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Environmental Laboratory

US Army Corps of Engineers®
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Wetlands Regulatory Assistance Program

Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Caribbean Islands Region (Version 2.0)

U.S. Army Corps of Engineers

May 2011

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U.S. Army Corps of Engineers

U.S. Army Engineer Research and Development Center
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Final report

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

Abstract: This document is one of a series of Regional Supplements to the Corps of Engineers Wetland Delineation Manual, which provides technical guidance and procedures for identifying and delineating wetlands that may be subject to regulatory jurisdiction under Section 404 of the Clean Water Act or Section 10 of the Rivers and Harbors Act. The development of Regional Supplements is part of a nationwide effort to address regional wetland characteristics and improve the accuracy and efficiency of wetland-delineation procedures. This supplement is applicable to the Caribbean Islands Region, which consists of the Commonwealth of Puerto Rico and the Territory of the United States Virgin Islands.

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Preface

This document is one of a series of Regional Supplements to the Corps of Engineers Wetland Delineation Manual. It was developed by the U.S. Army Engineer Research and Development Center (ERDC) at the request of Headquarters, U.S. Army Corps of Engineers (USACE), with funding provided through the Wetlands Regulatory Assistance Program (WRAP). This is Version 2.0 of the Caribbean Islands Regional Supplement; it replaces the "interim" version, which was published in August 2009.

This document was developed in cooperation with the Caribbean Islands Regional Working Group. Working Group meetings were held in San Juan, PR, on 22-24 October 2007 and 26-27 March 2008. Members of the Regional Working Group and contributors to this document were:

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Independent peer reviews were performed in accordance with Office of Management and Budget guidelines. The peer-review team consisted of Amy Claire Dempsey, BioImpact, Inc., Kingshill, St. Croix, U.S. Virgin Islands; Jorge L. Coll-Rivera, Coll Rivera Environmental, San Juan, Puerto Rico; Dr. Luis R. Pérez-Alegría, Agricultural and Biosystems Engineering Department, University of Puerto Rico, Mayagüez; and Dr. Antonio A. Vázquez-Berrios, Environmental Consultant, San Juan, Puerto Rico.

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Technical editors for this Regional Supplement were Dr. James S. Wakeley, Robert W. Lichvar, Chris V. Noble, and Jacob F. Berkowitz, ERDC. Karen C. Mulligan was the project proponent and coordinator at Headquarters, USACE. During the conduct of this work, R. Daniel Smith was Acting Chief of the Wetlands and Coastal Ecology Branch; Dr. Edmond Russo was Chief, Ecosystem Evaluation and Engineering Division; Sally Yost was Acting Program Manager, WRAP; and Dr. Elizabeth Fleming was Director, EL.

COL Kevin J. Wilson was Commander and Executive Director of ERDC. Dr. Jeffery Holland was Director.

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1 Introduction

Purpose and use of this regional supplement

This document is one of a series of Regional Supplements to the Corps of Engineers Wetland Delineation Manual (hereafter called the Corps Manual). The Corps Manual provides technical guidance and procedures, from a national perspective, for identifying and delineating wetlands that may be subject to regulatory jurisdiction under Section 404 of the Clean Water Act (33 U.S.C. 1344) or Section 10 of the Rivers and Harbors Act (33 U.S.C. 403). According to the Corps Manual, identification of wetlands is based on a three-factor approach involving indicators of hydrophytic vegetation, hydric soil, and wetland hydrology. This Regional Supplement presents wetland indicators, delineation guidance, and other information that is specific to the Caribbean Islands Region.

This Regional Supplement is part of a nationwide effort to address regional wetland characteristics and improve the accuracy and efficiency of wetland-delineation procedures. Regional differences in climate, geology, soils, hydrology, plant and animal communities, and other factors are important to the identification and functioning of wetlands. These differences cannot be considered adequately in a single national manual. The development of this supplement follows National Academy of Sciences recommendations to increase the regional sensitivity of wetland-delineation methods (National Research Council 1995). The intent of this supplement is to bring the Corps Manual up to date with current knowledge and practice in the region and not to change the way wetlands are defined or identified. The procedures given in the Corps Manual, in combination with wetland indicators and guidance provided in this supplement, can be used to identify wetlands for a number of purposes, including resource inventories, management plans, and regulatory programs. The determination that a wetland is subject to regulatory jurisdiction under Section 404 or Section 10 must be made independently of procedures described in this supplement.

This Regional Supplement is designed for use with the current version of the Corps Manual (Environmental Laboratory 1987) and all subsequent versions. Where differences in the two documents occur, this Regional Supplement takes precedence over the Corps Manual for applications in the Caribbean Islands Region. Table 1 identifies specific sections of the

Table 1. Sections of the Corps Manual replaced by this Regional Supplement for applications in the Caribbean Islands Region.

Item	Replaced Portions of the Corps Manual (Environmental Laboratory 1987)	Replacement Guidance (this Supplement)
Hydrophytic Vegetation Indicators	Paragraph 35, all subparts, and all references to specific indicators in Part IV.	Chapter 2
Hydric Soil Indicators	Paragraphs 44 and 45, all subparts, and all references to specific indicators in Part IV.	Chapter 3
Wetland Hydrology Indicators	Paragraph 49(b), all subparts, and all references to specific indicators in Part IV.	Chapter 4
Growing Season Definition	Glossary	Chapter 4, Growing Season; Glossary
Hydrology Standard for Highly Disturbed or Problematic Wetland Situations	Paragraph 48, including Table 5 and the accompanying User Note in the online version of the Manual	Chapter 5, Wetlands that Periodically Lack Indicators of Wetland Hydrology, Procedure item 3(f)

Corps Manual that are replaced by this supplement. Other guidance and procedures given in this supplement and not listed in Table 1 are intended to augment the Corps Manual but not necessarily to replace it. The Corps of Engineers has final authority over the use and interpretation of the Corps Manual and this supplement in the Caribbean Islands Region.

Indicators and procedures given in this Supplement are designed to identify wetlands as defined jointly by the Corps of Engineers (33 CFR 328.3) and Environmental Protection Agency (40 CFR 230.3). Wetlands are a subset of the “waters of the United States” that may be subject to regulation under Section 404. One key feature of the definition of wetlands is that, under normal circumstances, they support “a prevalence of vegetation typically adapted for life in saturated soil conditions.” Many waters of the United States are unvegetated and thus are excluded from the Corps/EPA definition of wetlands, although they may still be subject to Clean Water Act regulation. Other potential waters of the United States in the Caribbean Islands Region include, but are not limited to, tidal flats and shorelines along the coast and in estuaries; lakes; rivers; ponds; salt and mud flats; and perennial, intermittent, and ephemeral stream channels. Delineation of these waters is based on the high tide line, the “ordinary high water mark” (33 CFR 328.3e), or other criteria and is beyond the scope of this Regional Supplement.

Amendments to this document will be issued periodically in response to new scientific information and user comments. Between published versions, Headquarters, U.S. Army Corps of Engineers, may provide updates to this document and any other supplemental information used to make wetland determinations under Section 404 and Section 10. Wetland delineators should use the most recently approved versions of this document and supplemental information. See the Corps of Engineers Headquarters regulatory web site for information and updates (http://www.usace.army.mil/CECW/-Pages/reg_supp.aspx). The Corps of Engineers has established an interagency National Advisory Team for Wetland Delineation. The Team's role is to review new data and make recommendations for changes in wetland-delineation procedures to Headquarters, U.S. Army Corps of Engineers. Items for consideration should include full documentation and supporting data and should be submitted to:

National Advisory Team for Wetland Delineation
Regulatory Branch (Attn: CECW-CO)
U.S. Army Corps of Engineers
441 G Street, N.W.
Washington, DC 20314-1000

Applicable region

This supplement is applicable to the Caribbean Islands Region, which consists of the Commonwealth of Puerto Rico and the Territory of the United States Virgin Islands (Figure 1). The area corresponds to Land Resource Region (LRR) Z recognized by the U. S. Department of Agriculture (USDA Natural Resources Conservation Service 2006). Wetland indicators presented in this supplement are applicable throughout the entire region.

Physical and biological characteristics of the region

Puerto Rico and the U. S. Virgin Islands lie at the boundary between the Greater and Lesser Antilles at the northern edge of the Caribbean Sea, approximately 1,280 miles (2,000 km) from the United States mainland. The islands are the exposed tops of a partly submerged mountain range. The Commonwealth of Puerto Rico contains approximately 3,515 square miles (9,100 km^2) of land area, including the islands of Puerto Rico, Vieques, Culebra, Mona, and associated islands. The U.S. Virgin Islands consist of approximately 135 square miles (350 km^2) of land, including

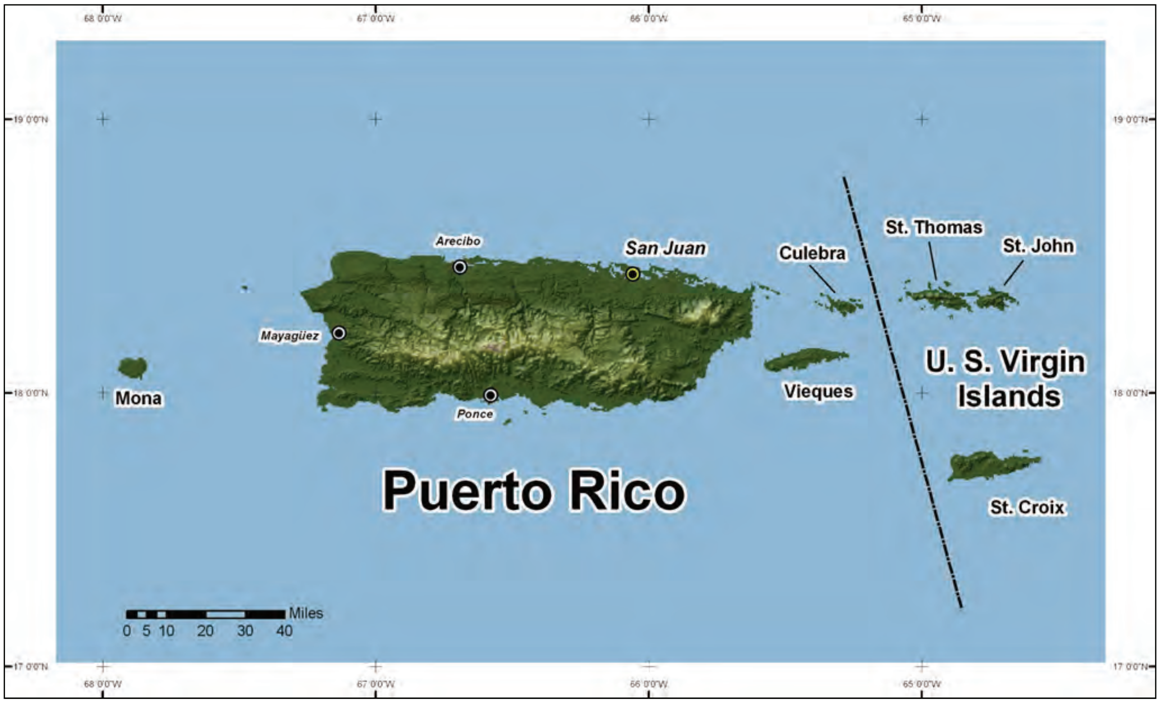

Figure 1. Map of the Caribbean Islands Region, consisting of the Commonwealth of Puerto Rico and the Territory of the United States Virgin Islands.

St. Thomas, St. John, St. Croix, and many smaller islands. The Island of Puerto Rico is the largest in the region and has the greatest topographic relief. The east-west trending Cordillera Central forms the backbone of the island and rises to a maximum elevation of 4,389 ft (1,338 m) (Bailey 1995).

The region has a subtropical climate with average annual temperatures ranging from 70 °F (21 °C) in the humid mountains to 79 °F (26 °C) on the semiarid coastal plain (Bailey 1995, USDA Natural Resources Conservation Service 2006). The region is frost-free and the growing season is year-round. Rainfall, however, is seasonal and is affected by altitude and exposure. The wettest months are during the hurricane season from August to November. December through March are the driest months. April and May are wetter again but rainfall declines through the summer. The islands lie in the trade winds, which move across the islands from a direction slightly north of east. Average annual rainfall in the Virgin Islands ranges from 37 to 45 in. (940 to 1,145 mm). In Puerto Rico, the windward northern side of the island receives 45 to 60 in. (1,145 to 1,525 mm) of rain per year on the coastal plain and 60 to 90 in. (1,525 to 2,285 mm) in the uplands. However, the rainforest area of the Sierra de Luquillo in northeastern Puerto Rico averages 120 to 200 in. (3,050 to 5,080 mm) of rain per year. On the semi-arid southern side of the island, in the rain shadow of the central mountains, annual rainfall on the coastal plain ranges from 10 to 45 in. (255 to 1,145 mm) (USDA Natural Resources Conservation Service 2006).

Puerto Rico is formed primarily of Cretaceous volcanic and older rocks that are cut by igneous intrusions and flanked by marine limestone on the north and south (Bailey 1995, USDA Natural Resources Conservation Service 2006). Areas of mature karst topography are present mainly along the northern coast with some smaller karst formations on the southern coast (Adams and Hefner 1996a). Soils in the region are very diverse, with 10 of 12 soil orders represented.

The variety of topographic, edaphic, and climatic conditions on the islands has encouraged the development of a diverse flora. Before discovery and settlement by Europeans, the islands were largely forested with tropical hardwoods. However, forests in the Virgin Islands and on the Puerto Rico coastal plain were soon cleared for agriculture and other development, primarily for sugar cane production. Sugar cane production remained a dominant part of the economies of Puerto Rico and the Virgin Islands until the 1940s, and shaped many of the islands' existing habitats.

Today, the primary land use in Puerto Rico is agriculture, with pasture and cropland predominating; however, many of these areas are being converted to urban and industrial uses. Urban areas already occupy about 33 percent of the northern coastal plain and 23 percent of the southern coastal plain. On St. Thomas and St. John in the U.S. Virgin Islands, residential development has become the primary land use outside of the Virgin Islands National Park. On St. Croix, many former agricultural areas are now fallow and reverting to forest.

Forests occupy about 30 to 35 percent of the region, except in semi-arid areas (USDA Natural Resources Conservation Service 2006). Common or characteristic forest trees in moist coastal areas and lower slopes include West Indian locust or algarrobo (*Hymenaea courbaril*), angelin tree or moca (*Andira inermis*), palo de maría (*Calaphyllum calaba*), mamee apple or mamey (*Mammea americana*), ausubo (*Manilkara bidentata*), fiddlewood or péndula (*Citharexylum spinosum = C. fruticosum*), prickly ash or ayua (*Zanthoxylum martinicense*), camasey (*Tetrazygia elaeagnoides*), white cedar or roble blanco (*Tabebuia heterophylla*), Christmas tree or tintillo (*Randia aculeata*), dove plum or uvilla (*Coccoloba diversifolia*), turpentine or almácigo (*Bursera simaruba*), cigar-box cedar or cedro hembra (*Cedrela odorata*), and cupey (*Clusia rosea*). In dry coastal and limestone areas, common or characteristic forest trees include turpentine, black olive or ucar (*Bucida buceras*), fustic or tachuelo (*Pictetia aculeata*), black wattle or bejuco prieto (*Capparis cynophallophora*), fiddlewood, bastard cedar or guacima (*Guazuma ulmifolia*), snake-bark or achiotillo (*Colubrina arborescens*), corcho (*Pisonia albida*), and crabwood or ramón (*Gymnanthes lucida*). Characteristic tree species of humid mountain forests include trumpet tree or yagrumo hembra (*Cecropia schreberiana*), cacaillo (*Ocotea leucoxylon*), sweet pea or guama (*Inga laurina*), angelin tree, musk wood or guaraguao (*Guarea guidonia*), guara (*Cupania americana*), wild cherry or cabrilla (*Casearia arborea*), angelica tree (*Dendropanax arboreus*), and yagrumo macho (*Schefflera morototonii*) (Little et al. 1974; Liogier and Martorell 2000).

Types and distribution of wetlands

Wetlands in the Caribbean Islands Region can be classified generally as either saltwater or freshwater. Within those broad categories, there is a variety of wetland types, including vegetated flats, marshes, swamps, and bogs. Because of steep topography and the lack of interior basins on most islands, wetlands in island interiors tend to be smaller and more scattered than those near the coast. Many are associated with perennial, intermittent, or ephemeral streams, or they occur on slopes in areas that receive abundant rainfall or on mountain tops in the cloud-intercept zone. Wetlands are larger and more abundant along the immediate coastlines, in estuaries, and on relatively flat coastal plains (Environmental Laboratory 1978; Lugo and Brown 1988; Zack and Román-Mas 1988; Adams and Hefner 1996a, 1996b).

Saltwater flats or salt ponds are sparsely vegetated coastal flats that are flooded occasionally by high tides, especially during storms. Generally they are located in shallow depressions where evaporation of trapped surface water creates hypersaline soil and water conditions. They often support a sparse community of halophytes, including turtleweed (*Batis maritima*), sea purslane (*Sesuvium portulacastrum*), and salt heliotrope (*Heliotropium curassavicum*). Stunted black mangroves (*Avicennia germinans*) are often found along the edges of these wetlands. Saltwater flats are found throughout the islands but are most common on the dry southwestern coasts of Puerto Rico (Environmental Laboratory 1978) and the U.S. Virgin Islands.

Saltwater swamps dominated by mangroves occupy coastal fringes, tidal riverine situations, coastal basins, and overwash zones throughout the region. Mangle rojo or red mangrove (*Rhizophora mangle*) is more common in coastal and riverine situations, while mangle negro or black mangrove and mangle blanco or white mangrove (*Laguncularia racemosa*) dominate basin mangrove forests. Associated species, depending on salinity, may include leatherferns (*Acrostichum* spp.), swampbush (*Pavonia paludicola*), and medicine vine (*Hippocratea volubilis*). Mangrove forests can be found along the entire coastline of Puerto Rico. In the Virgin Islands, mangroves are common along protected bays and in salt ponds (Environmental Laboratory 1978, Adams and Hefner 1996b).

Freshwater marshes and wet meadows occur in coastal lowlands and around upland ponds and streams in island interiors. On Puerto Rico, they are common in disturbed areas where the original forested wetlands have been cleared and the plant community is maintained in an early successsional stage. Inland freshwater wetlands are relatively rare in the Virgin Islands and are usually associated with ponds created by damming intermittent streams. Freshwater marshes and wet meadows are dominated mainly by sedges and grasses, including spikerushes (*Eleocharis* spp.), beaksedges (*Rhynchospora* spp.), flatsedges (*Cyperus* spp.), trompetilla (*Hymenachne amplexicaulis*), redecilla de agua (*Paspalum vaginatum*), and knotgrass (*Paspalum distichum*). Southern cattail or yerba eneas (*Typha domingensis*), giant flatsedge or junco de ciénaga (*Cyperus giganteus*), and Jamaica swamp sawgrass (*Cladium mariscus* ssp. *jamaicense* = *C. jamaicense*) are common in deep marshes (Environmental Laboratory 1978). The introduced invasive yerba venezolana or Mexican crowngrass (*Paspalum fasciculatum*) often forms dense stands in wetlands in abandoned sugar cane fields, pastures, and river banks in Puerto Rico.

Freshwater forested wetlands are a threatened but highly diverse wetland type in the region. Forested wetlands, other than mangroves, are rare in the Virgin Islands, where steep terrain and limited rainfall limit their development (Adams and Hefner 1996b). On the island of Puerto Rico, however, Lugo and Brown (1988) list a number of oligohaline (low salinity) and freshwater forested wetland types, the most significant of which is *Pterocarpus* forest. The palo de pollo or dragonsblood tree (*Pterocarpus officinalis*) can tolerate low salinity and is found in coastal riverine wetlands above the mangrove zone and in interior swamps. Other plant species found in wetlands, and often associated with *Pterocarpus*, include helecho de río

(*Acrostichum* spp.), royal palm (*Roystonea borinquena*), palo de maría, pond apple (*Annona glabra*), angelin tree or moca, and cupey (Francis and Lowe 2000).

Cloud forest, palm brake forest, and colorado forest occupy mountain tops and slopes in areas where soils are saturated for long periods due to interception of cloud water and abundant rainfall. Cloud forests occupy the highest altitudes and support stunted evergreen trees, including roble de sierra (*Tabebuia rigida*), nemocá cimarrona (*Ocotea spathulata*), and guayabota de sierra (*Eugenia borinquensis*). They also support numerous epiphytes. Palm brake forests are dominated by palma de sierra (*Prestoea acuminata* var. *montana* = *P. montana*). Colorado forests occupy wet areas just below the cloud forests and are dominated by palo colorado or swamp titi trees (*Cyrilla racemiflora*) (Ewel and Whitmore 1973; Lugo and Brown 1988; Adams and Hefner 1996a).

Bogs and fens are peat-forming wetlands that differ in their primary water source (precipitation versus groundwater, respectively) and plant communities. Lugo and Brown (1988) describe fens that are present in the karst region on Puerto Rico's north coast where the discharge of groundwater keeps soils saturated for long periods. These wetlands have black organic soils and extremely diverse plant communities, including a number of carnivorous species. In addition, montane bogs that support *Sphagnum* moss and herbaceous plants, including carnivorous species, are found on Puerto Rico in high-altitude depressions that catch and hold rainwater due to the presence of relatively impermeable soil layers or hardpans.

Other wetland types in the Caribbean region include interdunal swales in coastal areas and wetlands created either deliberately or inadvertently by human activities. Furthermore, many areas that were cleared and drained in the past for agriculture are now reverting to wetlands.

2 Hydrophytic Vegetation Indicators

Introduction

The Corps Manual defines hydrophytic vegetation as the community of macrophytes that occurs in areas where inundation or soil saturation is either permanent or of sufficient frequency and duration to influence plant occurrence. The manual uses a plant-community approach to evaluate vegetation. Hydrophytic vegetation decisions are based on the assemblage of plant species growing on a site, rather than the presence or absence of particular indicator species. Hydrophytic vegetation is present when the plant community is dominated by species that require or can tolerate prolonged inundation or soil saturation during the growing season. Hydrophytic vegetation in the Caribbean Islands Region is identified by using the indicators described in this chapter.

Many factors other than site wetness affect the composition of the plant community in an area, including regional climate, local weather patterns, topography, soils, natural and human-caused disturbances, and current and historical plant distributional patterns at various spatial scales. Despite its relatively small size, the Caribbean Islands Region is climatically varied, due in large part to its topographic diversity (elevations rise from sea level to 4,389 ft [1,338 m] on the Island of Puerto Rico), northeasterly trade winds, and rain-shadow effects. The islands are composed of a variety of rock types, dominated by igneous rocks and marine limestones that have been subjected to intense weathering, creating a complex physiography and very diverse soil conditions. These factors control the types and locations of native plant communities in the islands, including those in wetlands. In addition, widespread natural and anthropogenic disturbances (e.g., hurricanes, landslides, flooding, fire, deforestation, human land use, and the introduction of non-native plant species) have affected the composition and character of island vegetation. For example, by 1950, less than 1 percent of the landscape of Puerto Rico consisted of native forests that had not experienced deforestation; less than 10 percent was mature secondary forest; more than 30 percent was young secondary forest and shrubland; more than 30 percent was in agriculture, grassland, and pasture; and more than 15 percent was developed or urban (Wadsworth 1951; Birdsey and Weaver 1982; Gould et al. 2006). There are more than 2,800 species of native and exotic flowering plants in the islands (Liogier and Martorell

2000), including about 860 species that regularly occur in wetlands (Reed 1988). About 9 percent of Puerto Rico's plant species are endemic. The Caribbean Islands share many wetland plant species with other subtropical regions, such as southern Florida.

Hydrophytic vegetation decisions are based on the wetland indicator status (Reed (1988) or current approved list) of species that make up the plant community. Species in the facultative categories (FACW, FAC, and FACU) are recognized as occurring in both wetlands and uplands to varying degrees. Although most wetlands are dominated mainly by species rated OBL, FACW, and FAC, some wetland communities may be dominated primarily by FACU species and cannot be identified by dominant species alone. In those cases, other indicators of hydrophytic vegetation must also be considered, particularly where indicators of hydric soils and wetland hydrology are present. This situation is not necessarily due to inaccurate wetland indicator ratings; rather, it is due to the broad tolerances of certain plant species that allow them to be widely distributed across the moisture gradient.

Hydrophytic vegetation indicators and procedures presented in this chapter are designed to identify the majority of wetland plant communities in the Caribbean region. However, some wetland communities may lack any of these indicators, at least at certain times. These situations are considered in Chapter 5 (Difficult Wetland Situations in the Caribbean Islands Region).

Guidance on vegetation sampling and analysis

General guidance on sampling of vegetation for wetland-delineation purposes is given in the Corps Manual. Those procedures are intended to be flexible and may need to be modified for application in a given region or on a particular site. Vegetation sampling done as part of a wetland delineation is designed to characterize the site in question rapidly. A balance must be established between the need to accomplish the work quickly and the need to characterize the site's heterogeneity accurately and at an appropriate scale. The following guidance on vegetation sampling is intended to supplement the Corps Manual for applications in the Caribbean region.

The first step is to identify the major landscape units or vegetation communities on a site so they can be evaluated separately. This may be done in advance using an aerial photograph or topographic map, or by walking the site. In general, routine wetland determinations are based on visual estimates of percent cover of plant species that can be made either (1) within the vegetation community as a whole, or (2) within one or more sampling plots established in representative locations within each community. Percent cover estimates are more accurate and repeatable if taken within a defined plot. This also facilitates field verification of another delineator's work. The sizes and shapes of plots, if used, may be modified as appropriate to adapt to site conditions and should be recorded on the field data form. When sampling near a plant-community boundary, and particularly near the wetland boundary, it may be necessary to adjust plot size or shape to avoid overlapping the boundary and extending into an adjacent community having different vegetation, soils, or hydrologic conditions.

If it is not possible to locate one or a few plots in a way that adequately represents the vegetation unit being sampled, then percent cover estimates for each species can be made during a meandering survey of the broader community. If additional quantification of cover estimates is needed, then the optional procedure for point-intercept sampling along transects (see Appendix B) or other sampling procedures may be used to characterize the vegetation unit. To use either of these sampling methods, soil and hydrologic conditions must be uniform across the sampled area.

Definitions of strata

Vegetation strata within the sampled area or plot are sampled separately when evaluating indicators of hydrophytic vegetation. In the Caribbean Islands Region, the vegetation strata described in the Corps Manual are recommended (see below). Unless otherwise noted, a stratum for sampling purposes is defined as having 5 percent or more total plant cover, unless it is the only stratum present. If a stratum has less than 5 percent cover during the peak of annual plant growth, then those species and their cover values may be combined with another stratum for hydrophytic vegetation determinations. For example, a sparse tree layer could be combined with the sapling/shrub layer. Depending upon their location in the canopy, a sparse woody vine stratum could be incorporated into the tree or sapling/shrub strata.

Tree stratum – Consists of woody plants 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/shrub stratum – Consists of woody plants less than 3 in. DBH and greater than or equal to 3.28 ft (1 m) tall.
Herb stratum – Consists of all herbaceous (non-woody) plants, including herbaceous vines, regardless of size, and woody plants less than 3.28 ft tall.
Woody vines – Consists of all woody vines greater than 3.28 ft in height.

Plot and sample sizes

Hydrophytic vegetation determinations under the Corps Manual are based on samples taken in representative locations within each community. Random sampling of the vegetation is not required except in rare cases where representative sampling might yield misleading results. For routine determinations in fairly uniform vegetation, one or more plots in each community are usually sufficient for an accurate determination.

One sampling option that may help to identify wetland boundaries quickly and efficiently involves a series of plots arrayed perpendicular to the perceived wetland boundary based on an initial site reconnaissance. Plots can be placed within a particular plant community along transect lines at regular or random intervals, or established as needed in response to shifts in community composition, topography, soils, or hydrologic conditions. On forested sites, a single tree plot on each side of the perceived wetland boundary may be sufficient to characterize the tree stratum in each community. Changes in understory vegetation across the boundary may be assessed with smaller plots arrayed along transects (Figure 2). On non-forested sites, only the smaller plots would be used. Percent cover of each species in a plot is estimated visually.

The appropriate size and shape for a sample plot depend on the type of vegetation (i.e., trees, shrubs, herbaceous plants, etc.) and the size or shape of the plant community or patch being sampled. Plots should be large enough to include sufficient numbers of individuals in all strata, but small enough so that plant species or individuals can be separated and measured without duplication or omission, and the sampling can be done in a timely fashion (Cox 1990, Barbour et al. 1999). For hydrophytic vegetation determinations, areal cover estimates are used to determine species abundance. Plot sizes should make visual sampling both accurate and efficient. In the Caribbean Islands Region, the following plot sizes are recommended:

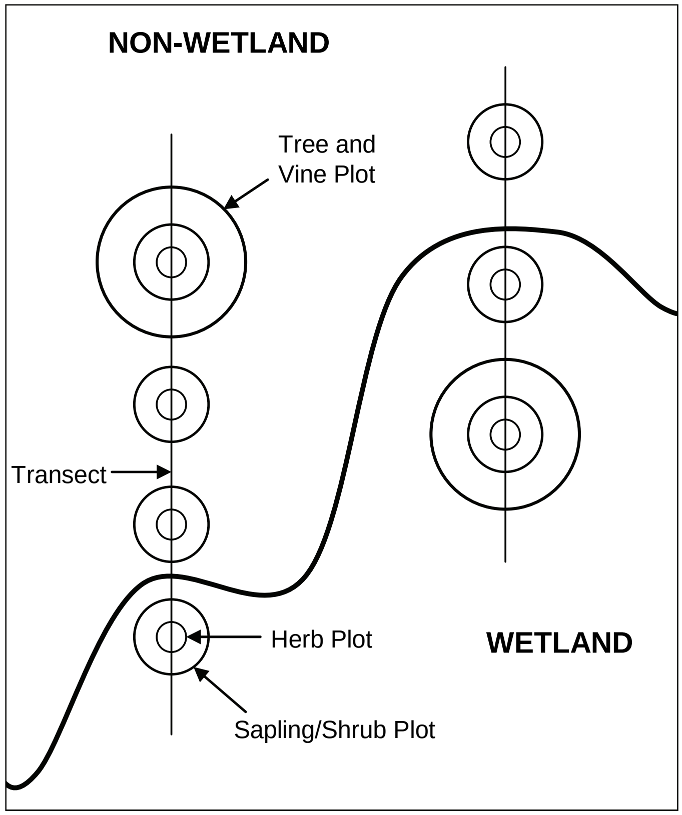

Figure 2. Suggested sampling design using transects and plots arrayed perpendicular to the perceived wetland boundary.

1. Trees – 30-ft (9.1-m) radius
2. Saplings and shrubs – 15-ft (4.6-m) radius
3. Herbaceous plants – 5-ft (1.5-m) radius
4. Woody vines – 30-ft (9.1-m) radius, or 15-ft (4.6-m) radius

The sampling plot should not be allowed to extend beyond the edges of the plant community being sampled. This may happen if vegetation patches are small or occur as narrow bands or zones along a topographic gradient. In such cases, plot sizes and shapes should be adjusted to fit completely within the vegetation patch or zone. For example, in linear riparian communities where the width of a standard plot may exceed the width of the plant community, an elongated rectangular plot or belt transect that follows the stream is recommended. If possible, the area sampled should be equivalent to the 30-ft-radius plot (2,827 ft^2 (263 m^2)) for the tree stratum or the 15-ft-radius plot (707 ft^2 (65.7 m^2)) for the sapling/shrub stratum. For example, a rectangular plot equivalent to the circular tree plot could be approximately 40 by 71 ft (12.2 by 21.6 m), and a rectangular plot equivalent to the circular sapling/shrub plot could be 10 by 71 ft (3.1 by 21.6 m), lying completely within the riparian fringe.

A 30-ft-radius tree plot works well in most forests but can be increased to 35 ft (10.7 m) or 40 ft (12.2 m) or more in a nonlinear forest stand if tree diversity is high or diameters are large. Highly diverse or patchy communities of herbs or other low vegetation may be sampled with nested 3.28- by 3.28-ft (1-m^2) quadrats randomly located within a 30-ft radius (Figure 3). Percent cover values are averaged across the small plots. In addition, point-intercept sampling performed along a transect is an alternative to plot-based methods that can improve the accuracy and repeatability of vegetation sampling in diverse or heterogeneous communities (see Appendix B).

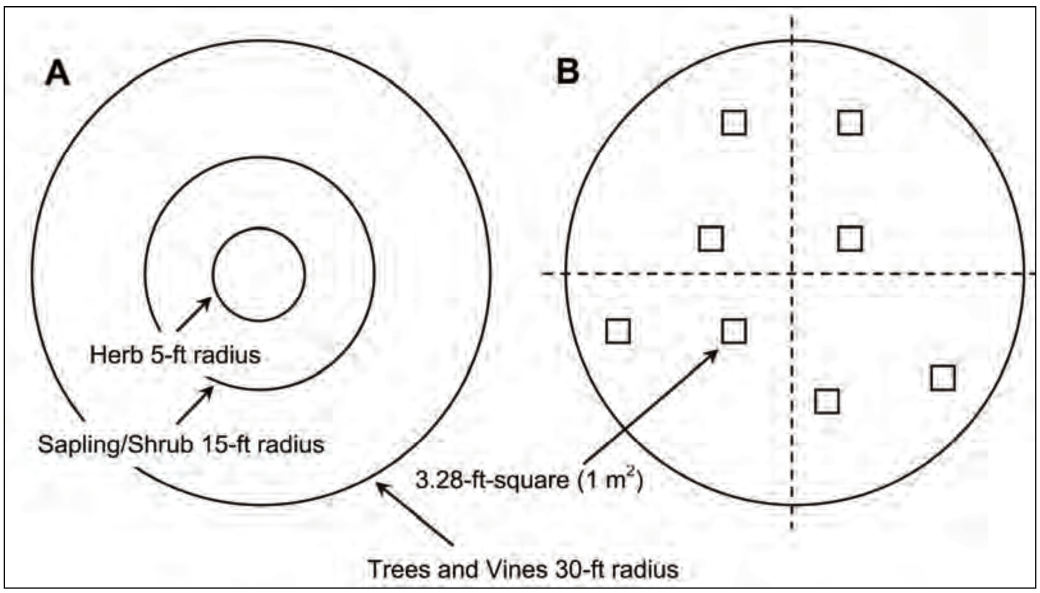

Figure 3. Example plot arrangements for vegetation sampling. (A) Single plots in graduated sizes. (B) Nested 3.28- by 3.28-ft square (1-m^2) plots within the 30-ft (9.1-m) radius plot for sampling a diverse ground layer.

Vegetation sampling guidance presented here should be adequate for hydrophytic vegetation determinations in most situations. However, many variations in vegetation structure, diversity, and spatial arrangement exist on the landscape and cannot be addressed adequately in this supplement. A list of references is given in Table 2 for more complex sampling situations. If alternative sampling techniques are used, they should be derived from the scientific literature and described in field notes or in the delineation report. The basic data must include abundance values for each species present. Typical abundance measures include basal area for tree species, percent

Table 2. Selected references to additional vegetation sampling approaches that could be used in wetland delineation.

Reference	Comment
Kent, M., and P. Coker. 1992. Vegetation Description and Analysis: A Practical Approach. New York, NY: Wiley.	Simple and clear methods for setting up a study and collecting and analyzing the data. Initial chapters are helpful for data collection and sampling approaches in wetland delineation.
Mueller-Dombois, D., and H. Ellenberg. 1974. Aims and Methods of Vegetation Ecology. New York, NY: Wiley.	A standard text in vegetation ecology, sampling, and analysis. This reference provides many sampling and analytical methods that are helpful in complex delineations.
U.S. Forest Service. 1982. Caribbean Service Forester's Handbook. Miscellaneous Report SA-MR 5. Washington, DC.	A reference on sampling of tropical forests.

areal cover, stem density, or frequency based on point-intercept sampling. In any case, the data must be in a format that can be used in the dominance test or prevalence index for hydrophytic vegetation (see Hydrophytic Vegetation Indicators).

In this supplement, absolute percent cover is the preferred abundance measure for all species. For percent cover estimates, it is not necessary for all plants to be rooted in the plot as long as they are growing under the same soil and hydrologic conditions. It may be necessary to exclude plants that overhang the plot if they are rooted in areas having different soil and hydrologic conditions, particularly when sampling near the wetland boundary.

Hydrophytic vegetation indicators

The following indicators should be applied in the sequence presented. The stepwise procedure is designed to reduce field effort by requiring that only one or two indicators (variations of the dominance test) be evaluated in the majority of wetland determinations. However, hydrophytic vegetation is present if any of the indicators is satisfied. All of these indicators are applicable throughout the Caribbean Islands Region.

Indicators of hydrophytic vegetation involve looking up the wetland indicator status of plant species on the wetland plant list (Region C of Reed (1988) or current list). For the purposes of this supplement, only the five basic levels of wetland indicator status (i.e., OBL, FACW, FAC, FACU, and UPL) are used in hydrophytic vegetation indicators. Plus (+) and minus (–) modifiers are not used (e.g., FAC–, FAC, and FAC+ plants are all considered to be FAC). For species listed as NI (reviewed but given no regional indicator) or NO (no known occurrence in the region at the time the list was compiled), apply the indicator status assigned to the species in the nearest adjacent region (i.e., Southeast – Region 2). If the species is listed as NI or NO in the Caribbean but is not assigned an indicator status on the Southeast list, do not use the species to calculate hydrophytic vegetation indicators. In general, species that are not listed on the wetland plant list are assumed to be upland (UPL) species. However, recent changes in plant nomenclature have resulted in a number of species that are not listed by Reed (1988) but are not necessarily UPL plants. Procedures described in Chapter 5, in the section on Problematic Hydrophytic Vegetation, can be used if it is believed that individual FACU, NI, NO, or unlisted plant species are functioning as hydrophytes on a particular site. For Clean Water Act purposes, wetland delineators should use the latest plant lists approved by Headquarters, U.S. Army Corps of Engineers (http://www.usace.army.mil/CECW/Pages/reg_supp.aspx).

Evaluation of the vegetation can begin with a rapid field test for hydrophytic vegetation to determine if there is a need to collect more detailed vegetation data. The rapid test for hydrophytic vegetation (Indicator 1) is met if all dominant species across all strata are OBL or FACW, or a combination of the two, based on a visual assessment. If the site is not dominated solely by OBL and FACW species, proceed to the standard dominance test (Indicator 2), which is the basic hydrophytic vegetation indicator. Either Indicator 1 or 2 should be applied in every wetland determination. Most wetlands in the Caribbean Islands Region have plant communities that will meet one or both of these indicators. These are the only indicators that need to be considered in most situations. However, some wetland plant communities may fail a test based only on dominant species. Therefore, in those cases where indicators of hydric soil and wetland hydrology are present, the vegetation should be reevaluated with the prevalence index (Indicator 3), which takes non-dominant plant species into consideration. Finally, certain disturbed or problematic wetland situations may lack any of these indicators and are described in Chapter 5.

Procedure

The procedure for using hydrophytic vegetation indicators is as follows:

1. Apply Indicator 1 (Rapid Test for Hydrophytic Vegetation).

   a. If the plant community passes the rapid test for hydrophytic vegetation, then the vegetation is hydrophytic and no further vegetation analysis is required.

   b. If the rapid test for hydrophytic vegetation is not met, then proceed to step 2.

2. Apply Indicator 2 (Dominance Test).

   a. If the plant community passes the dominance test, then the vegetation is hydrophytic and no further vegetation analysis is required.

   b. If the plant community fails the dominance test, and indicators of hydric soil and/or wetland hydrology are absent, then hydrophytic vegetation is absent unless the site meets the requirements for a problematic wetland situation (see Chapter 5).

   c. If the plant community fails the dominance test, but indicators of hydric soil and wetland hydrology are both present, proceed to step 3.

3. Apply Indicator 3 (Prevalence Index). This step assumes that at least one indicator of hydric soil and one primary or two secondary indicators of wetland hydrology are present.

   a. If the plant community satisfies the prevalence index, then the vegetation is hydrophytic. No further vegetation analysis is required.

   b. If the plant community fails the prevalence index, then hydrophytic vegetation is absent unless indicators of hydric soil and wetland hydrology are present and the site meets the requirements for a problematic wetland situation (Chapter 5).

Indicator 1: Rapid test for hydrophytic vegetation

Description: All dominant species across all strata are rated OBL or FACW, or a combination of these two categories, based on a visual assessment.

User Notes: This test is intended as a quick confirmation in obvious cases that a site has hydrophytic vegetation, without the need for more intensive sampling. Dominant species are selected visually from each stratum of the community using the "50/20 rule" (see Indicator 2 – Dominance Test below) as a general guide but without the need to gather quantitative data. Only the dominant species in each stratum must be recorded on the data form.

Indicator 2: Dominance test

Description: More than 50 percent of the dominant plant species across all strata are rated OBL, FACW, or FAC.

User Notes: Use the "50/20 rule" described below to select dominant species from each stratum of the community. Combine dominant species across strata and apply the dominance test to the combined list. Once a species is selected as a dominant, its cover value is not used in the dominance test; each dominant species is treated equally. Thus, a plant community with seven dominant species across all strata would need at least four dominant species that are OBL, FACW, or FAC to be considered hydrophytic by this indicator. Species that are dominant in two or more strata should be counted two or more times in the dominance test.

Procedure for Selecting Dominant Species by the 50/20 Rule: Dominant plant species are the most abundant species in the community; they contribute more to the character of the community than do the other non-dominant species present. The 50/20 rule is a repeatable and objective procedure for selecting dominant plant species and is recommended when data are available for all species in the community. The rule can also be used to guide visual sampling of plant communities in rapid wetland determinations.

Dominant species are chosen independently from each stratum of the community. In general, dominants are the most abundant species that individually or collectively account for more than 50 percent of the total coverage of vegetation in the stratum, plus any other species that, by itself, accounts for at least 20 percent of the total. For the purposes of this regional supplement, absolute percent cover is the recommended abundance measure for plants in all vegetation strata. See Table 3 for an example application of the 50/20 rule in evaluating a plant community. Steps in selecting dominant species by the 50/20 rule are as follows:

Table 3. Example of the selection of dominant species by the 50/20 rule and determination of hydrophytic vegetation by the dominance test.

Stratum	Species Name	Wetland Indicator Status	Absolute Percent Cover	Dominant?
Herb	*Sesuvium portulacastrum* *Batis maritima* *Sporobolus virginicus* *Heliotropium curassavicum* *Avicennia germinans*	FACW FACW FACW FACW OBL	10 15 25 5 2	No Yes Yes No No
		Total cover	57	
		50/20 Thresholds: 50% of total cover = 28.5% 20% of total cover = 11.4%		
Sapling/shrub	*Avicennia germinans* *Laguncularia racemosa* *Leucaena leucocephala* *Randia aculeata* *Mimosa pigra*	OBL OBL FAC FAC FACW	5 12 30 20 45	No No Yes No Yes
		Total cover	112	
		50/20 Thresholds: 50% of total cover = 56% 20% of total cover = 22.4%		
Tree	*Conocarpus erectus* *Thespesia populnea* *Terminalia catappa* *Coccoloba uvifera*	FACW FAC UPL FACU	30 25 12 8	Yes Yes No No
		Total cover	75	
		50/20 Thresholds: 50% of total cover = 37.5% 20% of total cover = 15%		
Woody vine	*Paullinia pinnata*	FAC	10	Yes
		Total cover	10	
		50/20 Thresholds: 50% of total cover = 5% 20% of total cover = 2%		
Hydrophytic Vegetation Determination	Total number of dominant species across all strata = 7. Percent of dominant species that are OBL, FACW, or FAC = 7/7 = 100%. Therefore, this community is hydrophytic by Indicator 2 (Dominance Test).			

1. Estimate the absolute percent cover of each species in the first stratum. Since the same data may be used later to calculate the prevalence index, the data should be recorded as absolute cover and not converted to relative cover.
2. Rank all species in the stratum from most to least abundant.
3. Calculate the total coverage of all species in the stratum (i.e., sum their individual percent cover values). Absolute cover estimates do not necessarily sum to 100 percent.
4. Select plant species from the ranked list, in decreasing order of coverage, until the cumulative coverage of selected species exceeds 50 percent of the total absolute coverage for the stratum. If two or more species are equal in coverage (i.e., they are tied in rank), they should all be selected. The selected plant species are all considered to be dominants. All dominants must be identified to species.
5. In addition, select any other species that, by itself, is at least 20 percent of the total absolute percent cover in the stratum. Any such species is also considered to be a dominant and must be accurately identified.
6. Repeat steps 1-5 for any other stratum present. Combine the lists of dominant species across all strata. Note that a species may be dominant in more than one stratum (e.g., a woody species may be dominant in both the tree and sapling/shrub strata).

Indicator 3: Prevalence index

Description: The prevalence index is 3.0 or less.

User Notes: The prevalence index ranges from one to five. A prevalence index of 3.0 or less indicates that hydrophytic vegetation is present. To calculate the prevalence index, at least 80 percent of the total vegetation cover on the plot (summed across all strata) must be of species that have been correctly identified and have assigned wetland indicator statuses (Reed (1988) or current list) or are upland (UPL) species.

Procedure for Calculating a Plot-Based Prevalence Index: The prevalence index is a weighted-average wetland indicator status of all plant species in the sampling plot, where each indicator status category is given a numeric value (OBL = 1, FACW = 2, FAC = 3, FACU = 4, and UPL=5) and weighting is by abundance (absolute percent cover). It is a more comprehensive analysis of the hydrophytic status of the community than one based on just a few dominant species. It is particularly useful in (1) communities with only one or two dominants, (2) highly diverse communities where many species may be present at roughly equal coverage, and (3) cases where strata differ greatly in total plant cover (e.g., total herb cover is 80 percent but sapling/shrub cover is only 10 percent). The prevalence index is used in this supplement to determine whether hydrophytic vegetation is present on sites where indicators of hydric soil and wetland hydrology are present but the vegetation initially fails the dominance test.

The following procedure is used to calculate a plot-based prevalence index. The method was described by Wentworth et al. (1988) and modified by Wakeley and Lichvar (1997). It uses the same field data (i.e., percent cover estimates for each plant species) that were used to select dominant species by the 50/20 rule, with the added constraint that at least 80 percent of the total vegetation cover on the plot must be of species that have been correctly identified and have an assigned indicator status (including UPL). For any species that occurs in more than one stratum, cover estimates are summed across strata. Steps for determining the prevalence index are as follows:

1. Identify and estimate the absolute percent cover of each species in each stratum of the community. Sum the cover estimates for any species that is present in more than one stratum.
2. Organize all species (across all strata) into groups according to their wetland indicator status (i.e., OBL, FACW, FAC, FACU, or UPL) and sum their cover values within groups. Do not include species that were not identified.
3. Calculate the prevalence index using the following formula:

$$PI = \frac{A_{OBL} + 2A_{FACW} + 3A_{FAC} + 4A_{FACU} + 5A_{UPL}}{A_{OBL} + A_{FACW} + A_{FAC} + A_{FACU} + A_{UPL}}$$

where:

PI = Prevalence index
A_{OBL} = Summed percent cover values of obligate (OBL) plant species;
A_{FACW} = Summed percent cover values of facultative wetland (FACW) plant species;
A_{FAC} = Summed percent cover values of facultative (FAC) plant species;
A_{FACU} = Summed percent cover values of facultative upland (FACU) plant species; and
A_{UPL} = Summed percent cover values of upland (UPL) plant species.

See Table 4 for an example calculation of the prevalence index using the same data set as in Table 3. The following web link provides free public-domain software for simultaneous calculation of the 50/20 rule, dominance test, and prevalence index: http://www.crrel.usace.army.mil/rsgisc/wetshed/wetdatashed.htm.

Table 4. Example of the prevalence index using the data in Table 3.

Indicator Status Group	Species Name	Absolute Percent Cover by Species	Total Cover by Group	Multiply by:[1]	Product
OBL species	*Avicennia germinans*[2] *Laguncularia racemosa*	7 12	19	1	19
FACW species	*Sesuvium portulacastrum* *Batis maritima* *Sporobolus virginicus* *Heliotropium curassavicum* *Mimosa pigra* *Conocarpus erectus*	10 15 25 5 45 30	130	2	260
FAC species	*Leucaena leucocephala* *Randia aculeata* *Thespesia populnea* *Paullinia pinnata*	30 20 25 10	85	3	255
FACU species	*Coccoloba uvifera*	8	8	4	32
UPL species	*Terminalia catappa*	12	12	5	60
Sum			254 (A)		626 (B)
Hydrophytic Vegetation Determination		Prevalence Index = B/A = 626/254 = 2.46 Therefore, this community is hydrophytic by Indicator 3 (Prevalence Index).			

[1] Where OBL = 1, FACW = 2, FAC = 3, FACU = 4, and UPL = 5.

[2] *Avicennia germinans* was recorded in two or more strata (see Table 3), so the cover estimates were summed across strata.

3 Hydric Soil Indicators

Introduction

The National Technical Committee for Hydric Soils (NTCHS) defines a hydric soil as a soil that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (USDA Soil Conservation Service 1994). Nearly all hydric soils exhibit characteristic morphologies that result from repeated periods of saturation or inundation for more than a few days. Saturation or inundation, when combined with microbial activity in the soil, causes the depletion of oxygen. This anaerobiosis promotes certain biogeochemical processes, such as the accumulation of organic matter and the reduction, translocation, or accumulation of iron and other reducible elements. These processes result in distinctive characteristics that persist in the soil during both wet and dry periods, making them particularly useful for identifying hydric soils in the field (USDA Natural Resources Conservation Service 2010).

This chapter presents indicators that are designed to help identify hydric soils in the Caribbean Islands Region. Indicators are not intended to replace or relieve the requirements contained in the definition of a hydric soil. Therefore, a soil that meets the definition of a hydric soil is hydric whether or not it exhibits indicators. Guidance for identifying hydric soils that lack indicators can be found later in this chapter (see the sections on documenting the site and its soils) and in Chapter 5 (Difficult Wetland Situations in the Caribbean Islands Region).

This list of indicators is dynamic; changes and additions to the list are anticipated with new research and field testing. The indicators presented in this supplement are a subset of the NTCHS *Field Indicators of Hydric Soils in the United States* (USDA Natural Resources Conservation Service (2010) or current version) that are commonly found in the Caribbean region. All of the indicators presented in this supplement are applicable throughout the region. Any change to the NTCHS *Field Indicators of Hydric Soils in the United States* represents a change to this subset of indicators for the Caribbean. The current version of the indicators can be found on the NRCS hydric soils web site (http://soils.usda.gov/use/hydric/). To use the indicators properly, a basic knowledge of soil/landscape relationships is necessary.

Concepts

Hydric soil indicators are formed predominantly by the accumulation or loss of iron, manganese, sulfur, or carbon compounds in a saturated and anaerobic environment. These processes and the features that develop are described in the following paragraphs.

Iron and manganese reduction, translocation, and accumulation

In an anaerobic environment, soil microbes reduce iron from the ferric (Fe^{3+}) to the ferrous (Fe^{2+}) form, and manganese from the manganic (Mn^{4+}) to the manganous (Mn^{2+}) form. Of the two, evidence of iron reduction is more commonly observed in soils. Areas in the soil where iron is reduced often develop characteristic bluish-gray or greenish-gray colors known as *gley*. Ferric iron is insoluble but ferrous iron easily enters the soil solution and may be moved or translocated to other areas of the soil. Areas that have lost iron typically develop characteristic gray or reddish-gray colors and are known as *redox depletions*. If a soil reverts to an aerobic state, iron that is in solution will oxidize and become concentrated in patches and along root channels and other pores. These areas of oxidized iron are called *redox concentrations*. Since water movement in these saturated or inundated soils can be multi-directional, redox depletions and concentrations can occur anywhere in the soil and have irregular shapes and sizes. Soils that are saturated and contain ferrous iron at the time of sampling may change color upon exposure to the air, as ferrous iron is rapidly converted to ferric iron in the presence of oxygen. Such soils are said to have a *reduced matrix* (Vepraskas 1992).

While indicators related to iron or manganese depletion or concentration are the most common in hydric soils, they cannot form in soils whose parent materials are low in Fe or Mn. Soils formed in such materials may have low-chroma colors that are not related to saturation and reduction. For such soils, features formed through accumulation of organic carbon may be present.

Sulfate reduction

Sulfur is one of the last elements to be reduced by microbes in an anaerobic environment. The microbes convert SO_4^{2-} to H_2S, or hydrogen sulfide gas.

This results in a very pronounced "rotten egg" odor in some soils that are inundated or saturated for very long periods. In non-saturated or non-inundated soils, sulfate is not reduced and there is no rotten egg odor. The presence of hydrogen sulfide is a strong indicator of a hydric soil, but this indicator is found only in the wettest sites in soils that contain sulfur-bearing compounds.

Organic matter accumulation

Soil microbes use carbon compounds found in organic matter as an energy source. However, the rate at which organic carbon is utilized by soil microbes is considerably lower in a saturated and anaerobic environment than under aerobic conditions. Therefore, in saturated soils, partially decomposed organic matter may accumulate. The result in wetlands is often the development of thick organic surfaces, such as peat or muck, or dark organic-rich mineral surface layers.

Determining the texture of soil materials high in organic carbon. Material high in organic carbon could fall into three categories: organic, mucky mineral, or mineral. In lieu of laboratory data, the following estimation method can be used for soil material that is wet or nearly saturated with water. This method may be inconclusive with loamy or clayey textured mineral soils. Gently rub the wet soil material between forefinger and thumb. If upon the first or second rub the material feels gritty, it is mineral soil material. If after the second rub the material feels greasy, it is either mucky mineral or organic soil material. Gently rub the material two or three more times. If after these additional rubs it feels gritty or plastic, it is mucky mineral soil material; if it still feels greasy, it is organic soil material. If the material is organic soil material, a further division should be made, as follows.

Organic soil materials are classified as sapric, hemic, or fibric. Differentiating criteria are based on the percentage of visible fibers observable with a hand lens in an undisturbed state and after rubbing between thumb and fingers 10 times (Table 5). Sapric, hemic, and fibric correspond to the textures muck, mucky peat, and peat. If there is a conflict between unrubbed and rubbed fiber content, rubbed content is used. *Live roots are not considered*.

Table 5. Proportion of sample that consists of fibers visible with a hand lens.

Soil Texture	Unrubbed	Rubbed	Horizon Descriptor
Muck	<33%	<17%	Sapric
Mucky peat	33-67%	17-40%	Hemic
Peat	>67%	>40%	Fibric
Adapted from USDA Natural Resources Conservation Service (1999).			

Another field method for determining the degree of decomposition for organic materials is a system modified from a method originally developed by L. von Post and described in detail in ASTM standard D 5715-00 (http://www.astm.org/). This method is based on a visual examination of the color of the water that is expelled and the soil material remaining in the hand after a saturated sample is squeezed (Table 6). If a conflict occurs between results for sapric, hemic, or fibric material using percent visible fiber (Table 5) and degree of humification (Table 6), then percent visible fiber should be used.

Table 6. Determination of degree of decomposition of organic materials.

<table>
<tr><th>Degree of Humification</th><th>Nature of Material Extruded upon Squeezing</th><th>Nature of Plant Structure in Residue</th><th>Horizon Descriptor</th><th>Soil Texture</th></tr>
<tr><td>H1</td><td>Clear, colorless water; no organic solids squeezed out</td><td>Unaltered, fibrous, undecomposed</td><td rowspan="3">Fibric</td><td rowspan="3">Peat</td></tr>
<tr><td>H2</td><td>Yellowish water; no organic solids squeezed out</td><td>Almost unaltered, fibrous</td></tr>
<tr><td>H3</td><td>Brown, turbid water; no organic solids squeezed out</td><td>Easily identifiable</td></tr>
<tr><td>H4</td><td>Dark brown, turbid water; no organic solids squeezed out</td><td>Visibly altered but identifiable</td><td rowspan="3">Hemic</td><td rowspan="3">Mucky Peat</td></tr>
<tr><td>H5</td><td>Turbid water and some organic solids squeezed out</td><td>Recognizable but vague, difficult to identify</td></tr>
<tr><td>H6</td><td>Turbid water; 1/3 of sample squeezed out</td><td>Indistinct, pasty</td></tr>
<tr><td>H7</td><td>Very turbid water; 1/2 of sample squeezed out</td><td>Faintly recognizable; few remains identifiable, mostly amorphous</td><td rowspan="4">Sapric</td><td rowspan="4">Muck</td></tr>
<tr><td>H8</td><td>Thick and pasty; 2/3 of sample squeezed out</td><td>Very indistinct</td></tr>
<tr><td>H9</td><td>No free water; nearly all of sample squeezed out</td><td>No identifiable remains</td></tr>
<tr><td>H10</td><td>No free water; all of sample squeezed out</td><td>Completely amorphous</td></tr>
</table>

Cautions

A soil that is artificially drained or protected (for instance, by dikes or levees) is still hydric if the soil in its undisturbed state would meet the definition of a hydric soil. To be identified as hydric, these soils should generally have one or more of the indicators. However, not all areas that have hydric soils will qualify as wetlands, if they no longer have wetland hydrology or support hydrophytic vegetation.

Morphological features that do not reflect contemporary or recent conditions of saturation and anaerobiosis are called relict features. Contemporary and relict hydric soil features can be difficult to distinguish. For example, nodules and concretions that are actively forming often have gradual or diffuse boundaries, whereas relict or degrading nodules and concretions have sharp boundaries (Vepraskas 1992). Additional guidance for some of the most common problem hydric soils can be found in Chapter 5. When soil morphology seems inconsistent with the landscape, vegetation, or observable hydrology, it may be necessary to obtain the assistance of an experienced soil or wetland scientist to determine whether the soil is hydric.

Procedures for sampling soils

Observe and document the site

Before making any decision about the presence or absence of hydric soils, the overall site and how it interacts with the soil should be considered. The questions below, while not required to identify a hydric soil, can help to explain why one is or is not present. Always look at the landscape features of the immediate site and compare them to the surrounding areas. Try to contrast the features of wet and dry sites that are in close proximity. When observing slope features, look first at the area immediately around the sampling point. For example, a nearly level bench or depression at the sampling point may be more important to site wetness than the overall landform on which it occurs. By understanding how water moves across the site, the reasons for the presence or absence of hydric soil indicators should be clear.

If one or more of the hydric soil indicators given later in this chapter is present, then the soil is hydric. If no hydric soil indicator is present, the additional site information below may be useful in documenting whether the soil is indeed non-hydric or if it might represent a "problem" hydric soil that meets the hydric soil definition despite the absence of indicators.

- *Hydrology*–Is standing water observed on the site or is water observed in the soil pit? What is the depth of the water table in the area? Is there indirect evidence of ponding or flooding?
- *Slope*–Is the site level or nearly level so that surface water does not run off readily, or is it steeper where surface water would run off from the soil?
- *Slope shape*–Is the surface concave (e.g., a depression), where water would tend to collect and possibly pond on the soil surface? On hillsides, are there convergent slopes (Figure 4), where surface or groundwater may be directed toward a central stream or swale? Or is the surface or slope shape convex, causing water to run off or disperse?

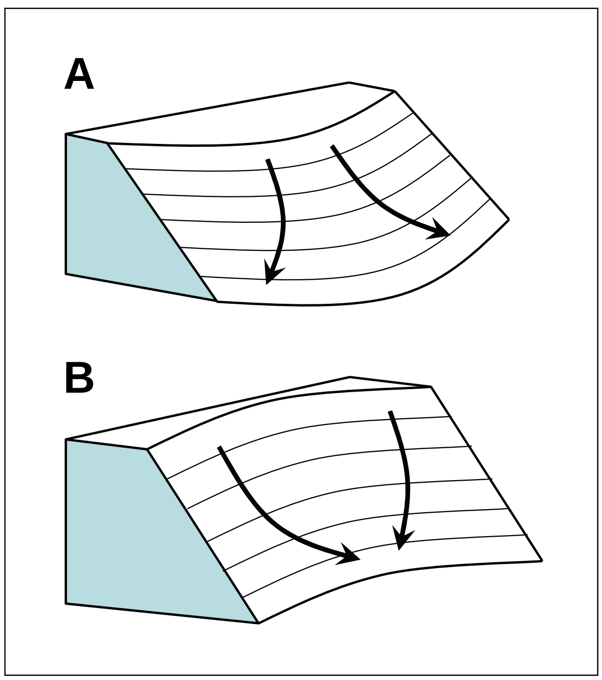

Figure 4. Divergent slopes (A) disperse surface water, whereas convergent slopes (B) concentrate water. Surface flow paths are indicated by the arrows.

- *Landform*–Is the soil in a floodplain, flat, or drainageway that may be subject to seasonal high water tables or flooding? Is it at the toe of a slope (Figure 5) where runoff may tend to collect or groundwater emerge at or near the surface? Has the microtopography been altered by cultivation or other disturbances?

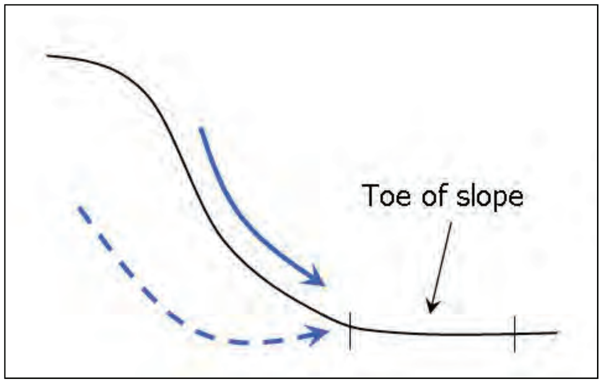

Figure 5. At the toe of a hill slope, the gradient is only slightly inclined or nearly level. Blue arrows represent flow paths of surface water (solid arrow) and groundwater (dashed arrow).

- *Soil materials*—Is there a restrictive layer in the soil that could slow or prevent the infiltration of water, perhaps resulting in a perched water table or hillslope seep? Restrictive layers could include consolidated bedrock, cemented layers such as duripans and petrocalcic horizons, layers of silt or substantial clay content, or strongly contrasting soil textures (e.g., silt over sand). Or is there relatively loose soil material (sand, gravel, or rocks) or fractured bedrock that would allow the water to flow laterally down slope?
- *Vegetation*—Does the vegetation at the site indicate wetter conditions than at other nearby sites, or is it similar to what is found at nearby upland sites?

Observe and document the soil

To observe and document a hydric soil, first remove any loose leaves, needles, or bark from the soil surface. Do not remove the organic surface layers of the soil, which usually consist of plant remains in varying stages of decomposition. Dig a hole and describe the soil profile. In general, the hole should be dug to the depth needed to document an indicator or to confirm the absence of indicators. For most soils, the recommended excavation depth is approximately 20 in. (50 cm) from the soil surface, although a shallower soil pit may suffice for some indicators (e.g., A2 – Histic Epipedon). Digging may be difficult in some areas due to rocks and hardpans. Use the completed profile description to determine which hydric soil indicators have been met (USDA Natural Resources Conservation Service 2010).

For soils with deep, dark surface layers, deeper examination may be required when field indicators are not easily seen within 20 in. (50 cm) of the surface. The accumulation of organic matter in these soils may mask redoximorphic features in the surface layers. Examination to 40 in. (1 m) or more may be needed to determine whether they meet the requirements of indicator A12 (Thick Dark Surface). A soil auger or probe may be useful for sampling soil materials below 20 in.

Whenever possible, excavate the soil deep enough to determine if there are layers or materials present that might restrict soil drainage. This will help to understand why the soil may or may not be hydric. Consider taking photographs of both the soil and the overall site, including a clearly marked measurement scale in soil pictures.

Depths used in the indicators are measured from the muck surface, or from the mineral soil surface if a muck surface is absent. For indicators A1 (Histosol), A2 (Histic Epipedon), and A3 (Black Histic), depths are measured from the top of the organic material (peat, mucky peat, or muck), or from the top of any mineral material that may overlie the organic layer.

All colors noted in this supplement refer to moist Munsell® colors (Gretag/Macbeth 2000). Dry soils should be moistened until the color no longer changes and wet soils should be allowed to dry until they no longer glisten. Care should be taken to avoid over-moistening dry soil. Soil colors specified in the indicators do not have decimal points (except for indicator A12); however, intermediate colors do occur between Munsell chips. Soil colors should not be rounded to qualify as meeting an indicator. For example, a soil matrix with a chroma between 2 and 3 should be recorded as having a chroma of 2+. This soil material does not have a chroma of 2 and would not meet any indicator that requires a chroma of 2 or less.

Always examine soil matrix colors in the field immediately after sampling. Ferrous iron, if present, can oxidize rapidly and create colors of higher chroma or redder hue. Soils that are saturated at the time of sampling may contain reduced iron and/or manganese that are not detectable by eye. Under saturated conditions, redox concentrations may be absent or difficult to see, particularly in dark-colored soils. It may be necessary to let the soil dry to a moist state (5 to 30 minutes or more) for the iron or manganese to oxidize and redox features to become visible.

Particular attention should be paid to changes in microtopography over short distances. Small changes in elevation may result in repetitive sequences of hydric/non-hydric soils, making the delineation of individual areas of hydric and non-hydric soils difficult. Often the dominant condition (hydric or non-hydric) is the only reliable interpretation (also see the section on Wetland/Non-Wetland Mosaics in Chapter 5). The shape of the local landform can greatly affect the movement of water through the landscape. Significant changes in parent material or lithologic discontinuities in the soil can affect the hydrologic properties of the soil. After a sufficient number of exploratory excavations have been made to understand the soil-hydrologic relationships at the site, subsequent excavations can be limited to the depth needed to identify hydric soil indicators.

Use of existing soil data

Soil surveys

Soil surveys are available for most areas of the Caribbean region and can provide useful information regarding soil properties and soil moisture conditions for an area. A list of available soil surveys is located at http://soils.usda.gov/survey/online_surveys/ and soil maps and data are available online from the Web Soil Survey at http://websoilsurvey.nrcs.usda.gov/. Soil survey maps divide the landscape into areas called map units. Map units usually contain more than one soil type or component. They often contain several minor components or inclusions of soils with properties that may be similar to or quite different from the major component. Those soils that are hydric are noted in the *Hydric Soils List* published separately from the soil survey report. Soil survey information can be valuable for planning purposes, but it is not site-specific and does not preclude the need for an on-site investigation.

Hydric soils lists

Hydric Soils Lists are developed for each detailed soil survey. Using criteria approved by the NTCHS, these lists rate each soil component as either hydric or non-hydric based on soil property data. If the soil is rated as hydric, information is provided regarding which hydric criteria are met and on what landform the soil typically occurs. Hydric Soils Lists are useful as general background information for an on-site delineation. However, not all areas within a mapping unit or polygon identified as having hydric soils may be hydric. Furthermore, inclusions of hydric soils may be found within soil mapping units where no hydric soils have been identified. The Hydric Soils List should be used as a tool, indicating that hydric soil will likely be found within a given area, but should never be used as a substitute for onsite investigation and field indicators of hydric soils.

Hydric Soils Lists developed for individual detailed soil surveys are known as Local Hydric Soils Lists. They are available from NRCS offices and over the internet from the Soil Data Mart (http://soildatamart.nrcs.usda.gov/). Local Hydric Soils Lists for Puerto Rico and the U. S. Virgin Islands are also available at http://www.pr.nrcs.usda.gov/technical/soil_survey/. Local Hydric Soils Lists have been compiled into a National Hydric Soils List available at http://soils.usda.gov/use/hydric/. However, use of the local lists is preferred since they are more current and reflect local variations in soil properties.

Hydric soil indicators

Many of the hydric soil indicators were developed specifically for wetland-delineation purposes. During the development of these indicators, soils in the interior of wetlands were not always examined; therefore, there are wetlands that lack any of the approved hydric soil indicators in the wettest interior portions. Wetland delineators and other users of the hydric soil indicators should concentrate their sampling efforts near the wetland edge and, if these soils are hydric, assume that soils in the wetter, interior portions of the wetland are also hydric, even if they lack an indicator.

Hydric soil indicators are presented in three groups. Indicators for "All Soils" are used in any soil regardless of texture. Indicators for "Sandy Soils" are used in soil layers with USDA textures of loamy fine sand or coarser. Indicators for "Loamy and Clayey Soils" are used with soil layers of loamy very fine sand and finer. Both sandy and loamy/clayey layers may be present in the same soil profile. Therefore, a soil that contains a loamy surface layer over sand is hydric if it meets all of the requirements of matrix color, amount and contrast of redox concentrations, depth, and thickness for a specific A (All Soils), F (Loamy and Clayey Soils), or S (Sandy Soils) indicator.

It is permissible to combine certain hydric soil indicators if all requirements of the individual indicators are met except thickness (see Hydric Soil Technical Note 4, http://soils.usda.gov/use/hydric/ntchs/tech_notes/index.html). The most restrictive requirements for thickness of layers in any indicators used must be met. Not all indicators are possible candidates for combination. For example, indicator F2 (Loamy Gleyed Matrix) has no thickness requirement, so a site would either meet the requirements of this indicator or it would not. Table 7 lists the indicators that are the most likely candidates for combining in the region.

Table 7. Minimum thickness requirements for commonly combined indicators in the Caribbean Islands Region.

Indicator	Thickness Requirement
S5 – Sandy Redox	4 in. (10 cm) thick starting within 6 in. (15 cm) of the soil surface
S7 – Dark Surface	4 in. (10 cm) thick starting within 6 in. (15 cm) of the soil surface
F3 – Depleted Matrix	6 in. (15 cm) thick starting within 10 in. (25 cm) of the soil surface
F6 – Redox Dark Surface	4 in. (10 cm) thick entirely within the upper 12 in. (30 cm)
F7 – Depleted Dark Surface	4 in. (10 cm) thick entirely within the upper 12 in. (30 cm)

Table 8 presents an example of a soil in which a combination of layers meets the requirements for indicators F6 (Redox Dark Surface) and F3 (Depleted Matrix). The second layer meets the morphological characteristics of F6 and the third layer meets the morphological characteristics of F3, but neither meets the thickness requirement for its respective indicator. However, the combined thickness of the second and third layers meets the more restrictive conditions of thickness for F3 (i.e., 6 in. (15 cm) starting within 10 in. (25 cm) of the soil surface). Therefore, the soil is considered to be hydric based on the combination of indicators.

Table 8. Example of a soil that is hydric based on a combination of indicators F6 and F3.

Depth (inches)	Matrix Color	Redox Concentrations			Texture
		Color	Abundance	Contrast	
0 – 3	10YR 2/1	--	--	--	Loamy/clayey
3 – 6	10YR 3/1	7.5YR 5/6	3 percent	Prominent	Loamy/clayey
6 – 10	10YR 5/2	7.5YR 5/6	5 percent	Prominent	Loamy/clayey
10 – 14	2.5Y 4/2	--	--	--	Loamy/clayey

Another common situation in which it is appropriate to combine the characteristics of hydric soil indicators is when stratified textures of sandy (i.e., loamy fine sand and coarser) and loamy (i.e., loamy very fine sand and finer) material occur in the upper 12 in. (30 cm) of the soil. For example, the soil shown in Table 9 is hydric based on a combination of indicators F6

Table 9. Example of a soil that is hydric based on a combination of indicators F6 and S5.

Depth (inches)	Matrix Color	Redox Concentrations			Texture
		Color	Abundance	Contrast	
0 – 3	10YR 3/1	10YR 5/6	3 percent	Prominent	Loamy/clayey
3 – 6	10YR 4/1	10YR 5/6	3 percent	Prominent	Sandy
6 – 16	10YR 4/1	--	--	--	Loamy/clayey

(Redox Dark Surface) and S5 (Sandy Redox). This soil meets the morphological characteristics of F6 in the first layer and S5 in the second layer, but neither layer by itself meets the thickness requirement for its respective indicator. However, the combined thickness of the two layers (6 in. (15 cm)) meets the more restrictive thickness requirement of either indicator (4 in. (10 cm)).

All soils

"All soils" refers to soils with any USDA soil texture. Use the following indicators regardless of soil texture.

Unless otherwise noted, all mineral layers above any of the layers meeting an A indicator must have a dominant chroma of 2 or less, or the layer(s) with a dominant chroma of more than 2 must be less than 6 in. (15 cm) thick to meet any hydric soil indicator. Nodules and concretions are not considered to be redox concentrations unless otherwise noted.

Indicator A1: Histosol

Technical Description: Classifies as a Histosol (except Folists)

User Notes: In a Histosol, 16 in. (40 cm) or more of the upper 32 in. (80 cm) is organic soil material (Figure 6). Histosols also include soils that have organic soil material of any thickness over rock or fragmental soil material that has interstices filled with organic soil material. Organic soil material has an organic carbon content (by weight) of 12 to 18 percent or more, depending on the clay content of the soil. The material includes muck (sapric soil material), mucky peat (hemic soil material), or peat (fibric soil material). See the glossary of *Field Indicators of Hydric Soils in the United States* (USDA Natural Resources Conservation Service 2010) for definitions of muck, mucky peat, peat, and organic soil material. See the Concepts section of this chapter for field methods to identify organic soil materials, and Appendix A for the definition of fragmental soil material.

Figure 6. Example of a Histosol, in which muck (sapric soil material) is greater than 3 ft (0.9 m) thick.

This indicator occurs in coastal areas in tidal swamps, tidal flats, depressions, and freshwater swamps and marshes. Places where this indicator can be seen include Boquerón State Forest, Caño Tiburones, Laguna Joyuda (Figure 7), Laguna Tortuguero, and Martin Peña swamp in Puerto Rico, and at Sandy Point, Great Pond, and Altona Lagoon in the U.S. Virgin Islands.

Figure 7. Histosols and histic epipedons are present around the margins of Laguna Joyuda.

Indicator A2: Histic Epipedon

Technical Description: A histic epipedon underlain by mineral soil material with a chroma of 2 or less.

User Notes: Most histic epipedons are surface horizons 8 in. (20 cm) or more thick of organic soil material (Figure 8). Aquic conditions or artificial drainage are required (see *Soil Taxonomy*, USDA Natural Resources Conservation Service 1999); however, aquic conditions can be assumed if indicators of hydrophytic vegetation and wetland hydrology are present. See the glossary of *Field Indicators of Hydric Soils in the United States* (USDA Natural Resources Conservation Service 2010) for definitions. See the Concepts section of this chapter for field methods to identify organic soil materials. See indicator A1 for organic carbon requirements. Slightly lower organic carbon contents are allowed in plowed soils.

Figure 8. In this soil, the organic surface layer is about 9 in. (23 cm) thick.

This indicator occurs in coastal areas in tidal swamps, tidal flats, depressions, and freshwater swamps and marshes. Places where this indicator can be seen include Boquerón State Forest, Caño Tiburones, Laguna

Joyuda, Laguna Tortuguero, and Martin Peña swamp in Puerto Rico, and at Sandy Point, Great Pond, and Altona Lagoon in the U.S. Virgin Islands.

Indicator A3: Black Histic

Technical Description: A layer of peat, mucky peat, or muck 8 in. (20 cm) or more thick that starts within 6 in. (15 cm) of the soil surface; has a hue of 10YR or yellower, value of 3 or less, and chroma of 1 or less; and is underlain by mineral soil material with a chroma of 2 or less (Figure 9).

Figure 9. A black organic surface layer greater than 11 in. (28 cm) thick.

User Notes: This indicator does not require proof of aquic conditions or artificial drainage. See the glossary of *Field Indicators of Hydric Soils in the United States* (USDA Natural Resources Conservation Service 2010) for definitions of peat, mucky peat, and muck. See the Concepts section of this chapter for field methods to identify organic soil materials. See indicator A1 for organic carbon requirements.

This indicator is rare in the Caribbean Islands Region. It is most likely to be associated with slope wetlands that are saturated to the surface or with depressional wetlands that are ponded or saturated nearly all year. The Black Histic indicator is generally not found at the boundaries between wetlands and non-wetlands.

Indicator A4: Hydrogen Sulfide

Technical Description: A hydrogen sulfide (rotten egg) odor within 12 in. (30 cm) of the soil surface.

User Notes: Any time the soil smells of hydrogen sulfide (rotten egg odor), sulfur is currently being reduced and the soil is definitely in an anaerobic state. In some soils, the odor is pronounced; in others it is very fleeting as the gas dissipates rapidly. If in doubt, quickly open several small holes in the area of concern to determine if a hydrogen sulfide odor is really present. Hydrogen sulfide odor is generally not found at the boundary between wetlands and non-wetlands.

This indicator is most common in permanently inundated or saturated tidal swamps and marshes and extremely rare in other parts of the region. It can be found in Boquerón State Forest, Caño Tiburones, Laguna Joyuda, Laguna Tortuguero, Piñones State Forest, and Martin Peña swamp in Puerto Rico, and at Sandy Point, Great Pond, and Altona Lagoon in the U.S. Virgin Islands.

Indicator A6: Organic Bodies

Technical Description: Presence of 2 percent or more organic bodies of muck or a mucky modified mineral texture starting within 6 in. (15 cm) of the soil surface.

User Notes: This indicator is rare in the Caribbean Islands Region, but it has been observed in coastal dune swales on St. Croix and may be present elsewhere. Use of this indicator may require assistance from a soil scientist with local experience. Organic bodies typically occur at the tips of fine roots. The content of organic carbon in organic bodies is the same as that in the muck (e.g., Indicator A8) or mucky (e.g., Indicator A7) indicators. See the Concepts section of this chapter for field methods to identify organic soil materials. The size of the organic bodies is not critical, but the content of organic carbon is critical. The bodies are commonly 0.5 to 1 in. (1 to 3 cm) in diameter (Figure 10). Many organic bodies lack the required amount of organic carbon and do not meet this indicator. Organic bodies of hemic material (mucky peat) and/or fibric material (peat) do not meet the requirements of this indicator, nor does material consisting of partially decomposed root tissue. The Organic Bodies indicator includes the indicator previously named "accretions" (Florida Soil Survey Staff 1992).

Figure 10. Organic bodies 0.5 to 1 in. (1 to 3 cm) in size. Scale in inches (upper) and centimeters (lower).

Indicator A7: 5 cm Mucky Mineral

Technical Description: A layer of mucky modified mineral soil material 2 in. (5 cm) or more thick starting within 6 in. (15 cm) of the soil surface (Figure 11).

Figure 11. The mucky mineral layer in this example is about 4 in. (10 cm) thick and begins at the soil surface. Scale in inches (right) and centimeters (left).

User Notes: Use of this indicator may require assistance from a soil scientist with local experience. "Mucky" is a USDA texture modifier for mineral soils. The organic carbon content is at least 5 percent and ranges as high as 18 percent. The percentage requirement is dependent upon the clay content of the soil; the higher the clay content, the higher the organic carbon requirement. An example is mucky fine sand, which has at least 5 percent but not more than about 12 percent organic carbon. Another example is mucky sandy loam, which has at least 7 percent but not more than about 14 percent organic carbon.

Indicator A8: Muck Presence

Technical Description: A layer of muck with a value of 3 or less and chroma of 1 or less starting within 6 in. (15 cm) of the soil surface.

User Notes: This indicator is most commonly seen in abandoned agricultural areas that are subject to occasional or frequent flooding. The presence of muck of any thickness within 6 in. (15 cm) is the only requirement. Normally, the layer is at the soil surface; however, it may occur at any depth within 6 in. (15 cm). Muck is sapric soil material with a minimum organic-carbon content of 12 to 18 percent, depending on clay content. Organic soil material is called muck if virtually all of the material has undergone sufficient decomposition to prevent the identification of plant parts. Hemic soil material (mucky peat) and fibric soil material (peat) do not qualify. Generally, muck is black and has a "greasy" feel; sand grains should not be evident. See the Concepts section of this chapter for field methods to identify organic soil materials.

Indicator A11: Depleted Below Dark Surface

Technical Description: A layer with a depleted or gleyed matrix that has 60 percent or more chroma of 2 or less, starting within 12 in. (30 cm) of the soil surface, and having a minimum thickness of either:

- 6 in. (15 cm), or
- 2 in. (5 cm) if the 2 in. (5 cm) consists of fragmental soil material.

Loamy/clayey layer(s) above the depleted or gleyed matrix must have a value of 3 or less and chroma of 2 or less. Any sandy material above the depleted or gleyed matrix must have a value of 3 or less and chroma of 1 or less and, when viewed with a 10- or 15-power hand lens, must have at least

70 percent of the visible soil particles masked with organic material. When viewed without a hand lens, the particles appear to be nearly 100 percent masked.

User Notes: This is a common indicator at wetland boundaries in the Caribbean Islands Region. It often occurs in agricultural areas that are subject to occasional to frequent flooding. This indicator applies to soils that have dark-colored surface layers, such as mollic and umbric epipedons and dark-colored ochric epipedons (Figure 12). For soils that have dark surface layers greater than 12 in. (30 cm) thick, use indicator A12. Two percent or more distinct or prominent redox concentrations, including iron/manganese soft masses, pore linings, or both, are required in soils that have matrix values/chromas of 4/1, 4/2, and 5/2 (Figure A1). If the soil is saturated at the time of sampling, it may be necessary to let it dry to a moist condition for redox features to become visible. Redox concentrations are not required in soils with matrix values of 5 or more and chroma of 1, or values of 6 or more and chromas of 2 or 1. The low-chroma matrix must be caused by wetness and not be a relict or parent material feature. See the Glossary (Appendix A) for definitions of depleted matrix, gleyed matrix, distinct and prominent features, and fragmental soil material.

Figure 12. In this soil, a depleted matrix starts immediately below the black surface layer at approximately 11 in. (28 cm).

In some places, the gleyed matrix may change color upon exposure to air (reduced matrix). This phenomenon is included in the concept of a gleyed matrix (USDA Natural Resources Conservation Service 2002).

Indicator A12: Thick Dark Surface

Technical Description: A layer at least 6 in. (15 cm) thick with a depleted or gleyed matrix that has 60 percent or more chroma of 2 or less starting below 12 in. (30 cm) of the surface. The layer(s) above the depleted or gleyed matrix must have a value of 2.5 or less and chroma of 1 or less to a depth of at least 12 in. (30 cm) and a value of 3 or less and chroma of 1 or less in any remaining layers above the depleted or gleyed matrix. Any sandy material above the depleted or gleyed matrix, when viewed with a 10- or 15-power hand lens, must have at least 70 percent of the visible soil particles masked with organic material. When viewed without a hand lens, the particles appear to be nearly 100 percent masked.

User Notes: This indicator is most commonly seen in the lower portions of the Lajas Valley, including Laguna Cartagena (Figure 13), Laguna Guánica, and Ciénaga El Anegado. The soil has a depleted matrix or gleyed matrix below a black or very dark gray surface layer 12 in. (30 cm) or more thick (Figure 14). This indicator is most often associated with overthickened soils in concave landscape positions. Two percent or more distinct or prominent redox concentrations (Table A1), including iron/manganese soft masses, pore linings, or both, are required in soils that have matrix values/chromas of 4/1, 4/2, and 5/2 (Figure A1). If the soil is saturated at the time of sampling, it may be necessary to let it dry to a moist condition for redox features to become visible. Redox concentrations are not required in soils with matrix values of 5 or more and chroma of 1, or values of 6 or more and chromas of 2 or 1. The low-chroma matrix must be caused by wetness and not be a relict or parent material feature. See the Glossary (Appendix A) for the definitions of depleted and gleyed matrix.

In some places, the gleyed matrix may change color upon exposure to air (reduced matrix). This phenomenon is included in the concept of a gleyed matrix (USDA Natural Resources Conservation Service 2002).

This indicator is almost never found at the wetland/non-wetland boundary and is much less common than indicators A11 (Depleted Below Dark Surface), F3 (Depleted Matrix), and F6 (Redox Dark Surface).

Figure 13. Soils with thick, dark surfaces are common around Laguna Cartagena.

Figure 14. Deep observations may be necessary to identify the depleted or gleyed matrix below a thick, dark surface layer. In this example, the depleted matrix starts at 20 in. (50 cm).

Sandy soils

"Sandy soils" refers to soil materials with a USDA soil texture of loamy fine sand and coarser. Use the following indicators in soil layers consisting of sandy soil materials.

Unless otherwise noted, all mineral layers above any of the layers meeting an S indicator, except for indicator S6, must have a dominant chroma of 2 or less, or the layer(s) with a dominant chroma of more than 2 must be less than 6 in. (15 cm) thick to meet any hydric soil indicator. Nodules and concretions are not considered to be redox concentrations unless otherwise noted.

Indicator S4: Sandy Gleyed Matrix

Technical Description: A gleyed matrix that occupies 60 percent or more of a layer starting within 6 in. (15 cm) of the soil surface (Figure 15).

Figure 15. In this example, the gleyed matrix begins at the soil surface.

User Notes: The gleyed matrix only has to be present within 6 in. (15 cm) of the surface. Soils with gleyed matrices are saturated for significant periods; therefore, *no minimum thickness of gleyed layer is required*. See the Glossary (Appendix A) for the definition of a gleyed matrix. Soils with dark gley colors (values less than 4) do not meet the definition of a gleyed matrix and this indicator would not apply. If dark gley soil colors are present, users should consider indicators involving high organic-matter content (e.g., A1, A2, A3) or dark-surface indicators (e.g., A11, A12, F6).

This indicator is most frequently found on tidal flats that are saturated for significant periods. Therefore, it is generally not found at the boundaries between wetlands and non-wetlands.

Indicator S5: Sandy Redox

Technical Description: A layer starting within 6 in. (15 cm) of the soil surface that is at least 4 in. (10 cm) thick and has a matrix with 60 percent or more chroma of 2 or less and 2 percent or more distinct or prominent redox concentrations occurring as soft masses and/or pore linings (Figure 16).

Figure 16. Redox concentrations (orange areas) in sandy soil material.

User Notes: Distinct and prominent are defined in the Glossary (Appendix A). Redox concentrations include iron and manganese masses (reddish mottles) and pore linings (Vepraskas 1992). Common (2 to less than 20 percent) to many (20 percent or more) redox concentrations (USDA Natural Resources Conservation Service 2002) are required. If the soil is saturated at the time of sampling, it may be necessary to let it dry to a moist condition for redox features to become visible.

This is a very common indicator of hydric soils and is often used to identify the hydric/non-hydric soil boundary in sandy soils. This indicator is often associated with depressions or swales within dune/swale complexes.

Indicator S6: Stripped Matrix

Technical Description: A layer starting within 6 in. (15 cm) of the soil surface in which iron/manganese oxides and/or organic matter have been stripped from the matrix and the primary base color of the soil material has been exposed. The stripped areas and translocated oxides and/or organic matter form a faintly contrasting pattern of two or more colors with diffuse boundaries. The stripped zones are 10 percent or more of the volume and are rounded (Figure 17).

User Notes: Use of this indicator may require assistance from a soil scientist with local experience. This indicator includes the indicator previously named "polychromatic matrix" as well as the term streaking (Environmental Laboratory 1987). The stripped areas are typically 0.5 to 1 in. (1 to 3 cm) in size but may be larger or smaller. Commonly, the stripped areas have a value of 5 or more and chroma of 1 and/or 2 and unstripped areas have a chroma of 3 and/or 4. However, there are no specific color requirements for this indicator. The mobilization and translocation of the oxides and/or organic matter are the important processes involved in this indicator and should result in splotchy masked and unmasked soil areas. This may be a difficult pattern to recognize and is often more evident in a horizontal slice. Use care to ensure that the splotchy pattern was not due to the mixing of soil layers by burrowing animals. A 10-power hand lens can be helpful in seeing stripped and unstripped areas.

This is a very common indicator of hydric soils and is often used to identify the hydric/non-hydric soil boundary in sandy soils. This indicator is found in all wetland types and all wet landscape positions. It is often associated with depressions or swales within dune/swale complexes.

Figure 17. Stripped areas form a diffuse, splotchy pattern in this hydric sandy soil.

Indicator S7: Dark Surface

Technical Description: A layer 4 in. (10 cm) thick starting within 6 in. (15 cm) of the soil surface with a matrix value of 3 or less and chroma of 1 or less. When viewed with a 10- or 15-power hand lens, at least 70 percent of the visible soil particles must be masked with organic material. When viewed without a hand lens, the material appears to be nearly 100 percent masked. The matrix color of the layer immediately below the dark layer must have the same colors as those described above or any color that has a chroma of 2 or less.

User Notes: If the dark layer is greater than 4 in. (10 cm) thick, then the indicator is met, because any dark soil material in excess of 4 in. (10 cm) meets the requirement that “the layer immediately below the dark layer must have the same colors as those described above....” If the dark layer is exactly 4 in. (10 cm) thick, then the material immediately below must have a matrix chroma of 2 or less. The organic carbon content of this indicator is slightly less than that required for “mucky.” An undisturbed sample must be observed (Figure 18). Many moderately wet soils have a ratio of about 50 percent soil particles that are masked with organic matter to about 50 percent unmasked soil particles, giving the soil a salt-and-pepper appearance. Where the coverage by organic matter is less than 70 percent, a Dark Surface indicator is not present.

Figure 18. This sandy soil has a dark surface approximately 6 in. (15 cm) thick. Scale in inches on the right.

Loamy and clayey soils

“Loamy and clayey soils” refers to soil materials with USDA textures of loamy very fine sand and finer. Use the following indicators in soil layers consisting of loamy or clayey soil materials.

Unless otherwise noted, all mineral layers above any of the layers meeting an F indicator, except for indicator F8, must have a dominant chroma of 2 or less, or the layer(s) with a dominant chroma of more than 2 must be less than 6 in. (15 cm) thick to meet any hydric soil indicator. Nodules and concretions are not considered to be redox concentrations unless otherwise noted.

Indicator F2: Loamy Gleyed Matrix

Technical Description: A gleyed matrix that occupies 60 percent or more of a layer starting within 12 in. (30 cm) of the soil surface (Figure 19).

User Notes: Soils with gleyed matrices are saturated for significant periods; therefore, no minimum thickness of gleyed layer is required. The gleyed matrix only has to start within 12 in. (30 cm) of the surface. See the Glossary (Appendix A) for the definition of a gleyed matrix. Soils with dark gley colors (values less than 4) do not meet the definition of a gleyed matrix and this indicator would not apply. If dark gley soil colors are present, users should consider indicators for soils with high organic-matter content (e.g., A1, A2, A3) or those with dark surface layers (e.g., A11, A12, F6).

Figure 19. This soil has a gleyed matrix in the lowest layer, starting about 7 in. (18 cm) from the soil surface. The layer above the gleyed matrix has a depleted matrix.

This indicator is found in soils that are inundated or saturated nearly all year in most years, and is not usually found at the boundaries between wetlands and non-wetlands.

Indicator F3: Depleted Matrix

Technical Description: A layer with a depleted matrix that has 60 percent or more chroma of 2 or less and that has a minimum thickness of either:

- 2 in. (5 cm) if the 2 in. (5 cm) is entirely within the upper 6 in. (15 cm) of the soil; or
- 6 in. (15 cm) starting within 10 in. (25 cm) of the soil surface.

User Notes: This indicator occurs mostly in active and abandoned agricultural areas that are subject to occasional or frequent flooding, and is one of the most commonly observed hydric soil indicators at wetland boundaries (Figure 20). Redox concentrations including iron/manganese soft masses or pore linings, or both, are required in soils with matrix values/chromas of 4/1, 4/2, and 5/2 (Figures 21 and 22). If the soil is saturated at the time of sampling, it may be necessary to let it dry to a moist condition for redox features to become visible. Redox concentrations are not required in soils with matrix values of 5 or more and chroma of 1, or values of 6 or more and chromas of 2 or 1. The low-chroma matrix must be caused by wetness and not be a relict or parent-material feature. See the Glossary (Appendix A) for the definition of a depleted matrix.

Figure 20. Indicator F3 (Depleted Matrix) is often found in active and abandoned agricultural fields.

Figure 21. Example of indicator F3 (Depleted Matrix), in which redox concentrations extend nearly to the surface.

Figure 22. This soil has a depleted matrix with redox concentrations in a low-chroma matrix.

Indicator F6: Redox Dark Surface

Technical Description: A layer that is at least 4 in. (10 cm) thick, is entirely within the upper 12 in. (30 cm) of the mineral soil, and has a:

- Matrix value of 3 or less and chroma of 1 or less and 2 percent or more distinct or prominent redox concentrations occurring as soft masses or pore linings, or
- Matrix value of 3 or less and chroma of 2 or less and 5 percent or more distinct or prominent redox concentrations occurring as soft masses or pore linings.

User Notes: This indicator is rare in the Caribbean Islands Region. The layer meeting the requirements of the indicator may extend below 12 in. (30 cm) as long as at least 4 in. (10 cm) occurs within 12 in. (30 cm) of the surface. Redox concentrations are often small and difficult to see in mineral soils that have dark (value of 3 or less) surface layers due to high organic-matter content (Figure 23). The organic matter masks some or all of the concentrations that may be present; it also masks the diffuse boundaries of the concentrations and makes them appear to be more sharp. Careful examination is required to see what are often brownish redox concentrations in the darkened materials. If the soil is saturated at the time of sampling, it may be necessary to let it dry at least to a moist condition for redox features to become visible. In some cases, further drying of the samples makes the concentrations (if present) easier to see. A hand lens may be helpful in seeing and describing small redox concentrations. Care should be taken to examine the interior of soil peds for redox concentrations. Dry colors, if used, also must have matrix chromas of 1 or 2, and the redox concentrations must be distinct or prominent (see Glossary, Appendix A).

In soils that are wet because of subsurface saturation, the layer immediately below the dark epipedon will likely have a depleted or gleyed matrix (see the Glossary for definitions). Soils that are wet because of ponding or have a shallow, perched layer of saturation may not always have a depleted/gleyed matrix below the dark surface. It is recommended that delineators evaluate the hydrologic source and examine and describe the layer below the dark-colored epipedon when applying this indicator.

Figure 23. Redox features can be small and difficult to see within a dark soil layer.

Indicator F7: Depleted Dark Surface

Technical Description: Redox depletions with a value of 5 or more and chroma of 2 or less in a layer that is at least 4 in. (10 cm) thick, is entirely within the upper 12 in. (30 cm) of the mineral soil (Figure 24), and has a:

- Matrix value of 3 or less and chroma of 1 or less and 10 percent or more redox depletions, or
- Matrix value of 3 or less and chroma of 2 or less and 20 percent or more redox depletions.

User Notes: This indicator occurs mostly in active and abandoned agricultural areas that are subject to occasional or frequent flooding. Care should be taken not to mistake the mixing of eluvial layers that have high value and low chroma (E horizon) or illuvial layers that have accumulated carbonates (calcic horizon) into the surface layer as depletions. Mixing of layers can be caused by burrowing animals or cultivation. Pieces of deeper layers that become incorporated into the surface layer are not redox depletions. Knowledge of local conditions is required in areas where light-colored eluvial layers and/or layers high in carbonates may be present.

Figure 24. Redox depletions (lighter colored areas) are scattered within the darker matrix. Scale is in centimeters.

Redox depletions will usually have associated microsites with redox concentrations that occur as pore linings or masses within the depletion(s) or surrounding the depletion(s). In soils that are wet because of subsurface saturation, the layer immediately below the dark surface is likely to have a depleted or gleyed matrix. Use of this indicator may require assistance from a soil scientist with local experience.

Indicator F8: Redox Depressions

Technical Description: In closed depressions subject to ponding, 5 percent or more distinct or prominent redox concentrations occurring as soft masses or pore linings in a layer that is 2 in. (5 cm) or more thick and is entirely within the upper 6 in. (15 cm) of the soil.

User Notes: This indicator occurs on depressional landforms, such as ephemeral pools (Figures 25 and 26); but not microdepressions on convex landscapes. Closed depressions often occur within flats or floodplain landscapes. *Note that there is no color requirement for the soil matrix*. The

Figure 25. In this example, the layer of redox concentrations begins at the soil surface and is slightly more than 2 in. (5 cm) thick.

Figure 26. Indicator F8 is a common hydric soil indicator at the boundaries of depressional wetlands.

layer containing redox concentrations may extend below 6 in. (15 cm) as long as at least 2 in. (5 cm) occurs within 6 in. (15 cm) of the surface. If the soil is saturated at the time of sampling, it may be necessary to let it dry to a moist condition for redox features to become visible. See the Glossary for definitions of distinct and prominent.

This is a common, but often overlooked indicator at the wetland/non-wetland boundary on depressional sites.

Hydric soil indicators for problem soils

The following indicators are not currently recognized for general application by the NTCHS in the Caribbean Islands Region. However, these indicators may be used in problem wetland situations in the region where there is evidence of wetland hydrology and hydrophytic vegetation, and the soil is believed to meet the definition of a hydric soil despite the lack of other indicators of a hydric soil. To use these indicators, follow the procedure described in the section on Problematic Hydric Soils in Chapter 5. If the following indicators are observed, it is recommended that the NTCHS be notified by following the protocol described in the "Comment on the Indicators" section of *Field Indicators of Hydric Soils in the United States* (USDA Natural Resources Conservation Service 2010).

Indicator A5: Stratified Layers

Technical Description: Several stratified layers starting within 6 in. (15 cm) of the soil surface. At least one of the layers has a value of 3 or less with a chroma of 1 or less or it is muck, mucky peat, peat, or mucky modified mineral texture. The remaining layers have chromas of 2 or less (Figure 27). Any sandy material that constitutes the layer with a value of 3 or less and a chroma of 1 or less, when viewed with a 10- or 15-power hand lens, must have at least 70 percent of the visible soil particles masked with organic material (Figure 28). When viewed without a hand lens, the particles appear to be nearly 100 percent masked.

User Notes: Use of this indicator may require assistance from a soil scientist with local experience. An undisturbed sample must be observed. Individual strata are dominantly less than 1 in. (2.5 cm) thick. Many alluvial soils have stratified layers at greater depths; these are not hydric soils. Many alluvial soils have stratified layers at the required depths, but lack a chroma of 2 or less; these do not fit this indicator. Stratified layers occur in any type of soil material, generally in floodplains and other areas where wet soils are subject to rapid and repeated burial with thin deposits of sediment.

Figure 27. Stratified layers in loamy material.

Figure 28. Stratified layers in sandy material.

Indicator F21: Red Parent Material

Technical Description: A layer derived from red parent materials (see glossary) that is at least 10 cm (4 inches) thick. Starting within 25 cm (10 inches) of the soil surface with a hue of 7.5YR or redder. The matrix has a value and chroma greater than 2 and less than or equal to 4. The layer must contain 10 percent or more depletions and/or distinct or prominent redox concentrations occurring as soft masses or pore linings. Redox depletions should differ in color by having:

a. Value one or more higher and chroma one or more lower than the matrix, or
b. Value of 4 or more and chroma of 2 or less.

User Notes: This indicator was developed for use in areas of red parent material. In order to confirm that it is appropriate to apply this indicator to particular soils, soils formed from similar parent materials in the area should have been evaluated to determine their Color Change Propensity Index (CCPI) and be shown to have CCPI values below 30 (Rabenhorst and Parikh, 2000). It cannot be assumed that sediment overlying red colored bedrock is derived solely from that bedrock. The total percentage of all redox concentrations and redox depletions must add up to at least 10% to meet the threshold of this indicator.

This indicator is typically found at the boundary between hydric and non-hydric soils. Users that encounter a depleted matrix in the upper part should consider F3-Depleted Matrix. F3 is often found in sites that are anaerobic for a longer period. Users that encounter a dark soil surface (value 3 or less and chroma 2 or less) should consider F6-Redox Dark Surface or F7-Depleted Dark Surface. If the site is in a closed depression subject to ponding users should consider F8-Redox Depressions. See glossary for definition of Red Parent Material.

Indicator TF12: Very Shallow Dark Surface

Technical Description: In depressions and other concave landforms, one of the following:

- If bedrock occurs between 6 in. (15 cm) and 10 in. (25 cm), a layer at least 6 in. (15 cm) thick starting within 4 in. (10 cm) of the soil surface with a value of 3 or less and chroma of 1 or less, and the remaining soil to bedrock must have the same colors as above or any other color that has a chroma of 2 or less.
- If bedrock occurs within 6 in. (15 cm), more than half of the soil thickness must have a value of 3 or less and chroma of 1 or less, and the remaining soil to bedrock must have the same colors as above or any other color that has a chroma of 2 or less.

4 Wetland Hydrology Indicators

Introduction

Wetland hydrology indicators are used in combination with indicators of hydric soil and hydrophytic vegetation to determine whether an area is a wetland under the Corps Manual. Indicators of hydrophytic vegetation and hydric soil generally reflect a site's medium- to long-term wetness history. They provide readily observable evidence that episodes of inundation or soil saturation lasting more than a few days have occurred repeatedly over a period of years and that the timing, duration, and frequency of wet conditions have been sufficient to produce a characteristic wetland plant community and hydric soil morphology. If hydrology has not been altered, vegetation and soils provide strong evidence that wetland hydrology is present (National Research Council 1995). Wetland hydrology indicators provide evidence that the site has a *continuing* wetland hydrologic regime and that hydric soils and hydrophytic vegetation are not relicts of a past hydrologic regime. Wetland hydrology indicators confirm that an episode of inundation or soil saturation occurred recently, but may provide little additional information about the timing, duration, or frequency of such events (National Research Council 1995).

Hydrology indicators are often the most transitory of wetland indicators. Some hydrology indicators are naturally temporary or seasonal, and many are affected by recent or long-term meteorological conditions. For example, indicators involving direct observation of surface water or saturated soils often are present only during the normal wet season and may be absent during the dry season or during drier-than-normal years. Hydrology indicators also may be subject to disturbance or destruction by natural processes or human activities. Most wetlands in the Caribbean will exhibit one or more of the hydrology indicators presented in this chapter. However, some wetlands may lack any of these indicators due to temporarily dry conditions, disturbance, or other factors. Therefore, *the lack of an indicator is not evidence for the absence of wetland hydrology*. See Chapter 5 (Difficult Wetland Situations in the Caribbean Islands Region) for help in identifying wetlands that may lack wetland hydrology indicators at certain times.

The Caribbean region has a subtropical climate with annual precipitation ranging from 10 to more than 200 in. (255 to 5,080 mm), depending upon location. On Puerto Rico, for example, annual rainfall is greater on the northern windward slopes while the southwestern portion of the island, in the rain shadow of the Cordillera Central, is semi-arid. The region is also affected by tropical weather systems and occasional hurricanes that can produce very heavy downpours. Some wetland hydrology indicators may be present on non-wetland sites immediately after a heavy rain or during periods of unusually high precipitation, river stages, tides, reservoir releases, or runoff. Therefore, it is important to consider weather and climatic conditions prior to the site visit to minimize both false-positive and false-negative wetland hydrology decisions. An understanding of normal seasonal and annual variations in rainfall, temperature, and other climatic conditions is important in interpreting hydrology indicators in the region. Some useful sources of climatic data are described in Chapter 5.

Areas that have hydrophytic vegetation and hydric soils generally also have wetland hydrology unless the hydrologic regime has changed due to natural events or human activities (National Research Council 1995). Therefore, when wetland hydrology indicators are absent from an area that has indicators of hydric soil and hydrophytic vegetation, further information may be needed to determine whether or not wetland hydrology is present. If possible, one or more site visits should be scheduled to coincide with the normal wet season, the period of the year when the presence or absence of wetland hydrology indicators is most likely to reflect the true wetland/non-wetland status of the site. In addition, aerial photography or other remote-sensing data, stream gauge data, runoff estimates, scope-and-effect equations for ditches and subsurface drainage systems, or groundwater modeling are tools that may help to determine whether wetland hydrology is present when indicators are equivocal or lacking (e.g., USDA Natural Resources Conservation Service 1997). Finally, on highly disturbed or problematic sites, direct hydrologic monitoring may be undertaken to determine whether wetland hydrology is present. The U. S. Army Corps of Engineers (2005) provides a technical standard for monitoring hydrology on such sites. This standard requires 14 or more consecutive days of flooding or ponding, or a water table 12 in. (30 cm) or less below the soil surface, during the growing season at a minimum frequency of 5 years in 10 (50 percent or higher probability) (National Research Council 1995) unless an alternative standard has been established for a particular region or wetland type. See Chapter 5 for further information on these techniques.

Growing season

In the Caribbean Islands Region, the growing season for wetland delineation purposes is year-round or 365 days long. The growing season is the period of the year when biological activity in plant roots and soil microbial populations is sufficient to bring about the depletion of oxygen and the chemical reduction of nitrogen, iron, and other elements in soils that become saturated for more than a few days. In the Caribbean region, soil temperatures are consistently above "biological zero" or 41 °F (5 °C) and significant biological activity occurs year-round, even at the highest elevations. Therefore, wetland hydrology indicators are applicable throughout the year. In the event that recorded hydrologic data, such as stream gauge or water-table monitoring data, must be analyzed to determine whether wetland hydrology is present on highly disturbed or problematic sites, extended periods of flooding, ponding, or high water tables are relevant at any time of year.

Wetland hydrology indicators

In this chapter, wetland hydrology indicators are presented in four groups. Indicators in Group A are based on the direct observation of surface water or groundwater during a site visit. Group B consists of evidence that the site is subject to flooding or ponding, although it may not be inundated currently. These indicators include water marks, drift deposits, sediment deposits, and similar features. Group C consists of other evidence that the soil is saturated currently or was saturated recently. Some of these indicators, such as oxidized rhizospheres surrounding living roots and the presence of reduced iron or sulfur in the soil profile, indicate that the soil has been saturated for an extended period. Group D consists of landscape, vegetation, and soil features that indicate contemporary rather than historical wet conditions. Wetland hydrology indicators are intended as one-time observations of site conditions that are sufficient evidence of wetland hydrology in areas where hydric soils and hydrophytic vegetation are present. All of the indicators presented in this supplement are applicable throughout the Caribbean Islands Region.

Within each group, indicators are divided into two categories – *primary* and *secondary* – based on their estimated reliability in this region. One primary indicator from any group is sufficient to conclude that wetland hydrology is present; the area is a wetland if indicators of hydric soil and hydrophytic vegetation are also present. In the absence of a primary indicator, two or more secondary indicators from any group are required to conclude that wetland hydrology is present. Indicators of wetland hydrology include, but are not necessarily limited to, those listed in Table 10 and described on the following pages. Other evidence of wetland hydrology may also be used with appropriate documentation.

Table 10. Wetland hydrology indicators for the Caribbean Islands Region.

	Category	
Indicator	Primary	Secondary
Group A – Observation of Surface Water or Saturated Soils		
A1 – Surface water	X	
A2 – High water table	X	
A3 – Saturation	X	
Group B – Evidence of Recent Inundation		
B1 – Water marks	X	
B2 – Sediment deposits	X	
B3 – Drift deposits	X	
B4 – Algal mat or crust	X	
B5 – Iron deposits	X	
B7 – Inundation visible on aerial imagery	X	
B9 – Water-stained leaves	X	
B13 – Aquatic fauna	X	
B6 – Surface soil cracks		X
B8 – Sparsely vegetated concave surface		X
B10 – Drainage patterns		X
Group C – Evidence of Current or Recent Soil Saturation		
C1 – Hydrogen sulfide odor	X	
C3 – Oxidized rhizospheres along living roots	X	
C4 – Presence of reduced iron	X	
C6 – Recent iron reduction in tilled soils	X	
C7 – Thin muck surface	X	
C10 – Fiddler crab burrows	X	
C2 – Dry-season water table		X
C9 – Saturation visible on aerial imagery		X
Group D – Evidence from Other Site Conditions or Data		
D2 – Geomorphic position		X
D3 – Shallow aquitard		X
D5 – FAC-neutral test		X

Group A – Observation of surface water or saturated soils

Indicator A1: Surface water

Category: Primary

General Description: This indicator consists of the direct, visual observation of surface water (flooding or ponding) during a site visit (Figure 29).

Cautions and User Notes: Care must be used in applying this indicator because surface water may be present in non-wetland areas immediately after a rainfall event or during periods of unusually high precipitation, runoff, tides, or river stages. Furthermore, some non-wetlands flood frequently for brief periods. Note that surface water may be absent from a wetland during the normal dry season or during extended periods of drought. Even under normal rainfall conditions, some wetlands do not become inundated or saturated every year (i.e., wetlands are inundated or saturated at least 5 out of 10 years, or 50 percent or higher probability). In addition, groundwater-dominated wetland systems may never or rarely contain surface water.

Figure 29. A coastal flat wetland in Puerto Rico with surface water present.

Indicator A2: High water table

Category: Primary

General Description: This indicator consists of the direct, visual observation of the water table 12 in. (30 cm) or less below the surface in a soil pit, auger hole, or shallow monitoring well (Figure 30). This indicator includes water tables derived from perched water, throughflow, and discharging groundwater (e.g., in seeps) that may be moving laterally near the soil surface.

Cautions and User Notes: Sufficient time must be allowed for water to infiltrate into a newly dug hole and to stabilize at the water-table level. The required time will vary depending upon soil texture. In some cases, the water table can be determined by examining the wall of the soil pit and identifying the upper level at which water is seeping into the pit. Care must be used in interpreting this indicator because water-table levels normally vary seasonally and are a function of both recent and long-term precipitation. Even under normal rainfall conditions, some wetlands do not become inundated or saturated every year (i.e., wetlands are inundated or saturated at least 5 out of 10 years, or 50 percent or higher probability). For an accurate determination of the water-table level, the soil pit, auger hole, or well should not penetrate any restrictive soil layer capable of perching water near the surface.

Figure 30. High water table observed in a soil pit.

Indicator A3: Saturation

Category: Primary

General Description: Visual observation of saturated soil conditions 12 in. (30 cm) or less from the soil surface as indicated by water glistening on the surfaces and broken interior faces of soil samples removed from the pit or auger hole (Figure 31). This indicator must be associated with an existing water table located immediately below the saturated zone; however, this requirement is waived under episaturated conditions if there is a restrictive soil layer or bedrock within 12 in. (30 cm) of the surface.

Cautions and User Notes: Glistening is evidence that the soil sample was taken either below the water table or within the saturated capillary fringe above the water table. Recent rainfall events and the proximity of the water table at the time of sampling must be considered in applying and interpreting this indicator. Water observed in soil cracks or on the faces of soil aggregates (peds) does not meet this indicator unless ped interiors are also saturated. Depth to the water table must be recorded on the data form or in field notes. A water table is not required below the saturated zone under episaturated conditions if the restrictive layer or bedrock is present within 12 in. (30 cm) of the surface. Note the restrictive layer in the soils section of the data form. The restrictive layer may be at the surface.

Figure 31. Water glistens on the surface of a saturated soil sample.

Group B – Evidence of recent inundation

Indicator B1: Water marks

Category: Primary

General Description: Water marks are discolorations or stains on the bark of woody vegetation, rocks, bridge supports, buildings, fences, or other fixed objects as a result of inundation (Figure 32).

Cautions and User Notes: When several water marks are present, the highest reflects the maximum extent of inundation. Water marks indicate a water-level elevation and can be extrapolated from nearby objects across lower elevation areas. Use caution with water marks that may have been caused by extreme, infrequent, or very brief flooding events. Along streams subject to severe downcutting in recent years, water marks may reflect historic rather than contemporary flooding levels.

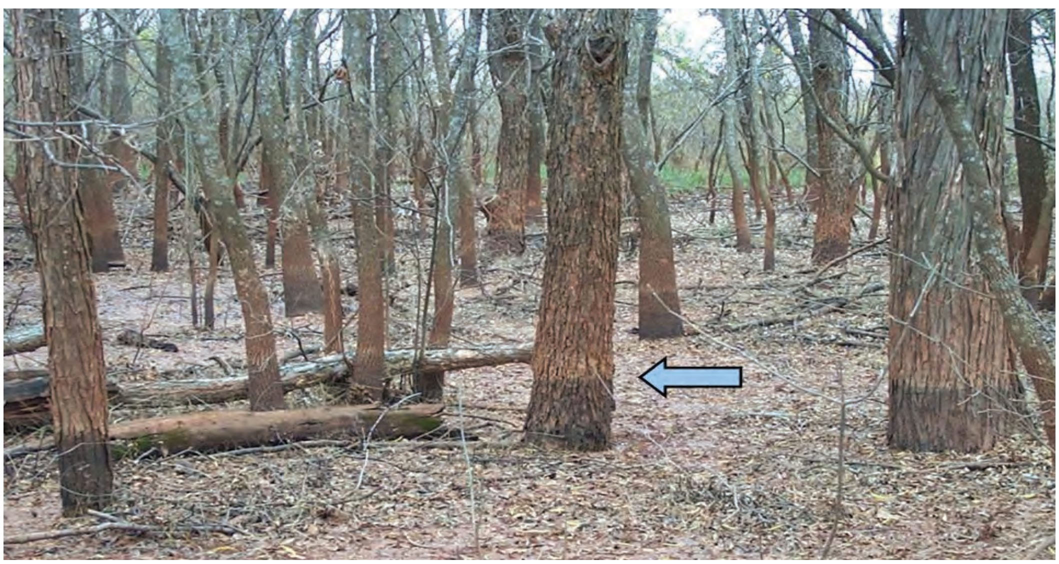

Figure 32. Water marks (dark stains) on trees in a seasonally flooded wetland. The top of one water mark is indicated by the arrow.

Indicator B2: Sediment deposits

Category: Primary

General Description: Sediment deposits are thin layers or coatings of fine-grained mineral material (e.g., silt or clay) or organic matter (e.g., pollen), sometimes mixed with other detritus, remaining on tree bark (Figure 33), plant stems or leaves, rocks, and other objects after surface water recedes.

Figure 33. Silt deposit left after a recent high-water event forms a tan coating on these tree trunks (upper edge indicated by the arrow).

Cautions and User Notes: Sediment deposits most often occur in riverine backwater and ponded situations where water has stood for sufficient time to allow suspended sediment to settle. Sediment deposits may remain for a considerable period before being removed by precipitation or subsequent inundation. Sediment deposits on vegetation or other objects indicate the minimum inundation level. This level can be extrapolated across lower elevation areas. Use caution with sediment left after infrequent high flows or very brief flooding events. This indicator does not include thick accumulations of sand or gravel in fluvial channels that may reflect historic flow conditions or recent extreme events.

Indicator B3: Drift deposits

Category: Primary

General Description: Drift deposits consist of rafted debris that has been deposited on the ground surface or entangled in vegetation or other fixed objects (Figure 34). Debris consists of remnants of vegetation (e.g., branches, stems, and leaves), man-made litter, or other waterborne materials. Drift material may be deposited at or near the high water line in ponded or flooded areas, piled against the upstream side of trees, rocks, and other fixed objects, or widely distributed within the dewatered area.

Figure 34. Drift material caught on a fence and in low vegetation in a coastal wetland, southwest Puerto Rico.

Cautions and User Notes: Deposits of drift material are often found adjacent to streams or other sources of flowing water in wetlands. They also occur in tidal wetlands, along lake shores, and in other ponded areas. The elevation of a drift line can be extrapolated across lower elevation areas. Use caution with drift lines that may have been caused by extreme, infrequent, or very brief flooding events, and in areas with functioning drainage systems capable of removing excess water quickly.

Indicator B4: Algal mat or crust

Category: Primary

General Description: This indicator consists of a mat or dried crust of algae, perhaps mixed with other detritus, left on or near the soil surface after dewatering.

Cautions and User Notes: Algal deposits include those produced by green algae (Chlorophyta) and blue-green algae (cyanobacteria). They may be attached to low vegetation or other fixed objects, or may cover the soil surface (Figures 35 and 36). Dried crusts of blue-green algae may crack

Figure 35. Algal crust (dark material on the surface) in a St. Croix coastal wetland.

Figure 36. Close-up view of algal crust in a coastal wetland.

and curl at plate margins (Figure 37). Algal deposits are usually seen in coastal flats, swales, and depressions; seasonally ponded areas; lake fringes; and low-gradient stream margins. They reflect prolonged wet conditions sufficient for algal growth and development.

Figure 37. Crust of blue-green algae showing cracks and curling at plate margins.

Indicator B5: Iron deposits

Category: Primary

General Description: This indicator consists of a thin orange or yellow crust or gel of oxidized iron on the soil surface or on objects near the surface.

Cautions and User Notes: Iron deposits form in localized areas where reduced iron discharges with groundwater and oxidizes upon exposure to air. The oxidized iron forms a film or sheen on standing water (Figure 38) and an orange or yellow deposit (Figure 39) on the ground surface after dewatering. This indicator should not be extrapolated beyond the immediate area where the iron deposit is found.

Figure 38. Iron sheen on the water surface may be deposited as an orange or yellow crust after dewatering.

Figure 39. Iron deposit (orange streaks) in a small channel.

Indicator B7: Inundation visible on aerial imagery

Category: Primary

General Description: One or more recent aerial photographs or satellite images show the site to be inundated.

Cautions and User Notes: Care must be used in applying this indicator because surface water may be present on a non-wetland site immediately after a heavy rain or during periods of unusually high precipitation, runoff, tides, or river stages. See Chapter 5 for procedures to evaluate the normality of precipitation prior to the photo date. Surface water may be absent from a wetland during the normal dry season or during extended periods of drought. Even under normal rainfall conditions, some wetlands do not become inundated or saturated every year (i.e., wetlands are inundated or saturated at least 5 out of 10 years, or 50 percent or higher probability). If available, it is recommended that multiple years of photography be evaluated. If 5 or more years of aerial photos are available, the procedure described in the Hydrology Tools for Wetland Determination (USDA Natural Resources Conservation Service 1997, section 650.1903) is recommended (see Chapter 5, section on Wetlands that Periodically Lack Indicators of Wetland Hydrology, for additional information).

Indicator B9: Water-stained leaves

Category: Primary

General Description: Water-stained leaves are fallen or recumbent dead leaves that have turned grayish or blackish in color due to inundation for long periods.

Cautions and User Notes: In the Caribbean region, water-stained leaves are often found in coastal wetlands, depressional wetlands, and along streams in shrub-dominated or forested habitats; however, they also occur in herbaceous communities. Staining generally occurs in leaves that are in contact with the soil surface while inundated for long periods. Water-stained leaves maintain their blackish or grayish colors when dry (Figure 40). They should contrast strongly with fallen leaves in nearby non-wetland landscape positions.

Figure 40. Water-stained leaves in a coastal wetland on St. Croix.

Indicator B13: Aquatic fauna

Category: Primary

General Description: Presence of live individuals, diapausing insect eggs or crustacean cysts, or dead remains of aquatic fauna, such as sponges, bivalves, aquatic snails, aquatic insects, ostracods, shrimp, other crustaceans, tadpoles, or fish, either on the soil surface or clinging to plants or other emergent objects.

Cautions and User Notes: Examples of dead remains include fiddler crab (*Uca* spp.) shells (Figure 41), clam shells, chitinous exoskeletons (e.g., dragonfly nymphs), insect head capsules, aquatic snail shells (Figure 42), and skins or skeletons of aquatic amphibians or fish. Aquatic fauna or their remains should be reasonably abundant; one or two individuals are not sufficient. Use caution in areas where faunal remains may have been transported by high winds, unusually high water, or other animals into non-wetland areas. Shells and exoskeletons are resistant to tillage but may be moved by equipment beyond the boundaries of the wetland. They may also persist in the soil for years after dewatering.

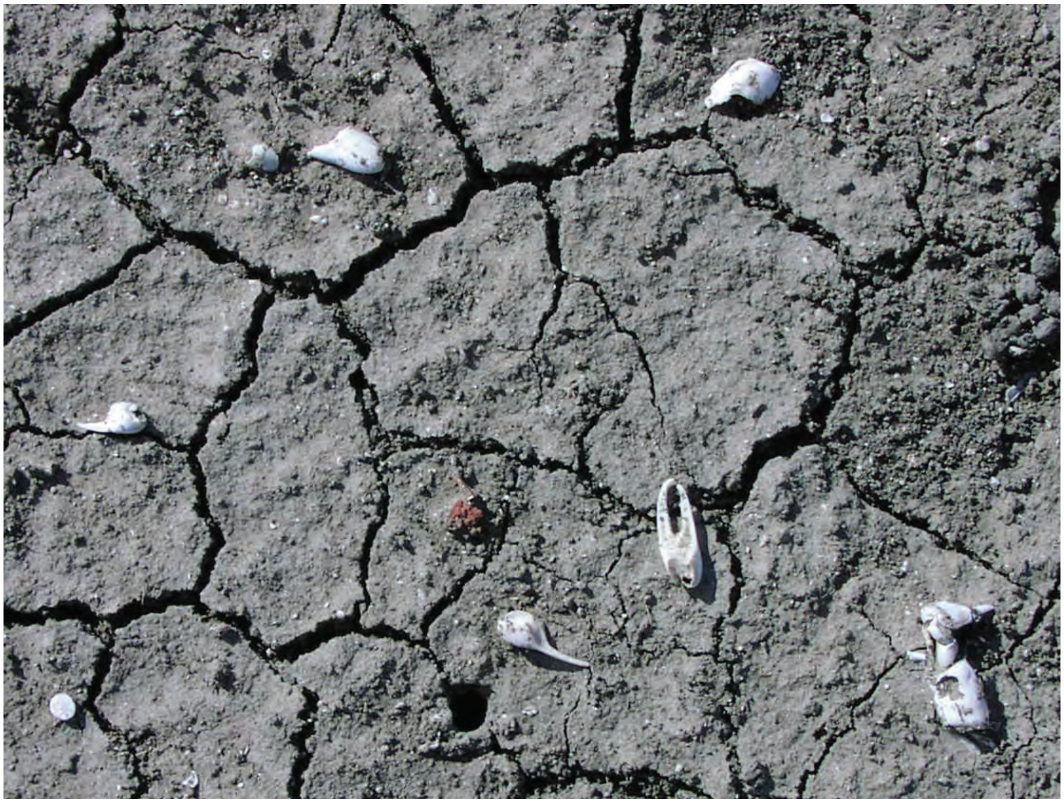

Figure 41. Remains of fiddler crabs in a coastal wetland.

Figure 42. Shells of aquatic snails in a seasonally ponded fringe wetland.

Indicator B6: Surface soil cracks

Category: Secondary

General Description: Surface soil cracks consist of shallow cracks that form when fine-grained mineral or organic sediments dry and shrink, often creating a network of cracks or small polygons (Figure 43).

Cautions and User Notes: Surface soil cracks are often seen in recent fine sediments and in concave landscape positions where water has ponded long enough to destroy surface soil structure, such as in depressions, lake fringes, and floodplains. Use caution, however, as they may also occur in temporary ponds and puddles in non-wetlands and in areas that have been effectively drained. This indicator does not include deep cracks due to shrink-swell action in clay soils (e.g., Vertisols).

Figure 43. Surface soil cracks in a Puerto Rican freshwater lagoon.

Indicator B8: Sparsely vegetated concave surface

Category: Secondary

General Description: On concave land surfaces (e.g., depressions and swales) and associated fringe areas, the ground surface is either unvegetated or sparsely vegetated (less than 5 percent ground cover) due to long-duration ponding (Figure 44).

Cautions and User Notes: Sparsely vegetated concave surfaces should contrast with vegetated slopes and convex surfaces in the same area. A woody overstory of trees or shrubs may or may not be present. Examples in the region include, but are not limited to, concave positions on floodplains and seasonally ponded depressions in flat landscapes. They also may be associated with saline conditions in shallow depressions on coastal flats.

Figure 44. A sparsely vegetated, frequently ponded depression (foreground and left center) adjacent to the Sandy Point lagoon on St. Croix.

Indicator B10: Drainage patterns

Category: Secondary

General Description: This indicator consists of flow patterns visible on the soil surface or eroded into the soil, low vegetation bent over in the direction of flow, absence of leaf litter or small woody debris due to flowing water, and similar evidence that water flowed across the ground surface.

Cautions and User Notes: Drainage patterns are usually seen in areas where water flows broadly over the surface and is not confined to a channel, such as in areas adjacent to streams, in seeps, slope wetlands, vegetated swales, and tidal flats (Figures 45 and 46). Use caution in areas subject to high winds or affected by recent extreme or unusual flooding events.

Figure 45. Drainage patterns seen during a flooding event. The patterns are also evident when the wetland is dry.

Figure 46. Vegetation bent over in the direction of water flow across a stream terrace.

Group C – Evidence of current or recent soil saturation

Indicator C1: Hydrogen sulfide odor

Category: Primary

General Description: A hydrogen sulfide (rotten egg) odor within 12 in. (30 cm) of the soil surface.

Cautions and User Notes: Hydrogen sulfide is a gas produced by soil microbes in response to prolonged saturation in soils where oxygen, nitrogen, manganese, and iron have been largely reduced and there is a source of sulfur. For hydrogen sulfide to be detectable, the soil must be saturated at the time of sampling and must have been saturated long enough to become highly reduced. These soils are often permanently saturated and anaerobic at or near the surface. To apply this indicator, dig the soil pit no deeper than 12 in. to avoid release of hydrogen sulfide from deeper in the profile. Hydrogen sulfide odor serves as an indicator of both hydric soil and wetland hydrology. This one observation proves that the soil meets the definition of a hydric soil (i.e., anaerobic in the upper part), plus it has an ongoing wetland hydrologic regime. Often these soils have a high water table (wetland hydrology indicator A2), but the hydrogen sulfide odor provides further proof that the soil has been saturated for a long period of time.

Indicator C3: Oxidized rhizospheres along living roots

Category: Primary

General Description: Presence of a layer containing 2 percent or more iron-oxide coatings or plaques on the surfaces of living roots and/or iron-oxide coatings or linings on soil pores immediately surrounding living roots within 12 in. (30 cm) of the soil surface (Figures 47 and 48).

Cautions and User Notes: Oxidized rhizospheres are the result of oxygen leakage from living roots into the surrounding anoxic soil, causing oxidation of ferrous iron present in the soil solution. They are evidence of saturated and reduced soil conditions during the plant's lifetime. Iron concentrations or plaques may form on the immediate root surface or may coat the soil pore adjacent to the root. In either case, the oxidized iron must be associated with living roots to indicate contemporary wet conditions and to distinguish these features from other pore linings. Care must be taken to distinguish iron-oxide coatings from organic matter associated with plant roots. Viewing with a hand lens may help to distinguish mineral from organic material and to identify oxidized rhizospheres along fine roots and root hairs. Iron coatings sometimes show concentric layers in cross section

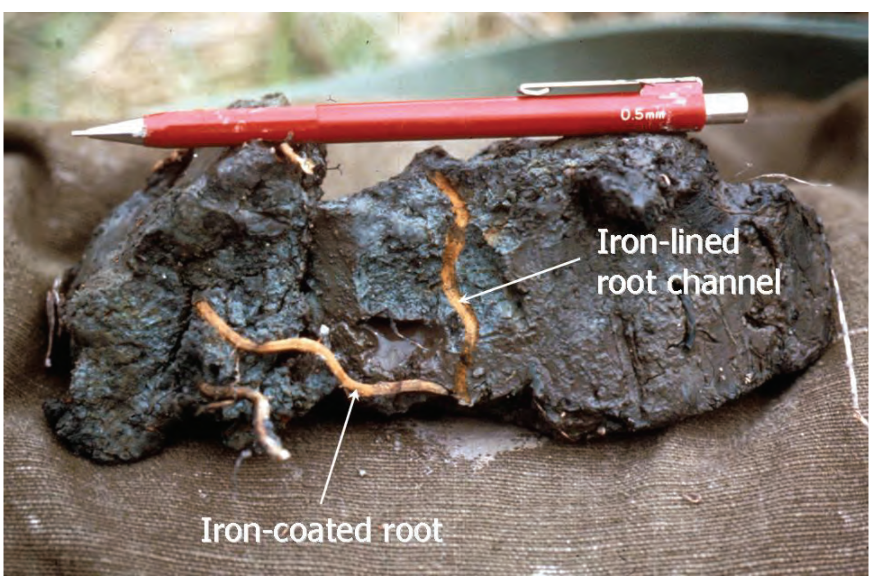

Figure 47. Iron-oxide plaque (orange coating) on a living root. Iron also coats the channel or pore from which the root was removed.

Figure 48. Soil with oxidized rhizospheres surrounding many fine roots.

and may transfer iron stains to the fingers when rubbed. Note the location and abundance of oxidized rhizospheres in the soil profile description or remarks section of the data form. There is no minimum thickness requirement for the layer containing oxidized rhizospheres. Oxidized rhizospheres must occupy at least 2 percent of the volume of the layer.

Indicator C4: Presence of reduced iron

Category: Primary

General Description: Presence of a layer containing reduced (ferrous) iron in the upper 12 in. (30 cm) of the soil profile, as indicated by a ferrous iron test or by the presence of a soil that changes color upon exposure to the air.

Cautions and User Notes: The reduction of iron occurs in soils that have been saturated long enough to become anaerobic and chemically reduced.

Ferrous iron is converted to oxidized forms when saturation ends and the soil reverts to an aerobic state. Thus, the presence of ferrous iron indicates that the soil is saturated and anaerobic at the time of sampling, and has been saturated for an extended period. The presence of ferrous iron can be verified with alpha, alpha-dipyridyl reagent (Figure 49) or by observing a soil that changes color upon exposure to air (i.e., a reduced matrix). A positive reaction to alpha, alpha-dipyridyl should occur over more than 50 percent of the soil layer in question. The reagent does not react when wetlands are dry; therefore, a negative test result is not evidence that the soil is not reduced at other times of year. Soil samples should be tested or examined immediately after opening the soil pit because ferrous iron may oxidize and colors may change soon after the sample is exposed to the air. Avoid areas of the soil that may have been in contact with iron digging tools. Soils that contain little weatherable iron may not react even when saturated and reduced. There are no minimum thickness requirements or initial color requirements for the soil layer in question.

Figure 49. When alpha, alpha-dipyridyl is applied to a soil containing reduced iron, a positive reaction is indicated by a pink or red coloration to the treated area.

Indicator C6: Recent iron reduction in tilled soils

Category: Primary

General Description: Presence of a layer containing 2 percent or more redox concentrations as pore linings or soft masses in the tilled surface layer of soils cultivated within the last two years. The layer containing redox concentrations must be within the tilled zone or within 12 in. (30 cm) of the soil surface, whichever is shallower.

Cautions and User Notes: Cultivation breaks up or destroys redox features in the plow zone. The presence of redox features that are continuous and unbroken indicates that the soil was saturated and reduced since the last episode of cultivation (Figure 50). Redox features often form around organic material, such as crop residue, that have been incorporated into the tilled soil. Use caution with older features that may be broken up but not

Figure 50. Redox concentrations in the tilled surface layer of a recently cultivated soil.

destroyed by tillage. The indicator is most reliable in areas that are cultivated regularly, so that soil aggregates and older redox features are more likely to be broken up. Information about the timing of last cultivation may be available from the land owner, if it is not immediately obvious. A plow zone 6 to 8 in. (15 to 20 cm) in depth is typical but may extend deeper. There is no minimum thickness requirement for the layer containing redox concentrations.

Indicator C7: Thin muck surface

Category: Primary

General Description: This indicator consists of a layer of muck 1 in. (2.5 cm) or less thick on the soil surface.

Cautions and User Notes: Muck is highly decomposed organic material (see the Concepts section of Chapter 3 for guidance on identifying muck). In this region, muck accumulates only where soils are saturated to the surface for long periods each year. Thick muck layers can persist for years after wetland hydrology is effectively removed; therefore, a muck layer greater than 1 in. thick does not qualify for this indicator. However, thin muck surfaces disappear quickly or become incorporated into mineral horizons when wetland hydrology is withdrawn. Therefore, the presence of a thin muck layer on the soil surface indicates an active wetland hydrologic regime.

Indicator C10: Fiddler crab burrows

Category: Primary

General Description: On coastal flats and shorelines, the presence of fiddler crab (*Uca* spp.) burrows, as indicated by openings in soft soil or sand approximately 0.5 to 1 in. (1 to 2 cm) in diameter, often associated with excavated balls of mud or sand (Figure 51).

Cautions and User Notes: *Uca* is a burrowing crab of the intertidal zone in mangrove swamps, saltwater marshes, tidal flats, and their fringes. Several species of fiddler crabs are present in Puerto Rico and the U.S. Virgin Islands. Fiddler crabs dig their burrows in intertidal wetlands and in adjacent areas where the water table is generally within 12 in. (30 cm) of the surface (Shinn 1968, Warner 1969, Thurman 1984, Grimes et al. 1989).

Figure 51. Fiddler crab burrows.

They forage in the intertidal zone at low tide and seldom move far from their protective burrows. Fiddler crab burrows should not be confused with those of the land crab (*Cardisoma guanhumi*), which are larger (generally 1 to 7 in. (2 to 18 cm) in diameter) and extend to a water table that may range from less than 12 in. (30 cm) to more than 60 in. (1.5 m) in depth (Gifford 1962, Herreid and Gifford 1963). Thus, land crab burrows are often found within wetlands, but they occur more often in drier habitats above the wetland boundary.

Indicator C2: Dry-season water table

Category: Secondary

General Description: Visual observation of the water table between 12 and 24 in. (30 and 60 cm) below the surface during the normal dry season or during a drier-than-normal year.

Cautions and User Notes: Due to normal seasonal fluctuations, water tables in wetlands often drop below 12 in. during the dry season. A water table between 12 and 24 in. during the dry season, or during an unusually dry year, indicates a normal wet-season water table within 12 in. of the surface. Sufficient time must be allowed for water to infiltrate into a newly dug hole and to stabilize at the water-table level. The required time will vary depending upon soil texture. In some cases, the water table can be determined by examining the wall of the soil pit and identifying the upper level at which water is seeping into the pit. For an accurate determination of the water-table level, the soil pit, auger hole, or well should not penetrate any restrictive soil layer capable of perching water near the surface. Water tables in wetlands often drop well below 24 in. during dry periods. Therefore, a dry-season water table below 24 in. does not necessarily indicate a lack of wetland hydrology. Water tables are a function of both recent and long-term precipitation; use caution in interpreting this indicator immediately following an unusually heavy rainfall event. See Chapter 5 (section on Wetlands that Periodically Lack Indicators of Wetland Hydrology) for determining average dry-season dates and drought periods.

Indicator C9: Saturation visible on aerial imagery

Category: Secondary

General Description: One or more recent aerial photographs or satellite images indicate soil saturation. Saturated soil signatures must correspond to field-verified hydric soils, depressions or drainage patterns, differential crop management, or other evidence of a seasonal high water table.

Cautions and User Notes: This indicator is useful when plant cover is sparse or absent and the ground surface is visible from above. Saturated areas generally appear as darker patches within the field (Figure 52). Inundated (indicator B7) and saturated areas may be present in the same field; if they cannot be distinguished, then use indicator C9 for the entire wet area. Care must be used in applying this indicator because saturation may be present on a non-wetland site immediately after a heavy rain or during periods of abnormally high precipitation, runoff, tides, or river stages. Saturation may be absent from a wetland during the normal dry season or during extended periods of drought. Even under normal rainfall conditions, some wetlands do not become inundated or saturated every year (i.e., the wetlands are inundated or saturated at least 5 out of 10 years, or with 50 percent or higher probability). If they are available, it is recommended that multiple years of photography be evaluated. If 5 or more years of aerial photos are available, the procedure described by the USDA Natural Resources Conservation Service (1997, section 650.1903) is recommended. Use caution, as similar signatures may be caused by factors other than saturation. This indicator requires on-site verification that saturation signatures seen on photos correspond to hydric soils or other evidence of a seasonal high water table.

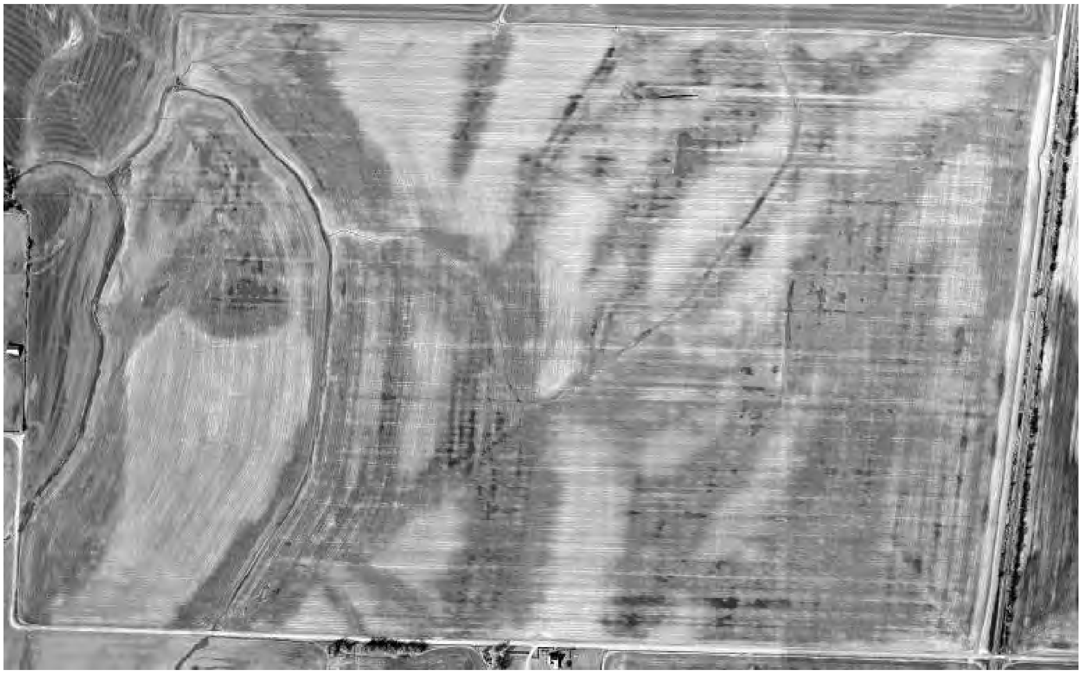

Figure 52. Aerial photograph of an agricultural field with saturated soils indicated by darker colors.

Group D – Evidence from other site conditions or data

Indicator D2: Geomorphic position

Category: Secondary

General Description: This indicator is present if the area in question is located on a tidal flat, in a localized depression, drainageway, concave position within a floodplain, at the toe of a slope, on the low-elevation fringe of a pond or other water body, or in an area where groundwater discharges.

Cautions and User Notes: Excess water from precipitation naturally accumulates in certain geomorphic positions in the landscape, particularly in low-lying areas such as depressions, drainages, toe slopes, and fringes of estuaries, oceans, lakes, and other water bodies. In regions with abundant rainfall, these geomorphic positions often, but not always, exhibit wetland hydrology. This indicator does not include concave positions on rapidly permeable soils (e.g., floodplains with sand and gravel substrates, coastal sand dunes) unless the water table is periodically near the surface.

Indicator D3: Shallow aquitard

Category: Secondary

General Description: This indicator occurs in and around the margins of depressions and in flat landscapes, and consists of the presence of an aquitard within the soil profile that is potentially capable of perching water within 12 in. (30 cm) of the surface.

Cautions and User Notes: An aquitard is a relatively impermeable soil layer or bedrock that slows the downward infiltration of water and can produce a perched water table, generally in flat or depressional landforms. In some cases, the aquitard may be at the surface (e.g., in clay soils) and cause water to pond on the surface. Potential aquitards include fragipans, spodic horizons, petrocalcic layers, cemented layers, lacustrine deposits, and clay layers. An aquitard can often be identified by the limited root penetration through the layer and/or the presence of redoximorphic features in the layer(s) above the aquitard. Use caution in areas with functioning drainage systems that are capable of removing perched water quickly.

Indicator D5: FAC-neutral test

Category: Secondary

General Description: The plant community passes the FAC-neutral test.

Cautions and User Notes: The FAC-neutral test is performed by compiling a list of dominant plant species across all strata in the community, and dropping from the list any species with a Facultative indicator status (i.e., FAC). The FAC-neutral test is met if more than 50 percent of the remaining dominant species are rated FACW and/ or OBL. This indicator may also be used in communities that contain no FAC dominants. If there are an equal number of dominants that are OBL and FACW versus FACU and UPL, or if all dominants are FAC, non-dominant species should be considered.

5 Difficult Wetland Situations in the Caribbean Islands Region

Introduction

Some wetlands can be difficult to identify because wetland indicators may be missing due to natural processes or recent disturbances. This chapter provides guidance for making wetland determinations in difficult-to-identify wetland situations in the Caribbean Islands Region. It includes regional examples of problem area wetlands and atypical situations as defined in the Corps Manual, as well as other situations that can make wetland delineation more challenging. Problem area wetlands are naturally occurring wetland types that periodically lack indicators of hydrophytic vegetation, hydric soil, or wetland hydrology due to normal seasonal or annual variability, or permanently due to the nature of the soils or plant species on the site. Atypical situations are wetlands in which vegetation, soil, or hydrology indicators are absent due to recent human activities or natural events. In addition, this chapter addresses certain procedural problems (e.g., wetland/non-wetland mosaics) that can make wetland determinations in the Caribbean difficult or confusing. The chapter is organized into the following sections:

- Lands Used for Agriculture and Silviculture
- Problematic Hydrophytic Vegetation
- Problematic Hydric Soils
- Wetlands that Periodically Lack Indicators of Wetland Hydrology
- Wetland/Non-Wetland Mosaics

The list of difficult wetland situations presented in this chapter is not intended to be exhaustive and other problematic situations may exist in the region. See the Corps Manual for general guidance. Furthermore, more than one wetland factor (i.e., vegetation, soil, and/or hydrology) may be disturbed or problematic on a given site. In general, *wetland determinations on difficult or problematic sites must be based on the best information available to the field inspector, interpreted in light of his or her professional experience and knowledge of the ecology of wetlands in the region.*

Lands used for agriculture and silviculture

Agriculture and silviculture are important land uses in the Caribbean region, and both of these activities present challenges to wetland identification and delineation. Wetlands used for agriculture or silviculture often lack a natural plant community and may be planted to crops, pasture species, or desirable tree species and may be altered by mowing, grazing, herbicide use, or other management practices. Soils may be disturbed by cultivation, land clearing, grading, or bedding, at least in the surface layers, and hydrology may or may not be manipulated. Some areas that are used for agriculture or silviculture still retain their natural wetland hydrology. In other areas, historic wetlands have been effectively drained and no longer meet wetland hydrology standards. Wetland indicators may still be present in these areas, making it difficult to distinguish current wetlands from those that have been effectively drained.

Agricultural and silvicultural drainage systems use ditches, subsurface drainage lines or "tiles," and water-control structures to manipulate the water table and improve conditions for crops or other desired species. A freely-flowing ditch or drainage line depresses the water table within a certain lateral distance or zone of influence (Figure 53). The effectiveness of drainage in an area depends in part on soil characteristics, the timing and amount of rainfall, and the depth and spacing of ditches or drains. Wetland determinations on current and former agricultural or silvicultural lands must consider whether a drainage system is present, how it is designed to function, and whether it is effective at removing wetland hydrology from the area.

In Puerto Rico and the U.S. Virgin Islands, agricultural drainage systems in many areas have been abandoned and some areas may be reverting to wetland hydrology. For example, the Humacao and Caño Tiburones Natural Reserves in Puerto Rico have reverted to wetlands after having been drained for sugar cane production.

A number of information sources and tools are listed below to help determine whether wetlands are present on lands where vegetation, soils, hydrology, or a combination of these factors have been manipulated. Some of these options are discussed in more detail later in this chapter under the appropriate section headings.

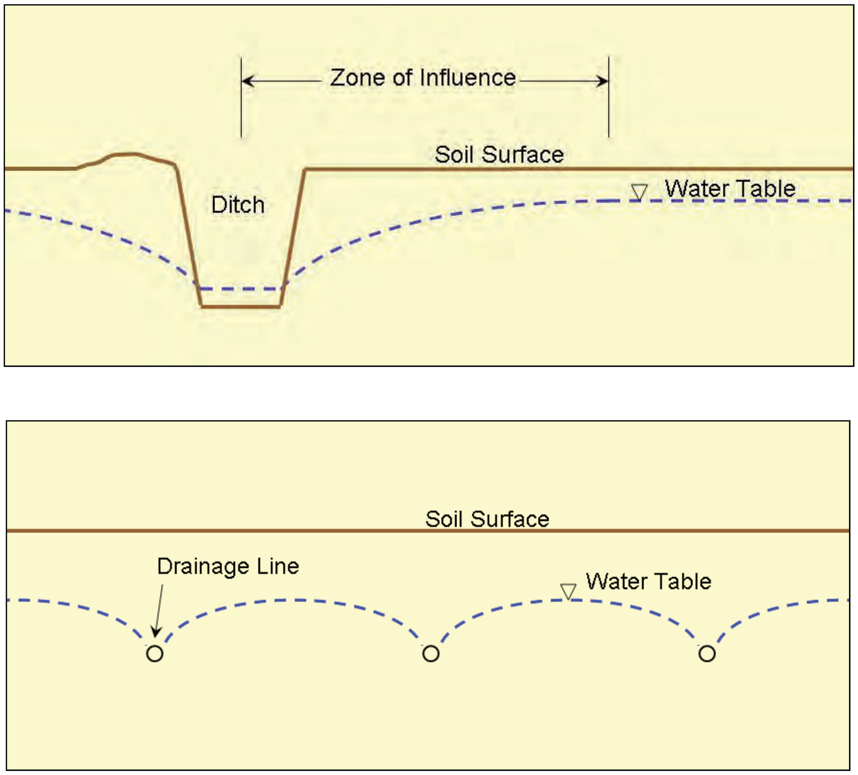

Figure 53. Effects of ditches (upper) and parallel subsurface drainage lines (lower) on the water table.

1. **Vegetation** – The goal is to determine the plant community that would occupy the site under normal circumstances, if the vegetation were not cleared or manipulated.

    a. Examine the site for volunteer vegetation that emerges between cultivations, plantings, mowings, or other treatments.

    b. Examine the vegetation on an undisturbed reference area with soils, hydrology, landscape position, and other conditions similar to those on the site.

    c. If the hydrology of the site has not been altered, check NRCS soil survey reports for information on the typical vegetation on soil map units.

    d. If the conversion to agriculture or silviculture was recent and the hydrology of the site was not manipulated, examine pre-disturbance aerial photography, NWI maps, and other sources for information on the previous vegetation.

e. Cease the clearing, cultivation, or manipulation of the site for a year or more and examine the plant community that develops.

2. **Soils** – Tilling of agricultural land mixes the surface layer(s) of the soil and may cause compaction below the tilled zone (i.e., a “plow pan”) due to the weight and repeated passage of farm machinery. Similar disturbance to surface soils may also occur in areas managed for silviculture. Nevertheless, a standard soil profile description and examination for hydric soil indicators are often sufficient to determine whether hydric soils are present. Other options and information sources include the following:

    a. Examine NRCS soil survey maps and the local hydric soils list for the likely presence of hydric soils on the site.

    b. Examine the soils on an undisturbed reference area with landscape position, parent materials, and hydrology similar to those on the site.

    c. Use alpha, alpha-dipyridyl reagent to check for the presence of reduced iron during the normal wet portion of the year, or note whether the soil changes color upon exposure to the air.

    d. Monitor the site in relation to the appropriate wetland hydrology or hydric soils technical standard.

3. **Hydrology** – The goal is to determine whether wetland hydrology is present on a managed site under normal circumstances, as defined in the Corps Manual and subsequent guidance. These sites may or may not have been hydrologically manipulated.

    a. Examine the site for existing indicators of wetland hydrology. If the natural hydrology of the site has been permanently altered, discount any indicators known to have been produced before the alteration (e.g., relict water marks or drift lines).

    b. In agricultural areas, examine five or more years of aerial photographs for wetness signatures listed in Part 513.30 of the National Food Security Act Manual (USDA Natural Resources Conservation Service 1994) or in wetland mapping conventions available from NRCS offices or online in the electronic Field

Office Technical Guide (eFOTG) (http://www.nrcs.usda.gov/technical/efotg/). Use the procedure given by the USDA Natural Resources Conservation Service (1997) to determine whether wetland hydrology is present.

c. Estimate the effects of ditches and subsurface drainage systems using scope-and-effect equations (USDA Natural Resources Conservation Service 1997). A web application to analyze data using various models is available at http://www.wli.nrcs.usda.gov/technical/-web_tool/tools_java.html. Scope-and-effect equations are approximations only and may not reflect actual field conditions. Their results should be verified by comparison with other techniques for evaluating drainage and should not overrule onsite evidence of wetland hydrology.

d. Use hydrologic models (e.g., runoff, surface water, and groundwater models) to determine whether wetland hydrology is present (USDA Natural Resources Conservation Service 1997).

e. Monitor the hydrology of the site in relation to the appropriate wetland hydrology technical standard (U. S. Army Corps of Engineers 2005).

Problematic hydrophytic vegetation

Description of the problem

Many factors affect the structure and composition of plant communities in the Caribbean Islands Region, including climatic variability, tropical storms, agricultural use, and other human land-use practices. As a result, some wetlands may exhibit indicators of hydric soil and wetland hydrology but lack any of the hydrophytic vegetation indicators presented in Chapter 2, at least at certain times. To identify and delineate these wetlands may require special sampling procedures or additional analysis of factors affecting the site. To the extent possible, the hydrophytic vegetation decision should be based on the plant community that is normally present during the wet season in a normal rainfall year. The following procedure addresses several examples of problematic vegetation situations in the Caribbean region.

Procedure

Problematic hydrophytic vegetation can be identified using a combination of observations made in the field and/or supplemental information from the scientific literature and other sources. These procedures should be applied only where indicators of hydric soil and wetland hydrology are present, unless one or both of these factors is also problematic, but no indicators of hydrophytic vegetation are evident. The following procedures are recommended:

1. Verify that at least one indicator of hydric soil and one primary or two secondary indicators of wetland hydrology are present. If indicators of either hydric soil or wetland hydrology are absent, the area is likely non-wetland unless soil and/or hydrology are also disturbed or problematic. If indicators of hydric soil and wetland hydrology are present (or are absent due to disturbance or other problem situations), proceed to step 2.
2. Verify that the area is in a landscape position that is likely to collect or concentrate water. If the landscape setting is appropriate, proceed to step 3. Appropriate settings include the following:

    a. Concave surface (e.g., depression or swale)

    b. Floodplain

    c. Level or nearly level area (e.g., 0- to 3-percent slope)

    d. Toe slope (Figure 5) or an area of convergent slopes (Figure 4)

    e. Fringe of another wetland or water body

    f. Area with a restrictive soil layer or aquitard capable of perching water within 12 in. (30 cm) of the surface

    g. Area where groundwater discharges (e.g., a seep)

    h. Other (explain in field notes why this area is likely to be inundated or saturated for long periods)

3. Use one or more of the approaches described in step 4 (Specific Problematic Vegetation Situations below) or step 5 (General Approaches to Problematic Hydrophytic Vegetation on page 104) to determine whether the vegetation is hydrophytic. In the remarks section of the data form or in the delineation report, explain the rationale for concluding that the plant community is hydrophytic even though indicators of hydrophytic vegetation described in Chapter 2 were not observed.
4. Specific Problematic Vegetation Situations

   a. *Seasonal shifts in vegetation*. As mentioned in Chapter 2, the species composition of some wetland plant communities in the Caribbean region can change from wet seasons to dry seasons. Wetland types in the region that are influenced by these shifts include ephemeral pools, depressional wetlands on the coastal plains, salt pans, seeps, and springs. During the dry season, when surface water dries up and water tables drop, these wetlands may be invaded and dominated by FACU and UPL grasses or annual plant species, such as guineagrass (*Urochloa maxima* = *Panicum maximum*). Therefore, the lack of hydrophytic vegetation during the dry season should not immediately eliminate a site from consideration as a wetland, because the site may have been dominated by wetland species at other times of year. A site qualifies for further consideration if the plant community at the time of sampling does not exhibit hydrophytic vegetation indicators, but indicators of hydric soil and wetland hydrology are present or known to be disturbed or problematic. The following sampling and analytical approaches are recommended in these situations:

      1) If possible, return to the site during the normal wet season and re-examine the site for indicators of hydrophytic vegetation.

      2) Examine the site for identifiable plant remains, either alive or dead, or other evidence that the plant community that was present during the normal wet season was hydrophytic.

      3) Use off-site data sources to determine whether the plant community that is normally present during the wet season is hydrophytic. Appropriate data sources include aerial

photography, NWI maps, soil survey reports, remotely sensed data, public interviews, and previous reports about the site. If necessary, re-examine the site at a later date to verify the hydrophytic vegetation determination.

4) If the vegetation on the site is substantially the same as that on a wetland reference site having similar soils, landscape position, and known wetland hydrology, then consider the vegetation to be hydrophytic (see step *5b* in this procedure for more information).

b. *Areas affected by grazing*. Both short- and long-term grazing can cause shifts in dominant species in the vegetation. For instance, trampling by large herbivores can cause soil compaction, thereby altering soil permeability and infiltration rates, and affecting the plant community. Grazers can also influence the abundance of plant species by selectively grazing certain species. For example, yerba venezolana or Mexican crowngrass (*Paspalum fasciculatum*) (not listed by Reed (1988)) often increases at the expense of herbaceous wetland species under heavy grazing pressure. Shifts in species composition due to grazing can influence the hydrophytic vegetation determination. Users should be aware that shifts in both directions, favoring either wetland species or upland species, can occur in these situations. Limited grazing does not necessarily affect the outcome of a hydrophytic vegetation decision. However, the following approaches are recommended in cases where the effects of grazing are so great that the hydrophytic vegetation determination would be unreliable or misleading.

1) Examine the vegetation on a nearby, ungrazed reference site having similar soils and hydrologic conditions. Ungrazed areas may be present on adjacent properties or in fenced exclosures or streamside management zones. Assume that the same plant community would exist on the grazed site, in the absence of grazing.

2) If feasible, remove livestock or fence representative livestock exclusion areas to allow the vegetation time to recover from grazing and reevaluate the vegetation.

3) If grazing was initiated recently, use offsite data sources such as aerial photography, NWI maps, and interviews with the land owner and other persons familiar with the site or area to determine what plant community was present on the site before grazing began. If the previously ungrazed community was hydrophytic, then consider the current vegetation to be hydrophytic.

4) If an appropriate ungrazed area cannot be located or if the ungrazed vegetation condition cannot be determined, make the wetland determination based on indicators of hydric soils and wetland hydrology.

c. *Managed plant communities.* Plant communities throughout the region have been altered and are managed to meet human goals. Examples include clearing of woody vegetation on pastures and grasslands, periodic disking or plowing, planting of native and non-native species (including cultivars or planted species that have escaped and become established on other sites), improving pastures, applying silvicultural treatments, using herbicides, and suppressing wildfires. These actions can result in elimination of certain species and their replacement with other species, changes in the abundance of certain plants, and shifts in dominant species, possibly influencing a hydrophytic vegetation determination. The following options are recommended if the natural vegetation has been altered through management to such an extent that a hydrophytic vegetation determination is not possible or would be unreliable:

1) Examine the vegetation on a nearby, unmanaged reference site having similar soils and hydrologic conditions. Assume that the same plant community would exist on the managed site in the absence of human alteration.

2) Determine whether managed plant communities would support hydrophytic vegetation by omitting planted species when evaluating hydrophytic vegetation indicators.

3) For recently cleared or tilled areas (not planted or seeded), leave representative areas unmanaged for at least one year with normal rainfall and reevaluate the vegetation.

4) Use offsite data sources such as aerial photography, NWI maps, and interviews with the land owner and other persons familiar with the site or area to determine what plant community was present on the site before the management occurred.

5) If the unmanaged vegetation condition cannot be determined, make the wetland determination based on indicators of hydric soil and wetland hydrology.

d. *Areas affected by fires, floods, and other disturbances.* Fires, floods, and other catastrophic disturbances can dramatically alter the vegetation on a site. Vegetation can be completely or partially removed, or its composition altered, depending upon the intensity of the disturbance. Fires in coastal forests, pastures, and grasslands often burn to the margins of the embedded wetlands, and may destroy the vegetation near the wetland boundary. Limited disturbance does not necessarily affect the investigator's ability to determine whether the plant community is or is not hydrophytic. However, if the vegetation on a site has been removed or made unidentifiable by a recent fire, flood, or other disturbance, then one or more of the following approaches may be used to determine whether the vegetation present before the disturbance was hydrophytic. Additional guidance can be found in the Atypical Situations section of the Corps Manual.

1) Examine the vegetation on a nearby, undisturbed reference site having similar soils and hydrologic conditions. Assume that the same plant community would exist on the disturbed site in the absence of disturbance.

2) Use offsite data sources such as aerial photography, NWI maps, and interviews with knowledgeable people to determine what plant community was present on the site before the disturbance.

3) If the undisturbed vegetation condition cannot be determined, make the wetland determination based on indicators of hydric soil and wetland hydrology.

5. General Approaches to Problematic Hydrophytic Vegetation. The following general procedures are provided to identify hydrophytic vegetation in difficult situations not necessarily associated with specific vegetation types or management practices, including wetlands dominated by FACU, NI, NO, or unlisted species that are functioning as hydrophytes. Examples of FACU or unlisted species that sometimes dominate wetlands in the Caribbean Islands Region include, but are not limited to, tropical almond (*Terminalia catappa*), coconut palm (*Cocos nucifera*), royal palm (*Roystonea borinquena*), and albizia (*Albizia procera*). The following procedures should be applied only where indicators of hydric soil and wetland hydrology are present (or are absent due to disturbance or other problem situations) but indicators of hydrophytic vegetation are not evident. The following approaches are recommended:

   a. *Direct hydrologic observations.* Verify that the plant community occurs in an area subject to prolonged inundation or soil saturation. This can be done by visiting the site at 2- to 3-day intervals during the portion of the year when surface water is most likely to be present or water tables are normally high. Hydrophytic vegetation is considered to be present, and the site is a wetland, if surface water is present and/or the water table is 12 in. (30 cm) or less from the surface for 14 or more consecutive days during a period when antecedent precipitation has been normal or drier than normal. If necessary, microtopographic highs and lows should be evaluated separately. The normality of the current year's rainfall must be considered in interpreting field results, as well as the likelihood that wet conditions will occur on the site at least every other year (for more information, see the section on "Wetlands that Periodically Lack Indicators of Wetland Hydrology" in this chapter).

   b. *Reference sites with known hydrology*. If indicators of hydric soil and wetland hydrology are present, the site may be considered to be a wetland if the landscape setting, topography, soils, and vegetation are substantially the same as those on nearby wetland reference areas whose hydrology is known. Hydrologic characteristics of wetland reference areas should be documented through long-term monitoring or by application of the procedure described in item *5a* above. Reference sites should be minimally disturbed and provide long-term access. Soils, vegetation, and hydrologic conditions should be thoroughly documented and the data kept on file in the District or field office.

c. *Technical literature.* Published and unpublished scientific literature may be used to support a decision to treat specific FACU species or species with no assigned indicator status (e.g., NI, NO, or unlisted) as hydrophytes or certain plant communities as hydrophytic. Preferably, this literature should discuss the species' natural distribution along the moisture gradient, its capabilities and adaptations for life in wetlands, wetland types in which it is typically found, or other wetland species with which it is commonly associated.

Problematic hydric soils

Description of the problem

Soils with faint or no indicators

Some soils that meet the hydric soil definition may not exhibit any of the indicators presented in Chapter 3. These problematic hydric soils exist for a number of reasons and require additional information, such as landscape position, presence or absence of restrictive soil layers, or information about hydrology, to identify properly. This section describes several soil situations in the Caribbean Islands Region that are considered to be hydric if additional requirements are met. In some cases, these hydric soils may appear to be non-hydric due to the color of the parent material from which the soils developed. In others, the lack of hydric soil indicators is due to conditions that inhibit the development of redoximorphic features despite prolonged soil saturation and reduction. In addition, recently developed wetlands may lack hydric soil indicators because insufficient time has passed for their development. Examples of problematic hydric soils in the Caribbean region include, but are not limited to, the following:

1. **Moderately to Very Strongly Alkaline Soils.** The formation of redox concentrations and depletions requires that soluble iron, manganese, and organic matter be present in the soil. In a neutral to acidic soil, iron and manganese readily enter into solution as reduction occurs and then precipitate in the form of redox concentrations as the soil becomes oxidized. Identifiable iron or manganese features do not readily form in saturated soils with high pH. High pH (7.5 or higher) can be caused by many factors. In the Caribbean region, salt content is a common cause of

high soil pH. If the pH is high, indicators of hydrophytic vegetation and wetland hydrology are present, and landscape position is consistent with wetlands in the area, then the soil may be hydric even in the absence of a recognized hydric soil indicator. In the absence of an approved indicator, thoroughly document soil conditions, including pH, in addition to the rationale for identifying the soil as hydric (e.g,. landscape position, vegetation, evidence of hydrology, etc.). The concept of high pH includes the USDA terms Moderately Alkaline, Strongly Alkaline, and Very Strongly Alkaline (USDA Natural Resources Conservation Service 2002).

2. **Fluvial Sediments within Floodplains.** These soils commonly occur on vegetated bars within the active channel of rivers and streams and above the bankfull stage. In some cases, these soils lack hydric soil indicators due to yearly or seasonal deposition of new soil material, low iron or manganese content, and low organic matter content. Redox concentrations can sometimes be found on the bottoms of coarse fragments or between stratifications where organic matter gets buried and should be examined closely to see if they satisfy an indicator.
3. **Recently Developed Wetlands.** Recently developed wetlands include mitigation sites, wetland management areas (e.g., for waterfowl), other wetlands intentionally or unintentionally produced by human activities, and naturally occurring wetlands that have not been in place long enough to develop hydric soil indicators.
4. **Seasonally Ponded Soils.** Seasonally ponded, depressional wetlands occur throughout the Caribbean region. Most are perched systems, with water ponding above a restrictive soil layer, such as a hardpan or clay layer that is at or near the surface (e.g., Vertisols). Some of these wetlands lack hydric soil indicators due to the limited saturation depth, saline conditions, or other factors.
5. **Coral Rubble and Cobble Soils.** Soils formed primarily of coral rubble and cobble can be found in coastal embayments, around salt ponds, and on cays, especially in the U.S. Virgin Islands. Some of these soils form when small inlets become closed off from the sea due to the development of coral reefs and rubble/cobble berms across their mouths, forming salt ponds (Thomas and Devine 2005). Mangrove communities often develop on the strip of land separating the pond from the sea. Coral rubble and cobble soils may lack hydric soil indicators due to their recent origin, the dominance of coarse fragments, and frequent deposition of new sediment.

Soils with relict or induced hydric soil indicators

Some soils in the Caribbean Islands Region exhibit redoximorphic features and hydric soil indicators that formed in the recent or distant past when conditions may have been wetter than they are today. These features have persisted even though wetland hydrology may no longer be present. For example, wetlands drained long ago for agricultural purposes may contain persistent hydric soil features. Wetland soils drained during historic times are still considered to be hydric but they may no longer support wetlands. Relict hydric soil features may be difficult to distinguish from contemporary features. However, if indicators of hydrophytic vegetation and wetland hydrology are present, then hydric soil indicators can be assumed to be contemporary.

Relict redoximorphic features are no longer active due to geologic or other changes that have permanently altered the hydrologic regime. Only on close examination is it evident that hydric soil morphologies are not present. Several morphological characteristics that can help distinguish between contemporary and relict redoximorphic features (Vepraskas 1992) are described below:

1. Contemporary hydric soils may have nodules or concretions with diffuse boundaries or irregular surfaces. If surfaces are smooth and round, then red to yellow coronas should be present. Relict hydric soils may have nodules or concretions with abrupt boundaries and smooth surfaces without accompanying coronas.
2. Contemporary hydric soils may have Fe depletions along stable macropores in which roots repeatedly grow that are not overlain by iron-rich coatings (redox concentrations). Relict hydric soils may have Fe depletions along stable macropores in which roots repeatedly grow that are overlain by iron-rich coatings.
3. Contemporary hydric soils may have iron-enriched redox concentrations with Munsell colors of 5YR or yellower and with value and chroma of 4 or more. Relict hydric soils may have iron-enriched redox concentrations with colors redder than 5YR and value and chroma less than 4.
4. Contemporary pore linings may be continuous while relict pore linings may be broken or discontinuous (Hurt and Galbraith 2005).

There are also areas where hydric soil features have developed in former uplands due to human activities, such as the diversion of water for irrigation or other uses. The application of irrigation water to upland areas can create wetland hydrology and, given adequate time, induce the formation of hydric soil indicators. In some cases, a soil scientist can distinguish naturally occurring hydric soil features from those induced by irrigation. Characterizing the naturally-occurring hydrology is often important to the determination and the timing of field observations can be critical. Observations made during the normal wet season, when natural hydrology is often at its peak and irrigation has not yet begun, may help to differentiate naturally-occurring and irrigation-induced hydric soil features.

Procedure

Soils that are thought to meet the definition of a hydric soil but do not exhibit any of the indicators described in Chapter 3 can be identified by the following recommended procedure. This procedure should be used only where indicators of hydrophytic vegetation and wetland hydrology are present, unless one or both factors are also disturbed or problematic, but indicators of hydric soil are not evident.

1. Verify that one or more indicators of hydrophytic vegetation are present, or that vegetation is problematic or has been altered (e.g., by tillage or other land alteration). If this is the case, proceed to step 2.
2. Verify that at least one primary or two secondary indicators of wetland hydrology are present or that indicators are absent due to disturbance or other factors. If so, proceed to step 3. If indicators of hydrophytic vegetation and/or wetland hydrology are absent, then the area is probably non-wetland and no further analysis is required.
3. Thoroughly describe and document the soil profile and landscape setting. Verify that the area is in a landscape position that is likely to collect or concentrate water. Appropriate settings are listed below. If the landscape setting is appropriate, proceed to step 4.

    a. Concave surface (e.g., depression or swale)

    b. Floodplains

    c. Level or nearly level area (e.g., 0- to 3-percent slope)

    d. Toe slope (Figure 5) or an area of convergent slopes (Figure 4)

    e. Fringe of another wetland or water body

f. Area with a restrictive soil layer or aquitard capable of perching water within 12 in. (30 cm) of the surface

g. Area where groundwater discharges (e.g., a seep)

h. Other (explain in field notes why this area is likely to be inundated or saturated for long periods)

4. Use one or more of the following approaches to determine whether the soil is hydric. In the remarks section of the data form or in the delineation report, explain why it is believed that the soil lacks any of the NTCHS hydric soil indicators described in Chapter 3 and why it is believed that the soil meets the definition of a hydric soil.

   a. Determine whether one or more of the following indicators of problematic hydric soils is present. See the descriptions of each indicator given in Chapter 3. If one or more indicators are present, then the soil is hydric.

      1) Stratified Layers (A5)

      2) Red Parent Materials (F21)

      3) Very Shallow Dark Surface (TF12)

   b. Determine whether one or more of the following problematic soil situations is present. If present, consider the soil to be hydric.

      1) Moderately to Very Strongly Alkaline Soils

      2) Fluvial Sediments within Floodplains

      3) Recently Developed Wetlands

      4) Seasonally Ponded Soils

      5) Coral Rubble and Cobble Soils

      6) Other (in field notes, describe the problematic soil situation and explain why it is believed that the soil meets the hydric soil definition)

   c. Soils that have been saturated for long periods and have become chemically reduced may change color when exposed to air due to the rapid oxidation of ferrous iron (Fe^{2+}) to Fe^{3+} (i.e., a reduced matrix) (Figures 54 and 55). If the soil contains sufficient iron, this can result in an observable color change, especially in hue or chroma. The soil is hydric if a mineral layer 4 in. (10 cm) or more thick starting within 12 in. (30 cm) of the soil surface that has a matrix value of 4 or more and chroma of 2 or less becomes redder by one or more pages in hue and/or increases one or more in chroma when exposed to air within 30 minutes (Vepraskas 1992).

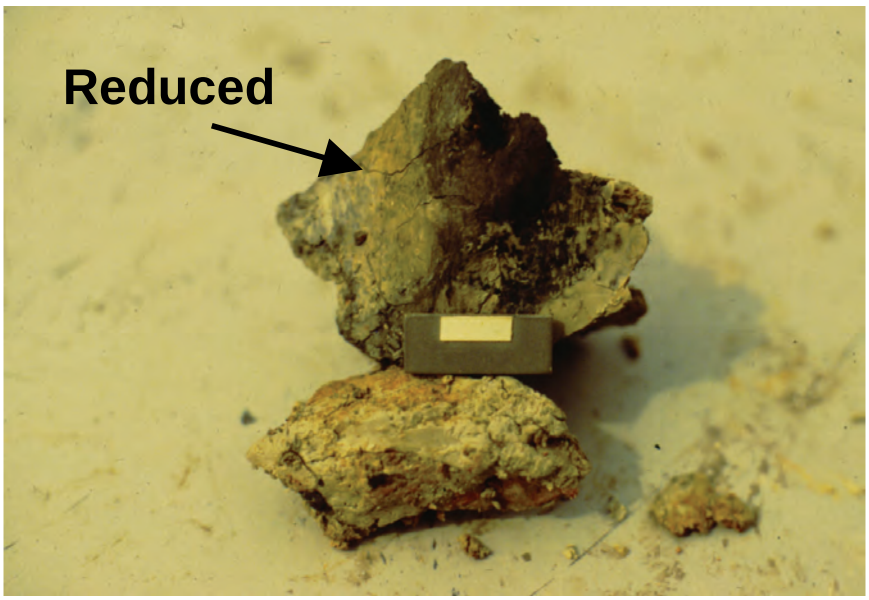

Figure 54. This soil exhibits colors associated with reducing conditions. Scale is 1 cm.

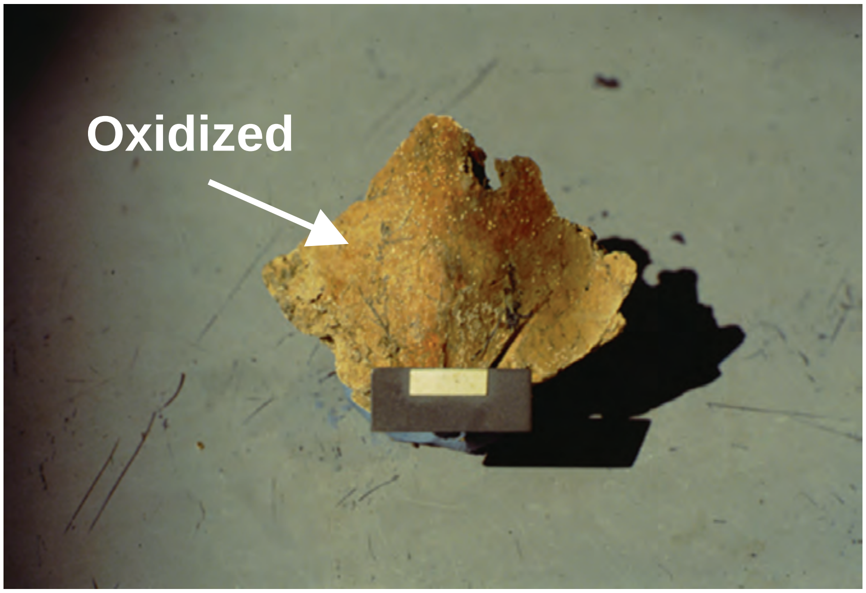

Figure 55. The same soil as in Figure 54 after exposure to the air and oxidation has occurred.

Care must be taken to obtain an accurate color of the soil sample immediately upon excavation. The colors should be observed closely and examined again after several minutes. Do not allow the sample to become dry. Dry soils will usually have a different color than wet or moist soils. As always, do not attempt to identify colors while wearing sunglasses. Colors must be identified in the field under natural light and not under artificial light.

d. If the soil is saturated at the time of sampling, alpha, alpha-dipyridyl reagent can be used in the following procedure to determine if reduced (ferrous) iron is present. If ferrous iron is present as described below, then the soil is hydric.

Alpha, alpha-dipyridyl is a reagent that reacts with reduced iron. In some cases, it can be used to provide evidence that a soil is hydric when it lacks other hydric soil indicators. The soil is likely to be hydric if the application of alpha, alpha-dipyridyl to mineral soil material in at least 60 percent of a layer at least 4 in. (10 cm) thick within a depth of 12 in. (30 cm) of the soil surface results in a positive reaction within 30 seconds, evidenced by a pink or red coloration to the reagent during the growing season.

Using a dropper, apply a small amount of reagent to a freshly broken ped face to avoid any chance of a false positive test due to iron contamination from digging tools. Look closely at the treated soil for evidence of color change. If in doubt, apply the reagent to a sample of known upland soil and compare the reaction to the sample of interest. A positive reaction will not occur in soils that lack iron and may not occur in soils with high pH. The lack of a positive reaction to the reagent does not preclude the presence of a hydric soil. Specific information about the use of alpha, alpha-dipyridyl can be found in NRCS Hydric Soils Technical Note 8 (http://soils.usda.gov/use/hydric/ntchs/tech_notes/index.html).

e. Using gauge data, water-table monitoring data, or repeated direct hydrologic observations, determine whether the soil is ponded or flooded, or the water table is 12 in. (30 cm) or less from the surface, for 14 or more consecutive days during the growing season in most years (at least 5 years in 10, or 50 percent or higher probability) (U. S. Army Corps of Engineers 2005). If so, then the soil is hydric. Furthermore, any soil that meets the NTCHS hydric soil technical standard (NRCS Hydric Soils Technical Note 11, http://soils.usda.gov/use/hydric/ntchs/tech_notes/index.html) is hydric.

Wetlands that periodically lack indicators of wetland hydrology

Description of the problem

Wetlands are areas that are flooded or ponded, or have soils that are saturated with water, for long periods in most years. If the site is visited during a time of normal precipitation amounts and it is inundated or the water table is near the surface, then the wetland hydrology determination is straightforward. During the dry season, however, surface water recedes from wetland margins, water tables drop, and many wetlands dry out completely. Furthermore, not all wetlands become inundated or saturated every year. Wetlands in general are inundated or saturated at least 5 years in 10 (50 percent or higher probability) over a long-term record. Consequently, some wetlands in the Caribbean region may not become inundated or saturated in some years.

Wetland hydrology determinations are based on indicators, many of which were designed to be used during dry periods when the direct observation of surface water or a shallow water table is not possible. However, some wetlands may lack any of the listed hydrology indicators, particularly during the dry season or in a dry year. The evaluation of wetland hydrology requires special care on any site where indicators of hydrophytic vegetation and hydric soil are present but hydrology indicators appear to be absent. Among other factors, this evaluation should consider the timing of the site visit in relation to normal seasonal and annual hydrologic variability, and whether the amount of rainfall prior to the site visit has been normal. This section describes a number of approaches that can be used to determine whether wetland hydrology is present on sites where indicators of hydrophytic vegetation and hydric soil are present but hydrology indicators may be lacking due to normal variations in rainfall or runoff, human activities that destroy hydrology indicators, and other factors.

Procedure

1. Verify that indicators of hydrophytic vegetation and hydric soil are present, or are absent due to disturbance or other problem situations. If so, proceed to step 2.
2. Verify that the site is in a landscape position that is likely to collect or concentrate water. Appropriate settings are listed below. If the landscape setting is appropriate, proceed to step 3.

    a. Concave surface (e.g., depression or swale)

    b. Floodplain

    c. Level or nearly level area (e.g., 0- to 3-percent slope)

    d. Toe slope (Figure 5) or an area of convergent slopes (Figure 4)

    e. Fringe of another wetland or water body

    f. Area with a restrictive soil layer or aquitard capable of perching water within 12 in. (30 cm) of the surface

    g. Area where groundwater discharges (e.g., a seep)

    h. Other (explain in field notes why this area is likely to be inundated or saturated for long periods)

3. Use one or more of the following approaches to determine whether wetland hydrology is present and the site is a wetland. In the remarks section of the data form or in the delineation report, explain the rationale for concluding that wetland hydrology is present even though indicators of wetland hydrology described in Chapter 4 were not observed.

a. *Site visits during the dry season*. Determine whether the site visit occurred during the normal annual "dry season." The dry season, as used in this supplement, is the period of the year when soil moisture is normally being depleted and water tables are falling to low levels in response to decreased precipitation and/or increased evapotranspiration. In the Caribbean region, the occurrence and timing of dry seasons depend on the location of the site in relation to island topography and the prevailing northeasterly trade winds. On the Island of Puerto Rico, for example, there is no significant dry season along the northern coast and windward mountain slopes due to sufficient year-round rainfall and mild temperatures. In the southern part of the island, however, average annual precipitation is less and there can be significant moisture deficits from December through August, until the beginning of the tropical storm season. Examples of wetland types that may dry out completely during the annual dry season include depressional wetlands, ephemeral pools, and floodplain wetlands associated with intermittent and ephemeral streams.

In many wetlands, direct observation of flooding, ponding, or a shallow water table would be unexpected during the dry season. Wetland hydrology indicators, if present, would most likely be limited to indirect evidence, such as water marks, drift deposits, or surface cracks. In some situations, particularly in seasonally saturated wetland systems, hydrology indicators may be absent during the dry season. At such times, the wetland determination should be based on the preponderance of evidence that the site either is or is not wetland. If the site visit occurred during the dry season on a site that contains hydric soils and hydrophytic vegetation and no evidence of hydrologic manipulation (e.g., no dams, levees, water diversions, land grading, etc., and the site is not within the zone of influence of any ditches or subsurface drains), then consider the site to be a wetland. If necessary, revisit the site during the normal wet season and check again for the presence or absence of wetland hydrology indicators. If wetland hydrology indicators are absent during the wet season in a normal or wetter-than-normal rainfall year, the site is probably non-wetland.

b. *Periods with below normal rainfall*. Determine whether the amount of rainfall that occurred in the 2-3 months preceding the site visit was normal, above normal, or below normal based on the normal range reported in WETS tables. WETS tables are provided by the NRCS National Water and Climate Center (http://www.wcc.nrcs.usda.gov/climate/wetlands.html) and are calculated from long-term (30-year) weather records gathered at National Weather Service meteorological stations. To determine whether precipitation was normal prior to the site visit, actual rainfall in the current month and in the previous 2-3 months should be compared with the normal ranges for each month given in the WETS table (USDA Natural Resources Conservation Service 1997, Sprecher and Warne 2000). The lower and upper limits of the normal range are indicated by the columns labeled "30% chance will have less than" and "30% chance will have more than" in the WETS table. The USDA Natural Resources Conservation Service (1997, Section 650.1903) also provides a procedure to weight the information from each month and determine whether the entire period was normal, wet, or dry.

When precipitation has been below normal, wetlands may not flood, pond, or develop shallow water tables even during the typical wet season and may not exhibit other indicators of wetland hydrology. Therefore, if precipitation was below normal prior to the site visit, and the site contains hydric soils and hydrophytic vegetation and no evidence of hydrologic manipulation (e.g., no dams, levees, water diversions, land grading, etc., and the site is not within the zone of influence of any ditches or subsurface drains), it should be identified as a wetland. If necessary, the site can be revisited during a period of normal rainfall and checked again for hydrology indicators.

c. *Reference sites with known hydrology*. If indicators of hydric soil and hydrophytic vegetation are present on a site that lacks wetland hydrology indicators, the site may be considered to be a wetland if the landscape setting, topography, soils, and vegetation are substantially the same as those on nearby wetland reference areas whose hydrology is known. Hydrology of wetland reference areas should be documented through long-term monitoring (see item *f* below) or by application of the procedure described in item *5a* on page 104 (Direct Hydrologic Observations) of the procedure for Problematic Hydrophytic Vegetation in this chapter. Reference sites should be minimally disturbed and provide long-term access. Soils, vegetation, and hydrologic conditions should be thoroughly documented and the data kept on file in the District or field office.

d. *Hydrology tools*. The “Hydrology Tools for Wetland Determination” (USDA Natural Resources Conservation Service 1997) is a collection of methods that can be used to determine whether wetland hydrology is present on a potential wetland site that lacks indicators due to disturbance or other reasons, particularly on lands used for agriculture. Generally they require additional information, such as aerial photographs or stream-gauge data, or involve hydrologic modeling and approximation techniques. They should be used only when an indicator-based wetland hydrology determination is not possible or would give misleading results. A hydrologist may be needed to help select and carry out the proper analysis. The six hydrology tools applicable to the Caribbean Islands Region are:

1) Analyze stream and lake gauge data

2) Estimate runoff volumes to determine duration and frequency of ponding in depressional areas

3) Evaluate the frequency of wetness signatures on aerial photography (see item *e* below for additional information)

4) Model water-table fluctuations in fields with parallel drainage systems using the DRAINMOD model

5) Estimate the “scope and effect” of ditches or subsurface drain lines

6) Analyze data from groundwater monitoring wells (see item *f* below for additional information)

e. Evaluating multiple years of aerial photography. NRCS has developed an offsite procedure that uses aerial photography to make wetland hydrology determinations (USDA Natural Resources Conservation Service 1997, Section 650.1903). The method is intended for use on agricultural lands where human activity has altered or destroyed other wetland indicators. However, the same approach may be useful in other environments.

The procedure uses five or more years of photography and evaluates each photo for wetness signatures that are listed in “wetland mapping conventions” developed by NRCS state offices. Wetland mapping conventions can be found in the electronic Field Office Technical Guide (eFOTG) for each state or territory (http://www.nrcs.usda.gov/technical/efotg/). From the national web site, choose the Caribbean Area, then select the appropriate island or district. Wetland mapping conventions are listed among the references in Section I of the eFOTG.

Wetness signatures for a particular area may include surface water, saturated soils, flooded or drowned-out crops, stressed crops due to wetness, differences in vegetation patterns due to different planting dates, inclusion of wet areas into set-aside programs, unharvested crops, isolated areas that are not farmed with the rest of the field, patches of greener vegetation during dry periods, and other evidence of wet conditions (see Part 513.30 of the National Food Security Act Manual (USDA Natural Resources Conservation Service 1994)). For each photo, the procedure described in item *b* above is used to determine whether the amount of rainfall in the 2 to 3 months prior to the date of the photo was normal, below normal, or above normal. Only photos taken in normal rainfall years, or an equal number of wetter-than-normal and drier-than-normal years, are used in the analysis. If wetness signatures are observed on photos in more than half of the years included in the analysis, then wetland hydrology is present. Data forms that may be used to document the wetland hydrology determination are given in section 650.1903 of USDA Natural Resources Conservation Service (1997).

f. *Long-term hydrologic monitoring*. On sites where the hydrology has been manipulated by man (e.g., with ditches, subsurface drains, dams, levees, water diversions, land grading or bedding) or where natural events (e.g., downcutting of streams) have altered conditions such that hydrology indicators may be missing or misleading, direct monitoring of surface and groundwater may be needed to determine the presence or absence of wetland hydrology. The U. S. Army Corps of Engineers (2005) provides minimum standards for the design, construction, and installation of water-table monitoring wells, and for the collection and interpretation of groundwater monitoring data, in cases where direct hydrologic measurements are needed to determine whether wetlands are present on highly disturbed or problematic sites. This standard calls for 14 or more consecutive days of flooding, ponding, or a water table 12 in. (30 cm) or less below the soil surface during the growing season at a minimum frequency of 5 years in 10 (50 percent or higher probability), unless a different standard has been established for a particular geographic area or wetland type. A disturbed or problematic site that meets this standard has wetland hydrology. If the site in question is naturally hummocky or has been graded to enhance microtopography (e.g., abandoned sugar cane plantations), then topographic highs and lows should be evaluated separately. This standard is not intended (1) to overrule an indicator-based wetland determination on a site that is not disturbed or problematic, or (2) to test or validate existing or proposed wetland indicators.

Wetland/non-wetland mosaics

Description of the problem

In this supplement, "mosaic" refers to a landscape where wetland and non-wetland components are too closely associated to be easily delineated or mapped separately. These areas often have complex microtopography, with repeated small changes in elevation occurring over short distances. Tops of ridges and hummocks are often non-wetland but are interspersed with wetlands clearly displaying hydrophytic vegetation, hydric soils, and wetland hydrology. Examples of wetland/non-wetland mosaics in the Caribbean Islands Region include coastal dune/swale systems, abandoned coconut palm plantations, and abandoned sugar cane plantations that have reverted to wetlands.

Wetland components of a mosaic are often not difficult to identify. The problem for the wetland delineator is that microtopographic features are too small and intermingled, and there are too many such features per acre, to delineate and map them accurately. Instead, the following sampling approach can be used to estimate the percentage of wetland in the mosaic. From this, the number of acres of wetland on the site can be calculated, if needed.

Procedure

First, identify and flag all contiguous areas of either wetland or non-wetland on the site that are large enough to be delineated and mapped separately. The remaining area should be mapped as "wetland/non-wetland mosaic" and the approximate percentage of wetland within the area determined by the following procedure.

1. Establish one or more continuous line transects across the mosaic area, as needed. Measure the total length of each transect. A convenient method is to stretch a measuring tape along the transect and leave it in place while sampling. If the site is shaped appropriately and multiple transects are used, they should be arranged in parallel with one another starting from a random point along one edge of the site. However, other arrangements of transects may be needed for oddly shaped sites.
2. Use separate data forms for the swale or trough and for the ridges or hummocks. Sampling of vegetation, soil, and hydrology should follow the general procedures described in the Corps Manual and this supplement. Plot sizes and shapes for vegetation sampling must be adjusted to fit the microtopographic features on the site. Plots intended to sample the troughs should not overlap adjacent hummocks, and vice versa. Only one or two data forms are required for each microtopographic position, and do not need to be repeated for similar features or plant communities.
3. Identify every wetland boundary in every trough or swale encountered along each transect. Each boundary location may be marked with a pin flag or simply recorded as a distance along the stretched tape.
4. Determine the total distance along each transect that is occupied by wetlands and non-wetlands until the entire length of the line has been accounted for. Sum these distances across transects, if needed. Determine the percentage of wetland in the wetland/non-wetland mosaic by the following formula.

$$\%\ wetland = \frac{Total\ wetland\ distance\ along\ all\ transects}{Total\ length\ of\ all\ transects} \times 100$$

An alternative approach involves point-intercept sampling at fixed intervals along transects across the area designated as wetland/non-wetland mosaic. This method avoids the need to identify wetland boundaries in each swale, and can be carried out by pacing rather than stretching a measuring tape across the site. The investigator uses a compass or other means to follow the selected transect line. At a fixed number of paces (e.g., every two steps) the wetland status of that point is determined by observing indicators of hydrophytic vegetation, hydric soil, and wetland hydrology. Again, a completed data form is not required at every point but at least one representative swale and hummock should be documented with completed forms. After all transects have been sampled, the result is a number of wetland sampling points and a number of non-wetland points. Estimate the percentage of wetland in the wetland/non-wetland mosaic by the following formula:

$$\%\ wetland = \frac{Number\ of\ wetland\ points\ along\ all\ transects}{Total\ number\ of\ points\ sampled\ along\ all\ transects} \times 100$$

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Appendix A: Glossary

This glossary is intended to supplement those given in the Corps Manual and other available sources. See the following publications for terms not listed here:

- Corps Manual (Environmental Laboratory 1987) (http://el.erdc.usace.army.mil/wetlands/pdfs/wlman87.pdf).
- Field Indicators of Hydric Soils in the United States (USDA Natural Resources Conservation Service 2010) (http://soils.usda.gov/use/hydric/).
- National Soil Survey Handbook, Part 629 (USDA Natural Resources Conservation Service 2005) (ftp://ftp-fc.sc.egov.usda.gov/NSSC/Soil_Survey_Handbook/629_glossary.pdf).

Absolute cover. In vegetation sampling, the percentage of the ground surface that is covered by the aerial portions (leaves and stems) of a plant species when viewed from above. Due to overlapping plant canopies, the sum of absolute cover values for all species in a community or stratum may exceed 100 percent. In contrast, “relative cover” is the absolute cover of a species divided by the total coverage of all species in that stratum, expressed as a percent. Relative cover cannot be used to calculate the prevalence index.

Aquitard. A layer of soil or rock that retards the downward flow of water and is capable of perching water above it. For the purposes of this supplement, the term aquitard also includes the term aquiclude, which is a soil or rock layer that is incapable of transmitting significant quantities of water under ordinary hydraulic gradients.

Contrast. The color difference between a redox concentration and the dominant matrix color. Differences are classified as faint, distinct, or prominent and are defined in the glossary of USDA Natural Resources Conservation Service (2010) and illustrated in Table A1.

Table A1. Tabular key for contrast determinations using Munsell notation.

Hues are the same (Δ h = 0)			Hues differ by 2 pages (Δ h = 2)		
Δ Value	Δ Chroma	Contrast	Δ Value	Δ Chroma	Contrast
0	≤1	Faint	0	0	Faint
0	2	Distinct	0	1	Distinct
0	3	Distinct	0	≥2	Prominent
0	≥4	Prominent	1	≤1	Distinct
1	≤1	Faint	1	≥2	Prominent
1	2	Distinct	≥2	---	Prominent
1	3	Distinct			
1	≥4	Prominent			
≤2	≤1	Faint			
≤2	2	Distinct			
≤2	3	Distinct			
≤2	≥4	Prominent			
3	≤1	Distinct			
3	2	Distinct			
3	3	Distinct			
3	≥4	Prominent			
≥4	---	Prominent			
Hues differ by 1 page (Δ h = 1)			Hues differ by 3 or more pages (Δ h ≥ 3)		
Δ Value	Δ Chroma	Contrast	Δ Value	Δ Chroma	Contrast
0	≤1	Faint	Color contrast is prominent, except for low chroma and value.		Prominent
0	2	Distinct			
0	≥3	Prominent			
1	≤1	Faint			
1	2	Distinct			
1	≥3	Prominent			
2	≤1	Distinct			
2	2	Distinct			
2	≥3	Prominent			
≥3	---	Prominent			
Note: If both colors have values of ≤3 and chromas of ≤2, the color contrast is Faint (regardless of the difference in hue). Adapted from USDA Natural Resources Conservation Service (2002)					

Depleted matrix. The volume of a soil horizon or subhorizon from which iron has been removed or transformed by processes of reduction and translocation to create colors of low chroma and high value. A, E, and calcic horizons may have low chromas and high values and may therefore be mistaken for a depleted matrix. However, they are excluded from the concept of depleted matrix unless common or many, distinct or prominent redox concentrations are present as soft masses or pore linings. In some places the depleted matrix may change color upon exposure to air (reduced matrix); this phenomenon is included in the concept of depleted matrix. The following combinations of value and chroma identify a depleted matrix:

- A matrix value of 5 or more and chroma of 1, with or without redox concentrations occurring as soft masses and/or pore linings; or
- A matrix value of 6 or more and chroma of 2 or 1, with or without redox concentrations occurring as soft masses and/or pore linings; or
- A matrix value of 4 or 5 and chroma of 2, with 2 percent or more distinct or prominent redox concentrations occurring as soft masses and/or pore linings; or
- A matrix value of 4 and chroma of 1, with 2 percent or more distinct or prominent redox concentrations occurring as soft masses and/or pore linings (USDA Natural Resources Conservation Service 2010).

Common (2 to less than 20 percent) to many (20 percent or more) redox concentrations (USDA Natural Resources Conservation Service 2002) are required in soils with matrix colors of 4/1, 4/2, and 5/2 (Figure A1). Redox concentrations include iron and manganese masses and pore linings (Vepraskas 1992). See “contrast” in this glossary for the definitions of “distinct” and “prominent.”

Diapause. A period during which growth or development is suspended and physiological activity is diminished, as in certain aquatic invertebrates in response to the drying of temporary wetlands.

Distinct. See Contrast.

Episaturation. A Condition in which the soil is saturated with water at or near the surface, but also has one or more unsaturated layers below the saturated zone. The zone of saturation is perched on top of a relatively impermeable layer.

Figure A1. Illustration of values and chromas that require 2 percent or more distinct or prominent redox concentrations and those that do not, for hue 10YR to meet the definition of a depleted matrix. *Due to inaccurate color reproduction, do not use this page to determine soil colors in the field.* Background image from the Munsell Soil Color Charts reprinted courtesy of Munsell Color Services Lab, a part of X-Rite, Inc. (Gretag/Macbeth 2000).

Fragmental soil material. Soil material that consists of 90 percent or more rock fragments; less than 10 percent of the soil consists of particles 2 mm or smaller (USDA Natural Resources Conservation Service 2010).

Gleyed matrix. A gleyed matrix has one of the following combinations of hue, value, and chroma and the soil is not glauconitic (Figure A2):

- 10Y, 5GY, 10GY, 10G, 5BG, 10BG, 5B, 10B, or 5PB with a value of 4 or more and a chroma of 1; or
- 5G with a value of 4 or more and a chroma of 1 or 2; or
- N with a value of 4 or more (USDA Natural Resources Conservation Service 2010).

Growing season. The period of the year when plants and soils are biologically active, causing the depletion of oxygen and chemical reduction of nitrogen, iron, and other elements in soils that are saturated for more than a few days. In the Caribbean Islands Region, the growing season is year-round, or 365 days long.

High pH. A pH of 7.5 or higher; Includes Slightly Alkaline, Moderately Alkaline, Strongly Alkaline, and Very Strongly Alkaline (USDA Natural Resources Conservation Service 2002).

Nodules and concretions. Irregularly shaped, firm to extremely firm accumulations of iron and manganese oxides. When broken open, nodules have uniform internal structure whereas concretions have concentric layers (Vepraskas 1992).

Petrocalcic layer. A soil horizon in which calcium carbonate has accumulated to the extent that the layer is cemented or indurated.

Prominent. See Contrast.

Red Parent Material. Parent material with a natural inherent reddish color attributable to the presence of iron oxides occurring as coatings on and occluded within the mineral grains. Soils that formed in red parent material have conditions that greatly retard the development and extent of the redoximorphic features that normally occur under prolonged aquic conditions. Most commonly, the material consists of dark red, consolidated Mesozoic or Paleozoic sedimentary rocks, such as shale, siltstone, and sandstone, or alluvial materials derived from such rocks. Assistance from a local soil scientist may be needed to determine where red parent material occurs.

Reduced matrix. A Soil matrix that has a low chroma in situ due to the presence of reduced iron; however its color changes in hue or chroma when exposed to air as Fe^{2+} is oxidized to Fe^{3+} (Vepraskas 1992).

Saturation. For wetland delineation purposes, a soil layer is saturated if virtually all pores between soil particles are filled with water (National Research Council 1995, Vepraskas and Sprecher 1997). This definition includes part of the capillary fringe above the water table (i.e., the tension-saturated zone) in which soil water content is approximately equal to that below the water table (Freeze and Cherry 1979).

Figure A2. For hydric soil determinations, a gleyed matrix has the hues and chroma identified in this illustration with a value of 4 or more. *Due to inaccurate color reproduction, do not use this page to determine soil colors in the field.* Background image from the Munsell Soil Color Charts reprinted courtesy of Munsell Color Services Lab, a part of X-Rite, Inc. (Gretag/Macbeth 2000).

Appendix B: Point-Intercept Sampling Procedure for Determining Hydrophytic Vegetation

The following procedure for point-intercept sampling is an alternative to plot-based sampling methods to estimate the abundance of plant species in a community. The approach may be used with the approval of the appropriate Corps of Engineers district to evaluate vegetation as part of a wetland delineation. Advantages of point-intercept sampling include better quantification of plant species abundance and reduced bias compared with visual estimates of cover. The method is useful in communities with high species diversity, and in areas where vegetation is patchy or heterogeneous, making it difficult to identify representative locations for plot sampling. Disadvantages include the increased time required for sampling and the need for vegetation units large enough to permit the establishment of one or more transect lines within them. The approach also assumes that soil and hydrologic conditions are uniform across the area where transects are located. In particular, transects should not cross the wetland boundary. Point-intercept sampling is generally used with a transect-based prevalence index (see below) to determine whether vegetation is hydrophytic.

In point-intercept sampling, plant occurrence is determined at points located at fixed intervals along one or more transects established in random locations within the plant community or vegetation unit. If a transect is being used to sample the vegetation near a wetland boundary, the transect should be placed parallel to the boundary and should not cross either the wetland boundary or into other communities. Usually a measuring tape is laid on the ground and used for the transect line. Transect length depends upon the size and complexity of the plant community and may range from 100 to 300 ft (30 to 90 m) or more. Plant occurrence data are collected at fixed intervals along the line, for example every 2 ft (0.6 m). At each interval, a “hit” on a species is recorded if a vertical line at that point would intercept the stem or foliage of that species. Only one “hit” is recorded for a species at a point, even if the same species would be intercepted more than once at that point. Vertical intercepts can be determined using a long pin or rod protruding into and through the various vegetation layers, a sighting device (e.g., for the canopy), or an imaginary vertical line. The total number of "hits" for each species along the transect is then determined. The result is a list of species and their frequencies of occurrence along the line (Mueller-Dombois and Ellenberg 1974, Tiner 1999). Species are then categorized by wetland indicator status (i.e., OBL, FACW, FAC, FACU, or UPL); the total number of hits determined within each category; and the data used to calculate a transect-based prevalence index. The formula is similar to that given in Chapter 2 for the plot-based prevalence index (see Indicator 3), except that frequencies are used in place of cover estimates. The community is hydrophytic if the prevalence index is 3.0 or less. To be valid, more than 80 percent of "hits" on the transect must be of species that have been identified correctly and placed in an indicator category.

The transect-based prevalence index is calculated using the following formula:

$$PI = \frac{F_{OBL} + 2F_{FACW} + 3F_{FAC} + 4F_{FACU} + 5F_{UPL}}{F_{OBL} + F_{FACW} + F_{FAC} + F_{FACU} + F_{UPL}}$$

where:

PI = Prevalence index
F_{OBL} = Frequency of obligate (OBL) plant species;
F_{FACW} = Frequency of facultative wetland (FACW) plant species;
F_{FAC} = Frequency of facultative (FAC) plant species;
F_{FACU} = Frequency of facultative upland (FACU) plant species;
F_{UPL} = Frequency of upland (UPL) plant species.

Appendix C: Data Form

WETLAND DETERMINATION DATA FORM – Caribbean Islands Region

Project/Site: ______________ Municipality/Town: ______________ Sampling Date: ________

Applicant/Owner: ______________ PR or USVI: ________ Sampling Point: ________

Investigator(s): ______________ Ward/Estate: ______________

Landform (hillslope, terrace, etc.): ________ Local relief (concave, convex, none): ________ Slope (%): ______

Lat: ________ Long: ________ Datum: ________

Soil Map Unit Name: ______________ NWI classification: ________

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ______ No ______ (If no, explain in Remarks.)

Are Vegetation ______, Soil ______, or Hydrology ______ significantly disturbed? Are "Normal Circumstances" present? Yes ______ No ______

Are Vegetation ______, Soil ______, or Hydrology ______ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present? Yes ______ No ______ Hydric Soil Present? Yes ______ No ______ Wetland Hydrology Present? Yes ______ No ______	**Is the Sampled Area within a Wetland? Yes ______ No ______**
Remarks:	

VEGETATION – Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: ________)			
1.			
2.			
3.			
4.			
5.			
	______ = Total Cover		
Sapling/Shrub Stratum (Plot size: ________)			
1.			
2.			
3.			
4.			
5.			
	______ = Total Cover		
Herb Stratum (Plot size: ________)			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	______ = Total Cover		
Woody Vine Stratum (Plot size: ________)			
1.			
2.			
3.			
4.			
	______ = Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: ________ (A)

Total Number of Dominant Species Across All Strata: ________ (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: ________ (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	______	x 1 = ______
FACW species	______	x 2 = ______
FAC species	______	x 3 = ______
FACU species	______	x 4 = ______
UPL species	______	x 5 = ______
Column Totals:	______ (A)	______ (B)

Prevalence Index = B/A = ________

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ______ No ______

Remarks:

SOIL

Sampling Point: ___________

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Organic Bodies (A6)
___ 5 cm Mucky Mineral (A7)
___ Muck Presence (A8)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Dark Surface (S7)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ Stratified Layers (A5)
___ Red Parent Material (F21)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ______________________________

Depth (inches): ______________________

Hydric Soil Present? Yes ______ No ______

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Inundation Visible on Aerial Imagery (B7)
___ Water-Stained Leaves (B9)
___ Aquatic Fauna (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres on Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Thin Muck Surface (C7)
___ Fiddler Crab Burrows (C10)
___ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

___ Surface Soil Cracks (B6)
___ Sparsely Vegetated Concave Surface (B8)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes _____ No _____ Depth (inches): ____________
Water Table Present? Yes _____ No _____ Depth (inches): ____________
Saturation Present? (includes capillary fringe) Yes _____ No _____ Depth (inches): ____________

Wetland Hydrology Present? Yes ______ No ______

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

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14. ABSTRACT

This document is one of a series of Regional Supplements to the Corps of Engineers Wetland Delineation Manual, which provides technical guidance and procedures for identifying and delineating wetlands that may be subject to regulatory jurisdiction under Section 404 of the Clean Water Act or Section 10 of the Rivers and Harbors Act. The development of Regional Supplements is part of a nationwide effort to address regional wetland characteristics and improve the accuracy and efficiency of wetland-delineation procedures. This supplement is applicable to the Caribbean Islands Region, which consists of the Commonwealth of Puerto Rico and the Territory of the United States Virgin Islands.

15. SUBJECT TERMS

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