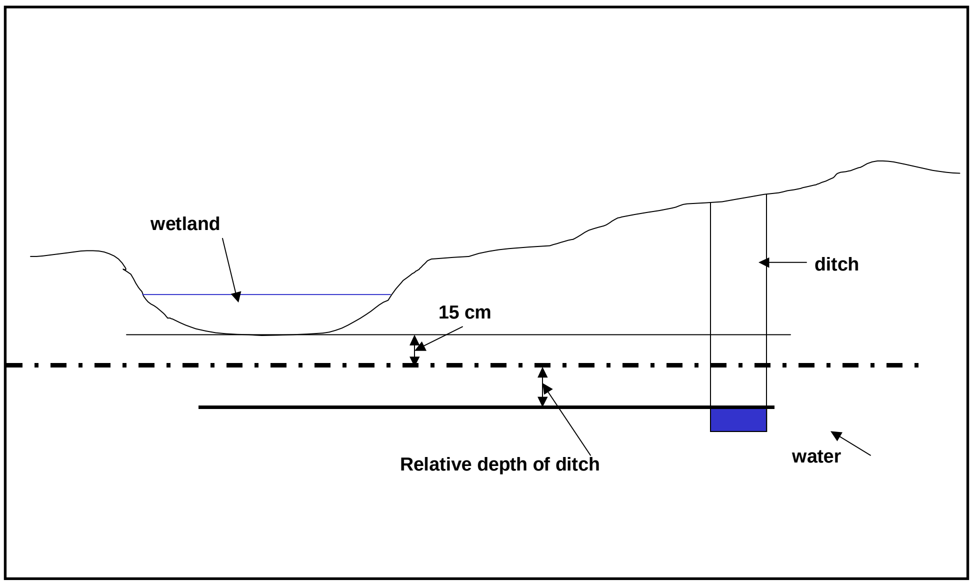


Figure 15. Relationship of the wetland landscape and Subsurface Outlet variables

d. If the elevation of the bottom of the ditch is above 0.15 m (6 in.) below the lowest point in the wetland, then the variable subindex would be 1.0.

e. If the elevation of the bottom of the ditch is below the lowest point in the wetland, use the local NRCS County Soil Survey to determine the dominant soil series between the wetland and the ditch and record on the field data sheet.

f. Using Table 8 select a category for the soil series mapped on the site and determine the impact distance for the difference between the bottom of the ditch and the lowest point in the wetland.

g. Determine the percent of the wetland that is within the impact distance of the ditch (Figure 16) and using Figure 17 determine the subindex score for lateral effect of ditches.

Table 8
Lateral Effects of Ditches, m (ft), for Selected Soil Profile Characteristics in Florida, Function 2

Profile Characteristics	Effective Depth of Ditch, cm									
	40	50	60	70	80	90	100	150	200	250
Soils with spodic horizon	19 (63)	22 (74)	37 (123)	81 (267)	98 (322)	112 (367)	129 (422)	191 (627)	231 (757)	238 (782)
Soils without a spodic horizon, but with an argillic horizon	128 (421)	153 (505)	170 (559)	188 (618)	197 (647)	211 (691)	223 (733)	229 (750)	234 (769)	243 (799)
Soils with neither a spodic or an argillic horizon	136 (446)	147 (482)	168 (551)	185 (606)	199 (652)	212 (695)	219 (720)	260 (854)	286 (938)	300 (985)

Note: First distance is in meters followed by feet in parentheses.

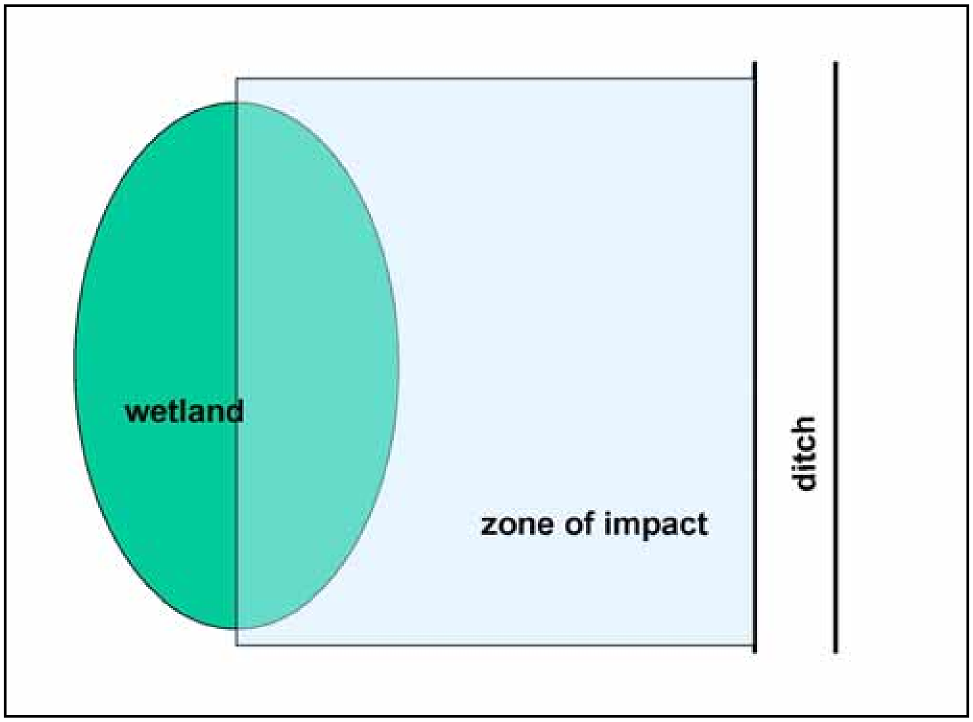


Figure 16. Fifty percent of the wetland is within the zone of impact and would receive a variable subindex score of 0.5, Functions 2, 4, and 5

In peninsular Florida reference depressional wetlands, the impact of ditches on surface water storage ranged from zero to 85 percent. Based on data from reference standard sites, a variable subindex of 1.0 is assigned to sites outside the impact zone. As the percent of the wetland within the zone of impact increases above zero, the subindex score decreases linearly to zero when 100 percent of the wetland is within the zone of impact. This is based on the assumption that the relationship between surface water storage and impact by a drainage ditch is linear. This assumption could be validated using the independent, quantitative measures of function in the definition of the function.

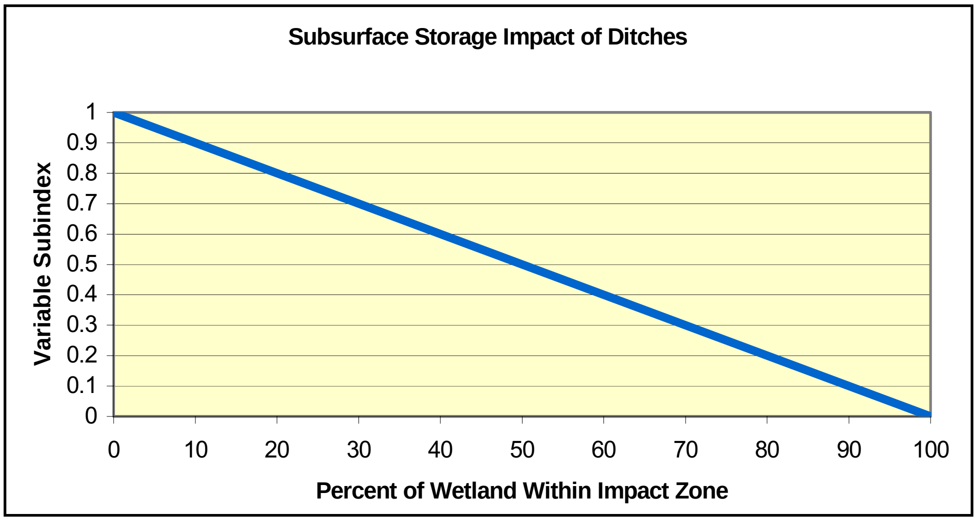


Figure 17. Relationship between lateral impact of ditches and functional capacity, subsurface storage impact, Function 2

Surface Soil Texture (*V_{SURTEX}*). This variable is defined as the USDA soil texture of the surface horizon or layer of the soil. Soil is the medium in which water is stored. Altering the texture of the soil through anthropogenic activities (e.g., fill, excavation) changes the capacity of the water storage. If no anthropogenic activities have occurred within the wetland, the variable subindex can be assumed to be 1.0. If such activities have occurred in the wetland, use the following procedure to determine this variable:

a. During the step point transects, at the midpoint of each wetland zone estimate the texture class of the surface horizon using the feel method. Chapter 5, "Assessment Protocol," provides guidance for location of the sample point. Appendix C describes the procedure for estimating textural class using the feel method.

b. Using Table 9, assign a score for each texture class found.

c. Determine the subindex by averaging the scores from each point sampled.

Soil texture in depressional wetlands ranged from sand (Figure 18) to clay and muck. Based on reference standard sites, textures were sand, muck, or mucky sand for cypress domes and sand, sandy loam, or loamy sand in herbaceous depressions. Other USDA textural classes received categorically lower scores down to zero for gravel or pavement.

Table 9
Soil Surface Texture for Cypress Dome Wetlands, Function 2

Soil Texture	Variable Subindex
Sand	1.0
Loamy sand	1.0
Sandy loam	1.0
Muck[1]	0.9
Sandy clay	0.9
Silt	0.8
Silt loam	0.7
Loam	0.6
Sandy clay loam	0.5
Clay loam	0.4
Silty clay loam	0.4
Clay	0.2
Silty clay	0.1
Gravel[1] (≥90% gravel)	0.0
Pavement[1]	0.0

[1] Term used in lieu of texture.

Figure 18. Soils with a sand surface texture receive a subindex score of 1.0

Upland Land Use (V_{UPUSE}). This variable is defined as the surface water runoff from the wetland catchment into the wetland. With increased disturbance and increased impervious surface surrounding the wetland, more surface water enters the wetland than under reference standard conditions. Burned natural areas should not receive an increased score. Determine the subindex score for this variable using the following procedure:

a. Using recent aerial photographs and GIS technology and verifying during field reconnaissance, determine the percent of the catchment that has the land uses listed in Table 10.

b. Using data from the local soil survey, determine the hydrologic group for the soils present in the catchment.

c. Using Table 10, from NRCS TR-55, determine the curve number for the catchment.

Table 10 Runoff Curve Numbers, Function 2				
	Hydrologic Soil Groups			
Cover Type	**A**	**B**	**C**	**D**
Open space (pasture, lawns, parks, golf courses, cemeteries):				
Poor condition (grass cover <50%)	68	79	86	89
Fair condition (grass cover 50% to 75%)	49	69	79	84
Good condition (grass cover >75%)	39	61	74	80
Impervious areas (parking lots, roofs, driveways, etc)	98	98	98	98
Gravel	76	85	89	91
Urban districts:				
Commercial and business (85% cover)	89	92	94	95
Industrial (72% cover)	81	88	91	93
Residential districts by average lot size:				
1/8 acre or less (town houses and apartments) (65% cover)	77	85	90	92
1/4 acre (38% cover)	61	75	83	87
1/3 acre (30% cover)	57	72	81	86
1/2 acre (25% cover)	54	70	80	85
1 acre (20% cover)	51	68	79	84
2 acres (12% cover)	46	65	77	82
Newly graded areas (no vegetation or pavement)	77	85	90	92
Fallow crop areas (poor)	76	85	90	93
Fallow crop areas (good)	74	83	88	90
Row crops	70	80	86	90
Small grain	64	75	83	87
Groves and orchards				
<50% ground cover	57	73	82	86
50% to 75% ground cover	43	65	76	82
>75% cover	32	58	72	79
Forest and native range				
<50% ground cover	45	66	77	83
50% to 75% ground cover	36	60	73	79
>75% ground cover	30	55	70	77

d. Determine a weighted average runoff score for the upland catchment. Examples can be found in Appendix C.

e. Verify during field reconnaissance.

f. Using Figure 19, determine the subindex score for upland runoff.

In peninsular Florida, reference wetlands were surrounded by native flatwoods (Figure 20), sand pine scrub, or sloughs within the catchment. All of these vegetative types have a runoff score of 80 or less and would receive a subindex score of 1.0. As runoff increases, the amount of water entering the wetland increases and the subindex decreases linearly to zero.

Change in Catchment Size (V_{CATCH}). This variable is defined as the percent change in the size of the wetland catchment or basin. Many impacts to the wetland can alter the water moving down slope on the soil surface or shallow subsurface into the wetland (i.e., ditching, diversions, detention areas, parking lots, roads, etc.). The intent of this variable is to assess the change in the amount of water diverted away from the wetland or prevented from entering the wetland. This variable is determined with the following procedure:

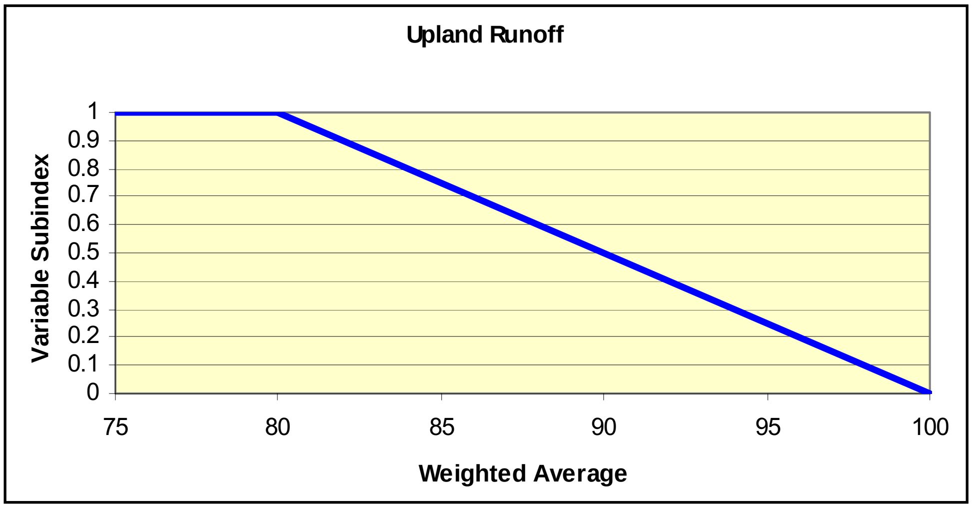


Figure 19. Relationship between upland runoff and functional capacity, Function 2

Figure 20. Forest and native range with greater than 75 percent cover on soils in hydrologic group D surround a reference standard Herbaceous Depressional Wetland

a. Using aerial photographs or topographic maps, determine the size of the catchment basin.

b. If the size of the catchment is unchanged, the subindex score would be 1.0.

c. If the size of the catchment has been changed, determine the percent change before and after the impacts.

d. Using Figure 21, determine the subindex score for change in catchment size.

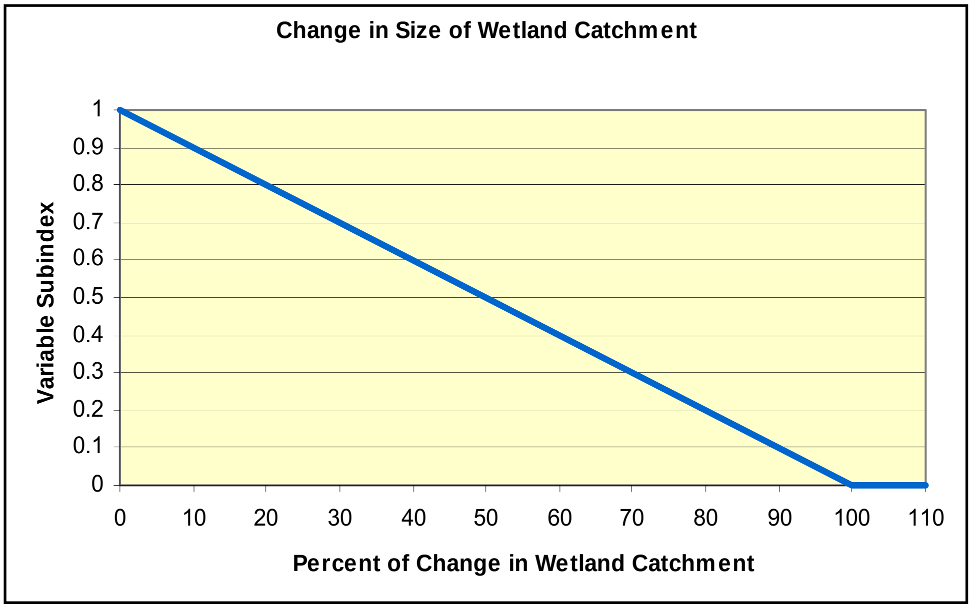


Figure 21. Relationship between the change in the size of wetland catchment and functional capacity

In peninsular Florida reference sites, percent change in the size of the wetland catchment ranged from 0 to 99 percent. Based on data from reference standard wetland sites, catchment size had no change. As the percentage of catchment size changes above zero percent, a linearly decreasing subindex score down to 0.0 is assigned for wetlands at 100 percent change in catchment size. This is based on the assumption that as the size of the wetland catchment decreases, the amount of water entering the wetland is proportionately reduced and is not available to be stored by the wetland.

Functional Capacity Index

The assessment model for calculating the FCI is as follows:

$$FCI = \left[\frac{\left(\frac{V_{CATCH} + V_{UPUSE}}{2} \right) + \left(\frac{V_{SUBOUT} + V_{SURTEX}}{2} \right)}{2} \right] \qquad (3)$$

In the model, the capacity of the depressional wetland to store water within the soil depends on two characteristics. The first variables V_{CATCH} and V_{UPUSE} indicate whether water is entering the wetland through runoff and shallow groundwater. The two variables are partially compensatory based on the assumption that they are independent and contribute equally to the performance of the function. The two variables are combined using an arithmetic mean because water will still enter the wetland regardless of the size of the catchment or land use in the upland.

In the second part of the model, the ability of the wetland to store water within the soil pore space is represented by the texture of the surface soil (V_{SURTEX}) and the effect of ditches (V_{SUBOUT}) to remove water from the soil. These two variables are also combined using an arithmetic mean because some water will be stored within the soil even if a large ditch is in the wetland and the soil texture is clay.

The two parts are averaged because water supply and storage are considered interdependent and equally important. An arithmetic mean is used to combine the two parts because no one variable or part is significant enough to completely represent the absence of water stored in the soil.

Function 3: Cycle Nutrients

Definition

The function Cycle Nutrients is defined as the ability of the depressional wetland to transform biotic essential elements and materials (e.g., carbon dioxide, water, phosphorus, nitrogen) needed for biological processes into organic forms (e.g., carbohydrates, fats, proteins) and to oxidize those organic molecules back into elemental forms through decomposition. Thus, nutrient cycling includes the biogeochemical processes of producers, consumers, and decomposers. Potential independent, quantitative measures for validating the functional index include standing stock of living and/or dead biomass, gm/m^2; net annual productivity gm/m^2; annual accumulation of organic matter, gm/m^2; and annual decomposition of organic matter, gm/m^2.

Rationale for selecting the function

Nutrient cycling is a fundamental function performed by all ecosystems, but tends to be accomplished at particularly high rates in many wetland systems (Mitsch and Gosselink 2000). A sustained supply of nutrients in the soil provides for maintenance of the characteristic plant community including annual primary productivity, composition, and diversity. The plant community (producers) provides the food and habitat structure (energy and materials) needed to maintain the characteristic animal community (consumers). In time the plant and animal communities serve as a source of detritus that is the source of energy and materials needed to maintain the characteristic community of decomposers. The decomposers break down these organic materials into simpler elements and compounds that can reenter the nutrient cycle.

The ability of a pothole wetland to perform this function is dependent upon the transfer of elements and materials between trophic levels within the wetland, the rates of decomposition, and the flux of materials in and out of the wetland. A change in the ability of one trophic level to transform materials will result in changes in the transformation of materials in other trophic levels (Carpenter 1988). Wetlands, as the ecotone between terrestrial and aquatic environments (Naiman et al. 1989), are particularly subject to anthropogenic change within a watershed that affects material transport from outside the wetland proper. These changes may greatly affect the way the depressional wetland performs this function.

Characteristics and processes that influence the function

Biogeochemical cycling of nutrients and compounds is a function of biotic and abiotic processes that result from conditions within and around the wetland. Biotic processes are based primarily on the vegetation that incorporates nutrients in biomass (Mitsch and Gosselink 2000). Nutrient cycling or biogeochemical cycling is probably best known through plants and the processes of photosynthesis and respiration. Oxygen is needed for respiration, and the diffusion of oxygen in water is 10,000 times slower in water than in air. Wetland plants, hydrophytes, are unique in that they have adapted to living in water or wet soil environments. Physiological adaptations in leaves, stems, and roots allow for greater gas exchange, permit respiration to take place, and allow the plant to harvest the stored chemical energy it has produced through photosynthesis. Although there is no clear starting or ending point for nutrient cycling, it can be argued that it is the presence of water in the wetland that determines the characteristic plant community of hydrophytes. In turn, it is the maintenance of the characteristic primary productivity of the plant community that sets the stage for all subsequent transformation of energy and materials at each trophic level within the wetland. It follows that alterations to hydrologic inputs, outputs, or storage and/or changes to the characteristic plant community will directly affect the way in which the wetland can perform this function.

Abiotic processes affecting retention and removal of nutrients and compounds are dependent primarily on the adsorption of materials to soils, the amount of water that passes through the wetland carrying dissolved materials, the hydroperiod to maintain anaerobic conditions and retention time, and importation of materials from surrounding areas (Beaulac and Reckhow 1982; Federico 1977; Grubb and Ryder 1972; Ostry 1982; Shahan 1982; Strecker et al. 1992; Zarbock et al. 1994). Natural soils, hydrology, and vegetation are important factors in maintaining these characteristic processes.

The ideal approach for assessing nutrient cycling in a pothole wetland would be to measure the rate at which elements and materials are transferred and transformed between and within each trophic level over several years. However, the time and effort required to make these measurements are well beyond a rapid assessment procedure. Reference data suggest that land use practices and current treatments within the wetland have great effect on the characteristic plant community structure (species composition and coverage), diversity, and primary productivity. Soil texture is an indicator of cation exchange and therefore an indication of long-term nutrient supply and a characteristic decomposer community. It is assumed that measurements of these characteristics reflect the level of nutrient cycling taking place within a wetland. Comparison of these data, between a target wetland and the characteristics of reference standard wetlands, indicates changes in the level of nutrient cycling.

Description of model variables

Change in Catchment Size (V_{CATCH}). This variable is defined as the change in the size of the wetland catchment or basin. Many impacts to the wetland can alter the water moving downslope on the soil surface or shallow subsurface into the wetland (i.e., ditching, diversions, detention areas, parking lots, roads, etc.). The intent of this variable is to assess the change in the amount of water diverted away from the wetland or prevented from entering the wetland. This variable is determined with the following procedure:

a. Using aerial photographs or topographic maps, determine the size of the catchment basin.

b. If the size of the catchment is unchanged, the subindex score would be 1.0.

c. If the size of the catchment has been changed, determine the percent change before and after the impacts.

d. Using Figure 22, determine the subindex score for change in catchment size.

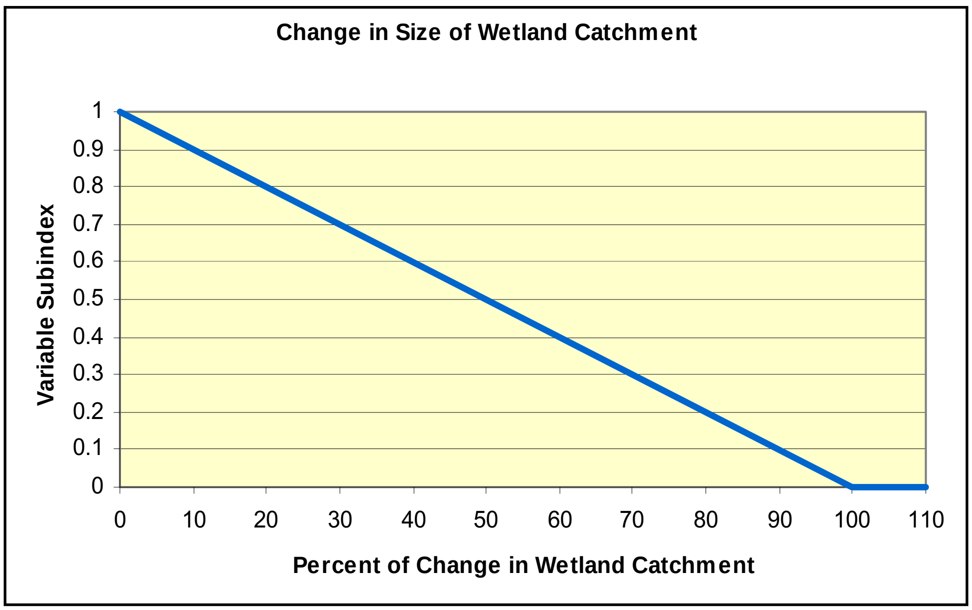


Figure 22. Relationship between the change in the size of wetland catchment and functional capacity, Function 3

In peninsular Florida reference sites, percent change in the size of the wetland catchment ranged from 0 to 99 percent. Based on data from reference standard wetland sites, catchment size had no change. As the percentage of catchment size changes above zero percent, a linearly decreasing subindex score down to 0.0 is assigned for wetlands at 100 percent change in catchment size.

This is based on the assumption that as the size of the wetland catchment decreases, the amount of water entering the wetland is proportionately reduced and is not available to be stored by the wetland.

Upland Land Use (V_{UPUSE}). This variable is defined as the surface water runoff from the wetland catchment into the wetland. With increased disturbance and increased impervious surface surrounding the wetland, more surface water enters the wetland than under reference standard conditions. Burned natural areas should not receive an increased score. Determine the subindex score for this variable using the following procedure:

a. Using recent aerial photographs and GIS technology and verifying during field reconnaissance, determine the percent of the catchment that has the land uses listed in Table 11.

Table 11
Runoff Curve Numbers, Function 3

Cover Type	Hydrologic Soil Groups			
	A	B	C	D
Open space (pasture, lawns, parks, golf courses, cemeteries):				
Poor condition (grass cover <50%)	68	79	86	89
Fair condition (grass cover 50% to 75%)	49	69	79	84
Good condition (grass cover >75%)	39	61	74	80
Impervious areas (parking lots, roofs, driveways, etc)	98	98	98	98
Gravel	76	85	89	91
Urban districts:				
Commercial and business (85% cover)	89	92	94	95
Industrial (72% cover)	81	88	91	93
Residential districts by average lot size:				
1/8 acre or less (town houses and apartments) (65% cover)	77	85	90	92
1/4 acre (38% cover)	61	75	83	87
1/3 acre (30% cover)	57	72	81	86
1/2 acre (25% cover)	54	70	80	85
1 acre (20% cover)	51	68	79	84
2 acres (12% cover)	46	65	77	82
Newly graded areas (no vegetation or pavement)	77	85	90	92
Fallow crop areas (poor)	76	85	90	93
Fallow crop areas (good)	74	83	88	90
Row crops	70	80	86	90
Small grain	64	75	83	87
Groves and orchards				
<50% ground cover	57	73	82	86
50% to 75% ground cover	43	65	76	82
>75% cover	32	58	72	79
Forest and native range				
<50% ground cover	45	66	77	83
50% to 75% ground cover	36	60	73	79
>75% ground cover	30	55	70	77

b. Using data from the local soil survey, determine the hydrologic group for the soils present in the catchment.

c. Using Table 11 from NRCS TR-55, determine the curve number for the catchment.

d. Determine a weighted average runoff score for the upland catchment. Examples can be found in Appendix C

e. Verify during field reconnaissance.

f. Using Figure 23, determine the subindex score for upland runoff.

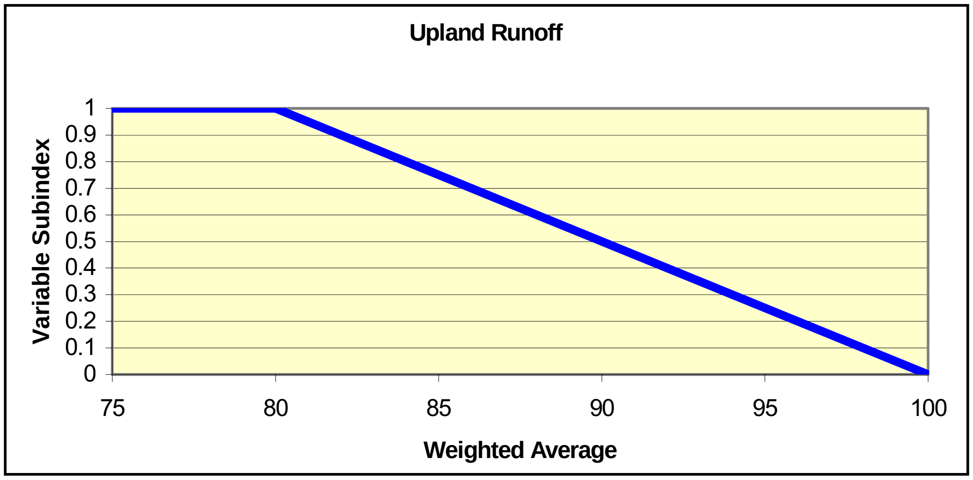


Figure 23. Relationship between upland runoff and functional capacity, Function 3

In peninsular Florida, reference wetlands were surrounded by native flatwoods, sand pine scrub, or sloughs within the catchment. All of these vegetative types have a runoff score of 80 or less and would receive a subindex score of 1.0. As upland land use changes (Figure 24), runoff increases, the amount of water entering the wetland increases, and the subindex decreases linearly to zero.

Surface Outlet (V_{SUROUT}). This variable is defined as the effectiveness of a drainage ditch to remove surface water from the wetland. Measure this variable using the following procedure:

a. Using recent aerial photographs and verifying during field reconnaissance, determine if any drainage ditches occur within the catchment or 100 m (330 ft) of the wetland, whichever is less. If no drainage ditches occur within or 100 m from the wetland, then the subindex score for this variable would be 1.0.

b. If one or more ditches occur within or 100 m from the wetland, examine the ditch(es) to determine if they are maintained and free of obstructions. If the ditch is overgrown with trees or brush, has a water control structure within the ditch, is not connected to an outlet (i.e., stream or larger canal system), or is otherwise not maintained, the variable subindex would be 1.0. If the ditch is maintained and free of obstructions, measure the depth of the ditch and record on the field data sheet.

c. If the elevation of the bottom of the ditch is above the lowest point in the wetland, then the variable subindex would be 1.0 (Figure 10).

Figure 24. Open space (pasture) in good condition with greater than 75 percent cover on hydrologic soil group D, Function 3

d. If the elevation of the bottom of the ditch is lower than the lowest point in the wetland, determine the difference in elevation between the bottom of the ditch and the lowest point in the wetland.

e. Using the local NRCS County Soil Survey, determine the dominant soil series between the wetland and the ditch and record on the field data sheet.

f. Using Table 12, select a profile characteristics category for the soil series between the ditch and the wetland. Determine the effective depth of the ditch in centimeters, which is the difference in elevation between the bottom of the ditch and the lowest point or elevation in the wetland.

g. Determine the percent of the wetland that is within the impact distance of the ditch using Figure 11. Determine the variable subindex score for Surface Outlet using Figure 25 and enter on the field data sheet.

In peninsular Florida reference depressional wetlands, the impact of ditches on surface water storage ranged from zero to 85 percent. Based on data from reference standard sites, a variable subindex of 1.0 is assigned to sites outside the impact zone. As the percent of the wetland within the zone of impact increases above zero, the subindex score decreases linearly to zero when 100 percent of the wetland is within the zone of impact. This is based on the assumption that the relationship between surface water storage and impact by a drainage ditch is linear. This assumption could be validated using the independent, quantitative measures of function defined in the definition of the function.

Table 12 **Lateral Effects of Ditches, m (ft), for Selected Soil Profile Characteristics in Florida, Function 3**										
Profile Characteristics	**Effective Depth of Ditch, cm**									
	40	**50**	**60**	**70**	**80**	**90**	**100**	**150**	**200**	**250**
Soils with spodic horizon	7 (23)	9 (28)	13 (43)	29 (94)	34 (112)	40 (130)	45 (149)	68 (223)	72 (238)	86 (281)
Soils without a spodic horizon, but with an argillic horizon	41 (134)	47 (153)	52 (170)	56 (185)	60 (197)	63 (208)	67 (220)	70 (229)	70 (229)	75 (245)
Soils with neither a spodic or an argillic horizon	54 (178)	56 (183)	62 (202)	67 (220)	72 (235)	75 (247)	78 (257)	92 (303)	92 (303)	100 (329)
Note: First distance is in meters followed by feet in parentheses.										

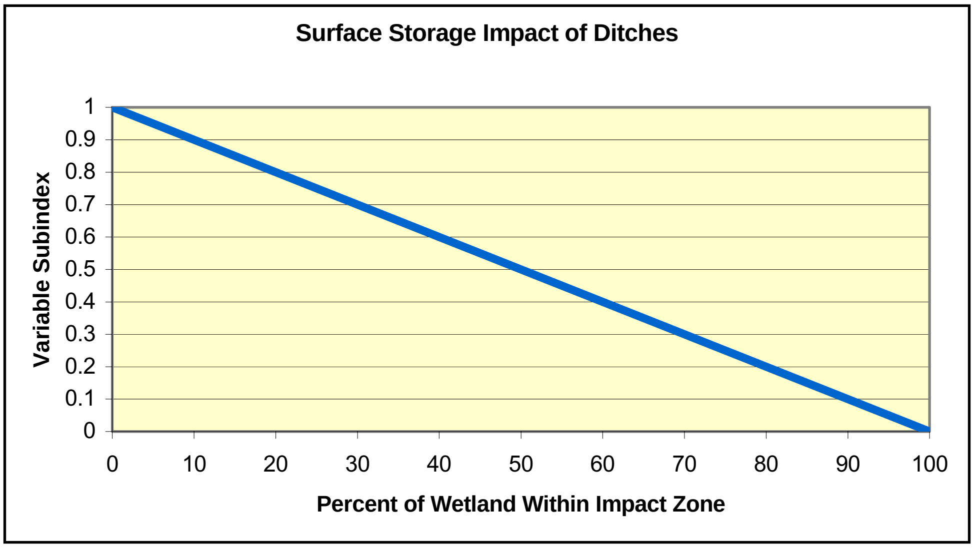


Figure 25. Relationship between lateral impact of ditches and functional capacity, surface storage impact, Function 3

Macrophytic Vegetation Cover (V_{MAC}). This variable represents the total cover of macrophytic vegetation in the wetland. This variable is defined as the average percent cover of macrophytic vegetation <1 m (3.3 ft) in height along multiple transects within each zone.

Percent cover of macrophytic vegetation is used to quantify this variable. Measure it using the following procedure:

a. Using the point intercept method described in Chapter 5, identify five or more points along four or more transects that cross each wetland zone (Mitchell and Hughes 1995). Using this method, at least 20 sampling points should be identified within each wetland zone. Record each point that intercepts macrophytic vegetation (Figure 26). Data Form 4 (Figure 61, discussed in Chapter 5) can be used for recording point data.

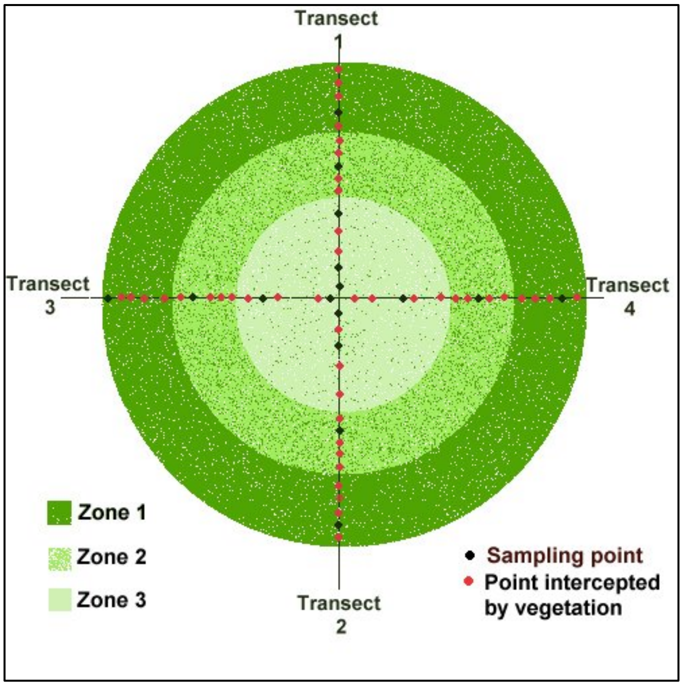


Figure 26. Diagram of point sampling

b. Multiply the number of points intercepted by macrophytic vegetation by 5 or the appropriate percent for the number of points collected. For example, if 16 of the 20 sampling points in the wet meadow zone were intercepted by macrophytic vegetation, the percent cover estimate would be 80 percent.

c. Average the percent cover of all wetland zones present and report macrophytic vegetation cover as a percent between 0 and 100.

d. Using Figure 27 for the wet meadow zone, the shallow marsh zone, or the deep marsh zone, determine the subindex score for percent cover of macrophytic vegetation.

In the herbaceous reference wetlands, macrophytic vegetation cover ranged from 40 to 100 percent in all zones for herbaceous wetlands. Based on data from reference standard wetlands sites, a variable subindex of 1.0 is assigned to wetland sites with macrophytic vegetative cover between 95 and 100 percent (Figure 28) for the wet meadow, shallow marsh, and deep marsh zones. Zero percent cover of macrophytic vegetation, while not measured, would indicate severely altered conditions. The rate at which the subindex decreases is based on the assumption that the relationship between percent cover of macrophytic vegetation and nutrient cycling is linear. These assumptions could be validated using the independent, quantitative measures of function defined previously.

Understory Vegetation Biomass (V_{SSD}). This variable represents the combined cover of macrophytic vegetation and woody vegetation >1 m in height and <10 cm diameter breast height (dbh) (e.g., shrubs, saplings, and understory trees). This variable is used to assess only cypress dome wetlands. In the context of this function, this variable serves as an indication that understory vegetation is present, taking up nutrients, and producing biomass.

Percent cover is used to quantify this variable. Measure it using the following procedure:

a. Using the point intercept method described in Chapter 5, identify five or more points along four or more transects that cross each wetland zone (Mitchell and Hughes 1995). Using this method, at least 20 sampling points should be identified within each wetland zone. Record each point

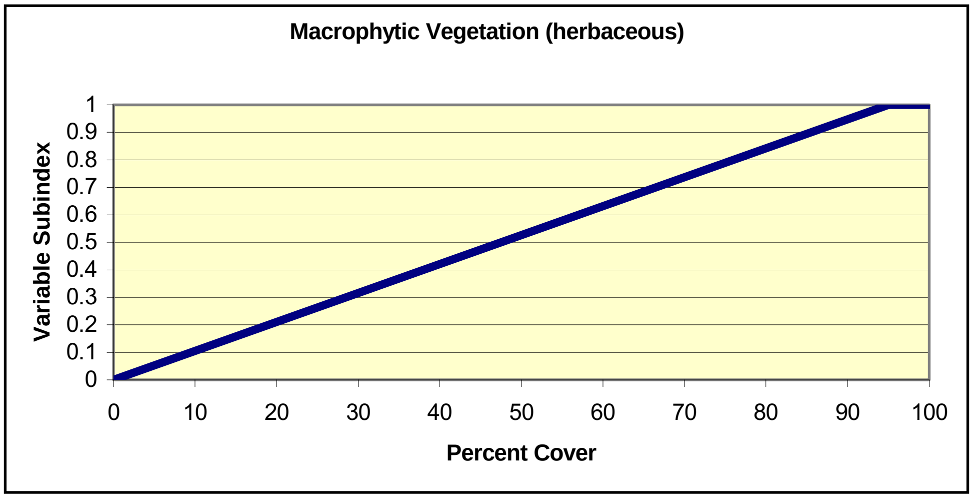


Figure 27. Relationship between macrophytic vegetation and functional capacity for herbaceous depressions, Function 3

Figure 28. Herbaceous depression with near reference standard percent cover of macrophytic vegetation

that intercepts macrophytic vegetation and woody vegetation (Figure 26). Data Form 4 (Figure 61, discussed in Chapter 5) can be used for recording point data.

b. Multiply the number of points intercepted by macrophytic vegetation by 5 and the woody vegetation by 5 or the appropriate percent for the number of points collected.

c. Report macrophytic vegetation cover as a percent between 0 and 200 for each wetland zone.

d. Using Figure 29 for wet meadow zone, Figure 30 for the tree zone, or Figure 31 for the deep marsh zone, determine the subindex score for percent cover of understory vegetation by wetland zone.

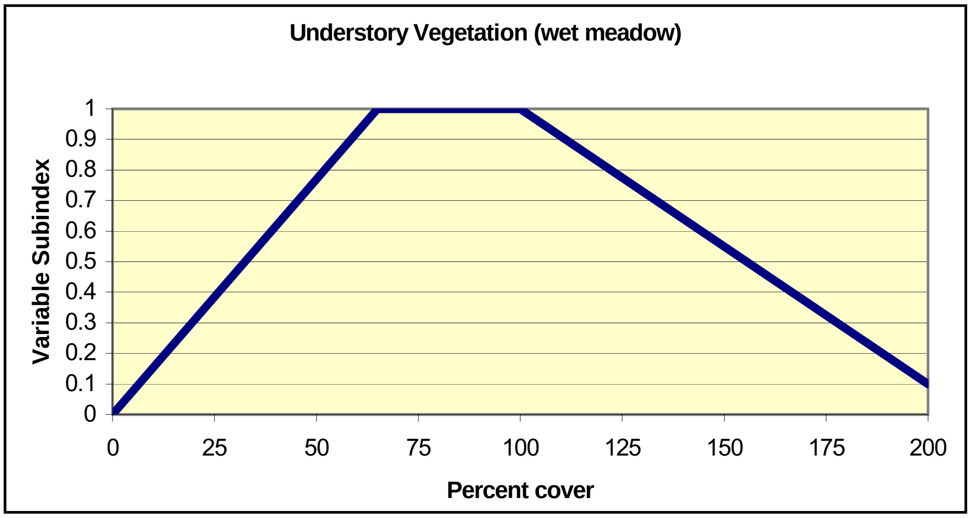


Figure 29. Relationship between percent cover of understory vegetation and functional capacity for the wet meadow zone, Function 3

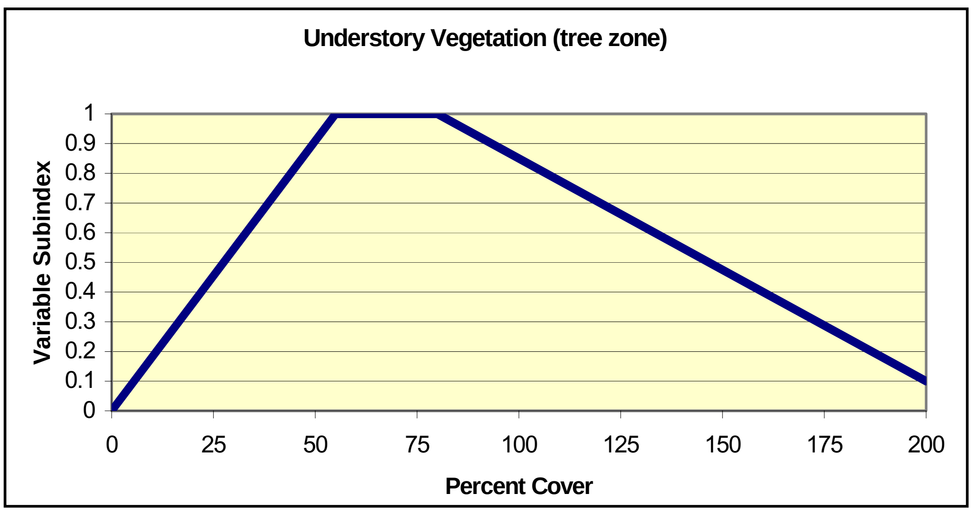


Figure 30. Relationship between percent cover of understory vegetation and functional capacity for the tree zone, Function 3

In Cypress Dome Depressions in Peninsular Florida reference wetlands, percent cover of understory vegetation ranged from 32 to 128 percent. Reference standard sites had percent cover of understory vegetation between 65 and 100 percent in the wet meadow zone (Figure 29), 55 to 80 percent in the tree zone (Figure 30), and 75 to 100 percent in the deep marsh zone (Figure 31). Zero percent cover of understory vegetation, while not measured, would indicate

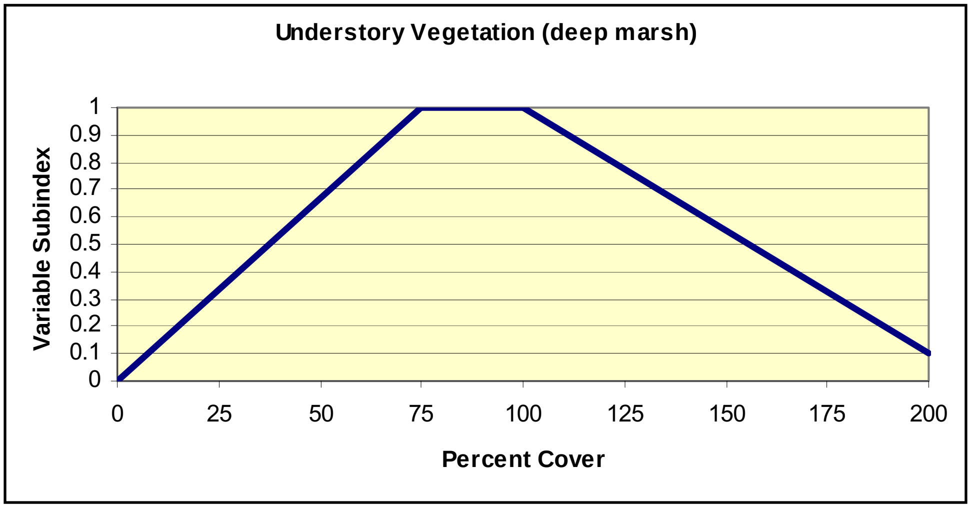


Figure 31. Relationship between percent cover of understory vegetation and functional capacity for the deep marsh zone, Function 3

severely altered conditions. As percent cover of understory vegetation increases above 100 percent in the wet meadow and deep marsh zones and 80 percent in the tree zone (Figure 32), a linearly decreasing subindex score down to 0.1 is assigned each zone at 200 percent cover of understory vegetation. This is based on the assumption that the increase in macrophytic vegetation cover indicates unnatural levels of productivity such as following fertilization. The rate at which the subindex decreases and the selection of 0.1 as the variable subindex end points at 200 percent cover are based on the assumption that the relationship between percent cover of understory vegetation and nutrient cycling is linear and that understory vegetation is contributing to nutrient cycling even when percent cover is high. These assumptions could be validated using the independent, quantitative measures of function defined in the preceding paragraph.

Tree Basal Area (V_{TBA}). Trees are defined as living woody stems ≥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 (Bonham 1989; Spurr and Barnes 1981; Tritton and Hornbeck 1982; Whittaker 1975; Whittaker et al. 1974). Tree basal area per hectare is the metric used to quantify this variable. Measure it using the following procedure:

a. Measure the diameter of all trees (living woody stems ≥10 cm or 4 in.) at breast height (dbh) in a circular 0.04-ha plot with a radius of 11.3 m (37 ft) or a square 20 m by 20 m at the midpoint along each transect within the cypress zone. Record tree species with corresponding diameter measurement in the table on Data Form 3 (Figure 60, discussed in Chapter 5). Accurate identification of woody species is critical for determining the dominant species in each plot. Sampling during the dormant season may require proficiency in recognizing plant form, bark, or dormant/dead plant parts. Users who do not feel confident in identifying trees should seek assistance. An electronic version of Data Form 3 is available at *http://www.wes.army.mil/el/wetlands/datanal.html* to complete the calculations in Steps *b*-*e*:

Figure 32. Reference standard cover of understory vegetation in tree zone of cypress dome

b. Convert the dbh measurement for each woody stem to square centimeters using the following formula: (dbh * dbh) * 0.25 * 3.14 = cm^2.

c. Convert the area of each woody stem in cm^2 to square meters using the following formula: cm^2 * 0.0001 = m^2.

d. Sum the m^2 measurements of all woody stems from the 0.04-ha plots to give m^2/0.04 ha.

e. Multiply by 25 to convert to m^2/ha.

f. Record this value as basal area/ha on the field data sheet.

g. Average the plot values on the field data sheet.

h. Using Figure 33 determine the variable subindex for tree biomass.

The number of 0.04-ha plots required to adequately characterize the depression being assessed will depend on the size and heterogeneity. Chapter 5, "Assessment Protocol," provides guidance for determining the number and layout of sample points and sampling units.

This variable applies only to Cypress Dome Depressions within this guidebook. In cypress dome depressions in peninsular Florida, tree basal area ranged from 32 to 211 m^2/ha. Based on the data from reference standard sites supporting mature, fully stocked forests, a variable subindex of 1.0 is assigned when tree basal area is $\geq$200 m^2/ha (Figure 33). At reference sites in middle to early stages of succession, logged, or cleared for agriculture, tree basal area decreases linearly to zero at zero tree basal area. This is based on the assumption that the

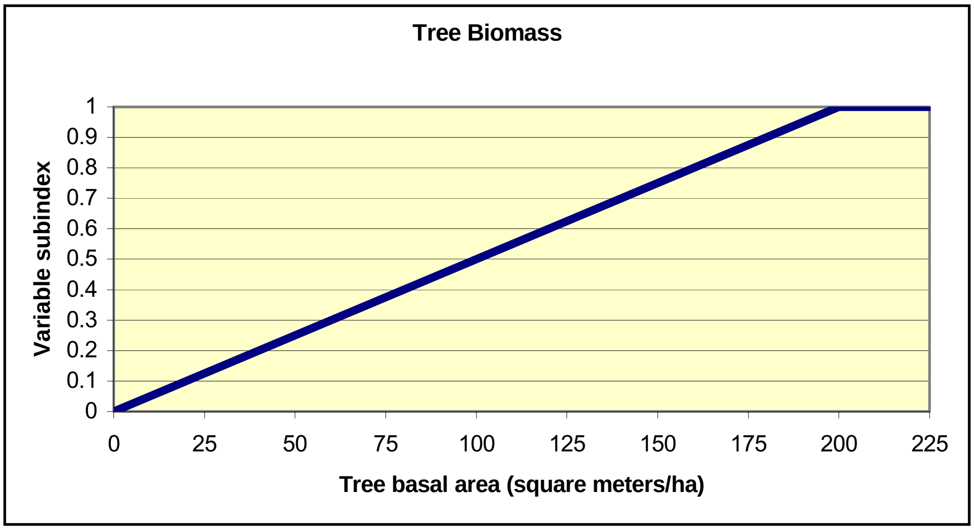


Figure 33. Relationship between tree basal area and functional capacity, Function 3

relationship between tree basal area and the capacity of the cypress dome to cycle nutrients is linear.

Surface Soil Texture (V_{SURTEX}). This variable is defined as the USDA soil texture of the surface horizon or layer of the soil. Soil is the medium in which water is stored. Altering the soil texture of the soil through anthropogenic activities (e.g., fill, excavation) changes the capacity of the water storage. If no anthropogenic activities have occurred within the wetland, the variable subindex can be assumed to be 1.0. If such activities have occurred in the wetland, use the following procedure to determine this variable:

a. During the step point transects, at the midpoint of each wetland zone estimate the texture class of the surface horizon using the feel method. Chapter 5, “Assessment Protocol,” provides guidance for location of the sample point. Appendix C describes the procedure for estimating textural class using the feel method.

b. Using Table 13, assign a score for each texture class found.

c. Determine the subindex by averaging the scores from each point sampled.

Soil texture in depressional wetlands ranged from sand to clay and muck. Based on reference standard sites, textures were sand, muck, or mucky sand for cypress domes and sand, sandy loam, or loamy sand in herbaceous depressions. Other USDA textural classes received categorically lower scores down to zero for gravel or pavement.

Table 13
Soil Surface Texture for Cypress Dome Wetlands, Function 3

Soil Texture	Variable Subindex
Sand	1.0
Loamy sand	1.0
Sandy loam	1.0
Muck *	0.9
Sandy clay	0.9
Silt	0.8
Silt loam	0.7
Loam	0.6
Sandy clay loam	0.5
Clay loam	0.4
Silty clay loam	0.4
Clay	0.2
Silty clay	0.1
Gravel * (≥ 90% gravel)	0.0
Pavement *	0.0

* Term used in lieu of texture.

Functional Capacity Index

The assessment models for calculating the FCI are as follows:

a. For Herbaceous Depressional Wetlands:

$$FCI = \left[\frac{V_{SURTEX} + V_{MAC} + \left(\frac{V_{CATCH} + V_{UPUSE} + V_{SUROUT}}{3} \right)}{3} \right] \quad (4)$$

b. For Cypress Dome Depressional Wetlands:

$$FCI = \left[\frac{V_{SURTEX} + \left(\frac{V_{CATCH} + V_{UPUSE} + V_{SUROUT}}{3} \right) + \left(\frac{V_{TBA} + V_{SSD}}{2} \right)}{3} \right] \quad (5)$$

In these models, the nutrient cycling capacity of depressional wetlands depends on inputs from the surrounding upland and increased outflow of water and nutrients, soils, and vegetation. The assumption is that if natural soils, vegetation, and hydrologic inputs are in place, then nutrient cycling is occurring at an appropriate rate. If soil texture (V_{SURTEX}) has been altered by fill or excavation, then the capacity of the wetland to cycle nutrients has been altered from the natural condition. Input from the surrounding upland is represented by the change in the size of the catchment (V_{CATCH}) and upland land use (V_{UPUSE}). The removal of surface water and nutrients is represented by surface water outlet (V_{SUROUT}). These three variables are combined using an arithmetic mean. This is based on the assumption of equal importance of the inputs and outflow of nutrients within the depressional wetland system.

Herbaceous depressional wetland vegetation is represented by percent cover of macrophytic vegetation (V_{MAC}). If the amount of vegetation, represented by percent cover, is reduced, then it is assumed that nutrient cycling will be reduced. In contrast, if the amount of vegetation is greater than that found in least disturbed natural conditions, then increased amounts of nutrients may already have reached the wetland.

Cypress dome depressional wetland vegetation is represented by percent cover of understory vegetation (V_{SSD}) and tree basal area (V_{TBA}). These partially compensatory variables are combined using an arithmetic mean. This is based on an assumption of equal importance for each stratum of the plant community and the fact that the total loss of one of the strata (i.e., a variable subindex of 0.0) does not cause nutrient cycling to cease, just to be reduced.

The three parts of the model are combined using an arithmetic mean. The implications are that all variables would have to equal zero for the function to receive an FCI of zero.

Function 4: Characteristic Plant Community

Definition

Maintain Characteristic Plant Community is defined as the capacity of a depressional wetland to provide the environment necessary for a characteristic plant community to develop and be maintained. 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. Potential independent, quantitative measures of this function, based on vegetation composition and abundance, include similarity indices (Ludwig and Reynolds 1988) or ordination axis scores from detrended correspondence analysis or other multivariate technique (Kent and Coker 1995). An alternative, independent quantitative measure of this function, based on vegetation composition and abundance as well as environmental factors, is ordination axis scores from canonical correlation analysis (ter Braak 1994).

Rationale for selecting the function

The ability to maintain a characteristic plant community is important because of the intrinsic value of the plant community and the many attributes and processes of depressional wetlands that are influenced by the plant community. For example, primary productivity, nutrient cycling, and the ability to provide a variety of habitats necessary to maintain local and regional diversity of animals (Harris and Gosselink 1990) are directly influenced by the plant community.

Characteristics and processes that influence the function

A variety of physical and biological factors determine the ability of a depressional wetland to maintain a characteristic plant community. One could simply measure the extant plant community and assume that the wetland was performing the function at a characteristic level if the composition and structure were similar to the reference standard wetlands. However, there are potential problems with this approach because of the dynamic nature of plant communities. For instance, soil perturbations and changes to hydrology change the habitat characteristics for characteristic plant communities.

Description of model variables

Macrophytic Vegetation Cover (V_{MAC}). This variable, which represents the total cover of macrophytic vegetation in the wetland, is defined as the average percent cover of macrophytic vegetation <1 m (3.3 ft) in height along multiple transects within each zone.

Percent cover of macrophytic vegetation is used to quantify this variable. Measure it using the following procedure:

a. Using the point intercept method described in Chapter 5, identify five or more points along four or more transects that cross each wetland zone (Mitchell and Hughes 1995). Using this method at least 20 sampling points should be identified within each wetland zone. Record each point that intercepts macrophytic vegetation (Figure 26). Data Form 4 (Figure 61, discussed in Chapter 5) can be used for recording point data.

b. Multiply the number of points intercepted by macrophytic vegetation by 5 or the appropriate percent for the number of points collected. For example, if 16 of the 20 sampling points in the wet meadow zone were intercepted by macrophytic vegetation, the percent cover estimate would be 80 percent.

c. Average the percent cover of all wetland zones present and report macrophytic vegetation cover as a percent between 0 and 100.

d. Use Figure 34 for wet meadow zone, the shallow marsh zone, or the deep marsh zone to determine the subindex score for percent cover of macrophytic vegetation.

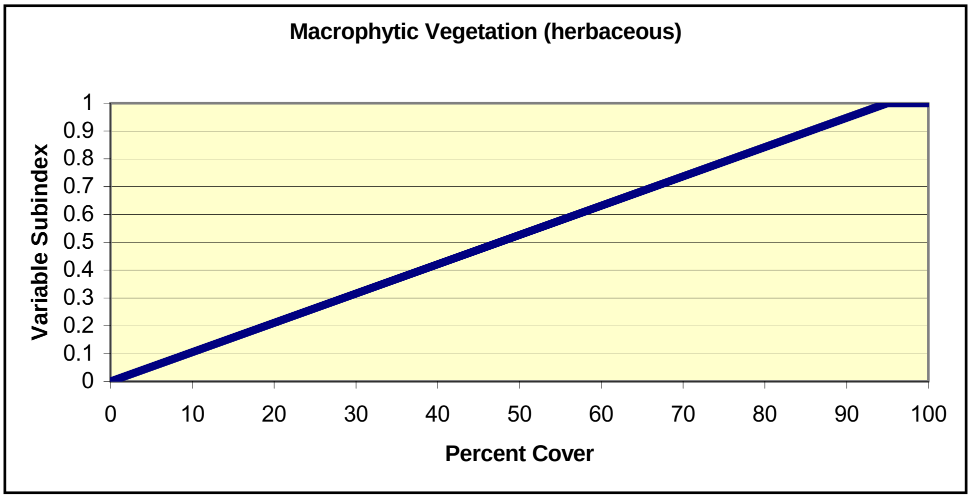


Figure 34. Relationship between macrophytic vegetation and functional capacity for herbaceous depressions

In the herbaceous reference wetlands, macrophytic vegetation cover ranged from 40 to 100 percent in all zones for herbaceous wetlands. Based on data from reference standard wetlands sites, a variable subindex of 1.0 is assigned to wetland sites with macrophytic vegetative cover between 95 and 100 percent for the wet meadow, shallow marsh, and deep marsh zones. Zero percent cover of macrophytic vegetation, while not measured, would indicate severely altered conditions. The rate at which the subindex decreases is based on the assumption that the relationship between percent cover of emergent macrophytic vegetation and nutrient cycling is linear. These assumptions could be validated using the independent, quantitative measures of function defined previously.

Tree Basal Area (V_{TBA}). Trees are defined as living woody stems $\geq$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 (Bonham

1989; Spurr and Barnes 1981; Tritton and Hornbeck 1982; Whittaker 1975; Whittaker et al. 1974). Tree basal area per hectare is the metric used to quantify this variable. Measure it using the following procedure:

a. Measure the diameter of all trees (living woody stems ≥10 cm or 4 in.) at breast height (dbh) in a circular 0.04-ha plot with a radius of 11.3 m (37 ft) or a square 20 m by 20 m at the midpoint along each transect within the cypress zone. Record tree species with corresponding diameter measurement in the table on Data Form 3 (Figure 60, discussed in Chapter 5). Data Form 3 can be used to record tree basal area. Accurate identification of woody species is critical for determining the dominant species in each plot. Sampling during the dormant season may require proficiency in recognizing plant form, bark, or dormant/dead plant parts. Users who do not feel confident in identifying trees should seek assistance. An electronic version of Data Form 3 is available at *http://www.wes.army.mil/el/wetlands/datanal.html* to complete the calculations in Steps *b-e*:

b. Convert the dbh measurement for each woody stem to square centimeters using the following formula: (dbh * dbh) * 0.25 * 3.14 = cm^2.

c. Convert the area of each woody stem in square centimeters to square meters using the following formula: cm^2 * 0.0001 = m^2.

d. Sum the m^2 measurements of all woody stems from the 0.04-ha plots to give m^2/0.04 ha.

e. Multiply by 25 to convert to m^2/ha.

f. Record this value as basal area/ha on the field data sheet.

g. Average the plot values on the field data sheet.

h. Using Figure 35, determine the variable subindex for tree biomass.

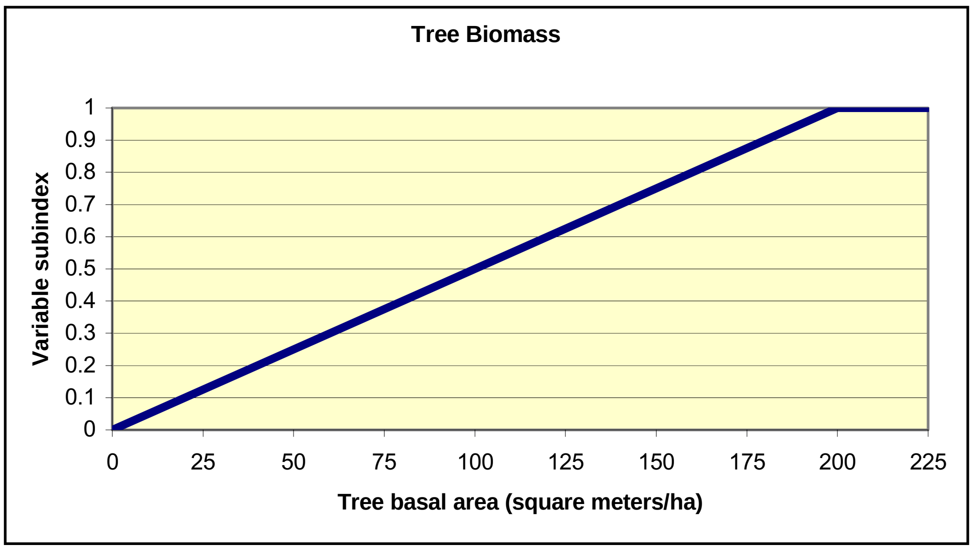


Figure 35. Relationship between tree basal area and functional capacity, Function 4

The number of 0.04-ha plots required to adequately characterize the depression being assessed will depend on the size and heterogeneity. Chapter 5, "Assessment Protocol," provides guidance for determining the number and layout of sample points and sampling units.

This variable applies only to Cypress Dome depressions within this guidebook. In cypress dome depressions in peninsular Florida, tree basal area ranged from 32 to 211 m^2/ha. Based on the data from reference standard sites supporting mature, fully stocked forests, a variable subindex of 1.0 is assigned when tree basal area is $\geq$200 m^2/ha (Figure 35). At reference sites in middle to early stages of succession, logged, or cleared for agriculture, tree basal area decreases linearly to zero at zero tree basal area. This is based on the assumption that the relationship between tree basal area and the capacity of the cypress dome to cycle nutrients is linear.

Understory Vegetation Biomass (V_{SSD}). This variable represents the combined cover of macrophytic vegetation and woody vegetation >1 m in height and <10 cm dbh (e.g., shrubs, saplings, and understory trees). This variable is used only to assess cypress dome wetlands. In the context of this function, this variable indicates that understory vegetation is present, taking up nutrients, and producing biomass.

Percent cover is used to quantify this variable. Measure it using the following procedure:

a. Using the point intercept method described in Chapter 5, identify five or more points along four or more transects that cross each wetland zone (Mitchell and Hughes 1995). Using this method, at least 20 sampling points should be identified within each wetland zone. Record each point that intercepts macrophytic vegetation and woody vegetation. Data Form 4 (Figure 61, discussed in Chapter 5) can be used for recording point data.

b. Multiply the number of points intercepted by macrophytic vegetation by 5 and the woody vegetation by 5 or the appropriate percent for the number of points collected.

c. Report macrophytic vegetation cover as a percent between 0 and 200 for each wetland zone.

d. Using Figure 36 for the wet meadow zone, Figure 37 for the tree zone, or Figure 38 for the deep marsh zone, determine the subindex score for percent cover of understory vegetation by wetland zone.

In Cypress Dome Depressions in Peninsular Florida reference wetlands, percent cover of understory vegetation ranged from 32 to 128 percent. Reference standard sites had percent cover of understory vegetation between 65 and 100 percent in the wet meadow zone (Figure 36), 55 to 80 percent in the tree zone (Figure 37), and 75 to 100 percent in the deep marsh zone (Figure 38). Zero percent cover of understory vegetation, while not measured, would indicate severely altered conditions. As percent cover of understory vegetation increases above 100 percent in the wet meadow and deep marsh zones and 80 percent in

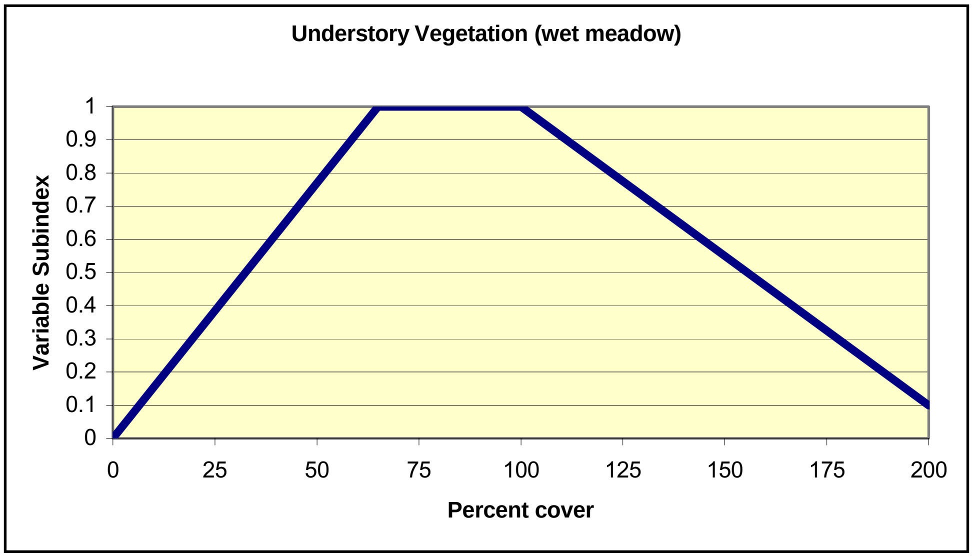


Figure 36. Relationship between percent cover of understory vegetation and functional capacity for the wet meadow zone, Function 4

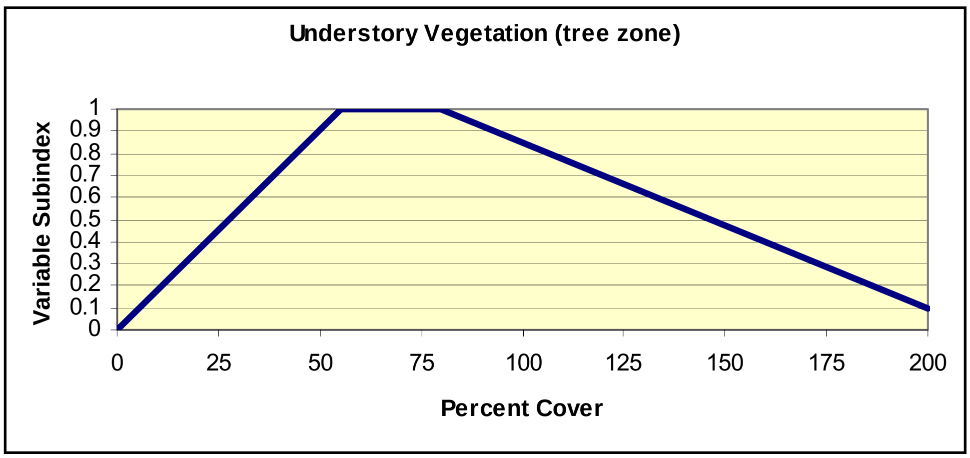


Figure 37. Relationship between percent cover of understory vegetation and functional capacity for the tree zone, Function 4

the tree zone, a linearly decreasing subindex score down to 0.1 is assigned each zone at 200 percent cover of understory vegetation. This is based on the assumption that the increase in macrophytic vegetation cover indicates unnatural levels of productivity such as following fertilization. The rate at which the subindex decreases and the selection of 0.1 as the variable subindex end points at 200 percent cover are based on the assumption that the relationship between percent cover of understory vegetation and nutrient cycling is linear and that understory vegetation is contributing to nutrient cycling even when percent cover is high. These assumptions could be validated using the independent, quantitative measures of function defined in the preceding paragraph.

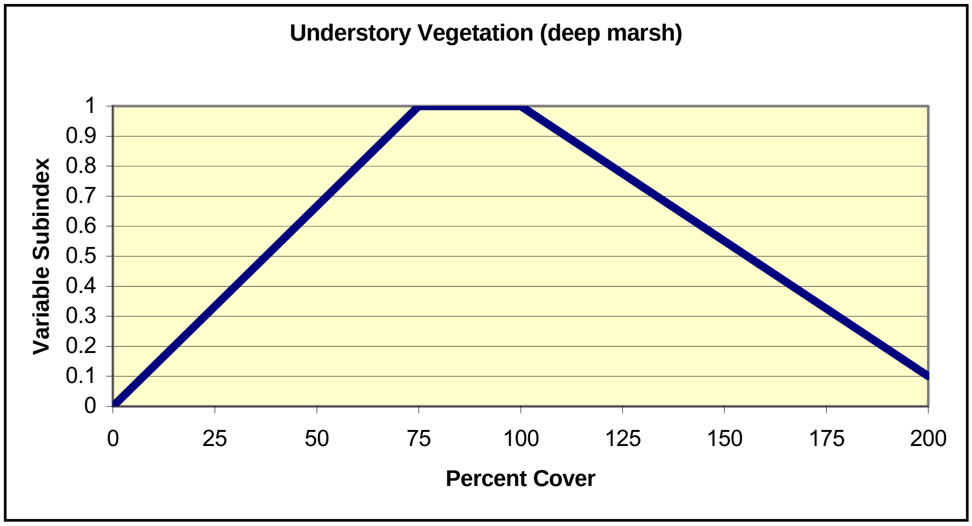


Figure 38. Relationship between percent cover of understory vegetation and functional capacity for the deep marsh zone, Function 4

Herbaceous Plant Species Composition (*V_{HCOMP}*). Plant species composition represents the dominance of certain native wetland plants in proportion to sites representing those with the least disturbance in herbaceous wetlands. Ideally, plant species composition would be determined with intensive sampling of herbaceous species within each wetland zone. Unfortunately, the time and taxonomic expertise required to accomplish this are not available in the context of rapid assessment. Thus, the focus here is on the dominant species in the herbaceous strata within each wetland zone.

Percent concurrence with the dominant species in the herbaceous stratum for each wetland zone is used to quantify this variable. Measure it with the following procedure:

a. Identify the dominant species in the ground vegetation strata using the 50/20 rule.[1] To apply the 50/20 rule, rank species from the herbaceous stratum in descending order of abundance from each wetland zone. Identify dominants by summing the relative abundances beginning with the most abundant species in descending order until 50 percent is exceeded. Additional species with ≥20 percent relative abundance should also be considered as dominants. If no species is equal to or greater than 20 percent, then identify the species with the greatest percent cover. Accurate species identification is critical for determining the dominant species in each plot. Sampling during the dormant season or after a fire may require a high degree of proficiency. Users who do not feel confident in identifying herbaceous plant species should get help with plant identification.

[1] Memorandum, 6 March 1992, Office, Chief of Engineers, Clarification of Use of the 1987 Delineation Manual.

b. Calculate percent concurrence by comparing the list of dominant plant species to the list of dominant species from each wetland zone in reference standard wetlands. Use Table 14 for the wet meadow zone, Table 15 for the shallow marsh zone, and Table 16 for the deep marsh zone. For example, if all the dominants from the area being assessed occur on the list of dominants from reference standard wetlands, then there is 100 percent concurrence. If three of the five dominant species from the area being assessed occur on the list, then there is a 60 percent concurrence.

c. Report concurrence of species dominants as a percent for each wetland zone present.

d. Average the percents and using Figure 39 determine the variable subindex for herbaceous plant species composition.

Table 14
Herbaceous Dominant Plant Species (Wet Meadow), Function 4

Scientific Name	Common Name
Amphicarpum muhlenbergianum	muhlenberg maidencane
Andropogon virginicus	broomsedge bluestem
Asclepias pedicellata	savannah milkweed
Carex squarrosa	squarrose sedge
Eleocharis microcarpa	smallfruit spikerush
Eriocaulon compressum	flattened pipewort
Gratiola ramose	branched hedgehyssop
Hypericum fasciculatum	peelbark St. Johnswort
Hyptis alata	clustered bushmint
Oxypolis filiformis	water cowbane
Panicum hemitomon	maidencane
Panicum rigidulum	redtop panicgrass
Pluchea rosea	rosy camphorweed
Polygala rugelii	yellow milkwort
Rhynchospora fascicularis	fascicled beaksedge
Sabatia grandiflora	largeflower rose gentian
Spartina bakeri	sand cordgrass
Xyris elliottii	Elliots yelloweyed grass

Table 15
Herbaceous Dominant Plant Species (Shallow Marsh), Function 4

Scientific Name	Common Name
Bacopa caroliniana	blue waterhyssop
Cladium jamaicense	Sawgrass
Eriocaulon compressum	flattened pipewort
Iris hexagona	Dixie iris
Juncus effusus	common rush
Lachnanthes caroliana	Carolina redroot
Nymphoides aquatica	big floatingheart
Panicum hemitomon	Maidencane
Panicum rigidulum	redtop panicgrass
Rhynchospora inundata	narrowfruit horned beaksedge
Rhynchospora nitens	shortbeak beaksedge
Rhynchospora tracyi	Tracy's breaksedge

Table 16
Herbaceous Dominant Plant Species (Deep Marsh), Function 4

Scientific Name	Common Name
Hibiscus grandiflorus	swamp rosemallow
Lachnanthes caroliana	Carolina redroot
Nelumbo lutea	American lotus
Nymphoides aquatica	big floatingheart
Panicum hemitomon	Maidencane
Pontederia cordata	pickerelweed
Rhynchospora inundata	narrowfruit horned breaksedge
Sagittaria lancifolia	bulltongue arrowhead
Thalia geniculata	bent alligator-flag

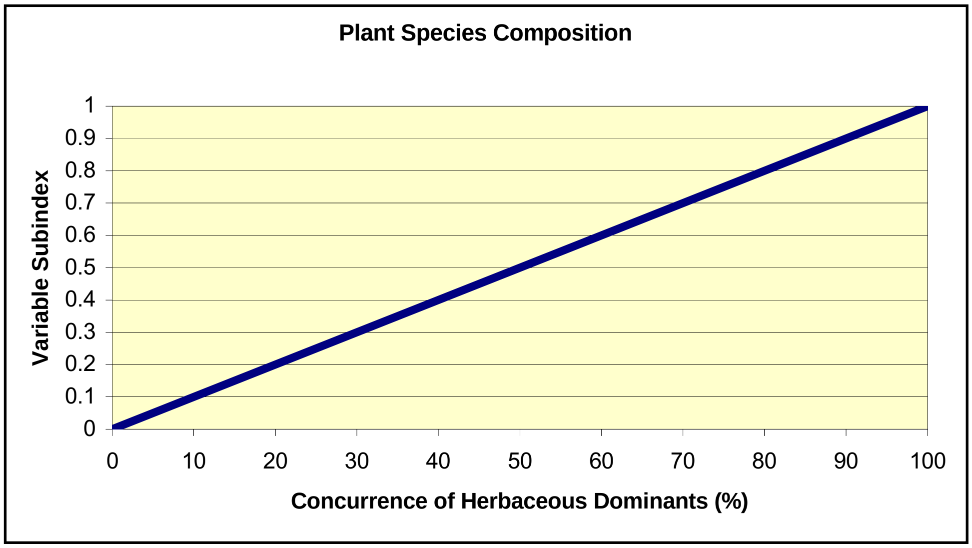


Figure 39. Relationship between percent concurrence of herbaceous dominants and functional capacity

In the herbaceous reference wetlands, percent concurrence with dominant species ranged from zero to 100 percent for each wetland zone. Based on the data from reference standard sites a variable subindex of 1.0 is assigned when concurrence with dominant species is 100 percent for all wetland zones. As percent concurrence decreases, a linearly decreasing subindex down to zero is assigned based on the assumption that the relationship between plant species composition and the capacity of herbaceous wetlands to maintain a characteristic plant community is linear (Figure 39).

Tree Species Composition (V_{TCOMP}). Plant species composition represents the dominance of certain native wetland trees in proportion to sites representing those with the least disturbance in cypress dome wetlands. Ideally, tree species composition would be determined with intensive sampling of tree species within the tree zone. Unfortunately, the time and taxonomic expertise required to accomplish this are not available in the context of rapid assessment. Thus, the focus here is on the dominant species in the tree strata within the tree wetland zone.

Percent concurrence with the dominant species in the herbaceous stratum for each wetland zone is used to quantify this variable. Measure it with the following procedure:

a. Identify the dominant species in the tree strata using the 50/20 rule.[1] To apply the 50/20 rule, rank species from the tree stratum in descending order of abundance from each wetland zone. Identify dominants by summing the relative abundances beginning with the most abundant species in descending order until 50 percent is exceeded. Additional species with $\geq$20 percent relative abundance should also be considered as dominants. If no species is equal to or greater than 20 percent, then identify the species with the greatest percent cover. Since *Taxodium ascendens* (pond cypress) is the only tree species dominant in the tree zone of reference standard sites, species identification is relatively easy. However, users who do not feel confident in identifying herbaceous plant species should get help with plant identification.

b. Calculate percent concurrence by comparing the list of dominant plant species to the list of dominant species from the tree zone in reference standard cypress dome wetlands. Use Table 17 to compare the list of dominants to those species found in reference standard sites. For example, if all the dominants from the area being assessed occur on the list of dominants from reference standard wetlands, then there is 100 percent concurrence. If one of the five dominant species from the area being assessed occurs on the list, then there is a 20 percent concurrence.

Table 17
Tree Dominant Plant Species (Tree Zone)

Scientific Name	Common Name
Taxodium ascendens	pond cypress
Taxodium distichum	bald cypress

c. Report concurrence of species dominants as a percent for the tree zone.

d. Use Figure 40 to determine the variable subindex for herbaceous plant species composition of the tree zone in cypress dome depressional wetlands.

In the cypress dome reference wetlands, percent concurrence with dominant species ranged from zero to 100 percent for the tree wetland zone. Based on the data from reference standard sites a variable subindex of 1.0 is assigned when concurrence with dominant species is 100 percent for all wetland zones. As percent concurrence decreases, a linearly decreasing subindex down to zero is assigned based on the assumption that the relationship between plant species composition and the capacity of cypress dome wetlands to maintain a characteristic plant community is linear (Figure 40).

Surface Soil Texture (V_{SURTEX}). This variable is defined as the USDA soil texture of the surface horizon, or layer, of the soil. Soil is the medium in which water is stored. Altering the soil texture of the soil through anthropogenic activities (e.g., fill, excavation) changes the capacity of the water storage. If no anthropogenic activities have occurred within the wetland, the variable subindex

---

[1] Memorandum, 6 March 1992, Office, Chief of Engineers, Clarification of Use of the 1987 Delineation Manual.

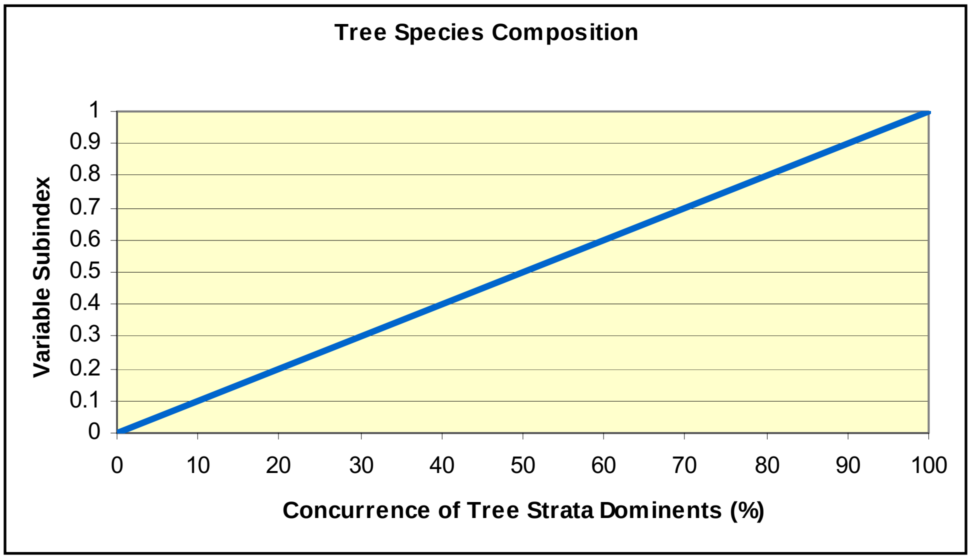


Figure 40. Relationship between percent tree strata species concurrence in the tree zone of cypress domes and functional capacity, Function 4

can be assumed to be 1.0. If such activities have occurred in the wetland, use the following procedure to determine this variable:

a. During the step point transects, at the midpoint of each wetland zone estimate the texture class of the surface horizon using the feel method. Chapter 5, "Assessment Protocol," provides guidance for location of the sample point. Appendix C describes the procedure for estimating textural class using the feel method.

b. Using Table 18, assign a score for each texture class found.

c. Determine the subindex by averaging the scores from each point sampled.

Soil texture in depressional wetlands ranges from sand to clay and muck (Figure 41). Based on reference standard sites, textures were sand, muck, or mucky sand for cypress domes and sand, sandy loam, or loamy sand in herbaceous depressions. Other USDA textural classes received categorically lower scores down to zero for gravel or pavement.

Subsurface Outlet (V_{SUBOUT}). This variable is defined as the effective drainage of ditches on the subsurface water storage of the wetland. Measure this variable using the following procedure:

Table 18
Soil Surface Texture for Cypress Dome Wetlands, Function 4

Soil Texture	Variable Subindex
Sand	1.0
Loamy sand	1.0
Sandy loam	1.0
Muck *	0.9
Sandy clay	0.9
Silt	0.8
Silt loam	0.7
Loam	0.6
Sandy clay loam	0.5
Clay loam	0.4
Silty clay loam	0.4
Clay	0.2
Silty clay	0.1
Gravel * (≥ 90% gravel)	0.0
Pavement *	0.0

* Term used in lieu of texture.

Figure 41. Muck surface soil texture

a. Using recent aerial photographs and verifying during field reconnaissance, determine if any drainage ditches occur within the catchment or 300 m (1,000 ft) of the catchment, whichever is less. If no drainage ditches occur within or 300 m from the catchment, then the subindex score for this variable would be 1.0.

b. If one or more ditches occur within or 300 m from the catchment, examine the ditch(es) to determine if they are maintained and free of obstructions. If the ditch is overgrown with trees or brush, has a water control structure within the ditch, is not connected to an outlet (i.e., stream or larger canal system), or is otherwise not maintained, the variable subindex would be 1.0. If the ditch is maintained and free of obstructions, measure the depth of the ditch.

c. Determine the difference in elevation between the bottom of the ditch and the lowest point in the wetland (Figure 15).

d. If the elevation of the bottom of the ditch is above 0.15 m (6 in.) below the lowest point in the wetland, then the variable subindex would be 1.0.

e. If the elevation of the bottom of the ditch is below the lowest point in the wetland, use the local NRCS County Soil Survey to determine the dominant soil series between the wetland and the ditch and record on the field data sheet.

f. Using Table 19 select a category for the soil series mapped on the site and determine the impact distance for the difference between the bottom of the ditch and the lowest point in the wetland.

g. Determine the percent of the wetland that is within the impact distance of the ditch (Figure 16) and using Figure 42 determine the subindex score for lateral effect of ditches.

Table 19
Lateral Effects of Ditches, m (ft), for Selected Soil Profile Characteristics in Florida, Function 4

Profile Characteristics	Effective Depth of Ditch, cm									
	40	50	60	70	80	90	100	150	200	250
Soils with spodic horizon	19 (63)	22 (74)	37 (123)	81 (267)	98 (322)	112 (367)	129 (422)	191 (627)	231 (757)	238 (782)
Soils without a spodic horizon, but with an argillic horizon	128 (421)	153 (505)	170 (559)	188 (618)	197 (647)	211 (691)	223 (733)	229 (750)	234 (769)	243 (799)
Soils with neither a spodic or an argillic horizon	136 (446)	147 (482)	168 (551)	185 (606)	199 (652)	212 (695)	219 (720)	260 (854)	286 (938)	300 (985)

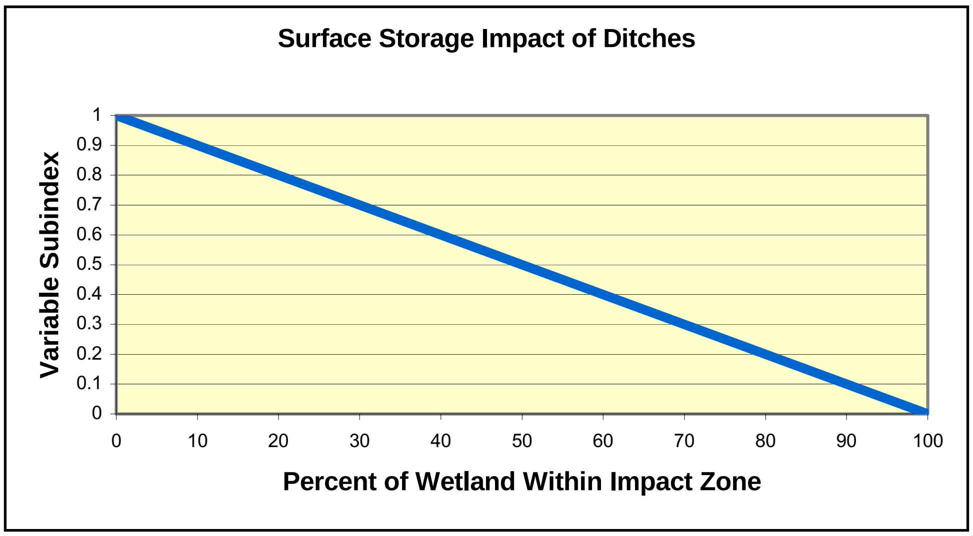


Figure 42. Relationship between lateral impact of ditches and functional capacity, surface storage impact, Function 4

In peninsular Florida reference depressional wetlands, the impact of ditches on surface water storage ranged from zero to 85 percent. Based on data from reference standard sites, a variable subindex of 1.0 is assigned to sites outside the impact zone. As the percent of the wetland within the zone of impact increases above zero, the subindex score decreases linearly to zero when 100 percent of the wetland is within the zone of impact. This is based on the assumption that the relationship between surface water storage and impact by a drainage ditch is linear. This assumption could be validated using the independent, quantitative measures of function defined in the definition of the function.

Functional Capacity Index

The assessment models for calculating the FCI are as follows:

a. For Herbaceous Depressional Wetlands:

$$FCI = \left[\left(\frac{V_{MAC} + V_{HCOMP}}{2} \right) \times \left(\frac{V_{SURTEX} + V_{SUBOUT}}{2} \right) \right]^{1/2} \tag{6}$$

b. For Cypress Dome Depressional Wetlands:

$$FCI = \left\{ \left[\frac{\left(\frac{V_{TBA} + V_{SSD}}{2} \right) + V_{TCOMP}}{2} \right] \times \left(\frac{V_{SURTEX} + V_{SUBOUT}}{2} \right) \right\}^{1/2} \tag{7}$$

In each of these models the capacity of the depressional wetland to maintain a characteristic plant community is dependent on the existing vegetation, soils, and hydrology. The Herbaceous Depressional Wetlands model averages the percent Macrophytic Vegetation Cover (V_{MAC}) and Herbaceous Plant Species Composition (V_{HCOMP}). This assumes that these two variables are of equal importance to the plant community.

The model for Cypress Dome Depressional Wetlands averages Tree Basal Area (V_{TBA}) and the percent cover of Understory Vegetation (V_{SSD}). The result is averaged with Tree Species Composition (V_{TCOMP}); therefore, the species composition of trees is weighted equally with the result of V_{TBA} and V_{SSD}.

The second part of the models averages the components Surface Soil Texture (V_{SURTEX}) and subsurface drainage (V_{SUBOUT}). Soils and hydrology components are averaged separately based on the assumption that they are of equal importance in the maintenance of the plant community and potential for restoration. If the percent vegetative cover and species diversity are appropriate for the subclass, then the soils or hydrology have probably not been impacted to a degree that vegetation cannot be restored to near-reference standard conditions. However, depending on the severity of soil or hydrology impacts, restoration may not be possible.

The two parts of the equations are averaged using a geometric mean based on the assumption that structure and species composition, as well as soil and hydrology variables, contribute equally to the maintenance of a characteristic plant community. If the subindices for the variables in either part of the model decrease, there will be a reduction in the FCI to zero if either part equals zero.

Function 5: Provide Wildlife Habitat

Definition

Provide Wildlife Habitat is defined as the ability of a depressional wetland to support the wildlife species that utilize herbaceous and cypress dome depressional wetlands during all or part of their life cycles. A potential independent, quantitative measure of this function is a similarity index calculated from species composition and abundance (Odum 1950; Sorenson 1948).

Rationale for selecting the function

Terrestrial, semiaquatic, and aquatic animals use depressional wetlands extensively to complete their life histories. The performance of this function ensures habitat for a diversity of invertebrate and vertebrate organisms, contributes to secondary production, maintains complex trophic interactions, and provides access to and from wetlands for completion of aquatic species life cycles. Performance of this function also provides refugia and habitat for wide-ranging or migratory birds and conduits for dispersal of species to other areas. Habitat requirements for individual species and even groups of similar species are sometimes highly specialized; however, most wildlife and fish species found in depressional wetlands depend on certain common characteristics such as hydroperiod, topography, vegetative composition and structure, and proximity to other habitats.

Characteristics and processes that influence the function

Hydrology in the form of seasonal inundation is one of the major factors influencing wildlife quality in depressional wetlands. Depressions fill with water during the wet summer months when rainfall exceeds evapotranspiration, delaying overland flow until the upland soils are saturated. This process is critical in establishing regional hydrology patterns (Ewel 1990). As rainfall decreases in the fall and winter, depressional wetlands in peninsular Florida dry and will often have no standing water over the soil surface by spring. Soils will usually remain moist in the deeper interior wetland zones. The wet-dry cycle is important for regeneration because cypress trees will not generate under inundated conditions. Drainage of depressional wetlands permits the invasion of species such as *Schinus terebinthifolius* (Brazilian pepper) that are less flood tolerant (Marois and Ewel 1983). In addition, reduced hydroperiod from drainage can increase shrub and hardwood density, increase fire potential, and cause a dramatic shift from aquatic and wading species to arboreal species (Harris and Vickers 1984; Marois and Ewel 1983). Conversely, increasing the hydroperiod of a swamp that receives more runoff when surrounding lands are developed may affect the growth rate of trees and regeneration of cypress trees (Ewel 1984).

Depressional wetlands support a diverse invertebrate community, which varies both seasonally and spatially within a particular depression and between depressions (Leslie et al. 1997). Benthic invertebrates are often the basis of swamp food chains (Ewel 1990). Invertebrates, especially insects and other arthropods, are common on the water surface and in the canopy as well as in the substrate of depressional wetlands. At least 18 species of mosquitoes have been found in depressional wetlands in peninsular Florida (Davis 1984).

Reptiles and amphibians are the most common vertebrates in cypress domes (Harris and Vickers 1984). The pronounced wet-dry cycles of peninsular Florida make depressional wetlands ideal year-round habitat for amphibians and frogs (Harris and Vickers 1984). In fact, many amphibians and reptiles depend on depressional wetlands for reproduction (Ewel 1990). Changing the vegetative structure can have a large impact on the populations of amphibians and reptiles. However, impacts that alter the wetland size may have little impact on amphibian species richness (Snodgrass et al. 1996).

Fish are not a primary component of depressional wetlands in peninsular Florida. In fact the periodic drying typical of depressions precludes the development of a diverse or important fish population (Ewel 1990). The addition of a permanent deep water zone in depressional wetlands could reduce invertebrate and amphibian populations by supporting predatory fish populations (Snodgrass et al. 1996).

Wading birds are more conspicuous in herbaceous depressions. While wading bird species are not dominant in cypress domes, other bird species are more dominant in swamps, including cypress domes, than in uplands during migration and in summer (Harris and Mulholland 1983). Upland birds are much more common than water birds in many mature cypress domes, feeding primarily on insects in the canopy (Ewel 1984).

Mammals such as *Glaucomy volans* (southern flying squirrel), *Ochrotomy nuttall* (golden mouse), and *Sciurus carolinensis* (eastern gray squirrel) live in the canopy edge of cypress domes (Harris and Vickers 1984). Other mammals such as black bear and turkey will use depressional wetlands during the dry periods.

Impacts such as clear cutting affect the availability of animal habitat. Virtually every swamp in Florida was logged between late 1800 and 1950 (Ewel 1990). In recent years entire cypress domes have been clear cut and mulched for use in landscaping. Removal of the cypress canopy obviously alters community composition, transpiration, and wildlife populations. Rooting by hogs can completely destroy the vegetation (Winchester et al. 1985).

Description of model variables

Subsurface Outlet (V_{SUBOUT}). This variable is defined as the effective drainage of ditches on the subsurface water storage of the wetland. Measure this variable using the following procedure:

a. Using recent aerial photographs and verifying during field reconnaissance, determine if any drainage ditches occur within or 300 m (1,000 ft) of the catchment, whichever is less. If no drainage ditches occur within or 300 m from the catchment, then the subindex score for this variable would be 1.0.

b. If one or more ditches occur within or 300 m from the catchment, examine the ditch(es) to determine if they are maintained and free of obstructions. If the ditch is overgrown with trees or brush, has a water control structure within the ditch, is not connected to an outlet (i.e., stream or larger canal system), or is otherwise not maintained, the variable subindex would be 1.0. If the ditch is maintained and free of obstructions, measure the depth of the ditch.

c. Determine the difference in elevation between the bottom of the ditch (Figure 15) and the lowest point in the wetland.

d. If the elevation of the bottom of the ditch is above 0.15 m (6 in.) below the lowest point in the wetland, then the variable subindex would be 1.0.

e. If the elevation of the bottom of the ditch is below the lowest point in the wetland, use the local NRCS County Soil Survey to determine the dominant soil series between the wetland and the ditch and record on the field data sheet.

f. Using Table 20 select a category for the soil series mapped on the site and determine the impact distance for the difference between the bottom of the ditch and the lowest point in the wetland.

g. Determine the percent of the wetland that is within the impact distance of the ditch (Figure 16) and using Figure 43 determine the subindex score for lateral effect of ditches.

In peninsular Florida reference depressional wetlands, the impact of ditches on subsurface water storage ranged from zero to 85 percent. Based on data from reference standard sites, a variable subindex of 1.0 is assigned to sites outside the impact zone. As the percent of the wetland within the zone of impact increases above zero, the subindex score decreases linearly to zero when 100 percent of the wetland is within the zone of impact. This is based on the assumption that the relationship between surface water storage and impact by a drainage ditch is linear. This assumption could be validated using the independent, quantitative measures of function in the definition of the function.

Table 20
Lateral Effects of Ditches, m (ft), for Selected Soil Profile Characteristics in Florida, Function 5

Profile Characteristics	Effective Depth of Ditch, cm									
	40	50	60	70	80	90	100	150	200	250
Soils with spodic horizon	19 (63)	22 (74)	37 (123)	81 (267)	98 (322)	112 (367)	129 (422)	191 (627)	231 (757)	238 (782)
Soils without a spodic horizon, but with an argillic horizon	128 (421)	153 (505)	170 (559)	188 (618)	197 (647)	211 (691)	223 (733)	229 (750)	234 (769)	243 (799)
Soils with neither a spodic or an argillic horizon	136 (446)	147 (482)	168 (551)	185 (606)	199 (652)	212 (695)	219 (720)	260 (854)	286 (938)	300 (985)

Note: First distance is in meters followed by feet in parentheses.

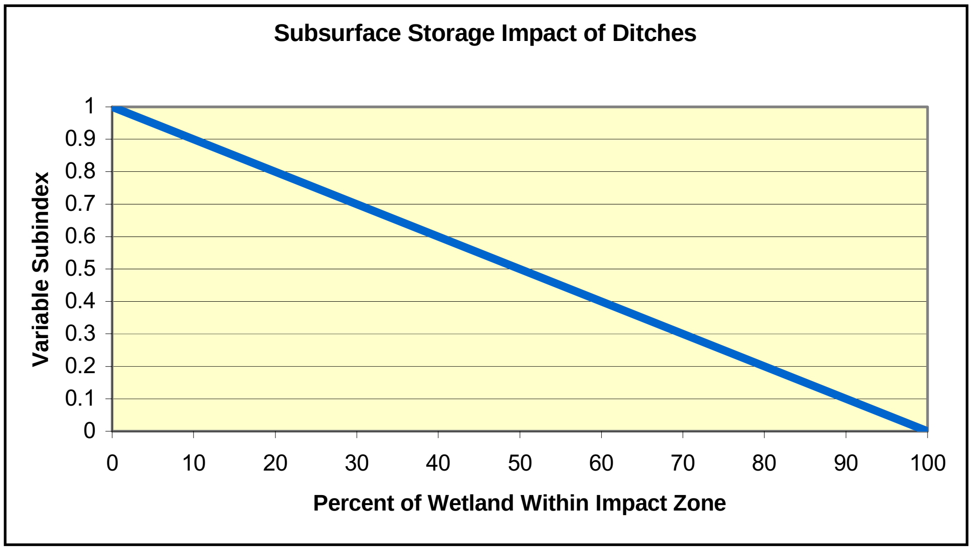


Figure 43. Relationship between lateral impact of ditches and functional capacity, subsurface storage impact, Function 5

Change in the Number of Wetland Zones (V_{ZONES}). This variable is defined as the change in the number of wetland zones in the depressional wetland being assessed. Decreasing the number of wetland zones represents a change in the water storage capacity of the wetland. The wet meadow or outermost zone is usually the first to be impacted by encroachment of upland land uses. Conversely, the addition of wetland zones, usually by excavating the innermost zone (shallow marsh or deep marsh) changes the storage capacity from the natural condition. This variable is determined with the following procedure:

a. Determine if wetland zones are complete and intact. If all zones are intact, the variable subindex score would be 1.0.

b. If the number of zones has been altered, determine the increase or decrease in the number of zones. Using Table 21 determine the subindex score for the change in the number of wetland zones.

Table 21
Subindex Score for Change in the Number of Wetland Zone(s)

Number of Natural Wetland Zone(s) Present After Disturbance	Number of Natural Wetland Zone(s) Present Before Disturbance			
	1	2	3	4
0	0.0	0.0	0.0	0.0
1	1.0	0.5	0.25	0.1
2	0.8	1.0	0.5	0.25
3	0.7	0.8	1.0	0.5
4	0.6	0.7	0.8	1.0

In peninsular Florida depressional wetlands the number of wetland zones ranged from 1 to 4. Based on the data from reference standard sites, a variable subindex score of 1.0 is assigned when the number of wetland zones does not change. As the number of zones changes, the variable subindex score decreases proportionately to zero when no wetland vegetative zones are present.

Upland Land Use (V_{UPUSE}). This variable is defined as the surface water runoff from the wetland catchment into the wetland. With increased disturbance and increased impervious surface surrounding the wetland, more surface water enters the wetland than under reference standard conditions. Burned natural areas should not receive an increased score. Determine the subindex score for this variable using the following procedure:

a. Using recent aerial photographs and GIS technology and verifying during field reconnaissance, determine the percent of the catchment that has the following land uses (Figure 44).

Figure 44. Several depressional wetlands surrounded by open space in poor condition (<50 percent cover) on hydrologic soil group D

b. Using data from the local soil survey, determine the hydrologic group for the soils present in the catchment.

c. Using Table 22, modified from NRCS TR-55, determine the curve number for the catchment.

d. Determine a weighted average runoff score for the upland catchment. Examples can be found in Appendix C.

e. Verify during field reconnaissance.

f. Using Figure 45 determine the subindex score for upland runoff.

Table 22 Runoff Curve Numbers, Function 5				
Cover Type	Hydrologic Soil Groups			
	A	B	C	D
Open space (pasture, lawns, parks, golf courses, cemeteries):				
Poor condition (grass cover <50%)	68	79	86	89
Fair condition (grass cover 50% to 75%)	49	69	79	84
Good condition (grass cover >75%)	39	61	74	80
Impervious areas (parking lots, roofs, driveways, etc)	98	98	98	98
Gravel	76	85	89	91
Urban districts:				
Commercial and business (85% cover)	89	92	94	95
Industrial (72% cover)	81	88	91	93
Residential districts by average lot size:				
1/8 acre or less (town houses and apartments) (65% cover)	77	85	90	92
1/4 acre (38% cover)	61	75	83	87
1/3 acre (30% cover)	57	72	81	86
1/2 acre (25% cover)	54	70	80	85
1 acre (20% cover)	51	68	79	84
2 acres (12% cover)	46	65	77	82
Newly graded areas (no vegetation or pavement)	77	85	90	92
Fallow crop areas (poor)	76	85	90	93
Fallow crop areas (good)	74	83	88	90
Row crops	70	80	86	90
Small grain	64	75	83	87
Groves and orchards				
<50% ground cover	57	73	82	86
50% to 75% ground cover	43	65	76	82
>75% cover	32	58	72	79
Forest and native range				
<50% ground cover	45	66	77	83
50% to 75% ground cover	36	60	73	79
>75% ground cover	30	55	70	77

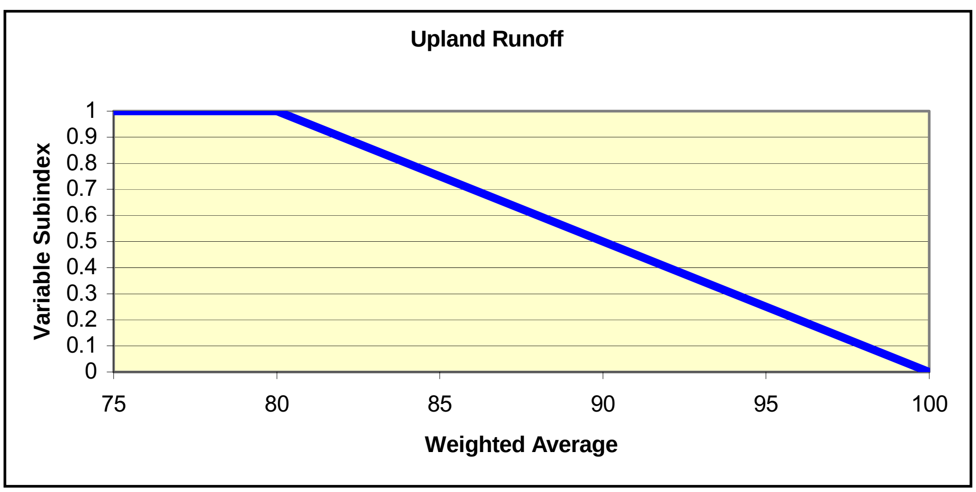


Figure 45. Relationship between upland runoff and functional capacity, Function 5

In peninsular Florida, reference wetlands were surrounded by native flatwoods, sand pine scrub, or sloughs within the catchment. All of these vegetative types have a runoff score of 80 or less and would receive a subindex score of 1.0. As upland land use changes (Figure 45) runoff increases the amount of water entering the wetland increases and the subindex decreases linearly to zero.

Wetland Proximity ($V_{WETPROX}$). This variable is a measure of the proximity and distribution of similar depressional wetlands nearby. This is a critical landscape variable that affects the ability of species to move from one wetland to another. Measure the variable using the following procedure:

a. Using recent aerial photographs, topographic maps, National Wetland Inventory (NWI) maps, or other appropriate resources, divide the area surrounding the wetland being assessed into eight sections (Figure 46).

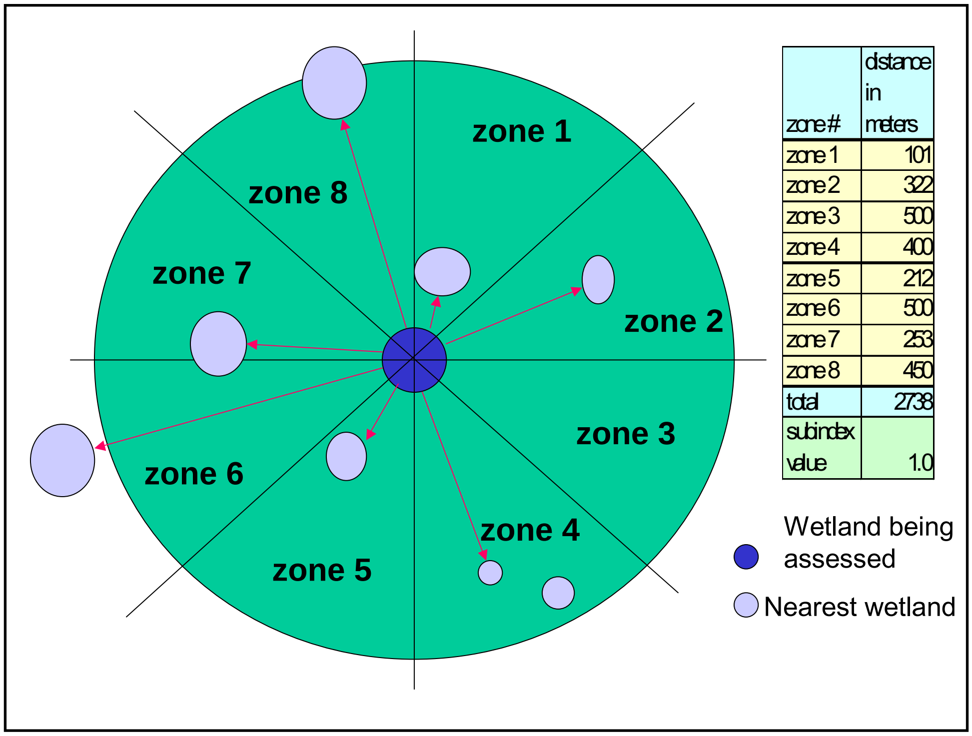


Figure 46. Example of reference standard condition for wetland proximity

b. Measure in meters the distance from the edge of the wetland being assessed to the edge of the nearest depressional wetland within each section and record on the field data sheet.

c. Record a distance of 500 m (1,640 feet) for any distance greater than 500 m.

d. Total the distances and using Figure 47, determine the variable subindex for wetland proximity.

e. Verify during field reconnaissance.

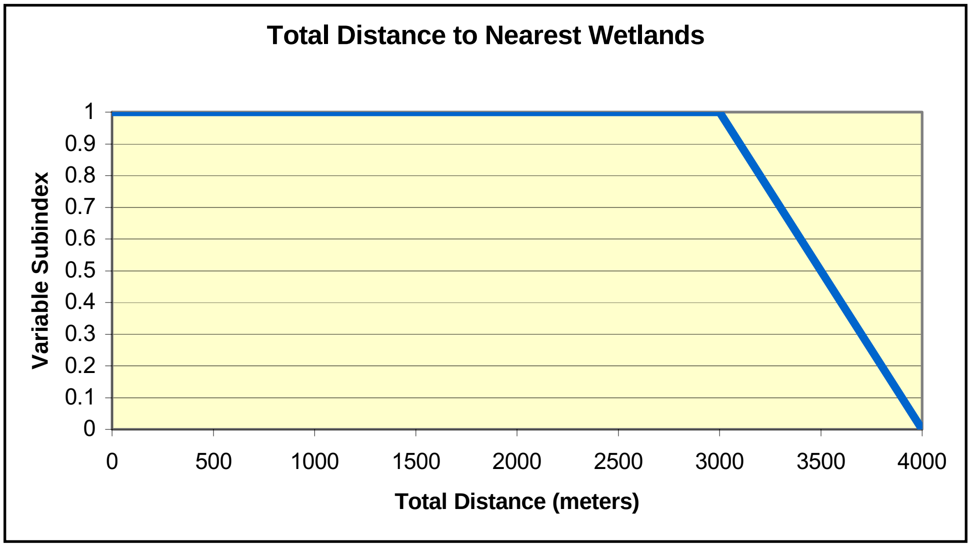


Figure 47. Relationship between proximity of nearest depressional wetlands and functional capacity

Depressional wetlands in peninsular Florida had a range in total distance to the nearest wetlands of 2,444 m (8,018 ft) to 3,872 m (12,703 ft) of a possible score of 4,000 m (13,123 ft) if the nearest wetland within each of the eight sections was 500 m or greater. Based on data from reference standard sites for depressional wetlands in peninsular Florida, a subindex score of 1.0 was assigned if total distance to the nearest wetlands was 3,000 m (9,843 ft) or less.

Macrophytic Vegetation Cover (V_{MAC}). This variable represents the total cover of macrophytic vegetation in the wetland. This variable is defined as the average percent cover of macrophytic vegetation <1 m (3.3 ft) in height along multiple transects within each zone.

Percent cover of macrophytic vegetation is used to quantify this variable. Measure it using the following procedure:

a. Using the point intercept method described in Chapter 5, identify five or more points along four or more transects that cross each wetland zone (Mitchell and Hughes 1995). Using this method at least 20 sampling points should be identified within each wetland zone. Record each point that intercepts macrophytic vegetation (Figure 26). Data Form 4 (Figure 61, discussed in Chapter 5) can be used for recording point data.

b. Multiply the number of points intercepted by macrophytic vegetation by 5 or the appropriate percent for the number of points collected. For example, if 16 of the 20 sampling points in the wet meadow zone were intercepted by macrophytic vegetation, the percent cover estimate would be 80 percent.

c. Average the percent cover of all wetland zones present and report macrophytic vegetation cover as a percent between 0 and 100.

d. Using Figure 48 for the wet meadow zone, the shallow marsh zone, or the deep marsh zone, determine the subindex score for percent cover of macrophytic vegetation.

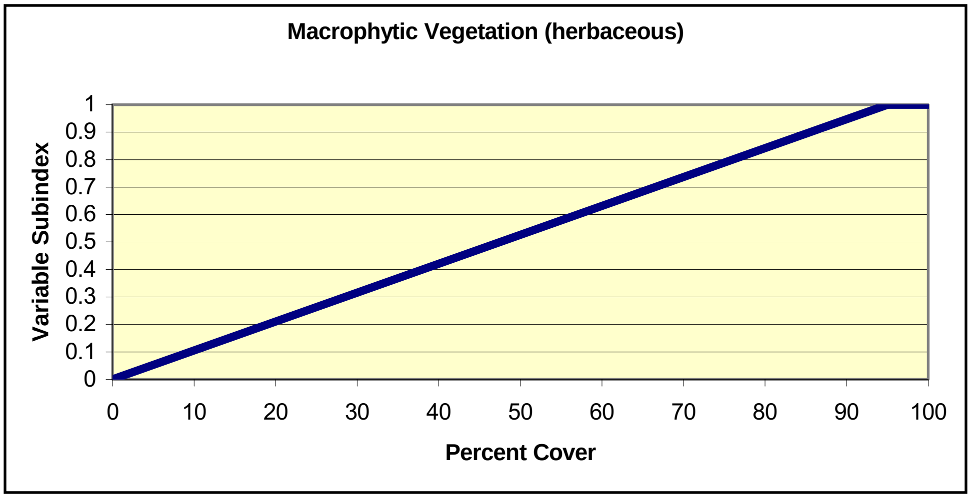


Figure 48. Relationship between macrophytic vegetation and functional capacity for herbaceous depressions, Function 5

In the herbaceous reference wetlands, macrophytic vegetation cover ranged from 40 to 100 percent in all zones for herbaceous wetlands. Based on data from reference standard wetlands sites, a variable subindex of 1.0 is assigned to wetland sites with macrophytic vegetative cover between 95 and 100 percent (Figure 48) for the wet meadow, shallow marsh, and deep marsh zones. Zero percent cover of macrophytic vegetation, while not measured, would indicate severely altered conditions. The rate at which the subindex decreases is based on the assumption that the relationship between percent cover of macrophytic vegetation and nutrient cycling is linear. These assumptions could be validated using the independent, quantitative measures of function defined previously.

Cypress Canopy (V_{CANOPY}). This variable represents the total cover of cypress trees in the cypress tree zone, and is defined as the average percent cover of cypress trees along selected transects within the cypress tree zone of cypress domes.

Percent cover of cypress trees is used to quantify this variable. Measure it using the following procedure:

a. Using the step point procedure described in Chapter 5, the section "Collect Field Data," estimate the percent cover of cypress trees with the cypress zone along the selected transects.

b. Average the percent cover of cypress trees along all transects.

c. Report cypress tree cover as a percent between 0 and 100.

d. Using Figure 49, determine the subindex score for the percent cover of cypress trees in the cypress tree zone.

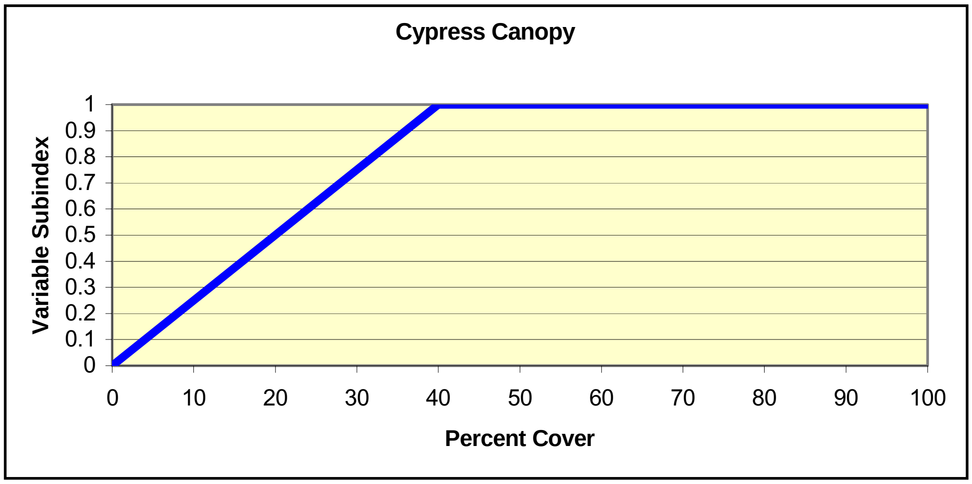


Figure 49. Relationship between cypress canopy cover and functional capacity, Function 5

In Cypress Dome Reference Wetlands the percent cover of cypress trees ranged from 17 to 48 percent. Based on the data from reference standard sites, a variable subindex score of 1.0 would be assigned when the percent cover of cypress trees is between 40 and 100 percent (Figure 49). Zero percent cover of cypress trees, while not measured, would indicate severely altered conditions. As percent cover of cypress trees decreases below 40 percent, a linearly decreasing subindex score down to zero is assigned at 0 percent cover of cypress trees. This is based on the assumption that the decrease in cypress tree cover indicates an increase in the amount of evapotranspiration (Heimburg 1984). The rate at which the subindex decreases and the selection of zero as variable subindex end point at zero percent cover are based on the assumption that the relationship between percent cover of cypress trees and increased evapotranspiration is linear. These assumptions could be validated using the independent quantitative measures of function in the definition of the function.

Tree Basal Area (V_{TBA}). Trees are defined as living woody stems $\geq$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 (Bonham 1989; Spurr and Barnes 1981; Tritton and Hornbeck 1982; Whittaker 1975; Whittaker et al. 1974). Tree basal area per hectare is the metric used to quantify this variable. Measure it using the following procedure:

a. Measure the diameter of all trees (living woody stems $\geq$10 cm or 4 in.) at breast height (dbh) in a circular 0.04-ha plot with a radius of 11.3 m (37 ft) or a square 20 m by 20 m at the midpoint along each transect within the cypress zone. Record tree species with corresponding diameter measurement in the table on Data Form 3 (Figure 60, discussed in Chapter 5). Accurate identification of woody species is critical for determining the dominant species in each plot. Sampling during the dormant season may require proficiency in recognizing plant form, bark, or dormant/dead plant parts. Users who do not feel confident in identifying trees should seek assistance. An electronic version of Data Form 3 is available at *http://www.wes.army.mil/el/wetlands/datanal.html* to complete the calculations in Steps *b-e*:

b. Convert the dbh measurement for each woody stem to square centimeters using the following formula: (dbh * dbh) * 0.25 * 3.14 = cm^2.

c. Convert the area of each woody stem in cm^2 to square meters using the following formula: cm^2 * 0.0001 = m^2.

d. Sum the m^2 measurements of all woody stems from the 0.04-ha plots to give m^2/0.04 ha.

e. Multiply by 25 to convert to m^2/ha.

f. Record this value as basal area/ha on the field data sheet.

g. Average the plot values on the field data sheet.

h. Using Figure 50 determine the variable subindex for tree biomass.

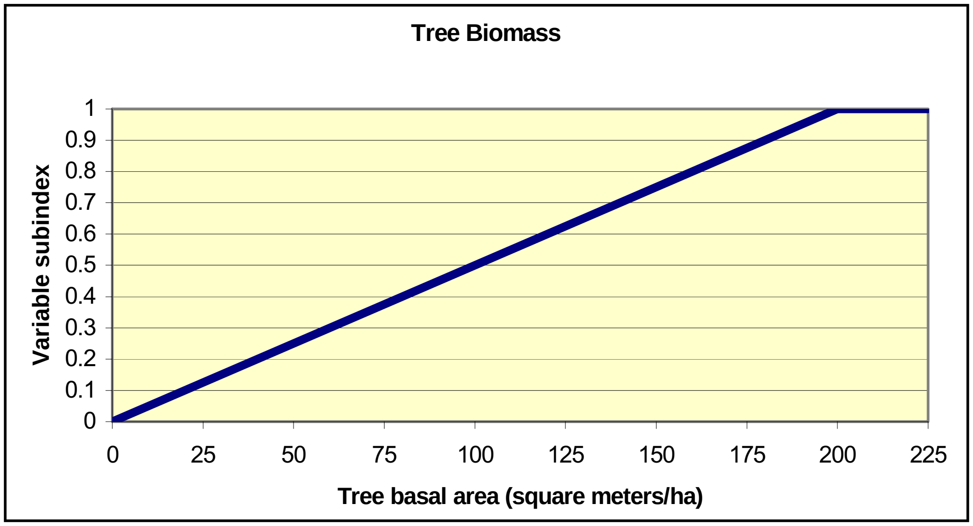


Figure 50. Relationship between tree basal area and functional capacity, Function 5

The number of 0.04-ha plots required to adequately characterize the depression being assessed will depend on the size and heterogeneity. Chapter 5, “Assessment Protocol,” provides guidance for determining the number and layout of sample points and sampling units.

This variable applies only to Cypress Dome Depressions within this guidebook. In cypress dome depressions in peninsular Florida, tree basal area ranged from 32 to 211 m^2/ha. Based on the data from reference standard sites supporting mature, fully stocked forests, a variable subindex of 1.0 is assigned when tree basal area is $\geq$200 m^2/ha (Figure 50). At reference sites in middle to early stages of succession, logged, or cleared for agriculture, tree basal area decreases linearly to zero at zero tree basal area. This is based on the assumption that the relationship between tree basal area and the capacity of the cypress dome to cycle nutrients is linear.

Herbaceous Plant Species Composition (V_{HCOMP}). Plant species composition represents the dominance of certain native wetland plants in proportion to sites representing those with the least disturbance in herbaceous wetlands. Ideally, plant species composition would be determined with intensive sampling of herbaceous species within each wetland zone. Unfortunately, the time and taxonomic expertise required to accomplish this are not available in the context of rapid assessment. Thus, the focus here is on the dominant species in the herbaceous strata within each wetland zone.

Percent concurrence with the dominant species in the herbaceous stratum for each wetland zone is used to quantify this variable. Measure it with the following procedure:

a. Identify the dominant species in the ground vegetation strata using the 50/20 rule.[1] To apply the 50/20 rule, rank species from the herbaceous stratum in descending order of abundance from each wetland zone. Identify dominants by summing the relative abundances beginning with the most abundant species in descending order until 50 percent is exceeded. Additional species with $\geq$20 percent relative abundance should also be considered as dominants. If no species is equal to or greater than 20 percent, then identify the species with the greatest percent cover. Accurate species identification is critical for determining the dominant species in each plot. Sampling during the dormant season or after a fire may require a high degree of proficiency. Users who do not feel confident in identifying herbaceous plant species should get help with plant identification.

b. Calculate percent concurrence by comparing the list of dominant plant species to the list of dominant species from each wetland zone in reference standard wetlands. Use Table 23 for the wet meadow zone, Table 24 for the shallow marsh zone, and Table 25 for the deep marsh zone. For example, if all the dominants from the area being assessed occur on the list of dominants from reference standard wetlands, then there is 100 percent concurrence. If three of the five dominant species from the area being assessed occur on the list, then there is a 60 percent concurrence.

c. Report concurrence of species dominants as a percent for each wetland zone present.

d. Average the percents and using Figure 51, determine the variable subindex for herbaceous plant species composition.

In the herbaceous reference wetlands, percent concurrence with dominant species ranged from zero to 100 percent for each wetland zone. Based on the data from reference standard sites a variable subindex of 1.0 is assigned when concurrence with dominant species is 100 percent for all wetland zones (Figure 52). As percent concurrence decreases, a linearly decreasing subindex down to zero is assigned based on the assumption that the relationship between plant species

---

[1] Memorandum, 6 March 1992, Office, Chief of Engineers, Clarification of Use of the 1987 Delineation Manual.

Table 23
Herbaceous Dominant Plant Species (Wet Meadow), Function 5

Scientific Name	Common Name
Amphicarpum muhlenbergianum	muhlenberg maidencane
Andropogon virginicus	broomsedge bluestem
Asclepias pedicellata	savannah milkweed
Carex squarrosa	squarrose sedge
Eleocharis microcarpa	smallfruit spikerush
Eriocaulon compressum	flattened pipewort
Gratiola ramose	branched hedgehyssop
Hypericum fasciculatum	peelbark St. Johnswort
Hyptis alata	clustered bushmint
Oxypolis filiformis	water cowbane
Panicum hemitomon	maidencane
Panicum rigidulum	redtop panicgrass
Pluchea rosea	rosy camphorweed
Polygala rugelii	yellow milkwort
Rhynchospora fascicularis	fascicled beaksedge
Sabatia grandiflora	largeflower rose gentian
Spartina bakeri	sand cordgrass
Xyris elliottii	Elliots yelloweyed grass

Table 24
Herbaceous Dominant Plant Species (Shallow Marsh), Function 5

Scientific Name	Common Name
Bacopa caroliniana	blue waterhyssop
Cladium jamaicense	sawgrass
Eriocaulon compressum	flattened pipewort
Iris hexagona	Dixie iris
Juncus effuses	common rush
Lachnanthes caroliana	Carolina redroot
Nymphoides aquatica	big floatingheart
Panicum hemitomon	maidencane
Panicum rigidulum	redtop panicgrass
Rhynchospora inundata	narrowfruit horned beaksedge
Rhynchospora nitens	shortbeak beaksedge
Rhynchospora tracyi	Tracy's breaksedge

Table 25
Herbaceous Dominant Plant Species (Deep Marsh), Function 5

Scientific Name	Common Name
Hibiscus grandiflorus	swamp rosemallow
Lachnanthes caroliana	Carolina redroot
Nelumbo lutea	American lotus
Nymphoides aquatica	big floatingheart
Panicum hemitomon	maidencane
Pontederia cordata	pickerelweed
Rhynchospora inundata	narrowfruit horned breaksedge
Sagittaria lancifolia	bulltongue arrowhead
Thalia geniculata	bent alligator-flag

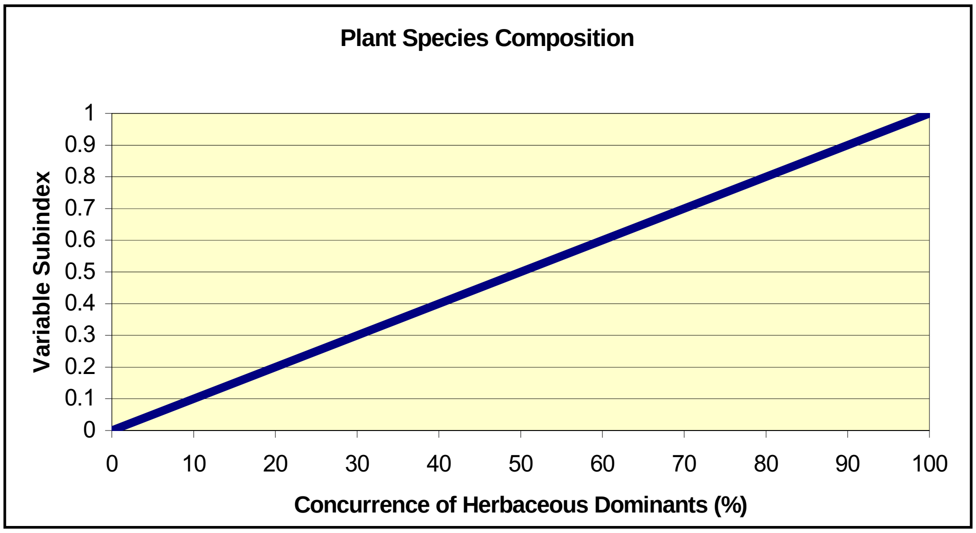


Figure 51. Relationship between percent concurrence of herbaceous dominants and functional capacity

Figure 52. Herbaceous depression dominated by *Panicum hemitomon (*maidencane) and *Hypericum fasciculatum (*peelbark St. Johnswort)

composition and the capacity of herbaceous wetlands to maintain a characteristic plant community is linear (Figure 51).

Tree Species Composition (V_{TCOMP}). Plant species composition represents the dominance of certain native wetland trees in proportion to sites representing those with the least disturbance in cypress dome wetlands. Ideally, tree species composition would be determined with intensive sampling of tree species within the tree zone. Unfortunately, the time and taxonomic expertise required to accomplish this are not available in the context of rapid assessment. Thus, the focus here is on the dominant species in the tree strata within the tree wetland zone.

Percent concurrence with the dominant species in the herbaceous stratum for each wetland zone is used to quantify this variable. Measure it with the following procedure:

a. Identify the dominant species in the tree strata using the 50/20 rule.[1] To apply the 50/20 rule, rank species from the tree stratum in descending order of abundance from each wetland zone. Identify dominants by summing the relative abundances beginning with the most abundant species in descending order until 50 percent is exceeded. Additional species with $\geq$20 percent relative abundance should also be considered as dominants. If no species is equal to or greater than 20 percent then identify the species with the greatest percent cover. Since *Taxodium ascendens* (pond cypress) or *Taxodium distichum* (bald cypress) are the only tree species dominant in the tree zone of reference standard sites, species identification is relatively easy. However, users who do not feel confident in identifying herbaceous plant species should get help with plant identification.

b. Calculate percent concurrence by comparing the list of dominant plant species to the list of dominant species from the tree zone in reference standard cypress dome wetlands. Use Table 26 to compare the list of dominants to those species found in reference standard sites. For example, if all the dominants from the area being assessed occur on the list of dominants from reference standard wetlands, then there is 100 percent concurrence. If one of the five dominant species from the area being assessed occur on the list, then there is a 20 percent concurrence.

Table 26
Tree Dominant Plant Species (Tree Zone)

Scientific Name	Common Name
Taxodium ascendens	pond cypress
Taxodium distichum	bald cypress

c. Report concurrence of species dominants as a percent for the tree zone.

d. Use Figure 53 to determine the variable subindex for herbaceous plant species composition of the tree zone in cypress dome depressional wetlands.

In the herbaceous reference wetlands, percent concurrence with dominant species ranged from zero to 100 percent for each wetland zone. Based on the data from reference standard sites a variable subindex of 1.0 is assigned when concurrence with dominant species is 100 percent for all wetland zones. As percent concurrence decreases, a linearly decreasing subindex down to zero is assigned based on the assumption that the relationship between plant species composition and the capacity of herbaceous wetlands to maintain a characteristic plant community is linear (Figure 53).

[1] Memorandum, 6 March 1992, Office, Chief of Engineers, Clarification of Use of the 1987 Delineation Manual.

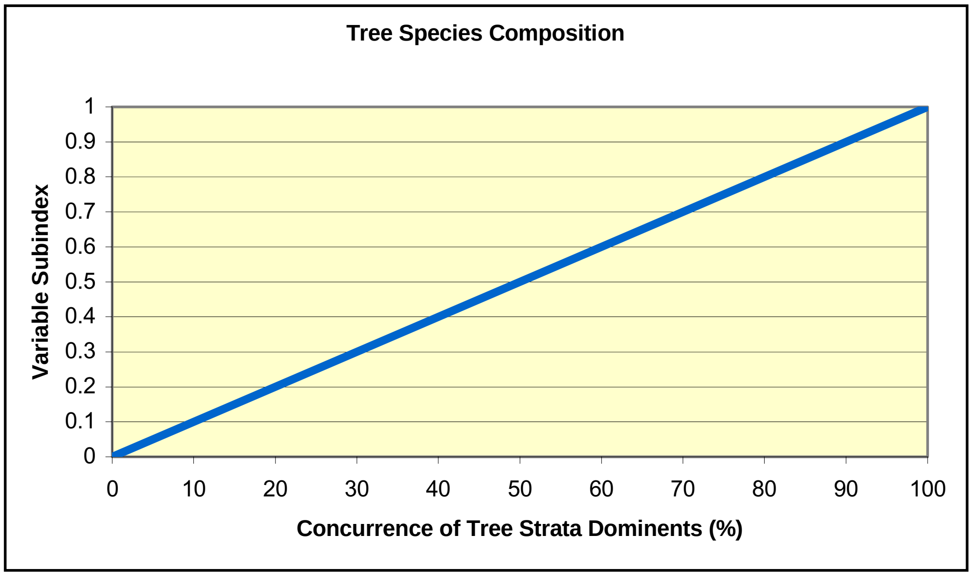


Figure 53. Relationship between percent tree strata species concurrence in the tree zone of cypress domes and functional capacity, Function 5

Surface Soil Texture (V_{SURTEX}). This variable is defined as the USDA soil texture of the surface horizon, or layer, of the soil. Soil is the medium in which water is stored. Altering the soil texture of the soil through anthropogenic activities (e.g., fill, excavation) changes the capacity of the water storage. If no anthropogenic activities have occurred within the wetland, the variable subindex can be assumed to be 1.0. If such activities have occurred in the wetland, use the following procedure to determine this variable:

a. During the step point transects, at the midpoint of each wetland zone estimate the texture class of the surface horizon using the feel method. Chapter 5, "Assessment Protocol," provides guidance for location of the sample point. Appendix C describes the procedure for estimating textural class using the feel method.

b. Using Table 27, assign a score for each texture class found.

c. Determine the subindex by averaging the scores from each point sampled.

Soil texture in depressional wetlands ranged from sand to clay and muck. Based on reference standard sites, textures were sand, muck, or mucky sand for cypress domes and sand, sandy loam, or loamy sand in herbaceous depressions. Other USDA textural classes received categorically lower scores down to zero for gravel or pavement.

Table 27
Soil Surface Texture for Cypress Dome Wetlands, Function 5

Soil Texture	Variable Subindex
Sand	1.0
Loamy sand	1.0
Sandy loam	1.0
Muck *	0.9
Sandy clay	0.9
Silt	0.8
Silt loam	0.7
Loam	0.6
Sandy clay loam	0.5
Clay loam	0.4
Silty clay loam	0.4
Clay	0.2
Silty clay	0.1
Gravel * ($\geq$ 90% gravel)	0.0
Pavement *	0.0

* Term used in lieu of texture.

Functional Capacity Index

The assessment models for calculating the FCI are as follows:

a. For Herbaceous Depressional Wetlands:

$$FCI = \left\{ \left[\frac{\left(\frac{V_{SUBOUT} + V_{ZONES}}{2} \right) + \left(\frac{V_{UPUSE} + V_{WETPROX}}{2} \right)}{2} \right] \times \left[\frac{\left(\frac{V_{MAC} + V_{HCOMP}}{2} \right) + V_{SURTEX}}{2} \right] \right\}^{1/2} \quad (8)$$

b. For Cypress Dome Depressional Wetlands:

$$FCI = \left\{ \left[\frac{\left(\frac{V_{SUBOUT} + V_{ZONES}}{2} \right) + \left(\frac{V_{UPUSE} + V_{WETPROX}}{2} \right)}{2} \right] \times \left[\frac{\left(\frac{V_{CANOPY} + V_{TBA}}{2} \right) + V_{TCOMP} + V_{SURTEX}}{3} \right] \right\}^{1/2} \quad (9)$$

These models are assumed to reflect the habitat that is necessary to provide food, cover, and nesting opportunities for birds and other wildlife species native to depressional wetland ecosystems in peninsular Florida. If all the components are similar to reference standard conditions, there is a high probability that native wildlife species will use the site. The variables have been grouped by the major components: landscape, hydrology, soils, and biotic community. It should be noted that the emphasis is on onsite conditions. Even in largely fragmented landscapes if reference standard conditions exist onsite, the majority of wildlife species will use the site during certain seasons or for part of their life cycle.

Alteration to the wetland hydrology is reflected in subsurface drainage (V_{SUBOUT}) and can result in a Change in the Number of Wetland Zones (V_{ZONES}). Changes in hydrology may have little immediate effect on the wildlife habitat, but will impact the ability to maintain a habitat for wildlife over time. The removal of one or more wetland zones reduces the available habitats for wildlife species to move into as the wetland dries. Equally important, the addition of wetland zones could potentially provide habitat for predatory wildlife species that would not normally be found in the wetland being assessed.

The variables measuring connectedness to other habitats Upland Land Use (V_{UPUSE}) and the proximity of adjacent depressional wetlands ($V_{WETPROX}$) reflect landscape scale attributes of the wetland. The assumption is that the nearby wetlands of a similar type are important for wildlife, especially amphibians and reptiles, to move to an alternate wetland habitat as one wetland dries and the natural surrounding landscape is important to connect the wetlands.

The habitat structure is represented by the individual components V_{MAC}, V_{CANOPY}, and V_{TBA} that are appropriate for each subclass. V_{HCOMP} or V_{TCOMP} represents the native species diversity.

Soil Surface Texture (V_{SURTEX}) is used in this function as an indication of habitat for invertebrates that live in the soils and as an indication of the site to be inundated.

In the first subpart of the equation, the hydrology features (V_{SUBOUT} and V_{ZONES}) are considered equally and are averaged. In the second subpart of the equation, the landscape level features (V_{UPUSE} and $V_{WETPROX}$) are considered separately from the first subpart, and are averaged as well. The two subparts are combined using an arithmetic mean. In the second part of the equation V_{MAC} and V_{HCOMP} or V_{CANOPY} and V_{TBA}, depending on the subclass, represent the plant community structure. Each variable is considered to exert an equivalent influence on the function and are averaged. In the equation for Herbaceous Depressional Wetlands V_{SURTEX} is considered as important as the combination of the vegetative structure and is combined using an arithmetic mean. For Cypress Domes V_{SURTEX} and V_{TCOMP} are considered equal to the combination of canopy cover (V_{CANOPY}) and tree basal area (V_{TBA}). In Cypress Domes the three components are averaged. The combination of landscape and hydrology components are multiplied by the combination of the vegetation and soils and averaged by a geometric mean. This arrangement of the aggregation equation reflects the assumption that site-specific aspects of the habitat (i.e., biotic community/habitat structure) carry greater weight than landscape features. In other words, if the onsite community is degraded, the use of the wetland by wildlife species will decrease in a relatively unfragmented landscape with intact hydrology.

5 Assessment Protocol

Introduction

Previous chapters of this Regional Guidebook provide background information on the HGM Approach, and document the variables, measures, and models used to assess the functions of Herbaceous and Cypress Dome wetlands. This chapter outlines a protocol for collecting and analyzing the data necessary to assess the functional capacity of a wetland in the context of a 404 permit review process or similar assessment scenario. The typical assessment scenario is a comparison of preproject and postproject conditions in the wetland. In practical terms, this translates into an assessment of the functional capacity of the WAA under both preproject and postproject conditions and the subsequent determination of how FCIs have changed as a result of the project. Data for the preproject assessment are collected under existing conditions at the project site, while data for the postproject assessment are normally based on the conditions that are expected to exist following proposed project impacts. A skeptical, conservative, and well-documented approach is required in defining postproject conditions. This recommendation is based on the often-observed lack of similarity between predicted or engineered postproject conditions and actual postproject conditions. This chapter discusses each of the tasks required to complete an assessment of depressional wetlands:

a. Define assessment objectives.

b. Characterize the project site.

c. Screen for red flags.

d. Define the Wetland Assessment Area.

e. Collect field data.

f. Analyze field data.

g. Apply assessment results.

Define Assessment Objectives

Begin the assessment process by unambiguously identifying the purpose for conducting the assessment. This can be as simple as stating, “The purpose of this assessment is to determine how the proposed project will impact wetland functions.” Other potential objectives could be as follows:

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

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

c. Document baseline conditions at the wetland site.

d. Determine mitigation requirements.

e. Determine mitigation success.

f. Determine the effects of a wetland management technique.

Characterize the Project Area

Characterizing the project area involves describing the project area in terms of climate, surficial geology, geomorphic setting, surface and groundwater hydrology, vegetation, soils, land use, proposed impacts, and any other characteristics and processes that have the potential to influence how wetlands at the project area perform functions. The characterization should be written, and accompanied by maps and figures that show project area boundaries, jurisdictional wetlands, WAA (discussed later in this chapter), proposed impacts, roads, ditches, buildings, streams, soil types, plant communities, threatened or endangered species habitat, and other important features. Some information sources that will be useful in characterizing a project area are aerial photographs, topographic and NWI maps, and county soil surveys.

Screen for Red Flags

Red flags are features within or in the vicinity of the project area to which special recognition or protection has been assigned on the basis of objective criteria (Table 28). Many red flag features, such as those based on national criteria or programs, are similar from region to region. Other red flag features are based on regional or local criteria. Screening for red flag features represents a proactive attempt to determine if the wetlands or other natural resources in and around the project area require special consideration or attention that may preempt or postpone an assessment of wetland function. If a red flag feature exists, the assessment of wetland functions may not be necessary if the project is unlikely to occur as a result of the red flag feature. For example, if a proposed project has the potential to impact a threatened or endangered species or habitat, an assessment of wetland functions may be unnecessary since the project may be denied or modified strictly on the basis of the impacts to threatened or endangered species or habitat.

Define the Wetland Assessment Area

The WAA is an area of wetland within a project area that belongs to a single regional wetland subclass, and is relatively homogeneous with respect to the site-specific criteria used to assess wetland functions (i.e., hydrologic regime, vegetation structure, topography, soils, successional stage, etc.). In many project

Table 28
Red Flag Features and Respective Program/Agency Authority

Red Flag Features	Authority[1]
Native Lands and areas protected under American Indian Religious Freedom Act	A
Hazardous waste sites identified under Comprehensive Environmental Response, Compensation, and Liability Act (Super Fund) (CERCLA) or Resource Conservation and Recovery Act (RCRA)	H
Areas protected by a Coastal Zone Management Plan	D
Areas providing Critical Habitat for Species of Special Concern	I
Areas covered under the Farmland Protection Act	K
Floodplains, floodways, or floodprone areas	J
Areas with structures/artifacts of historic or archeological significance	F
Areas protected under the Land and Water Conservation Fund Act	K
Areas protected by the Marine Protection Research and Sanctuaries Act	D
National wildlife refuges and special management areas	I
Areas identified in the North American Waterfowl Management Plan	I
Areas identified as significant under the Ramsar Treaty	
Areas supporting rare or unique plant communities	
Areas designated as Sole Source Groundwater Aquifers	I
Areas protected by the Safe Drinking Water Act	
City, County, State, and National Parks	F, C, L
Areas supporting threatened or endangered species	B, C, E, G, I
Areas with unique geological features	
Areas protected by the Wild and Scenic Rivers Act	
Areas protected by the Wilderness Act	

[1] Program Authority / Agency
A = Bureau of Indian Affairs
B = National Marine Fisheries Service (NMFS)
C = U.S. Fish and Wildlife Service
D = National Park Service (NPS)
E = State Coastal Zone Office
F = State Department of Natural Resources, Fish and Game, etc.
G = State Historic Preservation Officer (SHPO)
H = State Natural Heritage Offices
I = U.S. Environmental Protection Agency
J = Federal Emergency Management Administration
K = Natural Resources Conservation Service
L = Local Government Agencies

areas, there will be just one WAA representing a single wetland subclass as illustrated in Figure 54. 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 or Partial Wetland Assessment Areas (PWAAs) within a project area. At least three situations necessitate defining and assessing multiple PWAAs within a project area.

The first situation exists when widely separated wetland patches of the same regional subclass occur in the project area (Figure 55). The second situation exists when more than one regional wetland subclass occurs within a project area (Figure 56). The third situation exists when a physically contiguous wetland area of the same regional subclass exhibits spatial heterogeneity with respect to hydrology, vegetation, soils, disturbance history, or other factors that translate

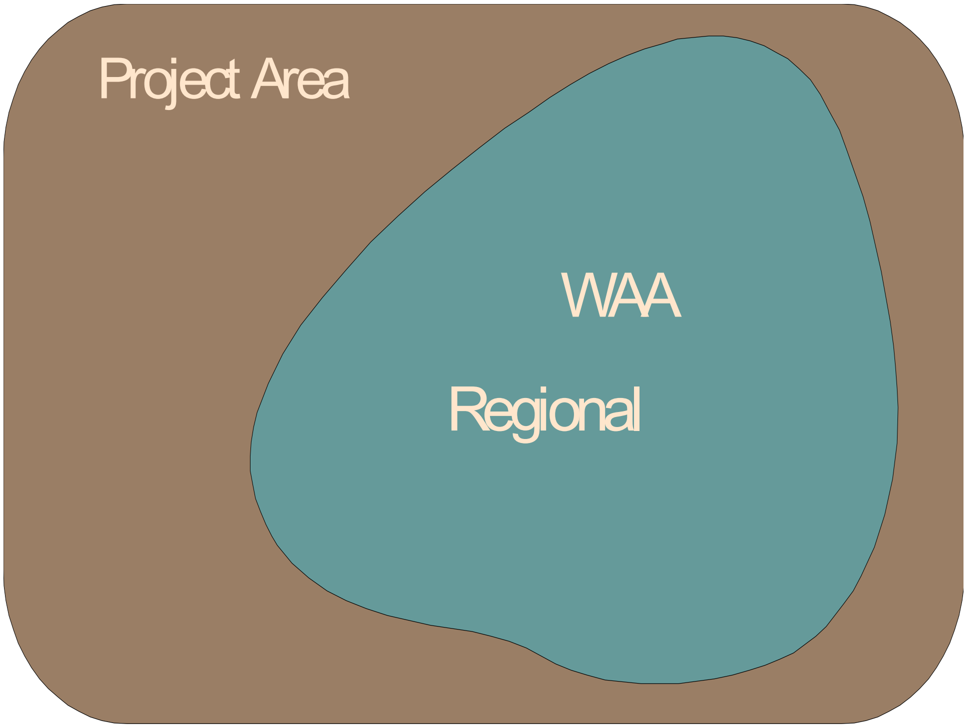


Figure 54. A single WAA within a project area

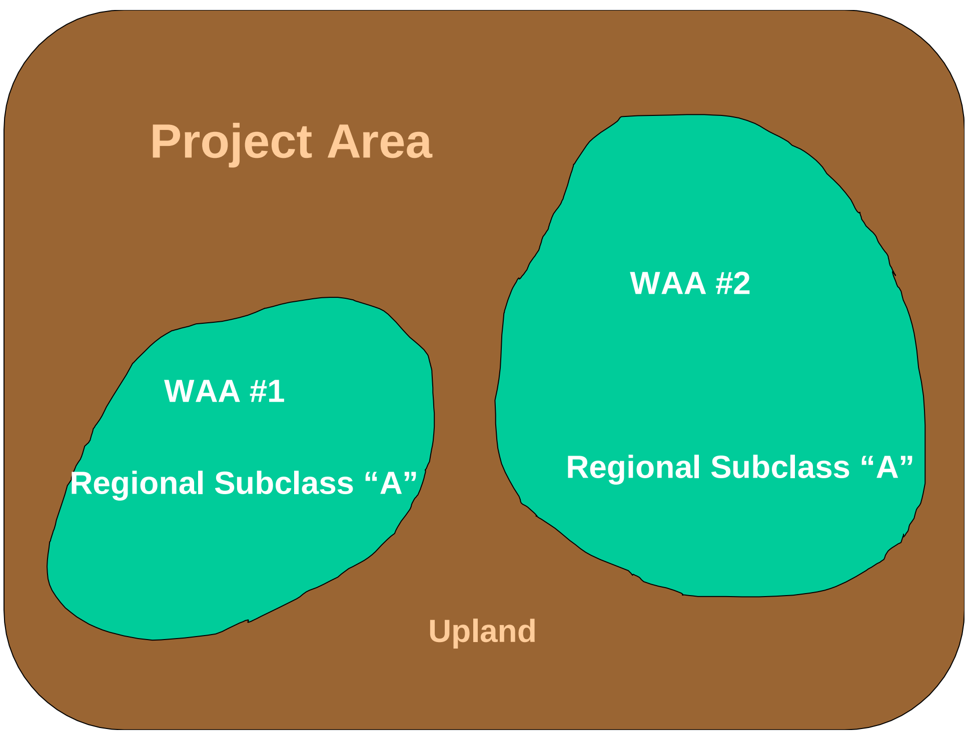


Figure 55. Spatially separated WAAs from the same regional wetland subclass within a project area

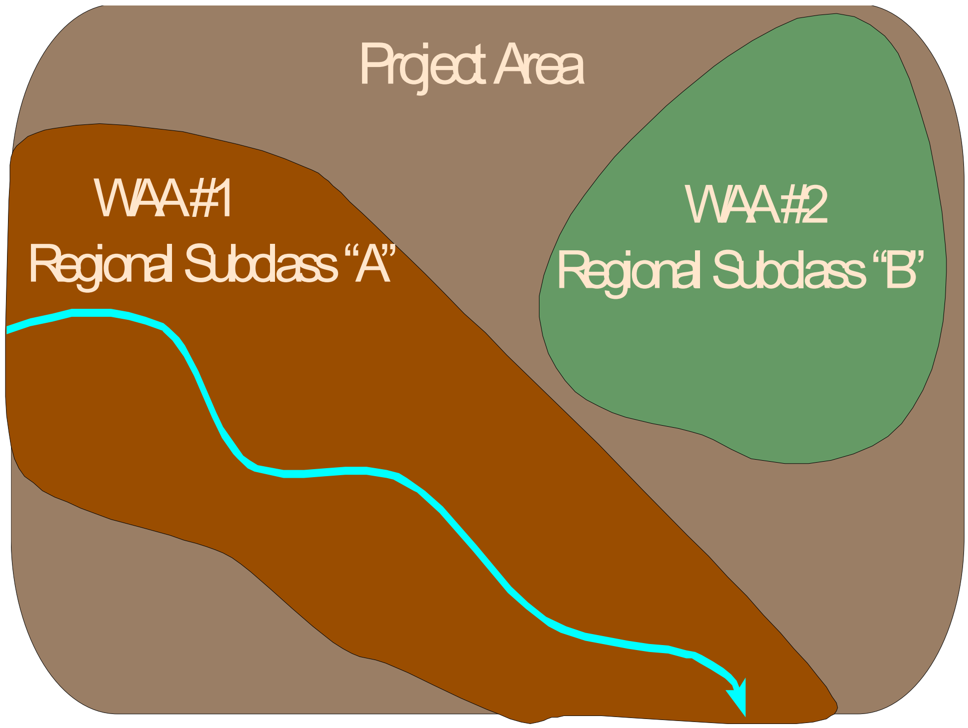


Figure 56. More than one regional subclass within a project area

into a significantly different value for one or more of the site-specific variable measures. These differences may be a result of natural variability (e.g., zonation on large river floodplains) or cultural alteration (e.g., logging, surface mining, hydrologic alterations) (Figure 57). Designate each of these areas as a separate PWAA and conduct a separate assessment on each area.

There are elements of subjectivity and practicality in determining what constitutes a significant difference in portions of the WAA. Field experience with the regional wetland subclass under consideration should provide the sense of the range of variability that typically occurs, and the common sense necessary to make reasonable decisions about defining multiple PWAAs. Splitting an area into many PWAAs in a project area based on relatively minor differences resulting from natural variability should not be used as a basis for dividing a contiguous wetland into multiple PWAAs. However, zonation caused by different hydrologic regimes or disturbances caused by rare and destructive natural events (i.e., hurricanes) should be used as a basis for defining PWAAs.

Determine Subclass

This guidebook describes two depressional wetland subclasses found in peninsular Florida. Determining the correct subclass is primary to completing an HGM assessment. The subclasses are based on dominant vegetation found on a

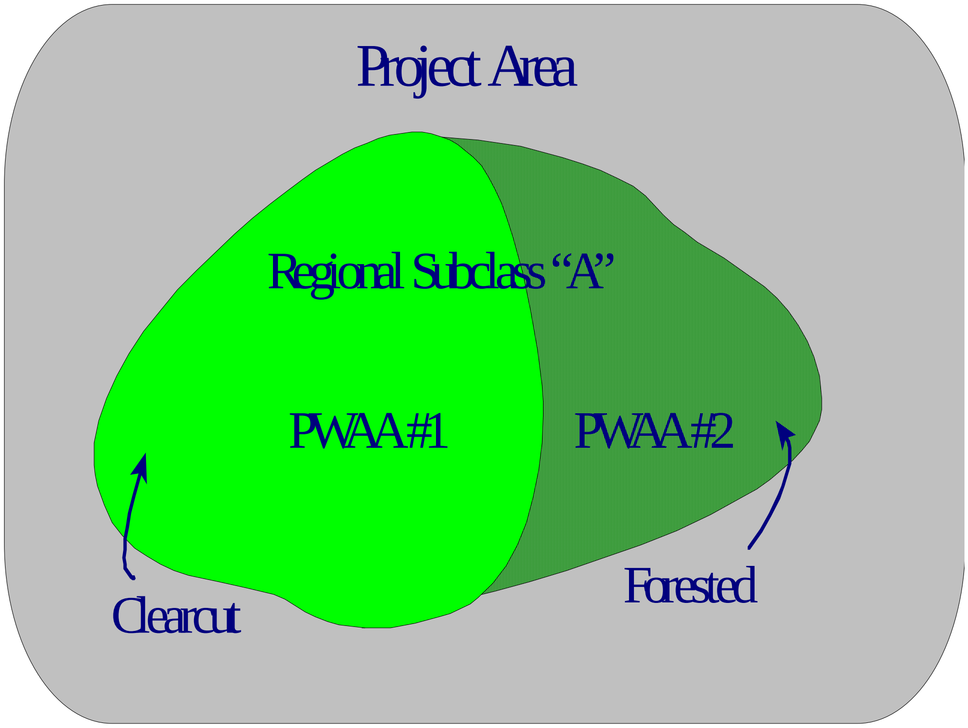


Figure 57. WAA defined based on differences in site-specific characteristics

site. Using current aerial photographs, topographic quads, soils maps, NWI maps, local knowledge, or other available information, determine if the depressional wetland is dominated by *Taxodium ascendens* (pond cypress), *Taxodium distichum* (bald cypress), or herbaceous vegetation. In some cases it will not be possible to determine the subclass from remotely sensed data, and onsite determination will be necessary to determine the wetland subclass. The subclasses of some extremely disturbed sites will be difficult to determine during an onsite examination. In these cases historical aerial photographs or knowledge from local experts will be helpful in determining the wetland subclass.

Collect Field Data

The following equipment is necessary to collect field data:

a. Plant identification keys.

b. Soil probe/sharpshooter shovel.

c. A 50-m-distance measuring tape, stakes, and flagging.

Information about the variables that are used to assess the function of depressional wetlands is collected at several different spatial scales. The field data sheets shown in Figures 58-61 are organized to facilitate data collection at each spatial scale. Information about landscape scale variables (i.e., variables 1-3 on the field data sheet) such as $V_{WETPROX}$ is collected using aerial photographs,

Herbaceous Field Data Sheet **Assessment Team:____** **Project Name:____** **Location:____** **Date:____Subclass: herbaceous depression**				
Sample variables 1-3 using aerial photography, topographic maps, National Wetland Inventory maps, soils survey maps, etc.				
1.	V_{CATCH}	Percent change in the size of the catchment (if no impact to catchment, variable subindex = 1.0)……………………………………………………………….….. Size of original catchment _______ha; Size of current catchment _______ ha	_____	%
2.	V_{UPUSE}	Percent cover of upland landuse (if native landscape in good condition, variable subindex = 1.0)…………………………………………………………………... Cover type _______ Curve #______ % ____Cover type ________ Curve #_____ % Cover type _______ Curve #______ % ____Cover type ________ Curve #_____ % Cover type _______ Curve #______ % ____Cover type ________ Curve #_____ % Cover type _______ Curve #______ % ____Cover type ________ Curve #_____ % Cover type _______ Curve #______ % ____Cover type ________ Curve #_____ %	_____	%
3.	$V_{WETPROX}$	Distance from wetlands edge to nearest depressional wetland within 500 m……… Sector 1 ______ m Sector 2 ______ m Sector 3 ________ m Sector 4 _______ m Sector 5 ______ m Sector 6 ______ m Sector 7 ________ m Sector 8 _______ m	_____	m
Sample variables 4-7 during on site field reconnaissance				
4.	V_{WETVOL}	Change in the volume of the wetland (if no fill or excavation variable subindex = 1.0)…………………………………………………………………………….. Diameter of wetland north-south ____m; Diameter of wetland north-south ____m Depth of the wetland__________m Length of fill material _____m; Width of fill material ____ m; Average thickness of fill material ____m	_____	% m
5.	V_{SUROUT}	Percent of wetland effected by lateral effect of ditches to surface water storage…... Difference in elevation of bottom of ditch and bottom of wetland ____m; Lateral effect of ditch _____ m; Distance of ditch to wetland _____ m	_____	%
6.	V_{SUBOUT}	Percent of wetland effected by lateral effect of ditches to subsurface water storage Difference in elevation of bottom of ditch and bottom of wetland + 6 in _____m; Lateral effect of ditch _____ m; Distance of ditch to wetland _____ m	_____	%
7.	V_{ZONES}	Change in the number of wetland zones (if no change in the number of zones variable subindex = 1.0)…………………………………………………………….		#
Sample variables 8-10 along 4 or more transects that cross each wetlands zone				
8.	V_{MAC}	Percent cover of emergent macrophytic vegetation…………………………………		%
10.	V_{SURTEX}	Average soil texture of surface horizon or layer of the WAA or PWAA………… Subindex score of sample point: Transect 1 zone1_____; zone2_____; zone3_____; zone 4_____ Transect 2 zone1_____; zone2_____; zone3_____; zone 4_____ Transect 3 zone1_____; zone2_____; zone3_____; zone 4_____ Transect 4 zone1_____; zone2_____; zone3_____; zone 4_____	_____	
13.	V_{HCOMP}	Average percent concurrence of dominant species from all wetland zones present.. Wet meadow zone __________ % Shallow marsh zone _________ % Deep marsh zone ___________ %	_____	%

Figure 58. Data Form 1, sample field data sheet for herbaceous depressional wetlands

Cypress Dome Field Data Sheet

Assessment Team:____
Project Name:____
Location:____
Date:_______________________________________Subclass: cypress dome

Sample variables 1-3 using aerial photography, topographic maps, National Wetland Inventory maps, soils survey maps, etc.

1.	V_{CATCH}	Percent change in the size of the catchment (if no impact to catchment, variable subindex = 1.0)…… Size of original catchment _______ha Size of current catchment _______ ha	_____	%
2.	V_{UPUSE}	Percent cover of upland landuse (if native landscape in good condition, variable subindex = 1.0)…… Cover type _______ Curve #______ % ____Cover type ________ Curve #____ % Cover type ______ Curve #______ % ____Cover type ________ Curve #_____ % Cover type ______ Curve #______ % ____Cover type _______ Curve #_____ % Cover type ______ Curve #______ % ____Cover type _______ Curve #_____ % Cover type ______ Curve #______ % ____Cover type _______ Curve #_____ %	_____	%
3.	$V_{WETPROX}$	Distance from wetlands edge to nearest depressional wetland within 500 m…….. Sector 1 m Sector 2 m Sector 3 m Sector 4 m Sector 5 m Sector 6 m Sector 7 m Sector 8 m	_____	m

Sample variables 4-7 during on site field reconnaissance

4.	V_{WETVOL}	Change in the volume of the wetland (if no fill or excavation variable subindex = 1.0)…….. Diameter of wetland north-south _____m; Diameter of wetland north-south ___m Depth of the wetland__________m Length of fill material _____m; Width of fill material ____ m; Average thickness of fill material ____m	______	%
5.	V_{SUROUT}	Percent of wetland effected by lateral effect of ditches to surface water storage….. Difference in elevation of bottom of ditch and bottom of wetland __________m; Lateral effect of ditch __________ m; Distance of ditch to wetland _________ m	______	%
6.	V_{SUBOUT}	Percent of wetland effected by lateral effect of ditches to subsurface water storage Difference in elevation of bottom of ditch and bottom of wetland + 6 in _____m; Lateral effect of ditch _________ m; Distance of ditch to wetland __________ m	______	%
7.	V_{ZONES}	Change in the number of wetland zones…….		#

Sample variables 8-11 along 4 or more transects that cross each wetlands zone

9.	V_{CANOPY}	Percent cover of cypress trees in the tree zone…...		%
10.	V_{SURTEX}	Soil texture of surface horizon or layer of the WAA or PWAA…… Subindex score of sample point: Transect 1 zone1_____; zone2_____; zone3_____; zone 4_____ Transect 2 zone1_____; zone2_____; zone3_____; zone 4_____ Transect 3 zone1_____; zone2_____; zone3_____; zone 4_____ Transect 4 zone1_____; zone2_____; zone3_____; zone 4_____	______	
11.	V_{TBA}	Average tree basal area within tree zone…… Plot 1______ m^2/ha; Plot 2_______ m^2/ha; Plot 3 _______ m^2/ha;Plot 4 ______ m^2/ha	______	m^2/ha
12.	V_{SSD}	Average % cover of emergent macrophytic and woody vegetation >1 m in height and <10 cm dbh……..		%
14.	V_{TCOMP}	Average percent concurrence of dominant species from the tree zone wetland zones…...		%

Figure 59. Data Form 2, sample field data sheet for cypress dome wetlands

Tree Basal Area Field Data Sheet

Assessment Team:____

Project Name:____

Location:____

Date:________________________________**Subclass: cypress dome**

Record the species and dbh (cm) of all trees (i.e., woody stems ≥ 10 cm (4 in.) in the plot within the tree zone

1 species code	**2** dbh (cm)	**3** area (cm^2)	**4** area (m^2)	**1** species code	**2** dbh (cm)	**3** area (cm^2)	**4** area (m^2)

Figure 60. Data Form 3, sample field data sheet for tree basal area for cypress dome wetlands

Transect Point Sampling Field Data Sheet

Assessment Team:____

Project Name:____

Location:____

Date:______________________________**Subclass:**

Record the transect #, zone (i.e., wet meadow, shallow marsh, deep marsh, tree), sample point, strata (i.e., herbaceous for herbaceous wetlands) (i.e., herbaceous, shrub, tree for cypress dome wetlands) and species

1	**2**	**3**	**4**	**5**	**6**			**7**
Transect #	zone	point #	# of species	species	% cover by point			% cover by species
					H	S	T	
Total herbaceous cover zone (%)								
Total shrub cover zone (%)								
Total tree cover zone (%)								

Figure 61. Data Form 4, sample point transect field data sheet for herbaceous and cypress dome depressional wetlands

maps, and field reconnaissance of the area surrounding the WAA. Subsequently, information about the WAA in general (i.e., variables 4-6) is collected during a walking reconnaissance of the WAA. Finally, detailed, site-specific information (i.e., variables 7-11 or 5-12) is collected using sample plots at a number of representative locations throughout the WAA.

Frequently, multiple purposes will be identified for conducting the assessment. Defining the purpose will facilitate communication and understanding among the people involved in conducting the assessment, and will make the purpose clear to other interested parties. In addition, it will help to establish the approach that is taken. The specific approach will vary to some degree depending on whether the project is a Section 404 permit review, an Advanced Identification (ADID), Special Area Management Plan (SAMP), or some other scenario.

After aerial photographs, topographic quads, soils maps, and NWI maps are acquired, the first step is to identify and delineate the WAA or PWAAs from locations provided and photo interpretation. Always use the best data available. If data are limited or questionable, the following procedures are recommended for gathering the necessary data in a timely manner. The variables Change in the Number of Wetland Zones (V_{ZONES}), Wetland Volume (V_{WETVOL}), Change in the Catchment Size (V_{CATCH}), and Surface Soil Texture (V_{SURTEX}) are disturbance variables, meaning that if no alteration has occurred onsite, then the subindex score will be 1.0.

The next step is to measure variables 1-9 using the equipment listed. It will usually be necessary to verify decisions made from photo interpretation in the field during field reconnaissance.

In herbaceous depressional wetlands variables 8, 10, and 13 or variables 9, 10, 11, 12, and 14 in cypress domes are measured along four or more transects that cross all wetland zones (Figure 62) using the step point sampling method (Mitchell and Hughes 1995).

The number and layout of transects are based on the size, shape, and complexity of the depression being assessed. Some large depressional wetlands greater than 20 ha (49 acres) may require more than four transects to characterize the current condition. Generally transects should be made along north-south and east-west directions for consistency, but impacts such as ditching, logging, placement of fill material, or wetland zones that are not continuous around the wetland may make this layout impractical. The number and placement of transects should be based on the complexity of the site and is up to the discretion of the assessment team.

In cypress domes it is necessary to locate 0.04-ha sample plots along the transects to sample V_{TBA}. These 20-m^2 plots should be near the midpoint along each transect within the tree zone. However, in some cypress domes the tree zone may be too small to place four 0.04-ha plots within the zone without overlapping the plots. In these wetlands the plots can be any combination that equals a 0.04-ha area.

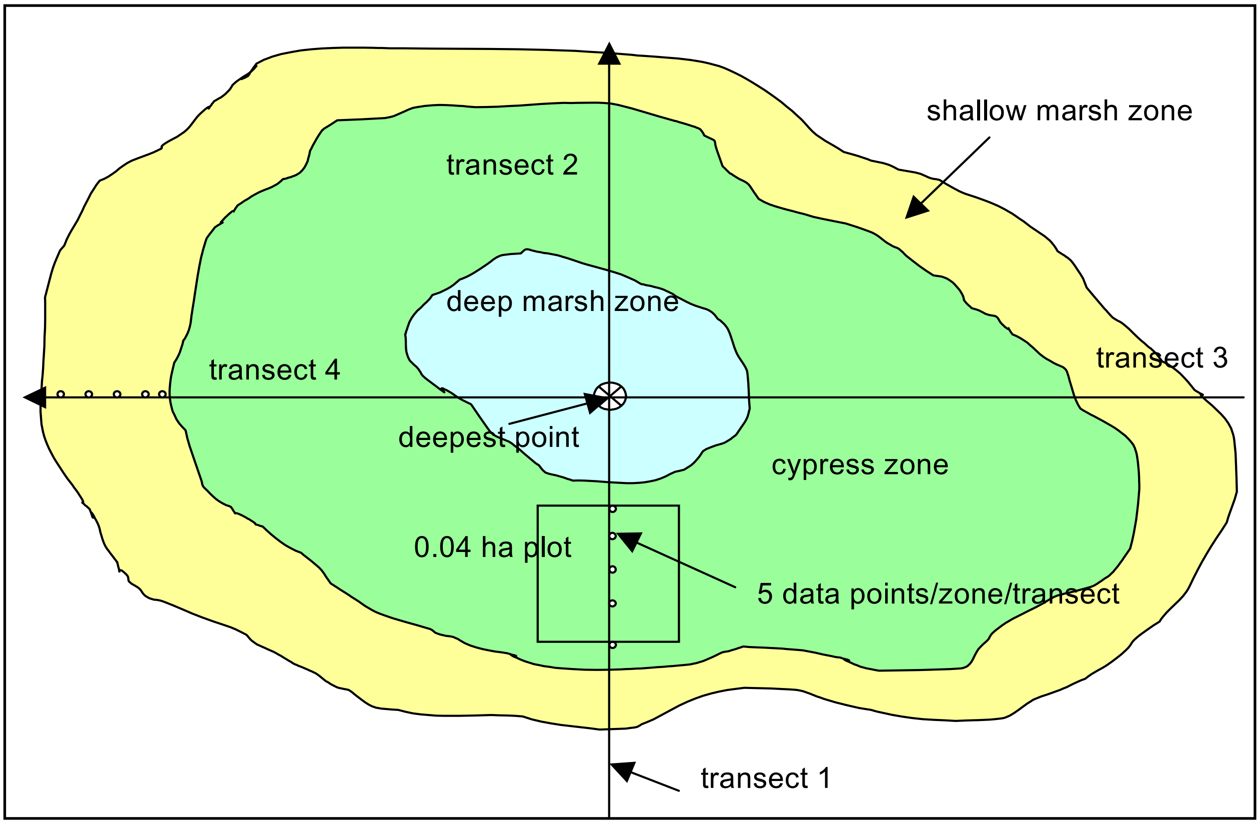


Figure 62. Example of sampling scheme for cypress dome wetland with three wetland zones

Analyze Field Data

The analysis of field data requires two steps. The first step is to transform the measure of each assessment variable into a variable subindex. This can be done using the graphs in Appendix B or in a spreadsheet that has been set up to do the calculations automatically. The second step is to insert the variable subindices into the assessment model and calculate the FCI using the relationships defined in the assessment models. Again, this can be done manually or automatically, using a spreadsheet.

Figure 63 shows an example of a spreadsheet that has been set up to do both steps of the analysis. The data from the field data sheet is transferred into the second column of the lower half of the spreadsheet to the right of the variable names. The calculated variable subindex is displayed in the fourth column of the lower half of the spreadsheet. The variable subindices are then used to calculate the FCI using the appropriate assessment model. The resulting FCI is displayed in the first column of the top half of the spreadsheet to the left of each function name. The spreadsheet format allows the user to ascertain instantly how a change in the field measure of a variable will affect the FCI of a particular function by simply entering a new variable measure in the bottom half of the spreadsheet.

Variable Subindex and FCI Calculation for Florida Depressions

FCI	Function
0.60	**Surface and Subsurface Water Storage**
0.40	**Subsurface Water Storage**
0.40	**Cycle Nutrients**
0.50	**Characteristic Plant Community**
0.50	**Wildlife Habitat**

>>>>>>> Enter quantitative or categorical measure from Field Data Sheet in shaded cells

Variables	Measure	Units	Subindex
1. V_{CATCH}	80	%	0.20
2. V_{UPUSE}	76	%	1.0
3. $V_{WETPROX}$	2000	m	1.0
4. V_{WETVOL}	20	%	0.80
5. V_{SUROUT}	60	%	0.40
6. V_{SUBOUT}	65	%	0.35
7. V_{ZONES}	2	number	0.50
8. V_{MAC}	60	%	0.60
9. V_{CANOPY}	100	%	0.50
10. V_{SURTEX}	95	VSI	0.0
11. V_{TBA}	30	m^2/ha	1.0
12. V_{SSD}	80	%	1.0
13. V_{HCOMP}	90	%	0.90
14. V_{TCOMP}	100	%	1.0

Figure 63. Example of an FCI calculation spreadsheet

Apply Assessment Results

Once the assessment and analysis phases are complete, the results can be used to (a) compare the same WAA at different points in time, (b) compare different WAAs at the same point in time, (c) compare different alternatives to a project, or (d) compare different HGM classes or subclasses as per Smith et al. (1995).

References

Beaulac, N. M., and Reckhow, K. H. (1982). "An examination of land use nutrient export relationships," *Journal Water Resources Bulletin* 18(6), 1013-24.

Bolen, E. G., Smith, L. H., and Schramm, H. L. (1989). "Playa lakes - prairie wetlands of the southern high plains," *Bioscience* 39, 615-23.

Bonham, C. D. (1989). *Measurements for terrestrial vegetation*. John Wiley and Sons, New York.

Brinson, M. M. (1993). "A hydrogeomorphic classification for wetlands," Technical Report WRP-DE-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1995a). "Assessing wetland functions using HGM," *National Wetlands Newsletter*, January/February, Environmental Law Institute, Washington, DC.

__________. (1995b). "The hydrogeomorphic approach explained," *National Wetlands Newsletter*, November/December, Environmental Law Institute, Washington, DC.

Brinson, M. M., Hauer, F. R., Lee, L. C., Nutter, W. L., Rheinhardt, R. D., Smith, R. D., and Whigham, D. (1995). "A guidebook for application of hydrogeomorphic assessments to riverine wetlands," Technical Report WRP-DE-11, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

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

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

Carlisle, V. W. (2000). *Hydric soils of Florida handbook*. 3d ed., Florida Association of Environmental Soil Scientists, Gainesville, FL, 95-101.

Carlisle, V. W., and Watts, F. C. (1995). “Factors of soil formation and Florida soils.” *Hydric soils of Florida handbook.* 2nd ed., V. W. Carlisle, ed., Florida Association of Environmental Soil Scientists, Gainesville, FL, 1-8.

Carpenter, S. R. (1988). *Complex interactions in lake communities*. Springer-Verlag, New York, 283 pp.

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

Dahl, T. E. (2000). “Status and trends of wetlands in the conterminous United States 1986 to 1997,” U.S. Department of the Interior, Fish and Wildlife Service. Washington, DC.

Davis, H. (1984). “Mosquito populations and arbovirus activity in cypress domes.” *Cypress swamps*. K. C. Ewel and H. T. Odum, ed., University of Florida Press, Gainesville, FL, Chapter 20.

Environmental Laboratory. (1987). “Corps of Engineers wetlands delineation manual,” Technical Report Y-87-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Ewel, K. C. (1984). “Effects of fire and wastewater on understory vegetation in cypress domes.” *Cypress swamps*. K. C. Ewel and H. T. Odum, ed., University of Florida Press, Gainesville, FL, Chapter 12.

__________. (1990). “Swamps.” *Ecosystems of Florida*. R. L. Myers and J. J. Ewel, ed., University of Central Florida Press, Orlando, FL, Chapter 9.

Federal Register. (1997). “The National Action Plan to implement the Hydrogeomorphic Approach to assessing wetland functions,” 62(119), June 20, 1997, 33607-33620.

Federico, A. D. (1977). “Investigations of the relationship between land use, rainfall, and runoff quality in the Taylor Creek watershed,” Technical Publication 77-3, South Florida Water Management District, West Palm Beach, FL.

Ferren, W. R., Jr., Fiedler, P. L., and Leidy, R. A. (1996a). ”Wetlands of California. Part I. History of wetland habitat,” *Madrono* 43, 105-24.

Ferren, W. R., Jr., Fiedler, P. L., Leidy, R. A., Lafferty, K. D., and Mertes, L. A. K. (1996b). “Wetlands of California. Part II. Classification and description of wetlands of the central California and southern California coast and coastal watershed,” *Madrono* 43, 125-82.

Ferren, W. R., Jr., Fiedler, P. L., Leidy, R. A., Lafferty, K. D., and Mertes, L. A. K. (1996c). "Wetlands of California. Part III. Key to the catalogue of wetlands of the central California and southern California coast and coastal watershed," *Madrono* 43, 183-233.

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

Grubb, H. F., and Ryder, P. D. (1972). "Effects of coal mining on the water resources of the Tradewater River Basin, Kentucky," Geological Survey Water-Supply Paper 1940, U.S. Government Printing Office, Washington, DC.

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

Harris, L. D., and Mulholland, R. (1983). "Southern bottomland ecosystems as wildlife habitat," *Appraisal of Florida's Wetland Hardwood Resource*. Flinchum, D. M., Doolittle, G. B., and Munson, K. R. ed.,

Harris, L. D., and Vickers, C. R. (1984). "Some faunal community characteristics of cypress ponds and the changes induced by perturbations." *Cypress swamps*. K. C. Ewel and H. T. Odum, ed., University of Florida Press, Gainesville, FL, Chapter 17.

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

Heimburg, K. (1984). "Hydrology of north-central Florida cypress domes." *Cypress swamps*. K. C. Ewel and H. T. Odum, ed., University of Florida Press, Gainesville, FL, Chapter 8.

Hubbard, D. E. (1988). "Glaciated prairie wetland functions and values: A synthesis of the literature," Biological Report 88(43), U.S. Fish and Wildlife Service, Washington, DC.

Kantrud, J. A., Krapu, G. L., and Swanson, G. A. (1989). "Prairie basin wetlands of the Dakotas: A community profile," Biological Report 85, U.S. Fish and Wildlife Service, Washington, DC.

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

Kurz, H., and Wagner, K. A. (1953). "Factors in cypress dome development," *Ecology* 34, 157-64.

Leibowitz, S. G., and Hyman, J. B. (1997). "Use of scale invariance in assessing the quality of judgement indicators," U.S. Environmental Protection Agency Laboratory, Corvallis, OR.

Leslie, A. J., Crisman, T. L., Prenger, J. P., and Ewel, K. C. (1997). "Benthic macroinvertebrates of small Florida pondcypress swamps and the influence of dry periods," *Wetlands* 17(4), 447.

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

Marois, K. C., and Ewel, K. C. (1983). "Natural and management-related variation in cypress domes," *Forest Science* 29, 627-640.

Mausbauch, M. J., and Richardson, J. L. (1994). "Biogeochemical processes in hydric soils," *Current Topics in Wetland Biogeochemistry, 1, 68-127*.

Merritt, R. W., and Cummins, K. W., ed. (1996). *An introduction to the aquatic insects of North America.* 3rd ed., Kendall/Hunt, Dubuque, IA.

Millar, J. B. (1971). "Shoreline-area ratio as a factor in rate of water loss from small sloughs," *Journal of Hydrology* 14, 259-284.

Mitchell, W. A., and Hughes, H. G. (1995). "Point Sampling: Section 6.2.1, U.S. Army Corps of Engineers Wildlife Resources Management Manual," Technical Report EL-95-25, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Mitsch, W. J., and Gosselink, J. G. (2000). *Wetlands.* 3rd ed., John Wiley and Sons, New York.

Naiman, R. J., Decamps, H., and Fournier, F., ed. (1989). *The role of land/inland water ecotones in landscape management and restoration: A proposal for collaborative research*. UNESCO, Paris.

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

Ostry, R. C. (1982). "Relationship of water quality and pollutant loads to land uses in adjoining watersheds," *Journal of Water Resources Bulletin* 18 (1), 99-104.

Rheinhardt, R. D., Brinson, M. M., and Farley, P. M. (1997). "A preliminary reference data set for wet forested flats in North Carolina and its application to wetland functional assessment, mitigation, and restoration," *Wetlands* 17, 195-215.

Riekerk, H., and Korhnak, L. V. (2000). "Hydrology of cypress wetlands in Florida pine flatwoods," *Wetlands* 20, 448-460.

Schneider, D. C. (1994). *Quantitative ecology: Spatial and temporal scaling*. Academic Press, New York.

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

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

Shahan, A. N. (1982). "Estimation of pre- and post-development nonpoint water quality loadings," *Journal of Water Resources Bulletin* 18, 231-37.

Smith, R. D. (2001). "Hydrogeomorphic approach to assessing wetland functions: Guidelines for developing regional guidebooks; Chapter 3, Developing a reference wetland system," ERDC/EL TR-01-29, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Smith, R. D., and Wakeley, J. S. (2001). "Hydrogeomorphic approach to assessing wetland functions: Guidelines for developing regional guidebooks; Chapter 4, Developing assessment models," ERDC/EL TR-01-30, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Smith, R. D., Amman, A., Bartoldus, C., and Brinson, M. M. (1995). "An approach for assessing wetland functions based on hydrogeomorphic classification, reference wetlands, and functional indices," Technical Report WRP-DE-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Snodgrass, J. W., Bryan, L. A., Jr., Lide, R. F., and Smith, G. M. (1996). "Factors affecting the occurrence and structure of fish assemblages in isolated wetlands of the upper coastal plain, U.S.A.," *Canadian Journal of Fisheries and Aquatic Sciences* 53, 443-454.

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

Spurr, S. H., and Barnes, B. V. (1981). *Forest ecology*. John Wiley and Sons, New York.

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

Strecker. E. W., Kernar, J. M., Driscoll, E. D., Horner, R. R., and Davenport, T. E. (1992). "The use of wetlands for controlling stormwater pollution," The Terrene Institute, Alexandria, VA.

ter Braak, C. J. F. (1994). "Canonical community ordination. Part 1: Basic theory and linear methods," *Ecoscience* 1, 127-140.

Tritton, L. M., and Hornbeck, J. W. (1982). "Biomass equations for major tree species, the northeast," General Technical Report NE-69, U.S. Forest Service, Northeast Forest Experiment Station.

U.S. Department of Agriculture. (1981). "Land resource regions and major land resource areas of the United States," Agriculture Handbook 296, Washington, DC.

__________. (1986). "Urban hydrology for small watersheds," Technical Release 55 (TR-55). Natural Resources Conservation Service, Washington, DC.

__________. (1987). "Twenty-six ecological communities of Florida," Soil Conservation Service, Washington, DC.

__________. (1997). "Hydrology tools for wetland determination," *Engineering handbook*, Part 650, Natural Resources Conservation Service, Washington, DC.

__________. (1998). "Soil survey of Collier County, Florida," Soil Conservation Service, Washington, DC.

__________. (1999). "Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys," Agricultural Handbook 436, Natural Resources Conservation Service, Washington, DC.

Wakeley, J. S., and Smith, R. D. (2001). "Hydrogeomorphic approach to assessing wetland functions: Guidelines for developing regional guidebooks; Chapter 7, Verifying, field testing, and validating assessment models," ERDC/EL TR-01-31, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

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

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

Whittaker, R. H., Bormann, F. H., Likens, G. E., and Siccama, T. G. (1974). "The Hubbard Brook Ecosystem Study: Forest biomass and production," *Ecological Monographs* 44, 233-54.

Winchester, B. H., Bays, J. S., Higman, J. C., and Knight, R. L. (1985). "Physiography and vegetation zonation of shallow emergent marshes in southwestern Florida," *Wetlands* 5, 99-118.

Wunderlin, R. P., and Hansen, B. F. (2003). *Atlas of Florida vascular plants* (*http://www.plantatlas.usf.edu/*) S. M. Landry and K. N. Campbell (application development), Florida Center for Community Design and Research. Institute for Systematic Botany, University of South Florida, Tampa. FL.

Zarbock, H., Janicki, A., Wade, D., Heimbuch, D., and Wilson, H. (1994). "Estimates of total nitrogen, total phosphorus, and total suspended solids loadings to Tampa Bay, Florida," Tampa Bay National Estuary Program, St. Petersburg, FL.

Zedler, P. H. (1987). "The ecology of southern California vernal pools: A community profile," Biological Report 85(7.11), U.S. Fish and Wildlife Service, Washington, DC.

Appendix A
Glossary

Abiotic: Not biological.

Assessment model: A simple model that defines the relationship between ecosystem and landscape scale variables and functional capacity of a wetland. The model is developed and calibrated using reference wetlands from a reference domain.

Assessment objective: The reason an assessment of wetland functions is being conducted. Assessment objectives normally fall into one of three categories: documenting existing conditions, comparing different wetlands at the same point in time (e.g., alternatives analysis), and comparing the same wetland at different points in time (e.g., impact analysis or mitigation success).

Assessment team (A-Team): An interdisciplinary group of regional and local scientists responsible for classification of wetlands within a region, identification of reference wetlands, construction of assessment models, definition of reference standards, and calibration of assessment models.

Biotic: Of or pertaining to life; biological.

Direct impacts: Project impacts that result from direct physical alteration of a wetland, such as the placement of dredge or fill.

Direct measure: A quantitative measure of an assessment model variable.

Exotics: See **Invasive species**.

Facultative (FAC): Equally likely to occur in wetlands or nonwetlands (estimated probability 34-66 percent).

Facultative wetland (FACW): Usually occurs in wetlands (estimated probability 67-99 percent), but occasionally found in nonwetlands.

Functional assessment: The process by which the capacity of a wetland to perform a function is measured. This approach measures capacity using an assessment model to determine a Functional Capacity Index.

Functional capacity: The rate or magnitude at which a wetland ecosystem performs a function. Functional capacity is dictated by characteristics of the wetland ecosystem and the surrounding landscape, and interaction between the two.

Functional Capacity Index (FCI): An index of the capacity of a wetland to perform a function relative to other wetlands in a regional wetland subclass. Functional Capacity Indices are by definition scaled from 0.0 to 1.0. An index of 1.0 indicates the wetland is performing a function at the highest sustainable functional capacity, the level equivalent to a wetland under reference standard conditions in a reference domain. An index of 0.0 indicates the wetland does not perform the function at a measurable level, and will not recover the capacity to perform the function through natural processes.

Highest sustainable functional capacity: The level of functional capacity achieved across the suite of functions by a wetland under reference standard conditions in a reference domain. This approach assumes that the highest sustainable functional capacity is achieved when a wetland ecosystem and the surrounding area are undisturbed.

Hydrogeomorphic wetland class: The highest level in the hydrogeomorphic wetland classification. There are five basic hydrogeomorphic wetland classes: depression, riverine, slope, fringe, and flat.

Hydrogeomorphic unit: Hydrogeomorphic units are areas within a wetland assessment area that are relatively homogeneous with respect to ecosystem scale characteristics such as microtopography, soil type, vegetative communities, or other factors that influence function. Hydrogeomorphic units may be the result of natural or anthropogenic processes. See **Partial wetland assessment area.**

Hydroperiod: The annual duration of flooding (in days per year) at a specific point in a wetland.

Indicator: Indicators are observable characteristics that correspond to identifiable variable conditions in a wetland or the surrounding landscape.

Indirect measure: A qualitative measure of an assessment model variable that corresponds to an identifiable variable condition.

Indirect impacts: Impacts resulting from a project that occur concurrently, or at some time in the future, away from the point of direct impact. For example, indirect impacts of a project on wildlife can result from an increase in the level of activity in adjacent, newly developed areas, even though the wetland is not physically altered by direct impacts.

Invasive species: Generally exotic species without natural controls that out-compete native species.

Jurisdictional wetland: Areas that meet the soil, vegetation, and hydrologic criteria described in the "Corps of Engineers Wetlands Delineation Manual" (Environmental Laboratory 1987)[1] or its successor.

Mitigation: Restoration or creation of a wetland to replace functional capacity that is lost as a result of project impacts.

Mitigation plan: A plan for replacing lost functional capacity resulting from project impacts.

Mitigation wetland: A restored or created wetland that serves to replace functional capacity lost as a result of project impacts.

Model variable: A characteristic of the wetland ecosystem or surrounding landscape that influences the capacity of a wetland ecosystem to perform a function.

Obligate wetland (OBL): Occurs almost always (estimated probability 99 percent) under natural conditions in wetlands.

Oligotrophic: Environments in which the concentration of nutrients available for growth is limited. Nutrient-poor habitats.

Organic matter: Plant and animal residue in the soil in various stages of decomposition.

Organic soil material: Soil material that is saturated with water for long periods or artificially drained and, excluding live roots, has an organic carbon content of 18 percent or more with 60 percent or more clay, or 12 percent or more organic carbon with 0 percent clay. Soils with an intermediate amount of clay have an intermediate amount of organic carbon. If the soil is never saturated for more than a few days, it contains 20 percent or more organic carbon.

Organic soils (Histosol): A soil of which more than half of the upper 80 cm (32 in.) of the soil is organic or if organic soil material of any thickness rests on rock or on fragmental material having interstices filled with organic material.

Oxidation: The loss of one or more electrons by an ion or molecule.

Partial wetland assessment area (PWAA): A portion of a Wetland Assessment Area (WAA) that is identified a priori, or while applying the assessment procedure, because it is relatively homogeneous and different from the rest of the WAA with respect to one or more model variables. The difference may occur naturally or as a result of anthropogenic disturbance. See **Hydrogeomorphic unit**.

[1] References cited in this appendix are included in the References at the end of the main text.

Peat (geologic definition): Unconsolidated soil material consisting largely of undecomposed, or slightly decomposed, organic matter accumulated under conditions of excessive moisture. Includes muck, mucky peat, and peat.

Project alternative(s): Different ways in which a given project can be done. Alternatives may vary in terms of project location, design, method of construction, amount of fill required, and other ways.

Project area: The area that encompasses all activities related to an ongoing or proposed project.

Project target: The level of functioning identified for a restoration or creation project. Conditions specified for the functioning are used to judge whether a project reaches the target and is developing toward site capacity.

Red flag features: Features of a wetland or the surrounding landscape to which special recognition or protection is assigned on the basis of objective criteria. The recognition or protection may occur at a Federal, State, regional, or local level and may be official or unofficial.

Reference domain: All wetlands within a defined geographic area that belong to a single regional wetland subclass.

Reference standards: Conditions exhibited by a group of reference wetlands that correspond to the highest level of functioning (highest sustainable capacity) across the suite of functions of the regional wetland subclass. By definition, highest levels of functioning are assigned an index of 1.0.

Reference wetlands: Wetland sites that encompass the variability of a regional wetland subclass in a reference domain. Reference wetlands are used to establish the range of conditions for construction and calibration of functional indices and to establish reference standards.

Region: A geographic area that is relatively homogeneous with respect to large-scale factors such as climate and geology that may influence how wetlands function.

Regional wetland subclass: Regional hydrogeomorphic wetland classes that can be identified based on landscape and ecosystem scale factors. There may be more than one regional wetland subclass for each of the hydrogeomorphic wetland classes that occur in a region, or there may be only one.

Seasonal high water table: The shallowest depth to free water that stands in an unlined borehole or where the soil moisture tension is zero for a significant period (for more than a few weeks).

Site potential: The highest level of functioning possible, given local constraints of disturbance history, land use, or other factors. Site capacity may be equal to or less than levels of functioning established by reference standards for the reference domain, and it may be equal to or less than the functional capacity of a wetland ecosystem.

Soil surface: The soil surface is the top of the mineral soil; or, for soils with an O horizon, the soil surface is the top of the part of the O horizon that is at least slightly decomposed. Fresh leaf or needle fall that has not undergone observable decomposition is excluded from soil and may be described separately (Carlisle 2000).

Value of wetland function: The relative importance of wetland function or functions to an individual or group.

Variable: An attribute or characteristic of a wetland ecosystem or the surrounding landscape that influences the capacity of the wetland to perform a function.

Variable condition: The condition of a variable as determined through quantitative or qualitative measure.

Variable index: A measure of how an assessment model variable in a wetland compares to the reference standards of a regional wetland subclass in a reference domain.

Wetland: See **Wetland ecosystems**.

Wetland ecosystems: In 404: "....... areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas" (Corps Regulation 33 CFR 328.3 and EPA Regulations 40 CFR 230.3). In a more general sense, wetland ecosystems are three-dimensional segments of the natural world where the presence of water at or near the surface creates conditions leading to the development of redoximorphic soil conditions, and the presence of a flora and fauna adapted to the permanently or periodically flooded or saturated conditions.

Wetland assessment area (WAA): The wetland area to which results of an assessment are applied.

Wetland functions: The normal activities or actions that occur in wetland ecosystems, or simply, the things that wetlands do. Wetland functions result directly from the characteristics of a wetland ecosystem and the surrounding landscape, and their interaction.

Wetland restoration: The process of restoring wetland function in a degraded wetland. Restoration is typically done as mitigation.

Appendix B Summaries and Forms for Field Use

This appendix contains the following information summaries and example sheets:

a. Summary of Functions for Herbaceous and Cypress Dome Depressional Wetlands.

b. Summary of Model Variables, Measure/Units, and Methods.

c. Summary of Model Variables by Function.

d. Summary of Graphs for Transforming Measures to Subindices.

e. Blank Field Data Sheets (Figures B1-B4).

Summary of Functions for Herbaceous and Cypress Dome Depressional Wetlands

Function 1: Surface and Subsurface Water Storage

a. *Definition.* Surface Water Storage is defined as the capacity of the depressional wetland to store water above the soil surface. The annual water budget of depressional wetlands is under the influence of precipitation and through the interception of the groundwater table. Storm runoff is collected and stored temporarily in wetland basins. Temporary storage is lost to evapotranspiration or to groundwater. Storage alters the amount and timing of runoff from a catchment into streams and recharge to groundwater. Surface water adds soil moisture to the unsaturated zone and interacts with long-term groundwater and water elevations within depressional wetlands largely under the control of groundwater. This function is affected by both evapotranspiration and groundwater properties of the local area. Surface water has a significant effect on biogeochemical cycling and in particular has a very strong effect on vegetation and invertebrate and vertebrate populations. Potential independent, quantitative measures for validating the functional index include data of catchment precipitation, depression storage, evapotranspiration, water table elevations, and vertical hydraulic gradient.

b. *Model variables – symbols – measures – units*.

(1) Wetland Volume - V_{WETVOL} - percent change in the wetland volume - unitless.

(2) Change in Catchment Size - V_{CATCH} - percent change in the size of the wetland catchment or basin - unitless.

(3) Upland Land Use - V_{UPUSE} - surface water runoff from the wetland catchment into the wetland - unitless.

(4) Surface Outlet - V_{SUROUT} - effectiveness of a drainage ditch to remove surface water from the wetland - unitless.

(5) Cypress canopy - V_{CANOPY} - percent cover of cypress trees along selected transects within the cypress zone of cypress domes - unitless.

c. *Assessment model*:

(1) For Herbaceous Depressional Wetlands:

$$FCI = \left\{ V_{WETVOL} \times \left[\frac{\left(\frac{V_{CATCH} + V_{UPUSE}}{2} \right) + V_{SUROUT}}{2} \right] \right\}^{1/2} \quad \text{(B1)}$$

(2) For Cypress Dome Depressional Wetlands:

$$FCI = \left\{ V_{WETVOL} \times \left[\frac{\left(\frac{V_{CATCH} + V_{UPUSE}}{2} \right) + \left(\frac{V_{SUROUT} + V_{CANOPY}}{2} \right)}{2} \right] \right\}^{1/2} \quad \text{(B2)}$$

Function 2: Subsurface Water Storage

a. *Definition.* Subsurface Water Storage is defined as the capacity of the depressional wetland to store water at and below the soil surface. The annual water budget of depressional wetlands is under the influence of precipitation and through the interception of the groundwater table. Storm runoff is collected and stored temporarily in wetland basins. Temporary storage is lost to evapotranspiration and to groundwater. Storage alters the amount and timing of runoff from a catchment into streams and recharge to groundwater. Subsurface water maintains soil moisture and interacts with long-term groundwater. This function is affected by both evapotranspiration and groundwater properties of the local area. Subsurface water has significant effect on biogeochemical cycling, vegetation, and invertebrate populations. While subsurface and surface water storage are connected during the wettest part of the year in most years, subsurface water has a longer impact on the wetland. Subsurface water storage may not be impacted even if surface water has been eliminated. In addition, during natural drought cycles subsurface water storage may be the only hydrologic function present to maintain wetland characteristics. Potential independent, quantitative measures for validating the functional index include data of catchment precipitation, depression storage, evapotranspiration, water table elevations, and vertical hydraulic gradient.

b. Model variables – symbols – measures – units.

(1) Subsurface Outlet - V_{SUBOUT} - effective drainage of ditches on the subsurface water storage of the wetland - unitless.

(2) Surface Soil Texture - V_{SURTEX} - USDA soil texture of the surface horizon or layer of the soil - unitless.

(3) Upland Land Use - V_{UPUSE} - surface water runoff from the wetland catchment into the wetland - unitless.

(4) Change in Catchment Size - V_{CATCH} - change in the size of the wetland catchment or basin - unitless.

c. Assessment model:

$$FCI = \left[\frac{\left(\frac{V_{CATCH} + V_{UPUSE}}{2} \right) + \left(\frac{V_{SUBOUT} + V_{SURTEX}}{2} \right)}{2} \right] \qquad \text{(B3)}$$

Function 3: Cycle Nutrients

a. Definition. Cycle Nutrients is defined as the ability of the depressional wetland to transform biotic essential elements and materials (e.g., carbon dioxide, water, phosphorus, nitrogen) needed for biological processes into organic forms (e.g., carbohydrates, fats, proteins) and to oxidize those organic molecules back into elemental forms through decomposition. Thus, nutrient cycling includes the biogeochemical processes of producers, consumers, and decomposers. Potential independent, quantitative measures for validating the functional index include standing stock of living and/or dead biomass, gm/m^2; net annual productivity, gm/m^2; annual accumulation of organic matter, gm/m^2; and annual decomposition of organic matter, gm/m^2.

b. Model variables – symbols – measures – units.

(1) Change in Catchment Size - V_{CATCH} - change in the size of the wetland catchment or basin - unitless.

(2) Upland Land Use - V_{UPUSE} - surface water runoff from the wetland catchment into the wetland - unitless.

(3) Surface Outlet - V_{SUROUT} - effectiveness of a drainage ditch to remove surface water from the wetland - unitless.

(4) Macrophytic Vegetation Cover - V_{MAC} - percent cover of macrophytic vegetation in the wetland - unitless.

(5) Understory Vegetation Biomass - V_{SSD} - percent combined cover of emergent macrophytic vegetation and woody vegetation >1 m in height and <10 cm diameter at breast height (dbh) (e.g., shrubs, saplings, and understory trees) - unitless.

(6) Tree Basal Area - V_{TBA} - percent living woody stems $\geq$10 cm (4 in.) dbh - unitless.

(7) Surface Soil Texture - V_{SURTEX} - USDA soil texture of the surface horizon or layer of the soil - unitless.

c. Assessment model:

(1) For Herbaceous Depressional Wetlands:

$$FCI = \left[\frac{V_{SURTEX} + V_{MAC} + \left(\frac{V_{CATCH} + V_{UPUSE} + V_{SUROUT}}{3} \right)}{3} \right] \quad \text{(B4)}$$

(2) For Cypress Dome Depressional Wetlands:

$$FCI = \left[\frac{V_{SURTEX} + \left(\frac{V_{CATCH} + V_{UPUSE} + V_{SUROUT}}{3} \right) + \left(\frac{V_{TBA} + V_{SSD}}{2} \right)}{3} \right] \quad \text{(B5)}$$

Function 4: Characteristic Plant Community

a. Definition. Characteristic Plant Community is defined as the capacity of a depressional wetland to provide the environment necessary for a characteristic plant community to develop and be maintained. 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. Potential independent, quantitative measures of this function, based on vegetation composition and abundance, include similarity indices (Ludwig and Reynolds 1988)[1] or ordination axis scores from detrended correspondence analysis or other multivariate technique (Kent and Coker 1995). An alternative, independent quantitative measure of this function, based on vegetation composition and abundance as well as environmental factors, is ordination axis scores from canonical correlation analysis (ter Braak 1994).

[1] References cited in this appendix are listed in the References section at the end of the main text.

b. *Model variables – symbols – measures – units.*

(1) Macrophytic Vegetation Cover - V_{MAC} - percent cover of macrophytic vegetation in the wetland - unitless.

(2) Tree Basal Area - V_{TBA} - percent living woody stems $\geq$10 cm (4 in.) diameter at breast height (dbh) - unitless.

(3) Understory Vegetation Biomass - V_{SSD} - percent combined cover of emergent macrophytic vegetation and woody vegetation >1 m in height and <10 cm dbh (e.g., shrubs, saplings, and understory trees) - unitless.

(4) Herbaceous Plant Species Composition - V_{HCOMP} - percent concurrence with dominant herbaceous species by wetland zone in herbaceous depressional wetlands - unitless.

(5) Tree Species Composition - V_{TCOMP} - percent concurrence with *Taxodium ascendens* (pond cypress) and *Taxodium distichum* (bald cypress) in the tree zone in cypress dome depressional wetlands - unitless.

(6) Surface Soil Texture - V_{SURTEX} - USDA soil texture of the surface horizon or layer of the soil - unitless.

(7) Subsurface Outlet - V_{SUBOUT} - percent effective drainage of ditches on the subsurface water storage of the wetland - unitless.

c. *Assessment model:*

(1) For Herbaceous Depressional Wetlands:

$$FCI = \left[\left(\frac{V_{MAC} + V_{HCOMP}}{2}\right) \times \left(\frac{V_{SURTEX} + V_{SUBOUT}}{2}\right)\right]^{1/2} \qquad \text{(B6)}$$

(2) For Cypress Dome Depressional Wetlands:

$$FCI = \left\{\left[\frac{\left(\frac{V_{TBA} + V_{SSD}}{2}\right) + V_{TCOMP}}{2}\right] \times \left(\frac{V_{SURTEX} + V_{SUBOUT}}{2}\right)\right\}^{1/2} \qquad \text{(B7)}$$

Function 5: Wildlife Habitat

a. *Definition*. Provide Wildlife Habitat is defined as the ability of a depressional wetland to support the wildlife species that utilize herbaceous and cypress dome depressional wetlands during all or part of their life cycles. A potential independent, quantitative measure of this function is a similarity index calculated from species composition and abundance (Odum 1950; Sorenson 1948).

b. Model variables – symbols – measures – units.

(1) Subsurface Outlet - V_{SUBOUT} - the effective drainage of ditches on the subsurface water storage of the wetland - unitless.

(2) Change in the Number of Wetland Zones - V_{ZONES} - change in the number of wetland zones in the depressional wetland being assessed - unitless.

(3) Upland Land Use - V_{UPUSE} - surface water runoff from the wetland catchment into the wetland - unitless.

(4) Wetland Proximity - $V_{WETPROX}$ - average distance to the eight nearest depressional wetlands - meters.

(5) Macrophytic Vegetation Cover - V_{MAC} - average percent cover of macrophytic vegetation by wetland zone - unitless.

(6) Cypress Canopy - V_{CANOPY} - average percent cover of cypress trees - unitless.

(7) Tree Basal Area - V_{TBA} - average percent living woody stems $\geq$10 cm (4 in.) diameter at breast height (dbh).

(8) Herbaceous Plant Species Composition - V_{HCOMP} - the dominance of certain native wetland plants in proportion to sites representing those with the least disturbance in herbaceous wetlands - unitless.

(9) Tree Species Composition - V_{TCOMP} - the dominance of certain native wetland trees in proportion to sites representing those with the least disturbance in cypress dome wetlands - unitless.

(10) Surface Soil Texture - V_{SURTEX} - USDA soil texture of the surface horizon or layer of the soil - unitless.

c. Assessment model:

(1) For Herbaceous Depressional Wetlands:

$$FCI = \left\{ \left[\frac{\left(\frac{V_{SUBOUT} + V_{ZONES}}{2} \right) + \left(\frac{V_{UPUSE} + V_{WETPROX}}{2} \right)}{2} \right] \times \left[\frac{\left(\frac{V_{MAC} + V_{HCOMP}}{2} \right) + V_{SURTEX}}{2} \right] \right\}^{1/2} \quad \text{(B8)}$$

(2) For Cypress Dome Depressional Wetlands:

$$FCI = \left\{ \left[\frac{\left(\frac{V_{SUBOUT} + V_{ZONES}}{2} \right) + \left(\frac{V_{UPUSE} + V_{WETPROX}}{2} \right)}{2} \right] \times \left[\frac{\left(\frac{V_{CANOPY} + V_{TBA}}{2} \right) + V_{TCOMP} + V_{SURTEX}}{3} \right] \right\}^{1/2} \tag{B9}$$

Summary of Model Variables, Measure/Units, and Methods

Change in Catchment Size (V_{CATCH})

Measure/Units: Percent change in the size of the wetland catchment or basin.

Method:

(1) Using aerial photographs or topographic maps, determine the size of the catchment basin.

(2) If the size of the catchment is unchanged, the subindex score would be 1.0.

(3) If the size of the catchment has been changed, determine the percent change before and after the impacts.

(4) Verify during field reconnaissance.

Upland Land Use (V_{UPUSE})

Measure/Units: Surface water runoff from the wetland catchment into the wetland.

Method:

(1) Using recent aerial photographs and geographic information system (GIS) technology and verifying during field reconnaissance, determine the percent of the catchment that has the land uses listed in Table B1, modified from NRCS TR-55 (USDA 1986).

(2) Using data from the local soil survey, determine the hydrologic group for the soils present in the catchment.

(3) Using Table B1, determine the curve number for the catchment.

Table B1
Runoff Curve Numbers

Cover Type	Hydrologic Soil Groups			
	A	B	C	D
Open space (pasture, lawns, parks, golf courses, cemeteries):				
Poor condition (grass cover <50%)	68	79	86	89
Fair condition (grass cover 50% to 75%)	49	69	79	84
Good condition (grass cover >75%)	39	61	74	80
Impervious areas (parking lots, roofs, driveways, etc)	98	98	98	98
Gravel	76	85	89	91
Urban districts:				
Commercial and business (85% cover)	89	92	94	95
Industrial (72% cover)	81	88	91	93
Residential districts by average lot size:				
1/8 acre or less (town houses and apartments) (65% cover)	77	85	90	92
1/4 acre (38% cover)	61	75	83	87
1/3 acre (30% cover)	57	72	81	86
1/2 acre (25% cover)	54	70	80	85
1 acre (20% cover)	51	68	79	84
2 acres (12% cover)	46	65	77	82
Newly graded areas (no vegetation or pavement)	77	85	90	92
Fallow crop areas (poor)	76	85	90	93
Fallow crop areas (good)	74	83	88	90
Row crops	70	80	86	90
Small grain	64	75	83	87
Groves and orchards				
<50% ground cover	57	73	82	86
50% to 75% ground cover	43	65	76	82
>75% cover	32	58	72	79
Forest and native range				
<50% ground cover	45	66	77	83
50% to 75% ground cover	36	60	73	79
>75% ground cover	30	55	70	77

(4) Determine a weighted average runoff score for the upland catchment.

(5) Verify during field reconnaissance.

Wetland Proximity ($V_{WETPROX}$)

Measure/Units: Proximity and distribution of the nearest depressional wetland within 500 m of eight equally divided sectors.

Method:

(1) Using recent aerial photographs, topographic maps, National Wetland Inventory (NWI) maps, or other appropriate resources, divide the area surrounding the wetland being assessed into eight equal sections (Figure 46, main text).

(2) Measure in meters the distance from the edge of the wetland being assessed to the edge of the nearest depressional wetland within each section and record on the field data sheet.

(3) Record a distance of 500 m (1,640 ft) for any distance greater than 500 m.

(4) Total the distances measured.

(5) Verify during field reconnaissance.

Change in Wetland Volume (V_{WETVOL})

Measure/Units: Percent change in the wetland volume.

Method:

(1) If no excavation or fill activity has occurred, then the variable subindex is 1.0. If fill or excavation activity has occurred, then estimate the volume of the fill material or the excavation and determine the difference in volume.

(2) Using geographic information system (GIS), planimeter, global positioning system (GPS), or other means, measure the diameter of the wetland along the longest and shortest axis. Average these two diameters and use half of this averaged diameter for the radius of the wetland.

(3) Measure the depth of the wetland.

(4) Using the formula for a cone for circular depressional wetlands determine the volume of the wetland.

(5) Measure the area and thickness of the fill material or the area and depth of the excavation. Using the appropriate volume calculations, determine the volume of the fill or excavation. Examples of this calculation can be found in Appendix C.

(6) Determine the percent of the fill or excavation of the wetland or Wetland Assessment Area (WAA).

(7) Using Figure 6 (main text), determine the variable subindex for the change in wetland volume.

Surface Outlet (V_{SUROUT})

Measure/Units: Effectiveness of a drainage ditch at removing surface water from the wetland.

Method:

(1) Using recent aerial photographs and verifying during field reconnaissance, determine if any drainage ditches occur within or 100 m (330 ft) from the catchment, whichever is less. If no drainage ditches occur within or 100 m from the catchment, then the subindex score for this variable would be 1.0.

(2) If one or more ditches occur within or 100 m from the wetland, examine the ditch(es) to determine if they are maintained and free of obstructions. If the ditch is overgrown with trees or brush, has a water control structure within the ditch, is not connected to an outlet (i.e. stream or larger canal system), or is otherwise not maintained, the variable subindex would be

1.0. If the ditch is maintained and free of obstructions, measure the depth of the ditch and record on the field data sheet.

(3) If the elevation of the bottom of the ditch is above the lowest point in the wetland, then the variable subindex would be 1.0.

(4) If the bottom of the ditch is lower than the lowest point in the wetland, determine the difference in elevation between the bottom of the ditch and the lowest point in the wetland.

(5) Using the local NRCS County Soil Survey determine the dominant soil series between the wetland and the ditch and record on the field data sheet.

(6) Using Table B2, select a profile characteristics category for the soil series between the ditch and the wetland. Determine the effective depth of the ditch in centimeters, which is the difference in elevation between the bottom of the ditch and the lowest point or elevation in the wetland.

(7) Determine the percent of the wetland that is within the impact distance of the ditch.

Table B2
Lateral Effects of Ditches for Selected Soil Profile Characteristics in Florida, Surface Outlet

Profile Characteristics	Effective Depth of Ditch, cm									
	40	50	60	70	80	90	100	150	200	250
Soils with spodic horizon	7 (23)	9 (28)	13 (43)	29 (94)	34 (112)	40 (130)	45 (149)	68 (223)	72 (238)	86 (281)
Soils without a spodic horizon, but with an argillic horizon	41 (134)	47 (153)	52 (170)	56 (185)	60 (197)	63 (208)	67 (220)	70 (229)	70 (229)	75 (245)
Soils with neither a spodic or an argillic horizon	54 (178)	56 (183)	62 (202)	67 (220)	72 (235)	75 (247)	78 (257)	92 (303)	92 (303)	100 (329)

Note: First distance is in meters followed by feet in parentheses.

Subsurface Outlet (V_{SUBOUT})

Measure/Units: Effectiveness of a drainage ditch at removing subsurface water from the wetland.

Method:

(1) Using recent aerial photographs and verifying during field reconnaissance, determine if any drainage ditches occur within or 300 m (1,000 ft) from the catchment, whichever is less. If no drainage ditches occur within or 300 m from the catchment, then the subindex score for this variable would be 1.0.

(2) If one or more ditches occur within or 300 m from the catchment, examine the ditch(es) to determine if they are maintained and free of obstructions. If the ditch is overgrown with trees or brush, has a water control structure within the ditch, is not connected to an outlet (i.e., stream or larger canal system), or is otherwise not maintained, the variable

subindex would be 1.0. If the ditch is maintained and free of obstructions, measure the depth of the ditch.

(3) Determine the difference in elevation between the bottom of the ditch and the lowest point in the wetland.

(4) If the elevation of the bottom of the ditch is above 0.15 m (6 in.) below the lowest point in the wetland, then the variable subindex would be 1.0.

(5) If the elevation of the bottom of the ditch is below the lowest point in the wetland, use the local NRCS County Soil Survey to determine the dominant soil series between the wetland and the ditch and record on the field data sheet.

(6) Using Table B3 select a category for the soil series mapped on the site and determine the impact distance for the difference between the bottom of the ditch and the lowest point in the wetland.

(7) Determine the percent of the wetland that is within the impact distance of the ditch.

Table B3
Lateral Effects of Ditches for Selected Soil Profile Characteristics in Florida, Subsurface Outlet

Profile Characteristics	Effective Depth of Ditch, cm									
	40	50	60	70	80	90	100	150	200	250
Soils with spodic horizon	19 (63)	22 (74)	37 (123)	81 (267)	98 (322)	112 (367)	129 (422)	191 (627)	231 (757)	238 (782)
Soils without a spodic horizon, but with an argillic horizon	128 (421)	153 (505)	170 (559)	188 (618)	197 (647)	211 (691)	223 (733)	229 (750)	234 (769)	243 (799)
Soils with neither a spodic or an argillic horizon	136 (446)	147 (482)	168 (551)	185 (606)	199 (652)	212 (695)	219 (720)	260 (854)	286 (938)	300 (985)

Note: First distance is in meters followed by feet in parentheses.

Change in the Number of Wetland Zones (V_{ZONES})

Measure/Units: Change in the number of wetland zones in the depressional wetland.

Method:

(1) Determine if wetland zones are complete and intact. If all zones are intact, the variable subindex score would be 1.0.

(2) If the number of zones has been altered, determine the increase or decrease in the number of zones. Using Table B4 determine the subindex score for the change in the number of wetland zones.

Emergent Macrophytic Vegetation (V_{MAC})

Measure/Units: Average percent cover of macrophytic vegetation in all wetland zones.

Table B4
Subindex Score for Change in the Number of Wetland Zone(s)

Number of Natural Wetland Zone(s) Present After Disturbance	Number of Natural Wetland Zone(s) Present Before Disturbance			
	1	2	3	4
0	0.0	0.0	0.0	0.0
1	1.0	0.5	0.25	0.1
2	0.8	1.0	0.5	0.25
3	0.7	0.8	1.0	0.5
4	0.6	0.7	0.8	1.0

Method:

(1) Using the point intercept method described in Appendix C identify five or more points along four or more transects that cross each wetland zone. Using this method, at least 20 sampling points should be identified within each wetland zone. Record each point that intercepts macrophytic vegetation.

(2) Multiply the number of points intercepted by macrophytic vegetation by 5 or the appropriate percent for the number of points collected.

(3) Report emergent macrophytic vegetation cover as a percent between 0 and 100 for each wetland zone.

Cypress Canopy (V_{CANOPY})

Measure/Units: Average percent cover of cypress trees within the tree zone.

Method:

(1) Using the step point procedure described in Chapter 5, estimate the percent cover of cypress trees with the cypress tree zone along the selected transects.

(2) Average the percent cover of cypress trees along all transects.

(3) Report cypress tree cover as a percent between 0 and 100.

Surface Soil Texture (V_{SURTEX})

Measure/Units: Average of the soil texture(s) of the surface horizon or layer of the Wetland Assessment Area (WAA) or Partial Wetland Assessment Area (PWAA).

Method:

(1) During the step point transects, at the midpoint of each wetland zone estimate the texture class of the surface horizon using the feel method.

(2) Using Table B5, assign a score for each texture class found.

(3) Determine the subindex by averaging the scores from each point sampled.

Table B5 Soil Surface Texture for Cypress Dome Wetlands	
Soil Texture	**Variable Subindex**
Sand	1.0
Loamy sand	1.0
Sandy loam	1.0
Muck[1]	0.9
Sandy clay	0.9
Silt	0.8
Silt loam	0.7
Loam	0.6
Sandy clay loam	0.5
Clay loam	0.4
Silty clay loam	0.4
Clay	0.2
Silty clay	0.1
Gravel[1] (≥ 90% gravel)	0.0
Pavement[1]	0.0

[1] Term used in lieu of texture.

Tree Basal Area (V_{TBA})

Measure/Units: Tree basal area in square meters per hectare.

Method:

(1) Measure the diameter of all trees (living woody stems ≥10 cm or 4 in.) at breast height (dbh) in a circular 0.04-ha plot with a radius of 11.3 m (37 ft) or a square 20 m by 20 m at the midpoint along each transect within the cypress zone. Record tree species with corresponding diameter measurement on Data Form 3 (Figure B3). Accurate identification of woody species is critical for determining the dominant species in each plot. Sampling during the dormant season may require proficiency in recognizing plant form, bark, or dormant/dead plant parts. Users who do not feel confident in identifying trees should seek assistance. An electronic version of Data Form 3 is available at *http://www.wes.army.mil/el/wetlands/datanal.html* to complete the calculations in Steps 2-5:

(2) Convert the dbh measurement for each woody stem to square centimeters using the following formula: (dbh * dbh) * 0.25 * 3.14 = cm^2.

(3) Convert the area of each woody stem in cm^2 to square meters using the following formula: cm^2 * 0.0001 = m^2.

(4) Sum the m^2 measurements of all woody stems from the 0.04-ha plots to give m^2/0.04 ha.

(5) Multiply by 25 to convert to m^2/ha.

(6) Record this value as basal area/ha on the field data sheet.

(7) Average the plot values on the field data sheet.

Understory Vegetation Biomass (V_{SSD})

Measure/Units: Combined percent cover of emergent macrophytic vegetation and woody vegetation >1 m in height and <10 cm dbh.

Method:

(1) Using the point intercept method described in Chapter 5, identify five or more points along four or more transects that cross each wetland zone. Using this method, at least 20 sampling points should be identified

within each wetland zone. Record each point that intercepts macrophytic vegetation and woody vegetation.

(2) Multiply the number of points intercepted by macrophytic vegetation by 5 and the woody vegetation by 5 or the appropriate percent for the number of points collected.

(3) Report emergent macrophytic vegetation cover as a percent between 0 and 200 for each wetland zone.

(4) Determine the subindex score for percent cover of understory vegetation by wetland zone.

Herbaceous Plant Species Composition (V_{HCOMP})

Measure/Units: Percent concurrence with the dominant species in the emergent herbaceous strata in all wetland zones present in herbaceous depressional wetlands.

Method:

(1) Identify the dominant species in the ground vegetation strata using the 50/20 rule.[1] To apply the 50/20 rule, rank species from the herbaceous stratum in descending order of abundance from each wetland zone. Identify dominants by summing the relative abundances beginning with the most abundant species in descending order until 50 percent is exceeded. Additional species with $\geq$20 percent relative abundance should also be considered as dominants. If no species is equal to or greater than 20 percent, then identify the species with the greatest percent cover. Accurate species identification is critical for determining the dominant species in each plot. Sampling during the dormant season or after a fire may require a high degree of proficiency. Users who do not feel confident in identifying herbaceous plant species should get help with plant identification.

(2) Calculate percent concurrence by comparing the list of dominant plant species to the list of dominant species from each wetland zone in reference standard wetlands. Use Table B6 for the wet meadow zone, Table B7 for the shallow marsh zone, and Table B8 for the deep marsh zone. For example, if all the dominants from the area being assessed occur on the list of dominants from reference standard wetlands, then there is 100 percent concurrence. If three of the five dominant species from the area being assessed occur on the list, then there is a 60 percent concurrence.

(3) Average the percent concurrence from all wetland zones present.

(4) Report concurrence of species dominants as a percent for each wetland zone present.

---

[1] Memorandum, 6 March 1992, Office, Chief of Engineers, Clarification of Use of the 1987 Delineation Manual.

Table B6
Herbaceous Dominant Plant Species (Wet Meadow)

Scientific Name	Common Name
Amphicarpum muhlenbergianum	muhlenberg maidencane
Andropogon virginicus	broomsedge bluestem
Asclepias pedicellata	savannah milkweed
Carex squarrosa	squarrose sedge
Eleocharis microcarpa	smallfruit spikerush
Eriocaulon compressum	Flattened pipewort
Gratiola ramose	branched hedgehyssop
Hypericum fasciculatum	Peelbark St. Johnswort
Hyptis alata	clustered bushmint
Oxypolis filiformis	water cowbane
Panicum hemitomon	maidencane
Panicum rigidulum	redtop panicgrass
Pluchea rosea	rosy camphorweed
Polygala rugelii	yellow milkwort
Rhynchospora fascicularis	Fascicled beaksedge
Sabatia grandiflora	largeflower rose gentian
Spartina bakeri	sand cordgrass
Xyris elliottii	Elliots yelloweyed grass

Table B7
Herbaceous Dominant Plant Species (Shallow Marsh)

Scientific Name	Common Name
Bacopa caroliniana	blue waterhyssop
Cladium jamaicense	sawgrass
Eriocaulon compressum	flattened pipewort
Iris hexagona	Dixie iris
Juncus effusus	common rush
Lachnanthes caroliana	Carolina redroot
Nymphoides aquatica	big floatingheart
Panicum hemitomon	maidencane
Panicum rigidulum	redtop panicgrass
Rhynchospora inundata	narrowfruit horned beaksedge
Rhynchospora nitens	shortbeak beaksedge
Rhynchospora tracyi	Tracy’s breaksedge

Table B8
Herbaceous Dominant Plant Species (Deep Marsh)

Scientific Name	Common Name
Hibiscus grandiflorus	swamp rosemallow
Lachnanthes caroliana	Carolina redroot
Nelumbo lutea	American lotus
Nymphoides aquatica	big floatingheart
Panicum hemitomon	maidencane
Pontederia cordata	pickerelweed
Rhynchospora inundata	narrowfruit horned breaksedge
Sagittaria lancifolia	bulltongue arrowhead
Thalia geniculata	bent alligator-flag

Tree Species Composition (V_{TCOMP})

Measure/Units: Percent concurrence with the dominant tree species in the tree strata in the tree zones of cypress domes.

Method:

(1) Identify the dominant species in the tree strata using the 50/20 rule.[1] To apply the 50/20 rule, rank species from the tree stratum in descending order of abundance from each wetland zone. Identify dominants by summing the relative abundances beginning with the most abundant species in descending order until 50 percent is exceeded. Additional species with ≥20 percent relative abundance should also be considered as dominants. If no species is equal to or greater than 20 percent, then identify the species with the greatest percent cover. Since *Taxodium ascendens* (pond cypress) is the only tree species dominant in the tree zone of reference standard sites, species identification is relatively easy. However, users who do not feel confident in identifying herbaceous plant species should get help with plant identification.

(2) Calculate percent concurrence by comparing the list of dominant plant species to the list of dominant species from the tree zone in reference standard cypress dome wetlands. Use Table B9 to compare the list of dominants to those species found in reference standard sites. For example, if all the dominants from the area being assessed occur on the list of dominants from reference standard wetlands, then there is 100 percent concurrence. If one of the five dominant species from the area being assessed occurs on the list, then there is a 20 percent concurrence.

Table B9
Tree Dominant Plant Species (Tree Zone)

Scientific Name	Common Name
Taxodium ascendens	pond cypress
Taxodium distichum	bald cypress

(3) Report concurrence of species dominants as a percent for the tree zone.

(4) Use Figure 40, main text, to determine the variable subindex for herbaceous plant species composition of the tree zone in cypress dome depressional wetlands.

Summary of Model Variables by Function

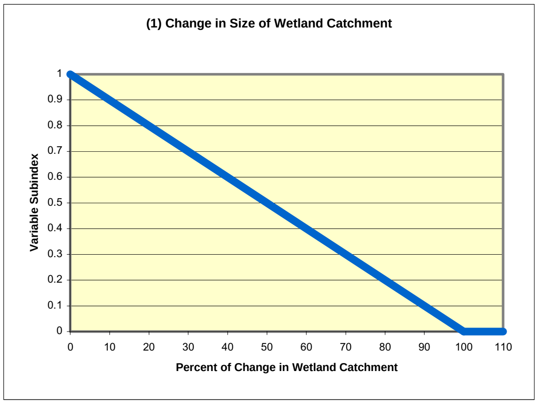
This section provides a listing of the model variables by function.

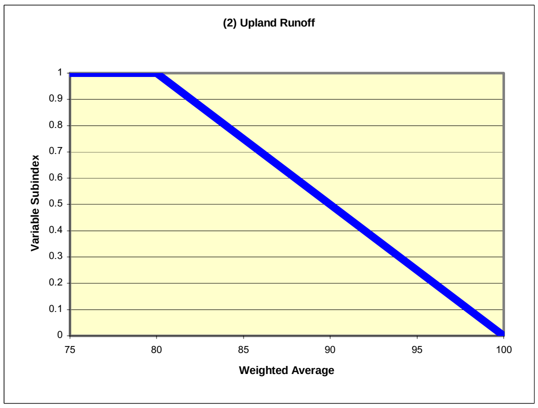
[1] Memorandum, 6 March 1992, Office, Chief of Engineers, Clarification of Use of the 1987 Delineation Manual.

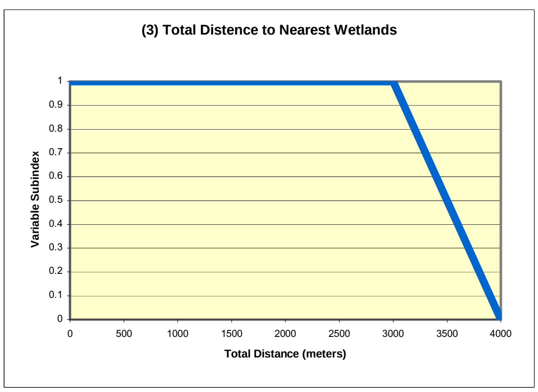
Herbaceous Depressional Wetlands	
Variable	**Function**
1. Change in Catchment Size (V_{CATCH})	Surface Water Storage Subsurface Water Storage Cycle Nutrients
2. Upland Land Use (V_{UPUSE})	Surface Water Storage Subsurface Water Storage Cycle Nutrients Wildlife Habitat
3. Wetland Proximity ($V_{WETPROX}$)	Wildlife Habitat
4. Change in Wetland Volume (V_{WETVOL})	Surface Water Storage Characteristic Plant Community
5. Surface Outlet (V_{SUROUT})	Surface Water Storage Cycle Nutrients
6. Subsurface Outlet (V_{SUBOUT})	Subsurface Water Storage Characteristic Plant Community Wildlife Habitat
7. Change in the Number of Wetland Zones (V_{ZONES})	Wildlife Habitat
8. Emergent Macrophytic Vegetation (V_{MAC})	Surface and Subsurface Water Storage Cycle Nutrients Characteristic Plant Community Wildlife Habitat
10. Surface Soil Texture (V_{SURTEX})	Subsurface Water Storage Cycle Nutrients Characteristic Plant Community Wildlife Habitat
13. Herbaceous Species Composition (V_{HCOMP})	Characteristic Plant Community Wildlife Habitat

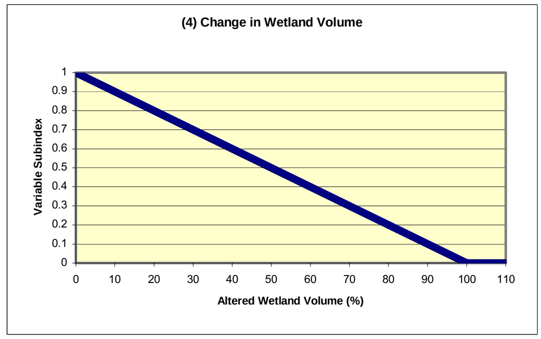
Cypress Dome Depressional Wetlands	
Variable	**Function**
1. Change in Catchment Size (V_{CATCH})	Surface Water Storage Subsurface Water Storage Cycle Nutrients
2. Upland Land Use (V_{UPUSE})	Surface Water Storage Subsurface Water Storage Cycle Nutrients Wildlife Habitat
3. Wetland Proximity ($V_{WETPROX}$)	Wildlife Habitat
4. Change in Wetland Volume (V_{WETVOL})	Surface Water Storage Characteristic Plant Community
5. Surface Outlet (V_{SUROUT})	Surface Water Storage Cycle Nutrients
6. Subsurface Outlet (V_{SUBOUT})	Subsurface Water Storage Characteristic Plant Community Wildlife Habitat
7. Change in the Number of Wetland Zones (V_{ZONES})	Wildlife Habitat
9. Cypress Tree Canopy (V_{CANOPY})	Surface and Subsurface Water Storage Cycle Nutrients Characteristic Plant Community Wildlife Habitat
10. Surface Soil Texture (V_{SURTEX})	Subsurface Water Storage Cycle Nutrients Characteristic Plant Community Wildlife Habitat
11. Tree Basal Area (V_{TBA})	Characteristic Plant Community Wildlife Habitat
12. Understory Vegetation (V_{SSD})	Characteristic Plant Community
14. Tree Species Composition (V_{TCOMP})	Characteristic Plant Community Wildlife Habitat

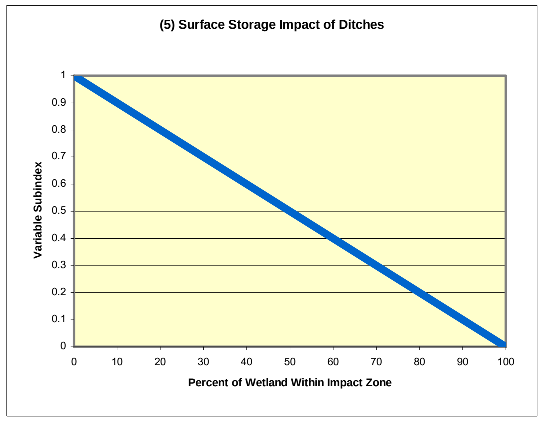
Summary of the Graphs for Transforming Measures to Subindices

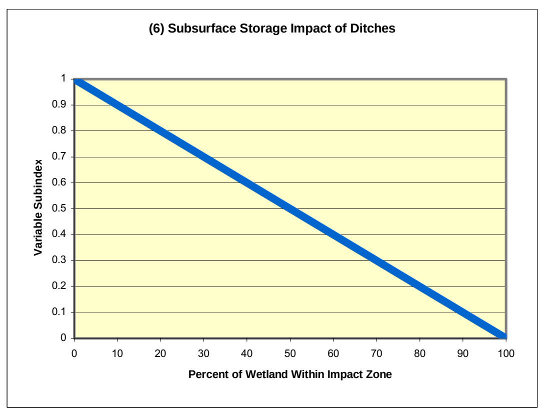


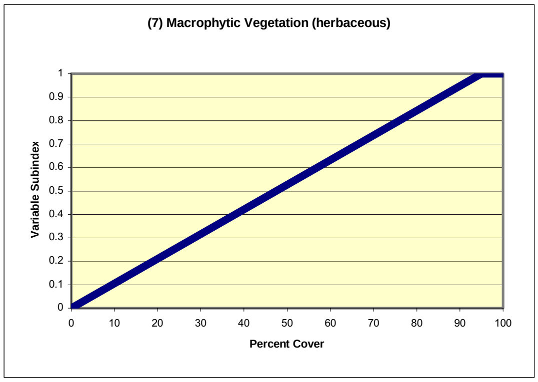


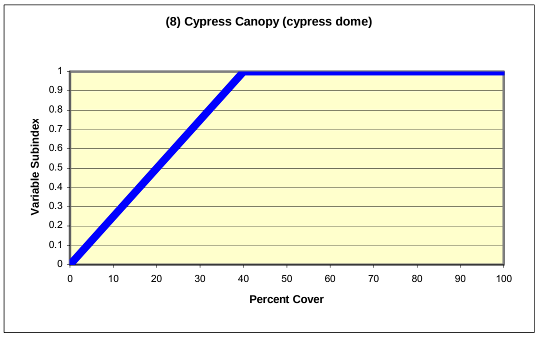


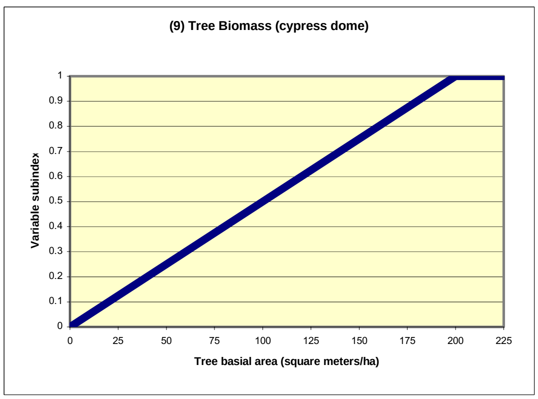


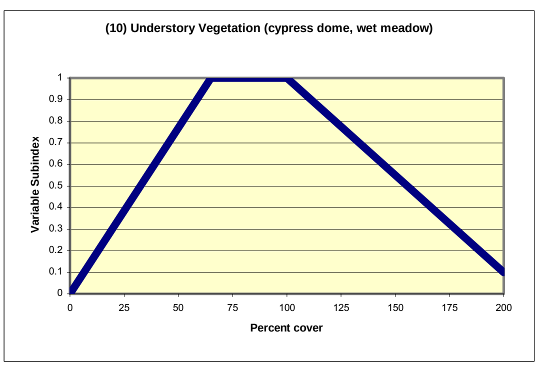


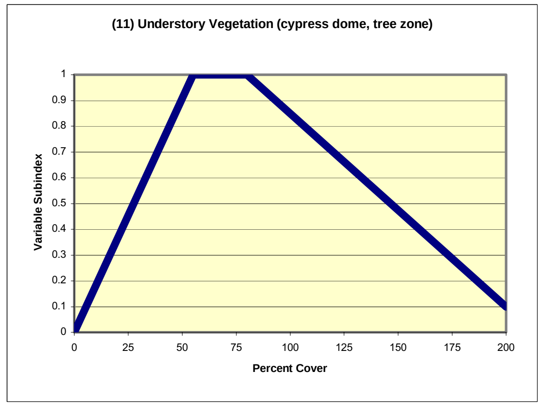


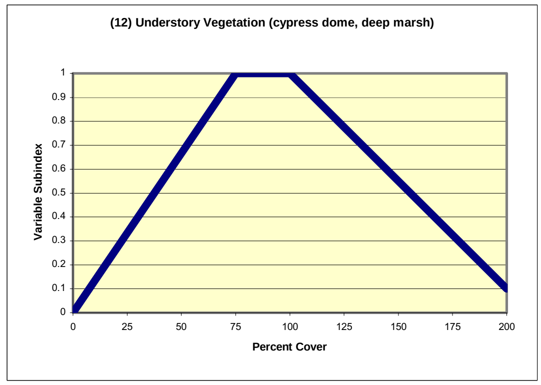

(7) Macrophytic Vegetation (herbaceous)
Variable Subindex
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
0 10 20 30 40 50 60 70 80 90 100
Percent Cover

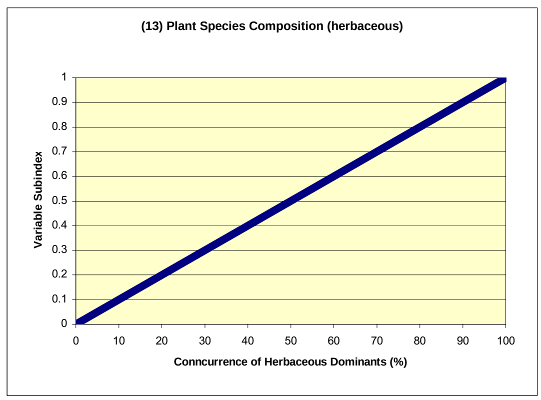

(8) Cypress Canopy (cypress dome)
Variable Subindex
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
0 10 20 30 40 50 60 70 80 90 100
Percent Cover

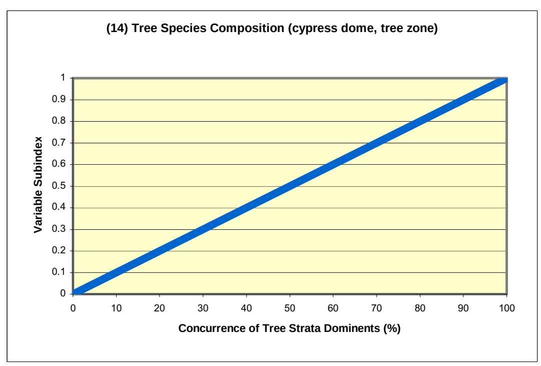

(9) Tree Biomass (cypress dome)
Variable subindex
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
0 25 50 75 100 125 150 175 200 225
Tree basial area (square meters/ha)


(10) Understory Vegetation (cypress dome, wet meadow)
Variable Subindex
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
0 25 50 75 100 125 150 175 200
Percent cover


(11) Understory Vegetation (cypress dome, tree zone)
Variable Subindex
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
0 25 50 75 100 125 150 175 200
Percent Cover


(12) Understory Vegetation (cypress dome, deep marsh)
Variable Subindex
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
0 25 50 75 100 125 150 175 200
Percent Cover


(13) Plant Species Composition (herbaceous)
Variable Subindex
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
0 10 20 30 40 50 60 70 80 90 100
Conncurrence of Herbaceous Dominants (%)


(14) Tree Species Composition (cypress dome, tree zone)
Variable Subindex
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
0 10 20 30 40 50 60 70 80 90 100
Concurrence of Tree Strata Dominents (%)

Herbaceous Field Data Sheet

Assessment Team:				
Project Name:				
Location:				
Date:		**Subclass: herbaceous depression**		
Sample variables 1-3 using aerial photography, topographic maps, National Wetland Inventory maps, soils survey maps, etc.				
1.	V_{CATCH}	Percent change in the size of the catchment (if no impact to catchment, variable subindex = 1.0)……………………………………………………………….….. Size of original catchment _______ha; Size of current catchment _______ ha	_____	%
2.	V_{UPUSE}	Percent cover of upland land use (if native landscape in good condition, variable subindex = 1.0)…………………………………………………………………... Cover type _______ Curve #______ % ____Cover type ________ Curve #_____ % Cover type _______ Curve #______ % ____Cover type ________ Curve #_____ % Cover type _______ Curve #______ % ____Cover type ________ Curve #_____ % Cover type _______ Curve #______ % ____Cover type ________ Curve #_____ % Cover type _______ Curve #______ % ____Cover type ________ Curve #_____ %	_____	%
3.	$V_{WETPROX}$	Distance from wetlands edge to nearest depressional wetland within 500 m……… Sector 1 ______ m Sector 2 ______ m Sector 3 ________ m Sector 4 _______ m Sector 5 ______ m Sector 6 ______ m Sector 7 ________ m Sector 8 _______ m	_____	m
Sample variables 4-7 during on site field reconnaissance				
4.	V_{WETVOL}	Change in the volume of the wetland (if no fill or excavation variable subindex = 1.0)……………………………………………………………………………….. Diameter of wetland north-south ____m; Diameter of wetland north-south ____m Depth of the wetland__________m Length of fill material _____m; Width of fill material ____ m; Average thickness of fill material ____m	_____	% m
5.	V_{SUROUT}	Percent of wetland effected by lateral effect of ditches to surface water storage…... Difference in elevation of bottom of ditch and bottom of wetland ____m; Lateral effect of ditch _____ m; Distance of ditch to wetland _____ m	_____	%
6.	V_{SUBOUT}	Percent of wetland effected by lateral effect of ditches to subsurface water storage Difference in elevation of bottom of ditch and bottom of wetland + 6 in _____m; Lateral effect of ditch _____ m; Distance of ditch to wetland _____ m	_____	%
7.	V_{ZONES}	Change in the number of wetland zones (if no change in the number of zones variable subindex = 1.0)……………………………………………………………		#
Sample variables 8-10 along 4 or more transects that cross each wetlands zone				
8.	V_{MAC}	Percent cover of emergent macrophytic vegetation…………………………………		%
10.	V_{SURTEX}	Average soil texture of surface horizon or layer of the WAA or PWAA…………. Subindex score of sample point: Transect 1 zone1_____; zone2_____; zone3_____; zone 4_____ Transect 2 zone1_____; zone2_____; zone3_____; zone 4_____ Transect 3 zone1_____; zone2_____; zone3_____; zone 4_____ Transect 4 zone1_____; zone2_____; zone3_____; zone 4_____	_____	
13.	V_{HCOMP}	Average percent concurrence of dominant species from all wetland zones present.. Wet meadow zone __________ % Shallow marsh zone _________ % Deep marsh zone ___________ %	_____	%

Figure B1. Field Data Sheet for herbaceous depressional wetlands

Cypress Dome Field Data Sheet

Assessment Team:			
Project Name:			
Location:			
Date:		**Subclass: cypress dome**	
Sample variables 1-3 using aerial photography, topographic maps, National Wetland Inventory maps, soils survey maps, etc.			
1.	V_{CATCH}	Percent change in the size of the catchment (if no impact to catchment, variable subindex = 1.0)…………………………………………………………………………………… _____ Size of original catchment _______ha Size of current catchment _______ ha	%
2.	V_{UPUSE}	Percent cover of upland land use (if native landscape in good condition, variable subindex = 1.0)………………………………………………………………………. _____ Cover type _______ Curve #______ % ____Cover type ________ Curve # % Cover type ______ Curve #______ % ____Cover type ________ Curve # % Cover type ______ Curve #______ % ____Cover type _______ Curve # % Cover type ______ Curve #______ % ____Cover type _______ Curve # % Cover type ______ Curve #______ % ____Cover type _______ Curve # %	%
3.	$V_{WETPROX}$	Distance from wetlands edge to nearest depressional wetland within 500 m…….. _____ Sector 1 m Sector 2 m Sector 3 m Sector 4 m Sector 5 m Sector 6 m Sector 7 m Sector 8 m	m
Sample variables 4-7 during on site field reconnaissance			
4.	V_{WETVOL}	Change in the volume of the wetland (if no fill or excavation variable subindex = 1.0)……………………………………………………………………………….. ______ Diameter of wetland north-south _____m; Diameter of wetland north-south ___m Depth of the wetland__________m Length of fill material _____m; Width of fill material ____ m; Average thickness of fill material ____m	%
5.	V_{SUROUT}	Percent of wetland effected by lateral effect of ditches to surface water storage….. ______ Difference in elevation of bottom of ditch and bottom of wetland __________m; Lateral effect of ditch __________ m; Distance of ditch to wetland _________ m	%
6.	V_{SUBOUT}	Percent of wetland effected by lateral effect of ditches to subsurface water storage ______ Difference in elevation of bottom of ditch and bottom of wetland + 6 in _____m; Lateral effect of ditch _________ m; Distance of ditch to wetland __________ m	%
7.	V_{ZONES}	Change in the number of wetland zones…………………………………………….	#
Sample variables 8-11 along 4 or more transects that cross each wetlands zone			
9.	V_{CANOPY}	Percent cover of cypress trees in the tree zone…………………………………...	%
10.	V_{SURTEX}	Soil texture of surface horizon or layer of the WAA or PWAA…………………… ______ Subindex score of sample point: Transect 1 zone1_____; zone2_____; zone3_____; zone 4_____ Transect 2 zone1_____; zone2_____; zone3_____; zone 4_____ Transect 3 zone1_____; zone2_____; zone3_____; zone 4_____ Transect 4 zone1_____; zone2_____; zone3_____; zone 4_____	
11.	V_{TBA}	Average tree basal area within tree zone…………………………………………… ______ Plot 1______ m^2/ha; Plot 2______ m^2/ha; Plot 3 ______ m^2/ha;Plot 4 _____ m^2/ha	m^2/ha
12.	V_{SSD}	Average % cover of emergent macrophytic and woody vegetation >1 m in height and <10 cm dbh………………………………………………………………………..	%
14.	V_{TCOMP}	Average percent concurrence of dominant species from the tree zone wetland zones……………………………………………………………………………...	%

Figure B2. Field Data Sheet for cypress dome depressional wetlands

Tree Basal Area Field Data Sheet

Assessment Team:____

Project Name:____

Location:____

Date:________________________________ **Subclass: cypress dome**

Record the species and dbh (cm) of all trees (i.e., woody stems $\geq$ 10 cm (4 in.) in the plot within the tree zone

1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
species code	dbh (cm)	area (cm^2)	area (m^2)	species code	dbh (cm)	area (cm^2)	area (m^2)

Figure B3. Field Data Sheet for tree basal area for cypress dome wetlands

Transect Point Sampling Field Data Sheet

Assessment Team:____

Project Name:____

Location:____

Date:____**Subclass:**

Record the transect #, zone (i.e., wet meadow, shallow marsh, deep marsh, tree), sample point, strata (i.e., herbaceous for herbaceous wetlands) (i.e., herbaceous, shrub, tree for cypress dome wetlands) and species

1	**2**	**3**	**4**	**5**	**6**			**7**
Transect #	zone	point #	# of species	species	% cover by point			% cover by species
					H	**S**	**T**	
Total herbaceous cover zone (%)								
Total shrub cover zone (%)								
Total tree cover zone (%)								

Figure B4. Point Transect Field Data Sheet for herbaceous and cypress dome depressional wetlands

Appendix C
Supplementary Information on Model Variables

This appendix contains the following summaries:

a. Soil Texture by Feel Guide and Soil Textural Triangle (Figure C1).

b. Change in Wetland Volume Example (Figure C2).

c. van Schilfgaarde equation (Figures C3 and C4).

d. Determination of Weighted Average for V_{UPUSE} (Figures C5 and C6 and Table C1).

e. Species List (Table C2).

f. Dominant species photographs (Figures C7-C37).

Change in Wetland Volume Example

Determine the volume of the wetland (Figure C2).

(1) Measure the distance from the diameter of the wetland along the longest and shortest axis in meters. Average the two diameters and determine the average radius of the wetland.

(2) Measure the depth of the wetland in meters.

Use the formula for the volume of a simple cone:

$$V = \frac{1}{3}\pi r^2 h$$

$$V = 1.0476 \times r^2 h$$

If the diameter of the long axis is 150 m and the diameter along the short axis is 50 m, then the average radius of this example wetland is 100 m.

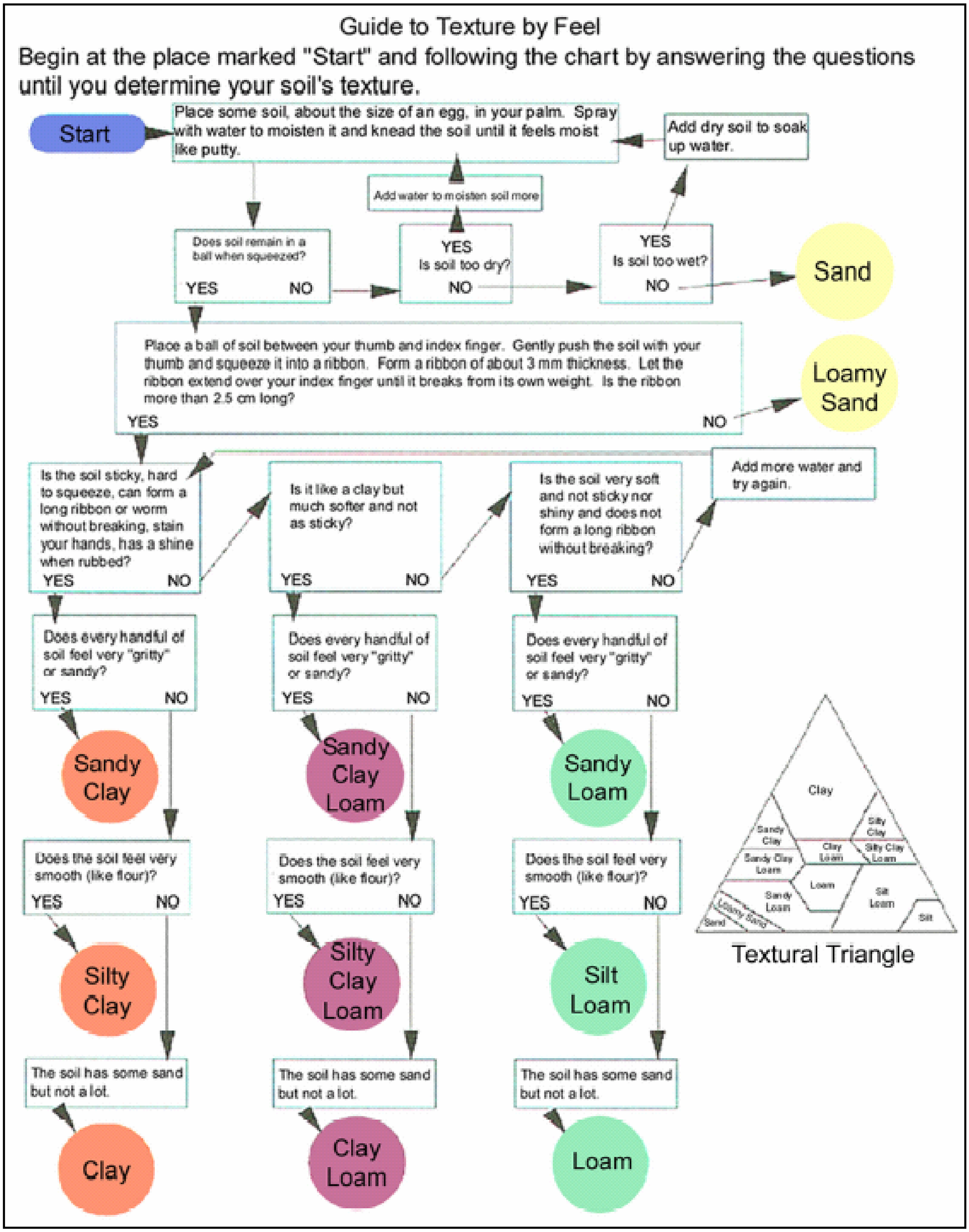


Figure C1. Soil texture by feel guide

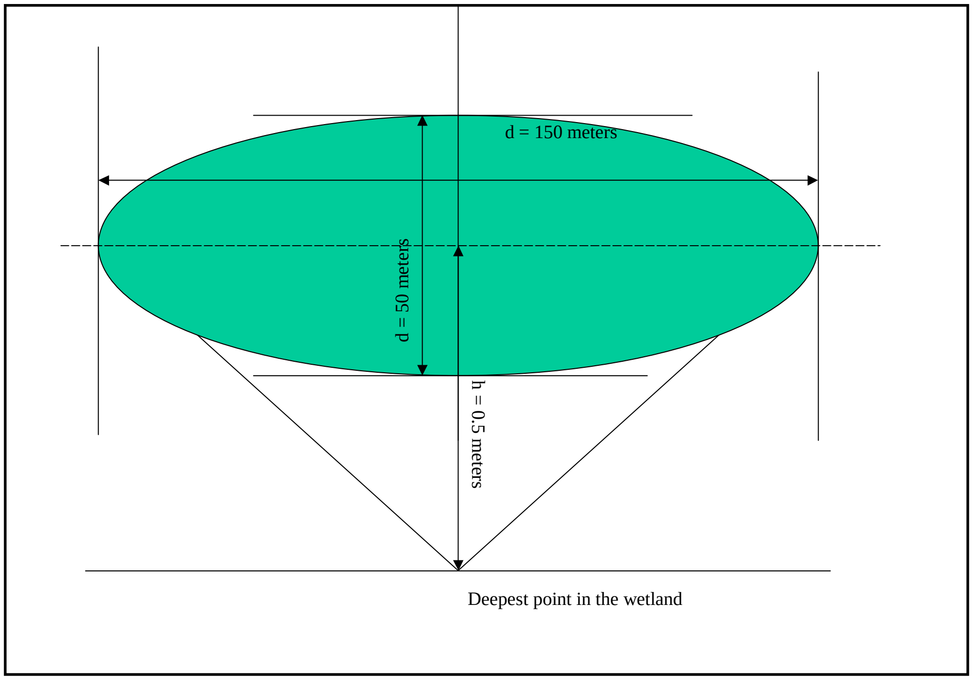


Figure C2. Measurements for wetland volume

The depth is 0.5 m. The result is:

$$V = 1.0476 \times 100^2 \times 0.5$$

$$V = 1.0476 \times 1000 \times 0.5$$

$$V = 5238 \text{ m}^3$$

Measure the size of the fill area and determine the volume of the fill.

If the fill material is rectangular, measure the length of one of the long sides and one of the short sides and the height of the fill material.

In this example if the fill material is:

Length = 50 m

Width = 40 m

Height = 1 m (use only that portion of the fill material that would affect the wetland). Since the wetland is only 0.5 m deep, use 0.5 as the height rather than 1 m.

$50 \times 40 \times 0.5 = 500 \text{ m}^3$

Determine the percent that 500 m^3 is of the total wetland volume.

$500/5238 \times 100 = 9.6\%$ of the volume has been changed.

van Schilfgaarde Equation

The van Schilfgaarde equation was originally developed to approximate the spacing and depth of ditches for agriculture (Figure C3). It is currently being used to determine hydrologic alteration in the context of crop production where the usual requirement is to lower the water table below the root zone within 24 to 48 hr after saturation (U.S. Department of Agriculture, Natural Resources Conservation Service (USDA NRCS) 1997).[1] The objective of utilizing the van Schilfgaarde equation in this Regional Guidebook is to assess the extent that a drainage ditch affects the Wetland Assessment Area (WAA). The water table slope in the WAA is assumed to mimic the wetland surface except when ditches, wells, or other alterations cause it to be modified. If a ditch is present, then the lateral extent of the effect on water table slope must be determined. The van Schilfgaarde equation is used as an indicator of alteration to the water table slope by providing an approximation of the lateral effect of a ditch.

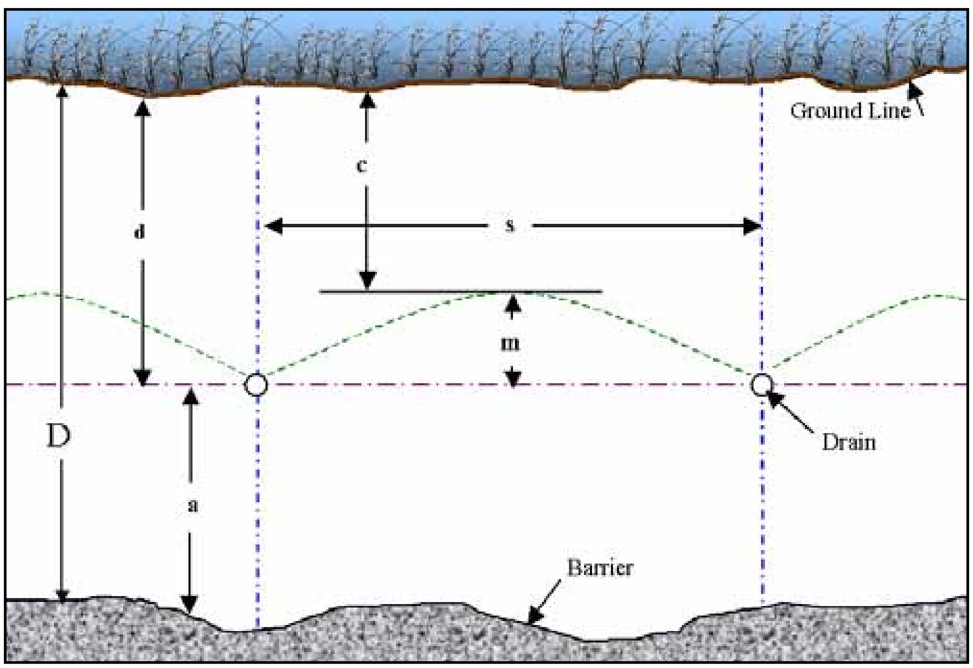


Figure C3. Parallel drainage spacing (USDA NRCS 1997)

[1] References cited in this appendix are included in the References section at the end of the main text.

The van Schilfgaarde equation was used to determine the lateral distance *Le* over which a drainage feature would be expected to alter the water table in depressional wetlands in peninsular Florida:

$$S = 2Le = \left[\left(\frac{9KtD}{\left\{f\left[\ln m_0\left(2D\ m\right) - \ln m\left(2D\ m_0\right)\right]\right\}}\right)\right]^{1/2}$$

where

S = drain spacing distance

Le = ½ S = horizontal distance of lateral effect

K = hydraulic conductivity (distance per unit time)

t = time for water table to drop from height m_0 to depth m

D = equivalent depth from drainage feature to impermeable layer

f = drainable porosity of the water-conducting soil expressed as a fraction

m_0 = height of water table above the center of the drainage feature at time $t = 0$

m = height of water table above the center of the drainage feature at time t

The following variables were entered into a van Schilfgaarde equation at the Agricultural Research Service (ARS) National Sedimentation Laboratory/NRCS Wetland Science Institute Web page site: *http://msa.ars.usda.gov/ms/oxford/nsl/java/Schilfgaarde_java.html* (Figure C4). In doing so, permeability K and drainable porosity f were determined for three soil series representing a soil with a spodic horizon, an argillic horizon, and one with neither a spodic or an argillic horizon. The program does not allow entries for f to be less than 0.01. When calculated, drainable porosity was less than 0.01; the lowest value allowed was used.

d = total depth to the impermeable layer (barrier) from the ground surface

f = drainable porosity varied for each soil

m_0 = height of water table in feet above the center of the drainage feature at time $t = 0$ (in this case, $m_0 = d$)

t = 14 days for all calculations (time in days for the water table to drop from ground level to –12 in.)

D = 10 (depth to impermeable layer in feet), held constant for all calculations

S = 0.0 (surface storage), held constant for all calculations

m = d - 1 (assuming regulatory criterion of soil saturation to 0.0 for V_{SUROUT} and 0.5 ft for V_{SUBOUT} required to meet wetland definition (sensu Environmental Laboratory 1987)

K = hydraulic conductivity varied for each soil

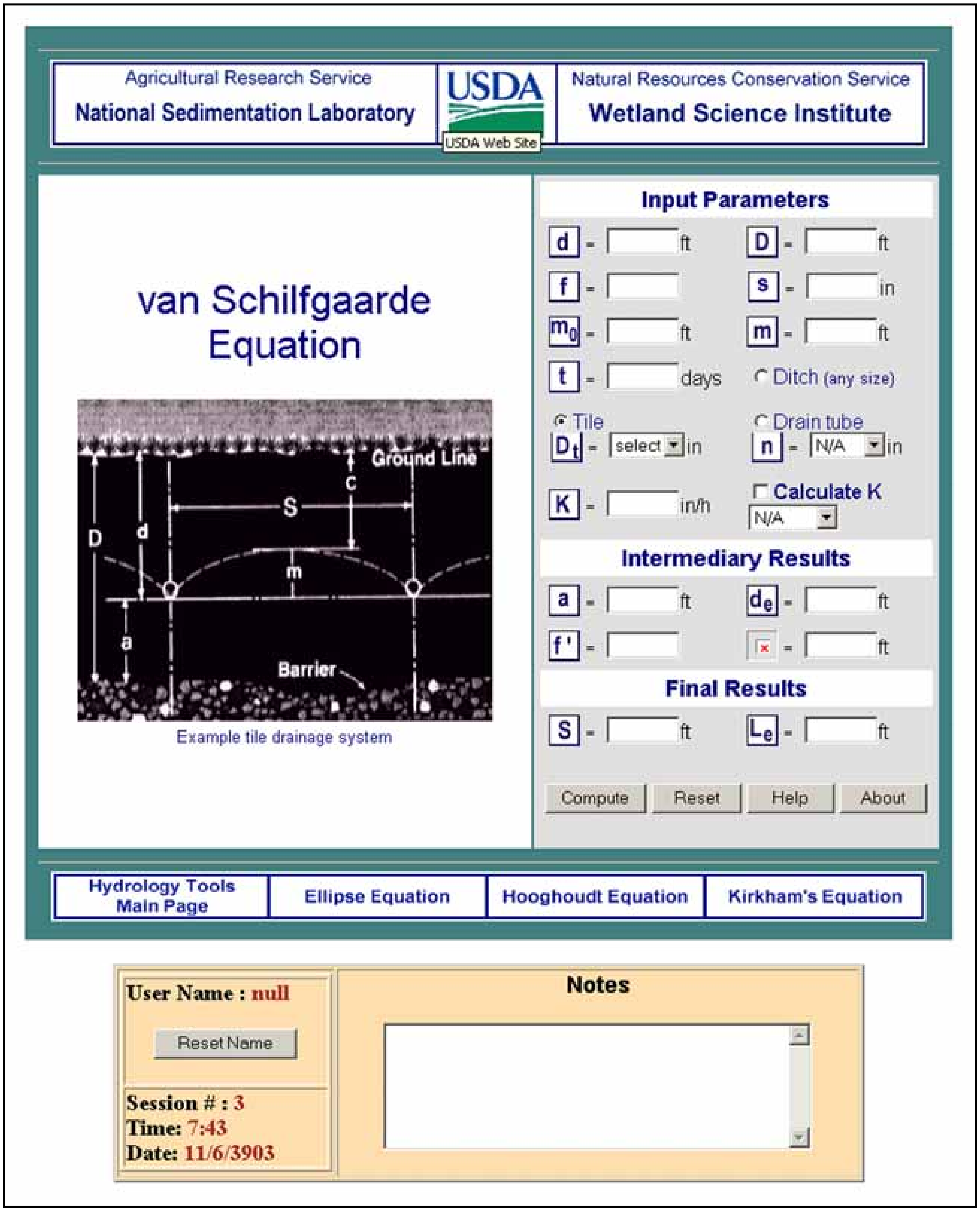


Figure C4. van Schilfgaarde equation

When these parameters are entered into the ARS National Sedimentation Laboratory model, *S* and *Le* are provided as output. Lateral drainage effect distances (*Le*) are values provided in Table 7 and Table 8 in the main text and are used to determine V_{SUROUT} and V_{SUBOUT}.

These calculations were based on the dominant conditions in the reference domain. One could calculate a more precise drainage distance (*Le*) for a specific soil type using soil data from a specific site.

Example:

d = variable ((40 cm (1.31 ft) – 250 cm (8.2 ft))

D = constant (10 ft)

f = variable

s = constant (0)

m_0 = variable (same as d)

m = variable (d – 1 ft)

t = constant (14 days)

ditch any size

K = variable

K was computed as a weighted average of the top 50.8 cm (20 in.) of the soil based on the median of the range of soil permeability for each soil series.

Drainable porosity (*f*) was estimated using the MUUF 2.14 program. This program is available from *ftp://ftp.wcc.nrcs.usda.gov/water_mgt/muuf*.

Determination of Weighted Average for V_{UPUSE}

An example of determining a weighted average for V_{UPUSE} is as follows:

a. Using recent aerial photography identify the different cover types found within the wetland catchment (Figure C5).

b. In this example all of the soils are within hydrologic soil group D.

c. Identify all cover types present.

d. Determine the percentage of the catchment for each cover type.

e. Determine the runoff curve number for each cover type present (Table C1).

f. Multiply the percentage of each cover type by the runoff curve number and divide by 100.

$$\left[\frac{(12\times84)+(19\times80)+(8\times93)+(38\times87)+(3\times77)+(5\times82)+(15\times79)}{100}\right]=84$$

Figure C5. Aerial photograph illustrating examples of some of the cover types found within the catchment of a wetland

Table C1 Land Use Example			
Cover Type	**Acres**	**Percent of Catchment**	**Runoff Curve Numbers**
Pasture fair condition	15	12	84
Pasture good condition	24	19	80
Industrial	10	8	93
Residential (38% cover)	48	38	87
Forest and native range (>75% ground cover)	4	3	77
Residential (12% cover)	6	5	82
Forest and native range (50 to 75% ground cover)	19	15	79
Total	126	100	

The weighted average for the site is 84.0.

g. Using the graph for V_{UPUSE} determine the variable subindex score for 80.0 (Figure C6). The variable subindex score for this example would be 8.0.

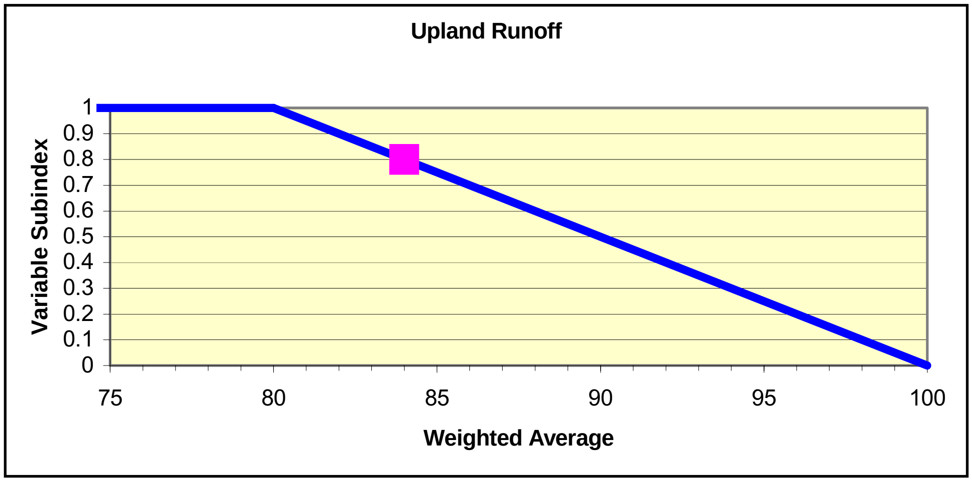


Figure C6. Example of upland runoff score

Table C2 Species List Found During Data Collection for All Subclasses	
Scientific Name	**Common Name**
Acer rubrum	red maple
Alternanthera sessilis	sessile joyweed
Andropogon brachystachyus	shortspike bluestem
Andropogon capillipes	chalky bluestem
Ampelopsis arborea	peppervine
Andropogon glomeratus	bushy bluestem
Andropogon virginicus	broomsedge bluestem
Annona glabra	pond apple
Aristida palustris	longleaf threeawn
Aristida purpurascens	arrowfeather threeawn
Baccharis glomeruliflora	Silverling
Baccharis halimifolia	eastern baccharis
Bacopa caroliniana	blue waterhyssop
Bacopa monnieri	herb of grace
Bigelowia nudata	pineland rayless goldenrod
Blechnum serrulatum	toothed midsorus fern
Boehmeria cylindrica	smallspike false nettle
Buchnera americana	american bluehearts
Callicarpa americana	american beautyberry
Cassytha filiformis	devil's gut
Casuarina equisetifolia	australian pine
Centella asiatica	Spadeleaf
Cephalanthus occidentalis	common buttonbush
Cladium jamaicense	Sawgrass
Coelorachis rugosa	wrinkled jointtail grass
	(Sheet 1 of 4)

Table C2 (Continued)

Scientific Name	Common Name
Coreopsis leavenworthii	leavenworth's tickseed
Crinum americanum	seven sisters
Cyperus haspan	haspan flatsedge
Cyperus odoratus	fragrant flatsedge
Cyperus polystachyos	manyspike flatsedge
Dichanthelium dichotomum	cypress panicgrass
Dichanthelium erectifolium	erectleaf panicgrass
Dichanthelium sabulorum	hemlock rosette grass
Diodia virginiana	Virginia buttonweed
Eleocharis cellulosa	coastal spikerush
Eragrostis elliottii	field lovegrass
Erechtites hieracifolia	burnweed
Erianthus giganteus	sugarcane plumgrass
Eriocaulon decangulare	tenangle pipewort
Eupatorium capillifolium	dogfennel
Eupatorium leptophyllum	false fennel
Fuirena breviseta	saltmarsh umbrella-sedge
Heliotropium polyphyllum	pineland heliotrope
Hydrocotyle umbellata	manyflower marshpennywort
Hypericum fasciculatum	peelbark st. johnswort
Hypericum hypericoides	st. andrew's cross
Hyptis alata	clustered bushmint
Ilex cassine	dahoon holly
Ipomoea sagittata	everglades morning-glory
Iva microcephala	piedmont marshelder
Juncus megacephalus	bighead rush
Juncus scirpoides	needlepod rush
Lachnanthes caroliana	carolina redroot
Leersia hexandra	southern cutgrass
Linum medium	stiff yellow flax
Ludwigia curtissii	curtiss' primrose-willow
Ludwigia microcarpa	smallfruit primrose-willow
Ludwigia octovalvis	mexican primrose-willow
Ludwigia peruviana	peruvian primrose-willow
Ludwigia repens	creeping primrose-willow
Mecardonia acuminata	Axilflower
Melaleuca quinquenervia	Melaleuca
Mikania scandens	climbing hempweed
Muhlenbergia capillaris	hairawn muhly
Myrica cerifera	wax myrtle
Nymphaea odorata	american white waterlily

(Sheet 2 of 4)

Table C2 (Continued)	
Scientific Name	**Common Name**
Osmunda cinnamomea	cinnamon fern
Osmunda regalis	royal fern
Oxypolis filiformis	water cowbane
Panicum dichotomiflorum	fall panicgrass
Panicum hemitomon	Maidencane
Panicum repens	Torpedograss
Panicum rigidulum	redtop panicgrass
Panicum tenerum	bluejoint panicgrass
Panicum virgatum	Switchgrass
Paspalum notatum	Bahiagrass
Persea palustris	swamp bay
Phlebodium aureum	golden polypody
Phragmites australis	common reed
Phyla nodiflora	turkey tangle fogfruit
Phyla stoechadifolia	southern fogfruit
Pinus elliottii	slash pine
Pluchea odorata	sweetscent
Pluchea rosea	rosy camphorweed
Polygala balduinii	baldwin's milkwort
Polygala grandiflora	showy milkwort
Polygonum hydropiperoides	swamp smartweed
Polygonum punctatum	dotted smartweed
Pontederia cordata	pickerelweed
Proserpinaca palustris	marsh mermaidweed
Proserpinaca pectinata	combleaf mermaidweed
Rhynchospora cephalantha	bunched beaksedge
Rhynchospora divergens	spreading beaksedge
Rhynchospora filifoli	threadleaf beaksedge
Rhynchospora inundata	narrowfruit horned beaksedge
Rhynchospora microcarpa	southern beaksedge
Rhynchospora tracyi	tracy's beaksedge
Sabal palmetto	cabbage palmetto
Sabatia grandiflora	largeflower rose gentian
Sacciolepis striata	american cupscale
Sagittaria graminea	grassy arrowhead
Sagittaria lancifolia	bulltongue arrowhead
Salix caroliniana	coastal plain willow
Sambucus canadensis	common elderberry
Schinus terebinthifolius	brazilian peppertree
Schizachyrium rhizomatum	florida little bluestem
Scleria reticularis	netted nutrush
	(Sheet 3 of 4)

Table C2 (Concluded)	
Scientific Name	**Common Name**
Sisyrinchium atlanticum	eastern blue-eyed grass
Spermacoce verticillata	shrubby false buttonweed
Stillingia aquatica	water toothleaf
Taxodium distichum	Bald cypress
Thalia geniculata	Bent alligator-flag
Toxicodendron radicans	eastern poison ivy
Triadenum virginicum	Virginia marsh st. johnswort
Typha domingensis	southern cattail
Urena lobata	Caesarweed
Utricularia biflora	humped bladderwort
Utricularia cornuta	horned bladderwort
Utricularia purpurea	eastern purple bladderwort
Viola lanceolata	bog white violet
Vitis rotundifolia	muscadine
Woodwardia virginica	Virginia chainfern
	(Sheet 4 of 4)

Figure C7. *Bacopa caroliniana* (blue waterhyssop)

Figure C8 *Cladium jamaicense* (sawgrass)

Figure C9. *Hyptis alata* (clustered bushmint)

Figure C10. *Rhynchospora tracyi* (tracy's beaksedge)

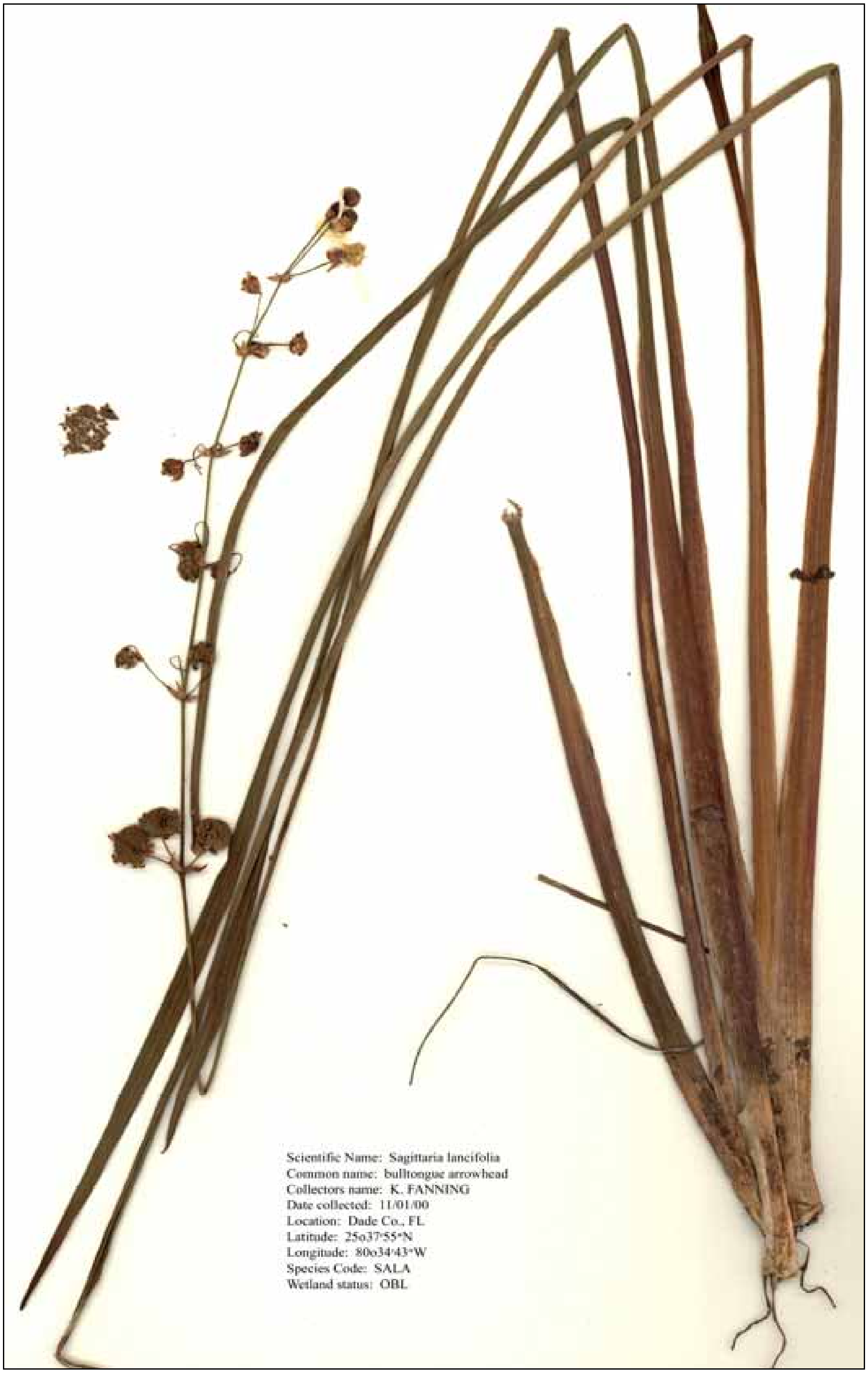


Figure C11. *Sagittaria lancifolia* (bulltongue arrowhead)

Figure C12. *Asclepias pedicellata* (savannah milkweed), detail

Figure C13. *Asclepias pedicellata* (savannah milkweed)

Figure C14. *Carex squarrosa* (squarrose sedge)

Figure C15. *Eriocaulon compressum* (flattened pipewort)

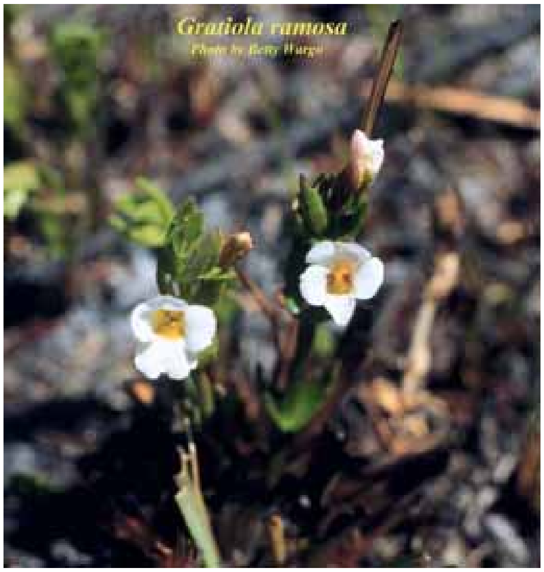


Figure C16. *Gratiola ramose* (branched hedgehyssop)


Figure C17. *Hypericum fasciculatum* (peelbark St. Johnswort)

Figure C18. *Hibiscus grandiflorus* (swamp rosemallow)

Figure C19. *Hibiscus grandiflorus* (swamp rosemallow), detail


Figure C20. *Juncus effusus* (common rush)


Figure C21. *Iris hexagona* (Dixie iris)

Figure C22. *Lachnanthes caroliana* (Carolina redroot)

Figure C23. *Lachnanthes caroliana* (Carolina redroot), detail

Figure C24. *Nelumbo lutea* (American lotus), detail

Figure C25. *Nelumbo lutea* (American lotus)

Figure C26. *Nymphoides aquatica* (big floatingheart)

Figure C27. *Oxpolis filiformis* (water cowbane)

Figure C28. *Oxpolis filiformis* (water cowbane)

Figure C29. *Panicum hemitomon* (maidencane)

Figure C30. *Panicum rigidulum* (redtop panicgrass)

Figure C31. *Pluchea rosea* (rosy camphorweed)

Figure C32. *Polygala rugelii* (yellow milkwort)

Figure C33. *Pontederia cordata* (pickerelweed)

Figure C34. *Rhynchospora fascicularis* (fascicled beaksedge)

Figure C35. *Rhynchospora inundata* (narrowfruit horned beaksedge)

Figure C36. *Rhynchospora nitens* (shortbeak beaksedge)

Figure C37. *Sabatia grandiflora* (largeflower rose gentian)

Figure C38. *Spartina bakeri* (sand cordgrass)

Figure C39. *Thalia geniculata* (bent alligator-flat)

Figure C40. *Thalia geniculata* (bent alligator-flat)

Figure C41. *Xyris elliottii* (Elliots yelloweyed grass)

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
May 2004	Final report	

4. TITLE AND SUBTITLE

A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Depressional Wetlands in Peninsular Florida

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Chris V. Noble, Rhonda Evans, Marti McGuire, Katherine Trott, Mary Davis, Ellis J. Clairain, Jr.

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER
32958

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

See reverse.

8. PERFORMING ORGANIZATION REPORT NUMBER

ERDC/EL TR-04-3

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

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 is unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The Hydrogeomophic (HGM) Approach is a method for developing functional indices and the protocols used to apply these indices to the assessment of wetland functions at a site-specific scale. The HGM Approach was initially designed to be used in the context of the Clean Water Act Section 404 Regulatory Program permit review 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.

This report uses the HGM Approach to develop a Regional Guidebook to (a) characterize the Depressional Wetlands in Peninsular Florida, (b) provide the rationale used to select functions for the herbaceous and cypress dome subclasses, (c) provide the rationale used to select model variables and metrics, (d) provide the rationale used to develop assessment models, (e) provide data from reference wetlands and document its use in calibrating model variables and assessment models, and (f) outline the necessary protocols for applying the functional indices to the assessment of wetland functions.

15. SUBJECT TERMS
See reverse.

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			**19b. TELEPHONE NUMBER** *(include area code)*
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED		173	

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

7. (Concluded)

U.S. Army Engineer Research and Development Center
Environmental Laboratory
3909 Halls Ferry Road
Vicksburg, MS 39180-6199;

Headquarters, U.S. Army Corps of Engineers
441 G Street NW
Washington, DC 20314-1000;

U.S. Environmental Protection Agency, Region IV
Sam Nunn Atlanta Federal Center
61 Forsyth Street, SW
Atlanta, GA 30303-8960;

Florida Department of Environmental Protection
2600 Blair Stone Road
Tallahassee, FL 32399-2400;

National Wildlife Federation
1313 West Peachtree
Atlanta, GA 30309

15. (Concluded)

404 Regulatory Program
Assessment
Classification
Clean Water Act
Cypress dome
Depressions
Ecosystem
Evaluation
Florida
Function
Functional assessment
Functional profile
Geomorphology
Herbaceous
HGM Approach
Hydrogeomorphic
Hydrogeomorphic (HGM) Approach
Hydrology
Impact analysis
Index
Indicators
Landscape
Method
Mitigation
Model
National Action Plan
Procedure
Reference wetlands
Restoration
Value
Wetland
Wetland assessment
Wetland functions