

# Recommendations for Sustainable Management of Cypress Forests in Coastal Areas of Louisiana

*Louisiana Society of American Foresters*

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## Preface

The Society of American Foresters (SAF), the national scientific and educational organization representing the forestry profession in the United States, supports sustainable forestry practices that will meet today's needs while providing for future generations. The SAF is the largest professional society for foresters in the world. Professional members are graduates of an SAF-accredited forestry curriculum or are scientists who hold a bachelor's or higher degree within the broad field of forestry.

This report is a compilation of existing knowledge and research on cypress forests assembled and authored by the Forested Wetlands Management Committee of the Louisiana Society of American Foresters (LASAF) from a variety of sources including scientific journals, books, reports, and other publications, and with input from scientists and professional foresters with extensive experience in cypress management. The members of the Forested Wetlands Management Committee are:

### LASAF Forested Wetlands Management Committee

Steven K. Templin (Chairman)	President	Templin Forestry, Inc.
Rick Jacob	Director of Conservation Forestry	The Nature Conservancy, Louisiana
Holly Morgan	Timber Sales Forester	USDA Forest Service, Kisatchie National Forest
Terry Haines	Research Forester	USDA Forest Service, Southern Research Station (retired)
James D. Haywood	Research Forester	USDA Forest Service, Southern Research Station (retired)
Dr. John Toliver	Supervisory Research Forester	USDA Forest Service (retired)
Dr. Terry Clason	Louisiana State Technical Forester	USDA Natural Resources Conservation Service (retired)
Jeff Peterson	Forestry Manager	Gray Estate-Stream Companies
Mickey Rachal	Vice President, Land & Timber	Roy O. Martin Lumber Company
Dr. James R. Meeker	Entomologist	USDA Forest Service, Forest Health Protection
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Michael Thomas	Silvicultural Specialist	Timber Investment Managers
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## Executive Summary

### 1. Introduction

Louisiana's cypress forests have long been of great biological, economic, and cultural importance to the state. Although reduced from their former extent, these forests still stand as one of the most iconic and enduring symbols of Louisiana's natural beauty and cultural heritage. Responsible stewardship of this unique and invaluable natural resource is a goal shared by many in Louisiana.

This report is the culmination of an effort by the Louisiana Society of American Foresters (LASAF) to build upon the findings of the Louisiana Governor's Coastal Wetland Forest Conservation and Use Science Working Group (SWG) by further summarizing the current state of knowledge on cypress ecology and management, and providing when possible science-based recommendations for sustainable cypress management practices in coastal areas of Louisiana. LASAF intends for the completed report to serve the following key purposes:

- 1) **Reference for practitioners** – We intend the report to be of practical benefit for foresters and other natural resource professionals responsible for on-the-ground management of cypress stands by providing a ready reference and current summary of cypress management topics.
- 2) **Tool for policy makers** – We encourage regulatory agencies to consider adopting the sustainability determination methodology and associated management recommendations provided herein, developed in furtherance of the SWG Report, as a blueprint for evaluating whether forest management activities proposed for a cypress site are subject to federal and state wetland permitting requirements (SWG 2005). This would allow protection of cypress forests on currently unsustainable sites, while providing a path forward for landowners

interested in conducting active management on sites where long-term sustainability can be expected.

- 3) **Catalyst for research** – Preparation of the report has helped highlight topics that would benefit from additional scientific research regarding cypress sustainability and management, and we support further investigation in these areas.
- 4) **Springboard for discussion** – We intend the report to serve as a basis for broader discussion among all stakeholders on sound science and policies to promote hydrologic restoration and other activities needed for long-term recovery and health of Louisiana’s magnificent cypress forests.

### 1.1. Report Origin and Development

In 2004, SWG was commissioned to provide an assessment of Louisiana’s coastal forests. The SWG Report, issued in 2005, concluded that Louisiana’s coastal forests are of tremendous economic, ecological, cultural, and recreational value but are threatened by extensive hydrologic alterations and forest conversion to other uses (SWG 2005). Regeneration is of particular concern in cypress forests, and SWG developed the following to describe regeneration condition classes (RCCs):

- 1) SWG Condition Class I: Sites with potential for natural regeneration
- 2) SWG Condition Class II: Sites with potential for artificial regeneration only
- 3) SWG Condition Class III: Sites with no potential for either natural or artificial regeneration

SWG recommended that these classes be used to categorize existing coastal forest site conditions for management, restoration, protection, and use purposes. SWG further recommended that before harvesting on Class I or II sites, a written management plan be reviewed by a state-approved entity to

ensure that cypress-tupelo regeneration and long-term establishment take place and that species or wetland type conversion does not occur.

In furtherance of the SWG recommendations, the LASAF in 2009 began an effort to develop additional guidance on evaluation, classification, and sustainable management of cypress sites in coastal areas of Louisiana. The LASAF established a committee of forestry professionals from varied backgrounds including conservation organizations, state and federal agencies, consultants, and researchers. This group, the Forested Wetlands Committee, was charged with drafting a set of guidelines for use by land managers in assessing whether specific forested wetland tracts can be sustainably managed and regenerated, and if so, what type of management is recommended.

The Committee began by compiling a list of over 40 cypress stakeholders representing a broad spectrum of potentially interested parties, including landowners, forestry and landowner trade associations, wood products manufacturers and retailers, government agencies, academic institutions, and environmental organizations. The Committee communicated with the stakeholders to notify them of the planned report and enlist their input throughout the process.

The Committee then began collecting the best available science on cypress silviculture, cypress swamp functionality, forested wetland harvesting techniques, and south Louisiana hydrologic changes. Additionally, the Committee visited several sites where harvesting has occurred, and interviewed foresters in Louisiana, Georgia, Florida, and Alabama with first-hand knowledge of forested wetland management.

An initial draft of the report was completed in August 2009. The report was then revised through several successive versions involving an iterative process of Committee input, literature review, and editing. In May 2012 the report was submitted for blind peer review administered by the Managing Editor of SAF Journals for the Society of American Foresters. The December 2014 draft was circulated to



cypress stakeholders for further input and comments, leading to the final version of the report, completed in August 2015.

## **1.2. Scope and Terminology of Report**

The geographic scope of this LASAF report is the 24 coastal parishes that encompass the majority of Louisiana cypress forests according to USDA Forest Service, Forest Inventory and Analysis (FIA) data. The term “cypress” is used in the report to refer collectively to bald cypress (*Taxodium distichum*) and pond cypress (*Taxodium ascendens*), and encompasses plant communities described as bald cypress and bald cypress-tupelo (*Nyssa spp.*) swamps, tupelo-blackgum (*Nyssa silvatica*) swamps, and pond cypress-blackgum swamps.

## **1.3. Overview of Louisiana’s Cypress Resources**

Timberland once covered approximately 3 million acres (1.2 million hectares) of the South Delta area of Louisiana, with at least 83% in the oak-cypress-tupelo forest type. Cypress and tupelo were cut heavily during the logging boom of 1890 to 1925, and harvesting peaked in 1914. In 1934 there were approximately 1.6 million acres (648,000 hectares) of cutover cypress forests in Louisiana. Many of these stands regenerated naturally, leading to a resurgence of cypress logging in the 1980’s and 1990’s. Subsequent concern in the early 2000’s about the sustainability of cypress forests eventually resulted in a market-based moratorium on cypress mulch produced in Louisiana. Trends regarding cypress acreage and stocking between 1991 and 2012 are inconclusive due to changes in FIA survey methods, but since 2005 cypress acreage and volume in Louisiana appear to have stabilized. Louisiana continues to produce some cypress sawtimber, but mulch production peaked in 2003 and is now largely limited to Florida, Georgia, and South Carolina.

#### 1.4. Hydrologic Changes in South Louisiana

Stewardship of Louisiana's remaining cypress forests and restoration of former cypress sites are complicated in modern-day coastal Louisiana by a combination of natural processes and man-made alterations occurring in the region. The SWG reported that the greatest loss of coastal forested wetlands is caused by man-made alterations to the landscape and the natural processes that have resulted from these alterations. Flood control levees along the Mississippi River and the Atchafalaya Floodway result in sediment being discharged into the Gulf rather than replenishing wetlands. An extensive system of dredged canals and flood-control structures, constructed to facilitate hydrocarbon exploration and production as well as commercial and recreational boat traffic, has enabled salt water from the Gulf of Mexico to intrude into brackish and freshwater wetlands. Forced drainage of the wetlands to accommodate development and agriculture also contribute to wetlands deterioration and loss. The resulting subsidence, altered hydrology, coastal erosion, and saltwater intrusion contribute to loss of coastal wetlands.

For example, changes in relative sea level rise, which incorporates both sea level rise and subsidence, along the Louisiana coast due to many factors is possibly averaging almost 1 centimeter per year at Grand Isle (9.24mm/year  $\pm$  .59mm/year) (0.39 inches/year [0.36 inches/year  $\pm$  0.02 inches/year]). Some rates recorded in the New Orleans area are currently greater than 9.24mm/year. These rates of relative sea level rise are 4.4 times greater than reported for Pensacola, Florida. Most projections have these rates increasing in the near future, with the amount of increase varying with different models. This may greatly influence future forestry management in lower elevation areas where sedimentation and accretion of organic matter/soils may not keep pace with subsidence and sea level rise.

## 2. Essential Knowledge for Land Managers

Restoration and management of cypress forests in Louisiana present unique silvicultural requirements and operational considerations often not encountered in working with other forest types. Thus **it is important that land managers responsible for cypress forests remain knowledgeable** about the best available science in order to implement sound management practices.

### 2.1. Cypress Silvics and Silviculture

Bald cypress and pond cypress are deciduous conifers that commonly grow on saturated and seasonally inundated soils in Louisiana. Tree associates of bald cypress include water tupelo, swamp tupelo, red maple, sweetbay, southern magnolia, sweetgum, and various oaks, ashes, and pines.

Cypress can be very long-lived. Virgin standing timber averaged four to six hundred years old while some older hollow trees may be close to twelve hundred years of age. On permanently flooded sites with little sediment deposition, changes in forest composition may not occur for hundreds of years without disturbance. High rates of sedimentation or drainage may foster a replacement of the cypress-tupelo forest with other bottomland forest types.

Cypress regenerates well in open or direct sunlight, growing at a rate nearly 1 ft (30 cm) in height in the first growing season and may grow an additional foot in the second year (Williston et al. 1980). Cypress is well suited for lands that are intermittently to permanently flooded with water up to several feet deep. Some seeds are produced every year and good seed crops occur at 3- to 5-year intervals. Floodwaters are the most important means of seed dissemination. A soil saturated, but not flooded, for a period of 1 to 3 months during the growing season after seedfall is best for germination and early growth. After germination, seedlings must grow fast enough to keep at least part of their crowns above

floodwaters for most of the growing season. Once newly germinated seedlings are 4 inches (10 cm) in height, they can survive complete submergence for 45 days. Bald cypress is one of the few conifer species that sprouts from cut stems. However, survival of these sprouts is often poor and those that live are usually poorly shaped and do not make quality sawtimber trees.

Site preparation is often unnecessary before planting cypress. To regenerate cypress, reliable harvesting methods for cypress include clearcuts, group selection, strip clearcuts, and seed trees. The shelterwood method is less effective for cypress because it is moderately shade intolerant and multiple entries into the stand are necessary for timber harvesting. After regeneration, control of competing vegetation and exotic invasive plants may be required, along with protection measures where nutria (*Myocastor coypus*) are present.

Cypress can grow rapidly under optimum conditions, at a diameter growth rate of a half-inch (13 mm) per year for cypress saplings. Cypress continues vertical growth until approximately two hundred years old and is noted for the large size it can attain and for its high merchantable yields. In virgin stands, yields of 8 to 14 thousand board feet (mbf) per acre (106 to 186 m<sup>3</sup>/ha) over large tracts were common, and some stands likely exceeded 100 mbf/acre (1,326 m<sup>3</sup>/ha). Some second-growth stands approach the yields of the best virgin stands.

Thinning in cypress stands appears to improve diameter and volume growth if a heavy thinning is applied. Thinning to 40% of maximum stand density index (SDI) has been found to increase diameter increment and net volume growth. Optimum thinning regimes for cypress have been developed in the form of stocking and yield tables, stocking percentage equations, and target SDI levels.

## 2.2. Determination of Productive Cypress Soils in Coastal Louisiana

Cypress is normally found in Louisiana on intermittently flooded and very poorly drained phases of Alfisols, Entisols, Histosols, Inceptisols, Mollisols, and Vertisols soil orders. To determine the suitability of specific soils for cypress management in Louisiana, cypress growth potential was evaluated by soil mapping unit within a study area comprising 24 Louisiana coastal parishes. The analysis categorized each soil mapping unit into one of the following cypress productivity classes:

- 1) Class A: Productive Cypress Soils – those soils that exhibit a potential for establishing and supporting the growth and development of naturally regenerated cypress stands;
- 2) Class B: Manageable Cypress Soils – those soils that exhibit a potential for establishing and supporting the growth and development of artificially regenerated cypress stands with intensive management; and
- 3) Class C: Low-productivity Cypress Soils – mucky soils which would require hydrological restoration to establish and support the growth and development of artificially regenerated cypress stands.

The productivity classifications can serve as a starting point or general guide as to which soils may be more or less suitable for cypress management, but **soil type alone does not determine the suitability of a site for cypress management**. Rather, it is a first step in evaluating the potential of a site to sustain cypress.

## 2.3. Operations in Forested Wetlands

Forest management activities in wetland areas involve unique legal requirements and present significant operational challenges. Prior to initiating management activities in forested wetlands, **the**

**land manager should become thoroughly familiar with all relevant federal and state statutes and regulations,** as well as any voluntary guidelines promulgated for these purposes.

Section 404 of the Clean Water Act (CWA) regulates the discharge of dredged or fill material into waters of the United States, including wetlands. Normal forestry operations in wetlands are exempt from permit requirements under Section 404(f), as long as the activity: 1) qualifies as “normal silviculture,” 2) is part of an “established” silvicultural operation, 3) does not convert a water of the United States to a different use, 4) follows the federal mandatory best management practices (BMPs) for road construction and site preparation, and 5) discharges no toxic pollutants into waters of the United States. Section 10 of the Rivers and Harbors Act of 1899 prohibits the unauthorized obstruction or alteration of any “navigable water of the United States” unless a permit has been issued by the U.S. Army Corps of Engineers (USACE). For purposes of cypress management, **the land manager should be aware that the USACE considers its jurisdiction under Section 10 to include marshes and forested wetlands that lie between the waterbody and the ordinary high water mark (OHWM).** Unlike the CWA, there is **no silvicultural exemption under Section 10** for regulated work within navigable waters of the United States. **The land manager should also be aware that forest management activities in the Louisiana Coastal Zone may require a coastal use permit** if USACE determines that a permit for the activity would be required under Section 404 of the CWA or Section 10 of the Rivers and Harbors Act. In addition to the above federal and state regulations, forest management operations should follow the voluntary BMPs for Louisiana.

Upon gaining a thorough understanding of applicable regulations, consideration should be given to the type of harvesting system to be employed at the site. The most common harvesting systems used in forested wetlands of Louisiana include skidder logging, shovel logging or mat logging, track-mounted equipment, forwarder systems, and helicopter logging; each harvesting system has its advantages and disadvantages in terms of cost, effectiveness as a harvesting system, and effects on water quality.



### 3. Sustainability Determination Methodology

A proposed methodology is outlined for land managers to determine the potential of a site to support sustainable cypress management in coastal areas of Louisiana. For the purposes of this report, **sustainability is defined as the capability of a site, with proper management, to support successive stands of cypress via natural or artificial regeneration.**

The sustainability determination methodology presented herein is designed for **immediate implementation** by meeting three readiness criteria. First, the methodology relies on **established field techniques** based on existing scientific knowledge; future research may streamline the methodology but is not necessary for immediate implementation. Second, it utilizes **off-the-shelf equipment and technology** readily available in the marketplace. Finally, the methodology is designed to be **implemented by a team of qualified natural resource professionals** contributing expertise routinely provided to landowners and land managers in Louisiana.

At the conclusion of the process, the land manager should have a well-documented analysis of the data collected and conclusions reached in classifying the site into one of several sustainability categories that are patterned after the SWG RCCs. Based on the sustainability determination, site-appropriate management recommendations are provided to support development of a comprehensive management plan for the site.

The key factors involved in determining the potential of a site to support sustainable cypress management include the soils present on the site, the hydrologic regime of the site, and the salinity of soil and water on the site. The general process is as follows:

- 1) Determine the potential of the **soils** on the site to produce sustainable cypress stands.
- 2) Evaluate the **vegetation** on the site as an indicator of hydrologic regime.

- 3) If vegetation analysis is inconclusive, conduct on-site **water level monitoring** to develop an understanding of hydrology at the site. Where available, employ river gage data analysis or documentation of hydrology by qualified natural resource professionals familiar with the site to reduce or eliminate the actual monitoring needed.
- 4) Assess the **salinity** levels of soil and water at the site.
- 5) Evaluate all of the above information to classify the site into one of several **sustainability categories**.

Detailed methodologies are provided to assist with completion of each step in the above process.

**The land manager should take into account the totality of evidence** obtained from soils, vegetation indicators, on-site hydrologic monitoring, and salinity to classify the sustainability of the site into one of the following categories, to the best of his or her professional judgment:

- 1) Category RCC-1: sustainable by natural regeneration. This category is characterized by favorable inundation cycles, an available cypress seed source, and acceptable water depth during growing season to allow natural seedling survival.
- 2) Category RCC-2a: sustainable only by artificial regeneration due to shallow prolonged flooding. This category is characterized by extended flooding, acceptable planting conditions, and acceptable depth during the growing season to allow planted seedling survival.
- 3) Category RCC-2b: sustainable only by artificial regeneration due to brief infrequent flooding. This category is characterized by infrequent flooding (allowing greater competition from less flood-tolerant hardwood species) but acceptable cypress planting conditions.
- 4) Category RCC-3a: not sustainable due to deep prolonged flooding. This category is characterized by extended flooding and excessive depth during the growing season, preventing natural or planted seedling survival.

- 5) Category RCC-3b: not sustainable due to excessive salinity. This category is characterized by frequent flooding combined with high salinity levels.

To aid in this classification, detailed tables are provided summarizing the typical characteristics of each cypress sustainability category.

#### **4. Management Recommendations**

At the conclusion of the sustainability determination process described above, the land manager should have a well-documented analysis of the data collected and conclusions reached in classifying the site into one of several sustainability categories that are patterned after the SWG's RCCs. Based on the sustainability determination, site-appropriate management recommendations are herein provided to support development of a comprehensive management plan for the site.

##### **4.1. Recommendations by Sustainability Category**

Based on the sustainability determination outlined above, the overall management recommendations for each sustainability category are as follows:

- 1) Category RCC-1: sustainable by natural regeneration
  - The site may be sustainably managed for cypress using natural regeneration
  - Stump sprouts may provide a supplemental regeneration source, but is not recommended as the main method of natural regeneration
  - Harvesting in established stands should be designed to encourage natural regeneration
  - Artificial regeneration may also be used to supplement natural regeneration if planting is operationally feasible

- 2) Category RCC-2a: sustainable only by artificial regeneration due to shallow prolonged flooding
  - Artificial regeneration must be used if the site is to be sustainably managed for cypress
  - Once established, cypress would tend to persist as a primary component of the stand
  - Normal silvicultural management of existing stands can be conducted if artificial regeneration is planned following harvest. Long-term establishment must be monitored and secured or conversion to marsh or open water will occur.
- 3) Category RCC-2b: sustainable only by artificial regeneration due to brief infrequent flooding
  - The hydrology of the site favors less flood-tolerant species
  - Without intensive management, harvest of existing cypress would tend to reduce the cypress component of the site over time due to competition from other vegetation
  - Artificial regeneration must be used if the site is to be sustainably managed for cypress
- 4) Category RCC-3a: not sustainable due to deep prolonged flooding
  - The hydrology of the site prohibits both natural and artificial regeneration
  - Established cypress would tend to persist as a primary component of the stand
  - Harvest of existing cypress would not be sustainable without restoration to reestablish favorable hydrologic conditions.
- 5) Category RCC-3b: not sustainable due to excessive salinity
  - The high salinity levels on the site prohibit both natural and artificial regeneration
  - Established cypress may need to be harvested if capture of anticipated mortality is desired

- Harvest of existing cypress would not be sustainable without restoration to ameliorate the effects of salinity on the site.

#### **4.2. Regeneration**

The body of the report provides detailed suggestions for achieving successful regeneration on appropriate sites. Below are additional factors to consider when planning for cypress regeneration:

- 1) Management plan should evaluate regeneration options prior to harvest.
- 2) On sites suitable for management that can be reliably regenerated, schedule ground-based harvesting in late fall or early winter. This is typically the driest time of the year which will minimize soil disturbance. Clearcutting with reliance on stump sprouting is not a recommended method for sustainable cypress management.
- 3) For artificial regeneration, completely harvest standing stems of all species to allow maximum sunlight for the regenerating stand (by group selection, strip clearcuts or typical clearcuts).
- 4) Direct seeding is not recommended for artificial regeneration of cypress. Nursery-grown seedlings may be bare-root or containerized. Bare-root seedlings should be at least 12 inches (30 cm) in height with a root collar diameter of at least one-quarter inch (6 mm).
- 5) Cypress seedlings are usually hand-planted. Densities of 436 to 680 trees per acre (1,077 to 1,680 trees/ha) are common for wood products objectives, but lower densities may be suitable for wildlife or ecological purposes.
- 6) Regeneration success should be evaluated at years 1, 3, and 5 after harvest to ensure sufficient regeneration. For wood products objectives, LASAF recommends having a minimum of 300 to 400 stems per acre (740 to 990 stems/ha) of well-established 3 to 5 ft tall (0.9 to 1.5 m) cypress and tupelo somewhat uniformly distributed across the site. For wildlife or ecological purposes,

or where timber management is not the primary use, 80 to 100 stems per acre (198 to 247 stems/ha) should be sufficient to establish a minimal cypress stand.

- 7) In all regeneration harvests, retain large, hollow cypress trees as den trees for the Louisiana black bear (*Ursus americanus luteolus*) as well as cavity trees of other species for black bear and other wildlife.

#### 4.3. Intermediate Stand Management

Once the stand is established according to the regeneration guidelines described above, subsequent management of the stand will be dictated in large part by the landowner's objectives for the property. For purposes of illustration, the body of the report provides example guidelines for two management regimes – intensive stand management emphasizing timber production and limited stand management emphasizing ecological objectives. Though there can be considerable overlap between the two regimes, with timber production providing significant ecological benefits and vice versa, the regimes are intended to highlight key differences in silvicultural practices as well as tradeoffs that may need to be considered. Thus, the contrasting examples are meant to encompass the spectrum of cypress management scenarios likely to be encountered in practice. **Actual management plans for a specific site should be guided by applicable regulations, landowner objectives, consultation with natural resource managers, sustainability considerations, and numerous other factors as described throughout this report.**

#### 4.4. Guidelines for Operations in Forested Wetlands

Regardless of the management objectives or harvesting system used, reduction of soil disturbance is a major consideration when operating in forested wetlands. To the greatest extent possible, ground-based forestry operations in wetlands should be limited to dry conditions, and forestry operations in



wetlands which are continually saturated or inundated should be limited to low-water conditions and sites that can and will be regenerated. When excessively wet harvesting conditions are unavoidable, low ground pressure equipment such as dual-tire skidders, tracked machines or special techniques such as “mat-logging” or “shovel-logging” should be employed where practical and economically feasible. Detailed operational guidelines are provided, derived from a compilation of applicable provisions adapted from the Louisiana, Mississippi, and Florida state forestry BMP manuals.

## **5. Conclusions and Research Needs**

A substantial amount is known about the ecology and management of cypress, but the species has not been studied in nearly as much detail as other commercially valuable southern U.S. trees. In addition, the native habitat of the species (i.e., frequently flooded wetland areas) creates operational challenges for routine management activities. Stewardship of cypress forests in Louisiana would be facilitated by additional research related to soil productivity, effectiveness of regeneration methods, growth and yield, harvest regimes for various management objectives, improvement of techniques for silvicultural equipment access and operation, and influence of forest management activities on other ecological attributes.

The sustainability determination methodology presented herein is designed for immediate implementation by relying on existing scientific knowledge, currently available equipment and technology, and expertise readily available from qualified natural resource professionals. A drawback of this approach is that completion of the sustainability determination on a site may require a substantial investment of time, particularly if extended water level monitoring is required. The process could be greatly facilitated by research into rapid assessment techniques including testing of field evaluation

criteria, refinement of vegetation and salinity indicators and sampling methods, and remote sensing and spatial analysis of hydrology at tract-level scales.

The cypress management recommendations and wetland operational guidelines developed for this report are based on the best available science consistent with applicable regulatory requirements. As knowledge improves and regulations change over time, management plans should incorporate these new developments. The best approach is to practice adaptive management, creating a circular process that includes plan development, implementation, monitoring, and feedback into revised plans. In this way, continual improvement in stewardship of our treasured cypress resources in Louisiana can be assured for future generations to come.

In summary, cypress has played an important role in the ecology, economy, and culture of Louisiana, but these forests are much reduced from their former extent. In light of the exacting regeneration requirements of the species, and given the many challenges posed by altered hydrology in coastal Louisiana, restoration and stewardship of our cypress forests will require a sustained, collective effort among a broad community of stakeholders if long-term success is to be achieved.

## 1 Introduction

Louisiana's cypress forests have long been of great biological, economic, and cultural importance to the state. Although reduced from their former extent, these forests still stand as one of the most iconic and enduring symbols of Louisiana's natural beauty and cultural heritage. Responsible stewardship of this unique and invaluable natural resource is a goal shared by many in Louisiana.

This report is the culmination of an effort by the Louisiana Society of American Foresters (LASAF) to build upon the findings of the Louisiana Governor's Coastal Wetland Forest Conservation and Use Science Working Group (SWG) by further summarizing the current state of knowledge on cypress ecology and management, and providing science-based recommendations for sustainable cypress management practices in coastal areas of Louisiana. The report is organized into five main sections:

Section 1, Introduction, describes the backdrop for this effort, including the impetus for the report, the report development process, the general scope and terminology used throughout the report, an overview of Louisiana's cypress resource, and a discussion of hydrologic changes in coastal Louisiana.

Section 2, Essential Knowledge for Land Managers, summarizes the background information needed for effective stewardship of cypress forests and provides source documentation for the recommendations presented later in the report. Topics include cypress silvics and silviculture, cypress soils, and regulatory and operational considerations when conducting management in forested wetlands.

Section 3, Sustainability Determination Methodology, outlines a proposed methodology for land managers to determine the potential of a site to support sustainable cypress management in coastal areas of Louisiana. The section is organized as a step-by-step process for evaluation of relevant field criteria including soils, vegetation, hydrology, and salinity, leading to a classification of the regeneration potential of the site.

Section 4, Management Recommendations, identifies site-appropriate management recommendations to support development of a comprehensive stewardship plan for the site. Topics include recommendations based on site sustainability, techniques for successful regeneration, intermediate stand management, and guidelines for operations in forested wetlands.

Section 5, Conclusions and Research Needs, is a brief summary in which closing thoughts and suggestions for future research are provided. **All five sections should be studied in their entirety** and given equal consideration in making informed and responsible decisions regarding stewardship of cypress forests in Louisiana.

## 1.1 Origin, Development, and Purpose of Report

This subsection describes the origin, development, and intended purposes of the report. With the work of the SWG serving as the foundation and catalyst, LASAF initiated an in-depth process of data collection, peer review, and stakeholder input, eventually leading to a report intended to accomplish several key purposes as described herein.

### 1.1.1 Science Working Group Report

In 2004, SWG was commissioned to provide a current assessment of Louisiana's coastal forests. The mission of SWG was to provide information and guidelines for the long-term utilization, conservation, and protection of Louisiana's coastal wetland forest ecosystem, from both environmental and economic perspectives. After extensive study, the findings and recommendations were published in a report entitled *Conservation, Protection, and Utilization of Louisiana's Coastal Wetland Forests* (SWG 2005) which will be referred to as the SWG Report herein.

The SWG Report included seven overall findings, the first five of which are reproduced below, in part:

- 1) Louisiana's coastal wetland forests are of tremendous economic, ecological, cultural, and recreational value to residents of Louisiana and the people of the United States and the world.
- 2) The functions and ecosystem services of Louisiana's coastal wetland forests are threatened by both large- and small-scale hydrologic and geomorphic alterations and by conversion of these forests to other uses.
- 3) Regeneration is a critical process of specific concern in maintaining coastal wetland forest resources. Currently, there is a lack of regeneration in coastal cypress-tupelo forests that is a direct result of factors identified above and their interactions with regeneration processes.
- 4) In those areas where flooding prevents or limits the natural regeneration of the cypress-tupelo forest, artificial regeneration through tree planting is the only currently viable mechanism to regenerate the forest. Some swamps are altered to such a significant extent that even artificial regeneration is not possible. Stump sprouting does not provide sufficient numbers of viable trees to reliably regenerate the forest, even under optimum conditions.
- 5) Conditions affecting the potential for forest regeneration and establishment are recognizable based upon existing biological and physical factors. SWG has developed a set of condition classes for the dominant wetland forest type in Louisiana's coastal cypress-tupelo forests. The SWG Cypress-Tupelo Coastal Wetland Forest regeneration condition classes (RCCs) are:

- a) SWG Condition Class I: Sites with potential for natural regeneration

These sites are generally connected to a source of fresh surface or ground water and are flooded or ponded periodically on an annual basis (pulsing). They must have seasonal flooding and dry cycles (regular flushing with freshwater), usually have both sediment and nutrient inputs, and sites in the best condition are not subsiding. These sites have some

level of positive tree growth, thereby providing increasing or stable biomass production, organic input, and experience re-charge of water table after drought periods. Sites in this category that are subject to increasing flood frequency, increased flood duration, or increasing flood water depths may eventually move into the next lower category unless action is taken to remedy these detrimental conditions.

b) SWG Condition Class II: Sites with potential for artificial regeneration only

These sites may have overstory trees with full crowns and few signs of canopy deterioration, but are either permanently flooded (which prevents seed germination and seedling establishment in the case of bald cypress and tupelo) or are flooded deeply enough that when natural regeneration does occur during low water, seedlings cannot grow tall enough between flood events for at least 50% of their crown to remain above the high water level during the growing season. These conditions require artificial regeneration, (i.e., planting of tree seedlings). Water depth for sites in this category is restricted to a maximum of 2 ft (61 cm) for practical reasons related to planting of tree seedlings. Planted seedlings should have at least 12 inches (30 cm) of crown (length of main stem with branches and foliage present) and must be tall enough for at least 50% of the crown to remain above the high water level during the growing season. Sites with a negative trajectory (increasing average annual water depth) may eventually move into SWG Condition Class III unless action is taken to remedy this detrimental condition.

c) SWG Condition Class III: Sites with no potential for either natural or artificial regeneration

These sites are either flooded for periods long enough to prevent natural regeneration and practical artificial regeneration, or are subject to saltwater intrusion with salinity levels that are toxic to cypress-tupelo forests. Two trajectories are possible for these two conditions:

1) freshwater forests transitioning to either floating marsh or open fresh water, or 2)



forested areas with saltwater intrusion that are transitioning to open brackish or saltwater (marsh may be an intermediate condition).

Based on these Findings, the SWG Report provided fourteen overall recommendations to the Louisiana Governor's Office. Recommendations 2 and 5, relevant to this LASAF Report, are listed below:

- 2) Recognize the RCCs (Finding 5) for cypress-tupelo forests contained in the SWG Report and use them to classify existing coastal forest site conditions for management, restoration, protection, and use purposes.
- 5) Before harvesting SWG Condition Class I and II sites, a written forest management plan with specific plans for regeneration must be reviewed by a state-approved entity so appropriate practices can be suggested based on local site conditions. The intent is to ensure that cypress-tupelo regeneration and long-term establishment take place and that species or wetland type conversion does not occur.

### **1.1.2 LASAF Report Development Process**

In furtherance of the above SWG recommendations, the LASAF in 2009 began an effort to develop additional guidance on evaluation, classification, and sustainable management of cypress sites in coastal areas of Louisiana. The LASAF established a committee of forestry professionals from varied backgrounds including conservation organizations, state and federal agencies, consultants, and researchers. This group, the Forested Wetlands Committee, was charged with drafting a set of guidelines for use by land managers in assessing whether specific forested wetland tracts can be sustainably managed and regenerated, and if so, what type of management is recommended.

The Committee began by compiling a list of over 40 cypress stakeholders representing a broad spectrum of potentially interested parties, including landowners, forestry and landowner trade

associations, wood products manufacturers and retailers, government agencies, academic institutions, and environmental organizations. The Committee communicated with the stakeholders to notify them of the planned report and enlist their input throughout the process. Several stakeholders provided valuable suggestions that helped guide the direction of the report in its early stages.

The Committee then began collecting the best available science on cypress silviculture, cypress swamp functionality, forested wetland harvesting techniques, and south Louisiana hydrologic changes. Additionally, the Committee visited several sites where harvesting has occurred, and interviewed foresters in Louisiana, Georgia, Florida, and Alabama with first-hand knowledge of forested wetland management.

An initial draft of the report was completed in August 2009. The report was then revised through several successive versions involving an iterative process of Committee input, literature review, and editing. In May 2012 the report was submitted for blind peer review administered by the Managing Editor of SAF Journals for the Society of American Foresters. Five experts provided valuable reviews and comments, which were then incorporated into several subsequent rounds of draft revisions. The December 2014 draft was approved by the LASAF Executive Committee as suitable for circulation to cypress stakeholders for further input and comments. Several stakeholders responded with helpful written comments which were incorporated into the final version of the report, completed in August 2015.

### **1.1.3 Intended Purposes of LASAF Report**

LASAF intends for the completed report to serve the following key purposes:

- 1) **Reference for practitioners:** We intend the report to be of practical benefit for foresters and other natural resource professionals responsible for on-the-ground management of cypress stands by providing a ready reference and current summary of cypress management topics.
- 2) **Tool for policy makers:** We encourage regulatory agencies to consider adopting the sustainability determination methodology and associated management recommendations provided herein, developed in furtherance of the SWG Report, as a blueprint for evaluating whether forest management activities proposed for a cypress site are subject to federal and state wetland permitting requirements. This would allow protection of cypress forests on currently unsustainable sites, while providing a path forward for landowners interested in conducting active management on sites where long-term sustainability can be demonstrated.
- 3) **Catalyst for research:** Preparation of the report has helped highlight topics that would benefit from additional scientific research regarding cypress sustainability and management, and we support further investigation in these areas.
- 4) **Springboard for discussion:** We intend the report to serve as a basis for broader discussion among all stakeholders on sound science and policies to promote hydrologic restoration and other activities needed for long-term recovery and health of Louisiana's magnificent cypress forests.

## 1.2 Scope and Terminology of Report

The geographic scope of this LASAF report is the 24 coastal parishes that encompass the majority of Louisiana cypress forests as identified by USDA Forest Service, Forest Inventory and Analysis (FIA) data (Figure 1-1). Although cypress does occur in limited settings in other areas of the state, the focus of this report will be on the 24 identified parishes due to 1) the extensive cypress forests still remaining in this

region and 2) the pervasive hydrologic alterations that have created unique challenges for cypress management in coastal Louisiana. Despite the emphasis on coastal issues, most if not all of the background and guidelines contained in this report should be applicable with limited modification to cypress stands elsewhere in the state.

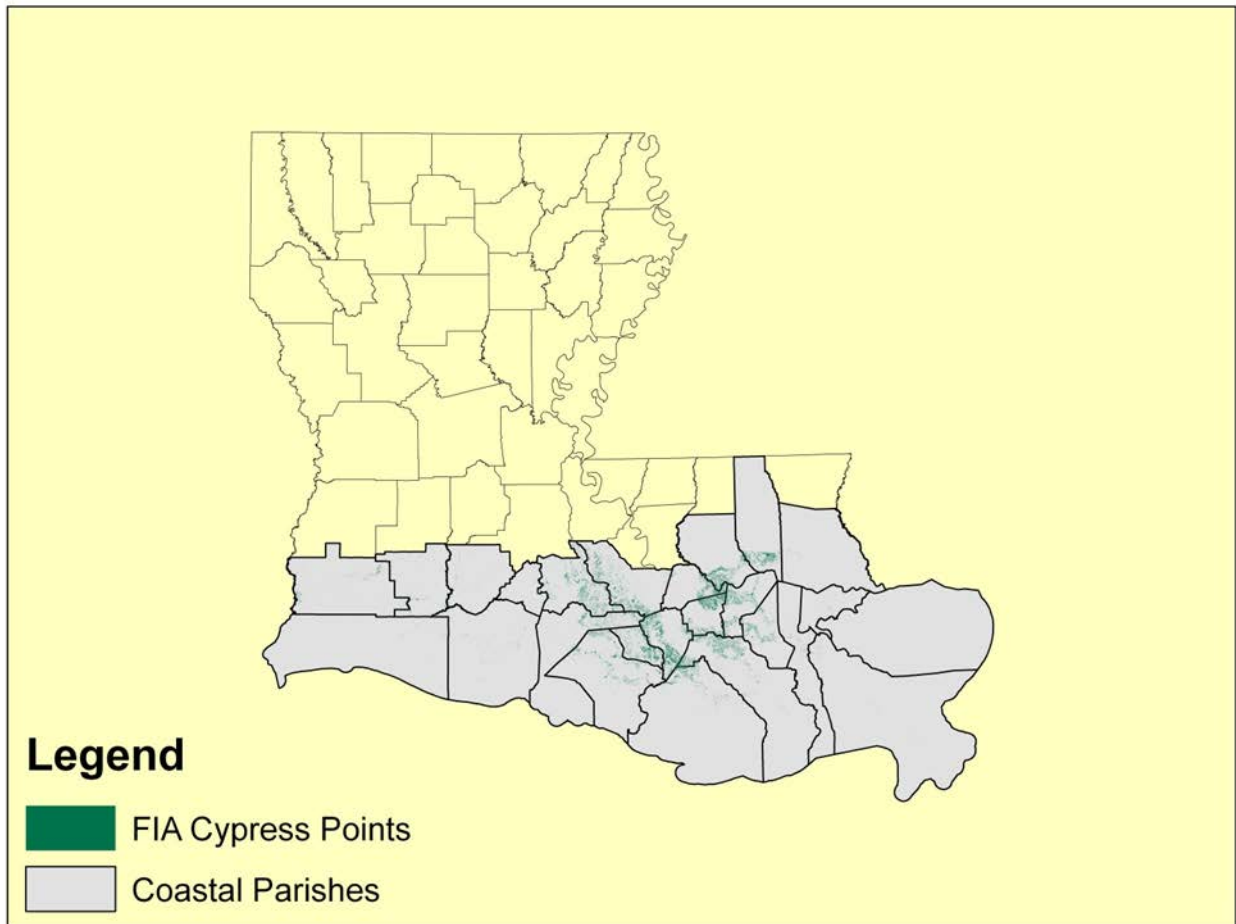
Information presented in this report is intended to apply primarily to the following plant communities as described in *The Natural Communities of Louisiana* (Louisiana Department of Wildlife and Fisheries 2009).

- 1) **Bald cypress-Tupelo Swamp:** forested, alluvial swamps growing on intermittently exposed soils. The soils are inundated or saturated by surface water or ground water on a nearly permanent basis throughout the growing season except during periods of extreme drought. Bayous commonly intersect these wetlands. There is relatively low floristic diversity. *Taxodium distichum* (bald cypress) and *Nyssa aquatica* (water tupelo) are codominants.
- 2) **Bald cypress Swamp:** forested, alluvial swamps growing on intermittently exposed soils. The soils are inundated or saturated by surface water or groundwater on a nearly permanent basis throughout the growing season except during periods of extreme drought. Bayous commonly intersect these wetlands. There is relatively low floristic diversity. Bald cypress is the dominant overstory species.
- 3) **Tupelo-Blackgum Swamp:** forested alluvial swamps growing on intermittently exposed soils. The soils are inundated or saturated by surface water or groundwater on a nearly permanent basis throughout the growing season except during periods of extreme drought. Often occurs at topographically higher positions than Bald cypress-Tupelo Swamp or Bald cypress Swamp. Overstory primarily composed of one or more species of *Nyssa spp.* (tupelos).
- 4) **Pond cypress-Blackgum Swamp:** This swamp type is found in the Florida Parishes of Louisiana along the north shores of Lakes Maurepas and Pontchartrain in depression and flatwoods or

other areas where surface water is persistent. The dominant tree species are *Taxodium ascendens* (pond cypress), *Nyssa biflora* (swamp tupelo), and *Acer rubrum* var. *drummondii* (swamp red maple).

This report refers to bald cypress and pond cypress collectively as “cypress.” However, referenced material may or may not make this distinction. Historically, pond cypress has generally been considered a variety of bald cypress, (*Taxodium distichum* var. *nutans*). The Forested Wetlands Committee has chosen the more current separate species distinction as designated by the USDA Natural Resource Conservation Service in the National Plants Database, which can be accessed on the internet (URL: <http://plants.usda.gov/java/>).

A key audience for this report is the foresters, biologists, hydrologists, and other qualified natural resource professionals who would be responsible for implementation of the guidelines and recommendations contained herein. For simplicity, the person(s) responsible for on-the-ground planning and implementation will be referred to as the “land manager.” In practice, the “land manager” will often comprise a team of experts as needed who, along with the landowner, will carry out ongoing stewardship activities in cypress forests.



**Figure 1-1.** LASAF area of interest – 24 coastal parishes encompassing the majority of Louisiana cypress forests as identified by USDA Forest Service, Forest Inventory and Analysis data.



### 1.3 Overview of Louisiana's Cypress Resources

Timberland once covered approximately 3 million acres (1.2 million hectares) of the South Delta area of Louisiana, with at least 83% in the oak-cypress-tupelo forest type (Rosson 1995). Harvesting in these wet swamps was seasonal in nature until the invention of the pullboat in 1889. Pullboats and the expansion of the railroad system (Sternitzke 1972), combined with a massive national campaign by cypress dealers, resulted in a logging boom during the period 1890 to 1925 (Messina and Conner 1998). Cypress and tupelo were cut heavily during this period, and harvesting peaked in 1914 (Conner and Toliver 1990). Victor Sonderegger, Louisiana State Forester, estimated that bald cypress-tupelo forests in the state would be depleted by 1940; by 1924 the estimate was revised to predict depletion by 1935 (SWG 2005). In 1934 there were approximately 1.6 million acres (648,000 hectares) of cutover cypress forests in Louisiana (Conner and Toliver 1990). Today, Greis et al. (2012) estimated the total area of bald cypress-tupelo timberland in the state is estimated to be about 893,000 acres (361,400 ha). Florida and Louisiana contain more than one-half of the South's cypress resource (Brown 2008).

Because inventory methods have varied, it is difficult to obtain accurate estimates of changes in cypress stocking and acreage over time. FIA historically collected cypress acreage information based on the oak-gum-cypress forest type category. Use of this category always overestimates actual cypress forest acreage because it includes acres of all bottomland hardwood stands, tupelo stands, cypress stands, and various other mixtures (Brown 2008). FIA developed a cypress-tupelo forest type definition, but it included pure tupelo stands along with pure cypress and any mixed stands. The cypress-tupelo forest type essentially includes all stands where cypress or tupelo equal 25 % or more of the stocking (U.S. Forest Service 2007). The new cypress-tupelo forest type came into use in the early 2000's.

However, it is evident that the total acreage of bald cypress-tupelo forests in Louisiana has declined in the past century, predominantly due to conversion to other uses such as agriculture, urban areas, and rights-of-way. Losses peaked in the 1970's, and subsequent FIA data indicated a small increase in

acreage (Figure 1-2) but with an increase in growing stock (Figure 1-3). Inventory estimates show cypress growing stock increased from 530 million ft<sup>3</sup> (15 million m<sup>3</sup>) in 1954 to 1.45 billion ft<sup>3</sup> (41 million m<sup>3</sup>) in 1984. The increase in volume represents second-growth trees that developed following the large scale logging activity at the beginning of the 20th century. Overall, the net annual growth was greater than removals for that period (Conner and Toliver 1990).

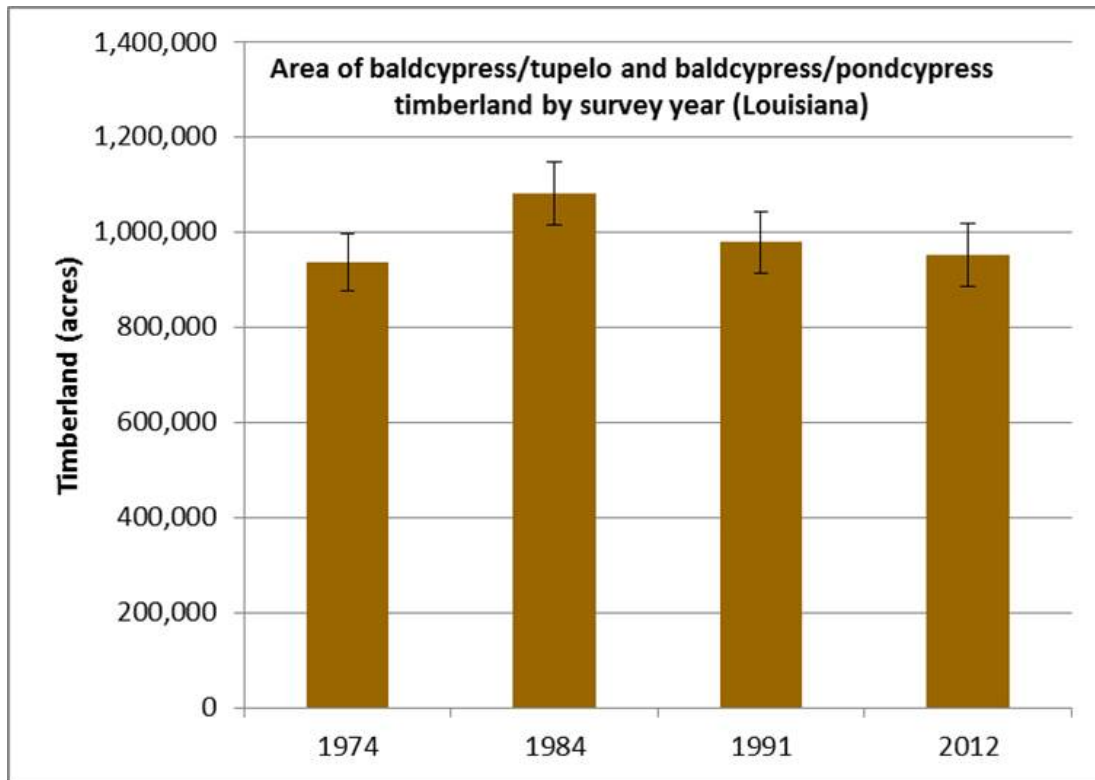
Most of these stands regenerated naturally after the timber extraction period in the early 20th century and received little subsequent attention. By the 1980's, the trees in these stands had grown large enough to be suitable for harvest, and consumer interest in cypress grew because of the perception that it is naturally rot resistant. These factors, combined with new techniques of logging and utilization, led to renewed lumbering of cypress in the 1980's and increased interest in long-term management of cypress forests in the southern United States (Marois and Ewel 1983). With reasonable levels of management, cypress could once again become a significant source of wood products (Williston et al. 1980).

In south Louisiana, however, extensive changes to hydrological systems had disrupted the natural course of wetland forest growth and development in many areas (SWG 2005). In addition, the use of cypress for mulch increased substantially during the 1990's, creating concerns about the sustainability of cypress forests in the southern United States. The wood industry, federal, state, and local governments, academia, environmental and conservation organizations, and retailers became involved in the issue, culminating in decisions by large retailers to cease selling cypress mulch that was produced in Louisiana (Brown 2008).

FIA data for the oak-gum-cypress forest type in Louisiana showed a small increase in acreage from 1974 to 1984 (Figure 1-2). Acreage decreased from 1984 to 1991 by approximately 8-9%, with virtually no change in 2012. Thus for the survey period average changes were negligible (Greis and Brown 2008). However, these apparent trends are complicated by the fact that significant changes in FIA inventory

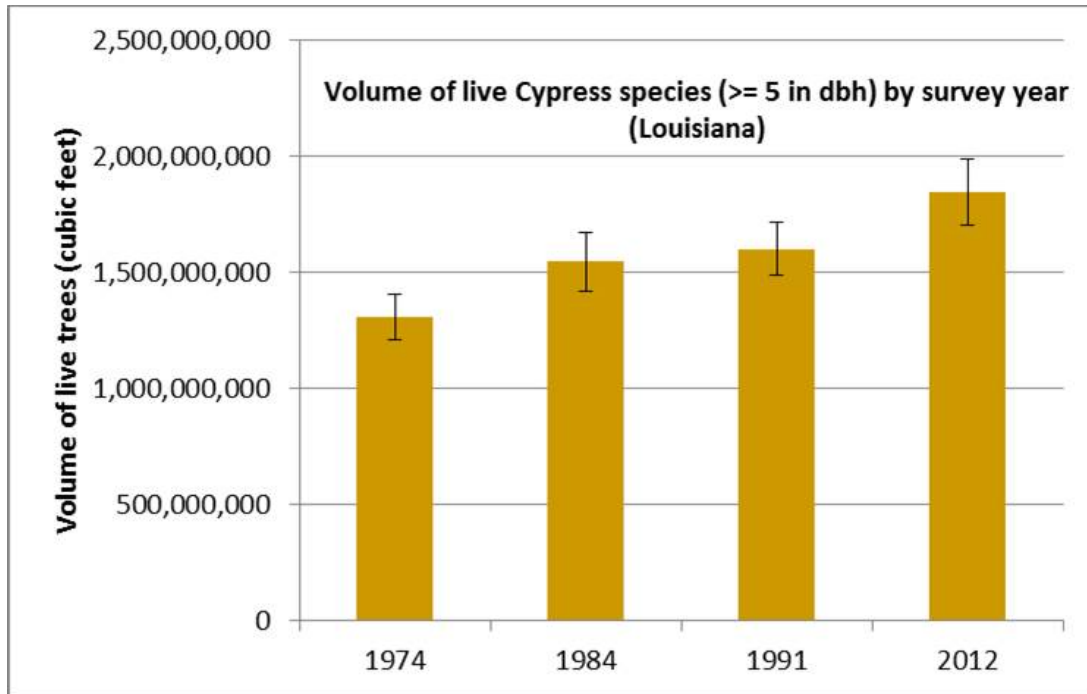
methods were made between the 1991 and 2012 inventories; plot designs changed from variable plots to fixed plots, and cypress-tupelo was categorized separately from the previously used oak-gum-cypress forest type. Until new area trend information compares variable plots to fixed plots while using the same forest-type algorithms, accurate comparisons regarding possible changes in the area of the resource over time cannot be made.

Although cypress acreage in Louisiana appears to have stabilized since 1991 (Figure 1-2), the volume of live trees is trending upward (Figure 1-3). Data reflecting the products for which cypress has been harvested indicates substantial use of cypress in most southern states for sawtimber, but mulch production is largely limited to Florida, Georgia, and South Carolina (Figure 1-4). Louisiana saw log production was less than one million cubic feet (28.3 thousand cubic meters). Sawtimber production in southern states remained relatively steady through 2009, but use of cypress for mulch production has declined since its peak in 2003 (Greis et al. 2012).



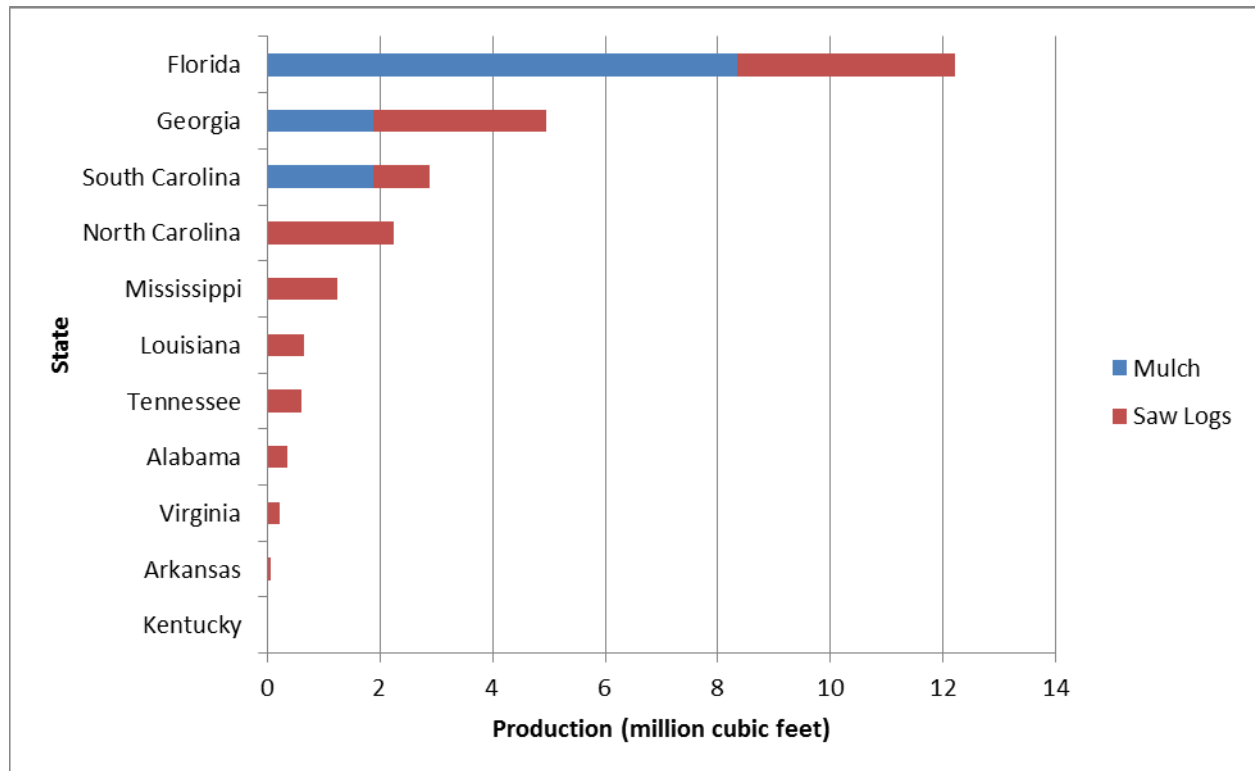
**Figure 1-2.** Louisiana bald cypress-tupelo timberland acres, 1974 – 2012.

Source: USDA Forest Service, Southern Research Station Forest Inventory & Analysis.



**Figure 1-3.** Louisiana bald cypress volume, 1974 – 2012.

Source: USDA Forest Service, Southern Research Station Forest Inventory & Analysis



**Figure 1-4.** Cypress production by state and product in the South, 2009 (adapted from Greis et al. 2012).

## 1.4 Hydrologic Changes in South Louisiana

Stewardship of Louisiana's remaining cypress forests and restoration of former cypress sites are complicated in modern-day coastal Louisiana by a combination of natural processes and man-made alterations occurring in the region. The seasonal flooding that previously provided sediments critical to the healthy growth of wetlands in the Mississippi River delta plain has been largely eliminated by construction of levees that channel the river for nearly 1,240 miles (2,000 kilometers); sediment carried by the river is now discharged far from the coast, depriving wetlands of vital sediment. In addition, throughout the wetlands, an extensive system of dredged canals and flood-control structures, constructed to facilitate hydrocarbon exploration and production as well as commercial and recreational boat traffic, has enabled salt water from the Gulf of Mexico to intrude into brackish and freshwater wetlands. Forced drainage of the wetlands to accommodate development and agriculture also contribute to wetlands deterioration and loss (U.S. Geological Survey Coastal and Marine Geology Program 2013).

Changes in relative sea level rise, which incorporates both sea level rise and land subsidence, along the Louisiana coast is possibly averaging almost 1 centimeter per year at Grand Isle (9.24mm/year  $\pm$  .59mm/year) (0.39 inches/year [0.36 inches/year  $\pm$  0.02 inches/year]). Some rates recorded in the New Orleans area are currently greater than 9.24mm/year. These rates of relative sea level rise are 4.4 times greater than reported for Pensacola, Florida. Most projections have these rates increasing in the near future, with the amount of increase varying with different models. This may greatly influence future forestry management in lower elevation areas where sedimentation and accretion of organic matter/soils may not keep pace with subsidence and sea level rise.

SWG reported that the greatest loss of coastal forested wetlands is caused by man-made alterations to the landscape and the natural processes that have resulted from these alterations (SWG 2005). Although all of Louisiana's swamps are threatened by land loss and encroaching interests, the swamps

of the lower Mississippi River Alluvial Plain in south central and southeastern Louisiana face additional degradation from subsidence, altered hydrology, coastal erosion, and saltwater intrusion – forces that promote rapid loss and prevent adequate regeneration of these swamps (Louisiana Department of Wildlife and Fisheries 2005).

The Mississippi River Delta, Atchafalaya Basin, and coastal zone of Louisiana have experienced widespread changes to natural hydrological and delta-building processes with significant detrimental effects in some regions. However, in some areas the effects from these alterations, such as increased subsidence, salt water intrusion, and intensified flood events have been offset by man-made levee breaches and sediment diversions; tree growth and developments improved in response to these activities (Visser et al. 1999, Louisiana Coastal Wetlands Conservation and Restoration Task Force 1998, Lane et al. 1999).

Hydrologic disruptions along major river systems and throughout the coast have altered flow patterns to such a degree that the alterations have changed the distribution and accumulation of sediment, which in turn has contributed to subsidence and land loss in coastal Louisiana. Flood-control levees along the Mississippi are believed to be the principle cause for the elimination of riverine inputs to most of the delta of the State (Turner and Boyer 1997).

Control of the Mississippi River began in earnest after the Great Flood of 1927, and the river was leveed for its entire length in Louisiana. All distributaries except Atchafalaya River have been closed; spillways, cut into the levees to release floodwater, guide the overflow between guide levees to the Gulf. Thus no floodwater can reach the adjoining swamps and sloughs.

Improved flood control, drainage, and technology increased acreage suitable for agriculture. These activities, combined with a spike in soybean prices, resulted in unprecedented land-clearing activities across the Mississippi Alluvial Valley (MAV) in the 1960's and 1970's. By the time Congress passed the Farm Bill legislation in the late 1980's which introduced "swampbuster" provisions to slow wetland



conversions, the forested landscape of the MAV had been reduced to a highly fragmented 20% of its former extent (LMVJV Forest Resource Conservation Working Group 2007).

On a more local level, alterations to hydrological patterns such as highways, railroads, spoil levees from dredged canals and river diversions, and flood control structures within a given watershed have all contributed to the reduction in freshwater and sediment input, allowing subsidence to exceed sedimentation in many areas of the state (Keim et al. 2006). Land loss is accelerated by access canals to the sites of oil and gas wells. After the canals are dredged, their width increases as they erode from the inside. There are over 10,000 miles (16,090 km) of canals in Louisiana (Cowdry 1977).

There are four distinct basins affected by hydrological disruptions in Louisiana: Pontchartrain, Barataria, Lake Verret, and Atchafalaya River. Each is experiencing different problems as a result of flood-control structures. The Pontchartrain basin no longer receives any overflow from the Mississippi River and is experiencing subsidence and salt water intrusion from the Gulf of Mexico backflow. The bed of the Mississippi River in South Louisiana is so elevated relative to sea level that a flow of at least 120,000 ft<sup>3</sup>/second (3,400 m<sup>3</sup>/second) is needed to hold back salt water (McPhee 1989). The first place water naturally escapes the Mississippi River is Bayou Baptiste Collette, 60 miles (97 km) below New Orleans. Sediment that would have been deposited into adjoining swamplands instead moves into the Gulf at the rate of 356,000 tons/day (323,000 tonnes/day) (Keim et al. 2006). The Barataria basin is fairly healthy, but is not receiving the overflow of sediment and nutrients from the Mississippi River as it once did and is succumbing to subsidence. Lake Verret is no longer receiving periodic overflow from Atchafalaya River, and is experiencing subsidence. Instead, the Atchafalaya levee ends at Morgan City, and the water comes around the end and back into the Lake Verret basin, creating permanent flooding (Keim et al. 2006).

#### 1.4.1 Hydrologic Changes in the Atchafalaya Basin

Atchafalaya River, the largest tributary of the Mississippi River, was originally a tributary of the Red River beginning at its mouth near the point where the Red River entered the Mississippi. The Atchafalaya was formed when an enlarging loop of the Mississippi, later called Turnbull's Bend, broke into the basin of the Red River and water was forced down a marshy valley between the Teche and Lafourche ridges. At first the small stream was blocked by drift timber, keeping it from becoming a larger river. However, humans intervened by continually removing the raft, allowing the waters of the Mississippi to enlarge it from north to south. The Mississippi River would soon find a much nearer path to the Gulf down the Atchafalaya, if not for the intervention of humans (Cowdry 1977).

In 1963, the Atchafalaya Basin was leveed on both sides, reducing the area from 2.4 million acres (1 million hectares) to approximately 600,000 acres (243,000 hectares). The result is increased water depth in the remaining forested wetlands inside the Basin, and no flushing of forested wetlands outside the levees (McPhee 1989). The guide levees have concrete floodwalls along the tops, which retain not only water but also silt. Gradually, the swamp elevations within the leveed area are building up. The Atchafalaya, unlike most watersheds, has a finite and uniquely defined structure as a result of hydrologic manipulation which makes overflow or exchange of water and sediment outside of the watershed all but impossible, except at the south end.

The unique definition of this watershed was created by the hydrologic structures to the north at Old River, where water and sediment enter the system in a controlled fashion as mandated by Congress. The guide levees to the east and west that were erected for flood control prevent the lateral distribution of sediments and water. As a result, sediment accumulates at the lower end of the Basin, above Morgan City, which is gradually forming a barrier to flow out of the Basin to the Gulf, much like the lip of a bowl. This watershed suffers from flooding by impounded water, as well as subsidence and obstructions to water flow created by spoil banks, oilfield canals, and flow lines.

#### **1.4.2 Effects on Forested Wetlands and Wildlife**

The forested wetlands of coastal Louisiana rely on regular flooding from the major waterways for replenishment of nutrients and sediment and for flushing of stagnant water and debris. Historically, spring overbank floods have maintained a supply of fluvial sediments to the intertributary marshes, adding nutrients, and contributing structurally to their stability. Progressive channelization of the Mississippi River over the past century for flood control purposes has prematurely terminated the fluvial phase of the basin's development (Hatton 1981).

Cypress is particularly dependent on the seasonal rise and fall of the water level, as the floating fruit disperses with the moving water to dry land where it germinates. Since the early 1950s, the water in many of the cypress-tupelo swamps has become ponded and flooded. The second-growth forests were able to adapt to this persistent flooding, but new germination is not possible in these permanently flooded areas. Only those forests not impounded have been able to continue the normal life cycle of the cypress-tupelo swamp.

One of the most notable consequences of altered hydrology in some regions of the State is the prolonged flooding of forested wetlands during the growing season. Field studies have usually found continuous or excessive flooding associated with reduced aboveground production in bottomland forests (Conner and Day 1976) and cypress swamps (Brown 1981, Conner et al. 1981). Natural and human-made impoundments have been linked to decreased growth (Mitsch et al. 1979, Megonigal et al. 1997) and increased mortality (Harms et al. 1980) in mature cypress swamps (Megonigal and Day 1992).

A major concern to forest resource and wildlife managers is the effect of changes in the cypress forest ecosystem on wildlife habitat. As part of its mission, The Louisiana Department of Wildlife and Fisheries (2005) identifies the potential threat posed by specific human influences on the cypress forest habitat resource (Table 1-1). Habitat threats are categorized as originating from such sources as channelization of waterways and streams, creation of reservoirs and operation of dams, construction of

drainage and diversion systems, clearing for development and maintenance of land-based infrastructure, incompatible forestry and agriculture practices, and introduction of invasive plant and animal species. Collectively, these influences contribute to loss of habitat and prevent adequate regeneration of these swamps. Direct consequences are identified as a variety of threats including habitat composition, fragmentation, and destruction, with additional consequences related to hydrologic alterations and sedimentation.

**Table 1-1.** Major threats to cypress habitat and their sources (Louisiana Department of Wildlife and Fisheries 2005).

Source of Threat	Threat					
	Altered Composition/ Structure	Habitat Destruction or Conversion	Habitat Disturbance	Habitat Fragmentation	Modification of Water Levels/ Natural Flow Patterns	Sedimentation
Channelization of Rivers or Streams					XXX	XXX
Construction of Ditches, Drainage, or Diversion Systems	XXX				XXX	XXX
Development/ Maintenance of Pipelines, Roads or Utilities		XXX	XXX	XXX	XXX	XXX
Incompatible Forestry Practices	XXX					XXX
Invasive/ exotic Species	XXX					
Operation of Dams/ Reservoirs	XXX				XXX	XXX

## 2 Essential Knowledge for Land Managers

Restoration and management of cypress forests in Louisiana present unique silvicultural requirements and operational considerations often not encountered in working with other forest types. **It is important that land managers responsible for cypress forests remain knowledgeable** about the best available science in order to implement sound management practices. This section is thus intended to serve two purposes: 1) provide the most crucial background information a land manager would need for effective stewardship of cypress forests, along with numerous references for further reading and 2) provide much of the source documentation underpinning the sustainability determination methodology and management recommendations presented in later sections. Topics in this Essential Knowledge section include cypress silvics and silviculture, productive cypress soils, and regulatory and operational factors to consider when conducting management in forested wetlands.

### 2.1 Cypress Silvics and Silviculture

The SAF defines silvics as “the study of the life history and general characteristics of forest trees and stands, with particular reference to environmental factors, as a basis for the practice of silviculture” (Helms 1998). The following information is intended to cover the key aspects of silvics and silviculture for cypress, but is by no means exhaustive. **Land managers are encouraged to consult additional references** for further details as needed.

#### 2.1.1 Silvics

Bald cypress and pond cypress are deciduous conifers that commonly grow on saturated and seasonally inundated soils in Louisiana. Bald cypress extends along the entire lower Gulf Coast Plain to

southeastern Texas, inland along the many rivers and streams of the middle and upper coastal plains, and northward throughout the entire state. Pond cypress grows in shallow ponds and wet areas in southeastern coastal Louisiana. Although there are differences in appearance between the two species, not all specimens are typical, and it is often difficult and sometimes impossible to distinguish between the two (Wilhite and Toliver 1990).

Bald cypress grows along streams that deposit or remove soil to the extent that the soil surface, and consequently the depth to the water table, can fluctuate several feet during the life of a stand. Therefore, its understory and even arboreal associates can vary from species tolerant of prolonged flooding to species requiring somewhat well-drained conditions. Pond cypress occupies the shallow ponds and poorly drained areas of the Coastal Plain and rarely grows in the river and stream swamps as does bald cypress (Wilhite and Toliver 1990).

Tree associates of bald cypress include water tupelo, swamp tupelo, red maple (*Acer rubrum*), sweetbay (*Magnolia virginiana*), southern magnolia (*M. grandifolia*), sweetgum (*Liquidambar styraciflua*), various oaks (*Quercus spp.*), ashes (*Fraxinus spp.*), and pines (*Pinus spp.*). Lesser vegetation associates include common buttonbush (*Cephalanthus occidentalis*), poison-ivy (*Toxicodendron radicans*), muscadine grape (*Vitis rotundifolia*), Spanish moss (*Tillandsia usneoides*), cattail (*Typha latifolia*), lizardtail (*Saururus cernuus*), various hollies (*Ilex spp.*), viburnums (*Viburnum spp.*), lyonias (*Lyonia spp.*), sedges, grasses, and ferns (Wilhite and Toliver 1990).

Cypress swamps contain a variety of combinations and densities of bald cypress, blackgum (*Nyssa sylvatica*), water tupelo, and associated hardwood species. Red maple, persimmon (*Diospyros virginiana*), green ash (*Fraxinus pennsylvanica*), hophornbeam (*Ostrya virginiana*), and Nuttall, overcup, willow, and water oak (*Quercus spp.*) are occasional associates. Shrubs may include but are not limited to buttonbush, eastern swampprivet (*Forestiera acuminata*), planertree (*Planera aquatica*), and Virginia sweet spire (*Itea virginica*). A suite of herbs are also present, and their abundance is greatly influenced

by shade. Whitegrass (*Leersia virginica*), American water-willow (*Justicia americana*), cypress swamp sedge (*Carex jorii*), and opposite-leaf spotflower (*Acmella oppositifolia*) are persistent in shady swamps (Mississippi Department of Wildlife, Fisheries, and Parks 2005).

Cypress is reputed to be slow-growing and very long-lived. However, studies have postulated that cypress trees are not as old as previously considered because assumptions of cypress age were based on an incorrect method of tree ring analysis for determining age. False rings caused by tree metabolism slowing during flooded site conditions leaves rings that are not true annual rings. Estimates for virgin cypress tree ages were exaggerated by as much as one and a half times the true age (Brown and Montz 1986, Hurst 2005). Virgin standing timber during the era of industrial harvest have now been more accurately dated as averaging four to six hundred years old (Hurst 2005) while some older hollow trees commonly referred to as snags may be approximately close to twelve hundred years of age (Wilhite and Toliver 1990; Hurst 2005). Because of its long life span, cypress is now being used extensively for dendochronological analysis of hydrological and climatic history (Keim and Amos 2012).

### **2.1.2 Successional Patterns**

On permanently flooded sites with little sediment deposition, forest succession tends to be stalled, and changes in composition may not occur for hundreds of years without disturbance. Cypress-tupelo forests may be 200-300 years old before canopy trees begin to die (Hodges 1997).

In some poorly drained areas, deposition of fine textured material on the floodplain eventually creates better drained conditions, where Eastern cottonwood (*Populus deltoides*) and black willow (*Salix nigra*) grow as pioneer species on recent alluvium. Black willow dominates on fine-textured, low lying soils subject to more frequent overflow. (Johnson and Shropshire 1983).



Further compositional changes depend on the degree of sedimentation. Low sedimentation rates usually result in an association of eastern swampprivet, planertree, and buttonbush which may eventually be replaced by bald cypress. High rates of sedimentation (or drainage) may foster a replacement of the cypress-tupelo forest with other bottomland forest types such as the water hickory-overcup oak association (Messina and Conner 1998).

### **2.1.3 Reproduction and Early Growth**

Cypress regenerates well in open or direct sunlight, growing at a rate of up to 1 ft (30 cm) in height in the first season and may grow an additional foot in the second season (Williston et al. 1980). The most critical site factor for cypress is hydrology: how often, for how long, and to what depth does water cover the site. Provided the seedlings can become established, cypress trees are well suited for lands that are intermittently to permanently flooded with water up to several feet deep (Vince and Duryea 2004).

**Flowering and Fruiting:** Bald cypress is monoecious. Male and female strobili mature in one growing season from buds formed the previous year. Number of seeds per cone averages 16 and ranges from 2 to 34. Cleaned seeds can number from about 2,540 to 8,360/lb (Wilhite and Toliver 1990).

**Seed Production and Dissemination:** Some seeds are produced every year and good seed crops occur at 3- to 5-year intervals. At maturity, cone scales with their resin-coated seeds adhering to them, or sometimes entire cones, drop to the water or ground. Drop of mature seeds is often hastened by squirrels, which eat bald cypress seeds and often drop several scales with undamaged seeds still attached. Floodwaters spread the scales or cones along streams and to backwater and overbank areas. Floodwaters are the most important means of seed dissemination (Wilhite and Toliver 1990).

Seed dispersal for both bald cypress and water tupelo is influenced by the hydrologic environment, and both species' seeds are capable of remaining buoyant for 2-3 months. Seed bank and trapping studies indicate that fewer seeds end up in open areas than are initially dropped there. Most dispersed water-transported seeds are concentrated near logs, knees, tree bases, and other emergent substrates (Schneider and Sharitz 1988).

**Seedling Development:** Germination is epigeal, with the initial leaf pushed above the ground. Under swamp conditions, germination generally takes place on exposed sphagnum moss or a wet-muck seedbed. Seeds will not germinate under water, but some will remain viable for 30 months under water. On the other hand, seeds usually fail to germinate on better drained soils because of the lack of surface water. Thus a soil saturated, but not flooded, for a period of 1 to 3 months during the growing season after seedfall is best for germination and early growth (Wilhite and Toliver 1990).

After germination, seedlings must grow fast enough to keep at least part of their crowns above floodwaters for most of the growing season. Seedlings in swamps often reach heights of 8 to 30 inches (20 to 76 cm) their first year. However, seedlings established on floating mats of vegetative debris must establish root systems in mineral soil for sustained growth. Mineral soil establishment is often rare in the true swamps or deep water areas. Bald cypress seedlings and trees are moderately shade intolerant. Seedlings require overhead light (50-80%) for good growth. Once newly germinated seedlings are 4 inches (10 cm) or greater in height, they can survive complete submergence for 45 days, but prolonged submergence after this will result in rapid mortality with complete mortality within 57 days. Another study found that survival fell rapidly after 25 to 35 days. Death occurs much quicker in water with suspended sediment. As light levels decrease, mortality is more variable and generally much greater. One-year-old growing seedlings can withstand flooding for 100-150 days with 25-40% mortality (Souther and Shaffer 2000). Bull (1949) found that only 67% of one-year-old seedlings survived 20 days

of submergence, 55% survived 20 to 29 days, and 31% survived 30 to 45 days. Dormant seedlings are much more tolerant of flooding.

**Vegetative Reproduction:** Bald cypress is one of the few conifer species that sprouts from cut stems. Thrifty sprouts are generally produced from stumps of young, small diameter trees, but trees up to 60 years old also send up healthy sprouts if the trees are cut during the fall or winter. However, survival of these sprouts is often poor (Conner et al. 1986, Ewel 1996), and those that live are usually poorly shaped and do not make quality sawtimber trees (Wilhite and Toliver 1990, Keim et al. 2006). Stumps of trees up to 200 years old may produce sprouts, but the sprouts are not as vigorous and are more subject to wind damage as the stump decays (Mattoon 1915).

Timbers harvested from sprouts are poorly developed and of much lower quality than timber cut from stems born of sexual reproduction (Wilhite and Toliver 1990). However, pond cypress sprouts can begin producing seed as soon as three years which contributes additional seedlings for regeneration (Vince and Duryea 2004). Planting by means of cuttings, the use of small limbs planted in hopes of stem development, are more productive when the donor tree is less than five years old (Wilhite and Toliver 1990).

#### **2.1.4 Regeneration**

Site preparation is often unnecessary before planting cypress. On harvested sites, seedlings should be planted as soon as possible after logging. Mechanical site preparation by chopping, disking, or shearing should be done only on dry sites when needed to remove dense shrubs no more than two months prior to planting. On some sites, prescribed fire may be a useful alternative method for removing unwanted vegetation (Vince and Duryea 2004).

#### **2.1.4.1 *Harvesting to Regenerate Cypress***

To regenerate cypress, the following harvesting methods may be used in cypress stands in keeping with the landowner's objectives and the site conditions. However, **the land manager should be aware that relatively little research has been conducted** to verify the reliability of these methods.

**Clearcut:** The clearcut method is intended to create open conditions by removing the entire stand in one cutting (Helms 1998). Reproduction is achieved through a number of processes following the harvest operation and can be natural or artificial. In natural systems, dormant or transported seed germinates. Cypress seed is naturally transported long distances by water, and this method of transport is more important as water levels rise. In south Louisiana however, such long distance transport is substantially reduced or has often been eliminated by the presence of levees or other barriers to water movement. Local recruitment probably predominates when water levels are low (Schneider and Sharitz 1988). Regeneration from stump sprouts or root suckers will minimally contribute to regeneration success. Although there are varying opinions on the ability of these sprouts to make a significant contribution to the next stand established, it has been shown that sprouts of pond cypress can produce seed within 2-3 years which could then contribute to regeneration success (Vince and Duryea 2004). Given favorable soils and hydrology, clearcut areas may also be artificially regenerated through planting seedlings. Direct seeding is an option although not recommended for the artificial regeneration of cypress.

**Group Selection:** This is a variation of the clearcut method, where the size of the openings is limited to 10 acres (4 hectares) or less. Regeneration is achieved by seed germination from dormant seed, seed floating or blowing in from adjacent stands, or less reliably from stump sprouts. Artificial regeneration is also appropriate if it is not cost prohibitive.

**Seed Tree:** All merchantable timber is clearcut in this method except for a few widely dispersed individuals (typically 6-10 trees per acre (15-25 trees/ha)) of the desired species left uniformly spaced to

reseed the area (Helms 1998). Once the new stand is established, the seed trees may be harvested in a second cutting. Because the seed of cypress can be distributed by water movement, the seed trees can be left along the edge of the cutting area where they can be easily harvested when the area is regenerated (Williston et al. 1980). However, another entry into the stand has to be made which can be expensive and difficult to execute in wetlands.

**Strip clearcuts:** This method is a variation of the seed tree method where mature trees of the desired species are left in strips rather than uniformly spaced across the site. Strip clearcuts work best in conditions where seed of the desired species are dispersed by wind, high water and eventually from older stump sprouts. Thus this method would appear to be suitable for cypress but has not been thoroughly studied. Because remaining merchantable trees are in strips, another entry into the stand to harvest them may be more economically viable than for a seed tree cut.

**Shelterwood:** This method calls for cutting of most trees, leaving those needed to produce sufficient shade to produce a new age class in a moderated microenvironment. The sequence of treatments can include three types of cuttings: (a) in mostly unmanaged stands, an optional preparatory cut to enhance conditions for seed production, (b) an establishment cut to prepare the seed bed and to create a new age class, and (c) a removal cut to release established regeneration from competition with the overwood (Helms 1998). Though little research has been conducted, the shelterwood system is not considered a preferred method for regenerating cypress stands due to its moderate shade intolerance and the need to make multiple entries into the stand to harvest trees.

#### ***2.1.4.2 Factors Affecting Regeneration Success***

**Vegetation Competition:** On sites where significant competition can occur, post-planting vegetation control is often recommended for planted cypress (Williston et al. 1980). Vegetative competition can be

managed by chemical herbicides, hand cutting, or mowing. If water control structures are available, controlled flooding can be used. However, the benefits of vegetation control are not certain on all wetland sites and may be outweighed by the costs (Vince and Duryea 2004). In one study, growth of cypress seedlings was enhanced when vines that overtopped and entangled them were cut back (Myers et al. 1995). In several others, control of herbaceous vegetation (mainly cattails and grasses) did not result in increased survival or growth of planted cypress (e.g., Rushton 1988).

**Exotic Invasives:** Because cypress is moderately shade intolerant, competition from fast growing non-native tree species can have a detrimental effect on the success of regeneration. In south Louisiana, Chinese tallow (*Triadica sebifera*) can be a major competitor. It is a prolific seeder, seeds are successfully spread by moving water, have very rapid early growth, and seedlings can adapt to a wide variety of sites. Selective herbicides that are labeled for wetland use have proven to be effective in controlling Chinese tallow and may be needed in some cases to aid cypress establishment.

**Nutria:** The presence of nutria can represent a significant threat to the successful establishment of planted seedlings. Studies have shown that planted seedlings can be completely eliminated by nutria if left unprotected (Conner and Toliver 1987). Protection provided by surrounding each seedling with a chicken wire fence or plastic seedling protector has proven successful in deterring nutria and allowing the seedlings to become established. However, this can be expensive and time consuming.

Alternatively, a change from the traditional winter or early spring planting of cypress seedlings to an earlier, fall schedule has been shown to reduce the incidence of nutria damage (Conner and Toliver 1987) and appears to be related to the amount of alternative food sources available at the time of planting. In winter and early spring, food sources are limited and the high nutrient content of the nursery-grown seedlings is attractive to nutria. Conversely, in the fall, there is a wide variety and adequate availability of food sources in addition to the planted seedlings. Therefore, nutria are less likely to target the seedlings, possibly leading to better survival rates and successful establishment.

### **2.1.5 Intermediate Stand Management**

The following information on growth and yield, thinning effects, and desired stocking levels address management of cypress stands from sapling stage to maturity.

#### ***2.1.5.1 Growth and Yield***

Planted cypress can grow rapidly under optimum conditions. Cypress planted in a yard and kept weeded and watered reached 12 ft (3.7 m) in height after three growing seasons (Williston et al. 1980). In more typical forested settings, growth rates of planted cypress vary substantially among sites and within sites, depending upon light availability, nutrient supply, soil characteristics, and water depth (Denton 1990). Cypress seedlings planted in a crayfish pond in Louisiana averaged 9.7 ft (3 m) in height and 1.4 inches (3.6 cm) in diameter at breast height (d.b.h.) after five years (Conner et al. 1993). A study that examined growth of a 21-year-old stand found a diameter growth rate of approximately a half-inch (13 mm) per year for cypress saplings (Krinard and Johnson 1976).

In a study of bald cypress planted at a 6 by 10-foot spacing on a Sharkey clay soil in Mississippi, average survival was 62 % (450 trees/acre (1,112 trees/ha)) and average height was 6.6 ft (2 m) at age 4 years. Average survival decreased to 41 % (296 trees/acre (731 trees/ha)) at age 21 and to 26 % (191 trees/acre (472 trees/ha)) at age 31 years. From age 21 to age 31, average diameter increased from 6.1 to 8.6 inches (15 to 22 cm), basal area from 72 to 90 square feet per acre (17 to 21 m<sup>2</sup>/ha), and total volume outside bark, for trees greater than 3.0 inches (8 cm) d.b.h., from 1,288 to 2,333 cubic feet per acre (91 to 164 m<sup>3</sup>/ha). The 30 largest cypress trees per acre (74 trees/ha) averaged 14.2 inches (36 cm) d.b.h. and 72 ft (22 m) tall at age 31 years (Krinard and Johnson 1987.)

Others have discussed the growth characteristics of older cypress stands. Hurst (2005) reported that cypress might continue vertical growth until approximately 200 years old, and can reach heights of 120 to 160 ft (37 to 49 m). In an analysis of 100-year-old second-growth stands which had regenerated after industrial harvest, cypress averaged 109 ft (33 m) in height and 21.3 inches (54 cm) d.b.h. (Williston et al. 1980, Hurst 2005).

Kennedy (1972) reported that bald cypress trees generally require about 200 years to reach sufficient size to yield a high proportion of rot-resistant heartwood lumber. At about age 200, height growth ceases and many bald cypress slowly die back from the top as a fungus-caused rot progresses downward through the stem. Wind damage from hurricanes often contributes to flattening of the crown and decline in height growth, but the trees are rarely overturned by wind (Wilhite and Toliver 1990).

Bald cypress is noted for the large size it can attain. In virgin forests, the largest trees were 84 to 144 inches (213 to 366 cm) in d.b.h. and 140 to 150 ft (43 to 46 m) in height. In the 2013 "National Register of Big Trees" published by *American Forests*, the co-champion bald cypress in Louisiana was reported to be 206 inches (523 cm) in d.b.h. and 96 ft (29 m) tall ([www.americanforests.org/our-programs/bigtree](http://www.americanforests.org/our-programs/bigtree)).

Bald cypress also is noted for its high merchantable yields. In virgin stands, yields of 8 to 14 thousand board feet (mbf) per acre (106 to 186 m<sup>3</sup>/ha) over large tracts were common, and some stands likely exceeded 100 mbf/acre (1,326 m<sup>3</sup>/ha) (Wilhite and Toliver 1990). Some second-growth stands approach the yields of the best virgin stands. A 96-year-old stand in Mississippi contained 70 mbf/acre (928 m<sup>3</sup>/ha) and its crop trees averaged 119 ft (36 m) tall (Williston et al. 1980). A 63-year-old second-growth stand in Louisiana averaged 504 cypress and 103 swamp tupelo trees per acre (1,245 cypress and 255 swamp tupelo trees/ha), respectively, resulting in volumes of 6,356 and 1,423 ft<sup>3</sup>/acre (445 and 100 m<sup>3</sup>/ha), respectively (Dicke and Toliver 1988).



### **2.1.5.2 Thinning Effects**

A number of studies have examined the effects of thinning on cypress growth in terms of stand volume and individual tree growth with varying results. Research in Florida showed that bald cypress grows well at high stand densities and at a faster rate than tupelo (McGarity 1979). From age 60 to 70 years, the bald cypress-hardwood stand increased from 168 to 189 ft<sup>2</sup>/acre (39 to 43 m<sup>2</sup>/ha) in basal area and from 57 to 68 cords/acre (360 to 430 m<sup>3</sup>/ha) in volume. Bald cypress grew at a faster rate than did tupelo and sweetgum. Thinning plots within the stand to various densities at age 60 years resulted in faster growth of individual crop trees, but in slower growth per unit area than for the unthinned part of the stand (McGarity 1979).

However, Williston et al. (1980) reported that an optimal level of thinning was determined that increased stand volume. The initial bald cypress density was 265 ft<sup>2</sup>/acre (61 m<sup>2</sup>/ha) at age 78 years. Thinning this stand to 75% of its basal area, (200 ft<sup>2</sup>/acre (46 m<sup>2</sup>/ha)), increased growth through age 96 years, more than a regime of no thinning or a heavier thinning. At age 96 years, this stand contained 70 mbf/acre (928 m<sup>3</sup>/ha).

In Louisiana, a study in a 63-year-old second-growth cypress-tupelo stand inside the Atchafalaya Basin sought to determine maximum stand density. The stand averaged a density of 220 ft<sup>2</sup>/acre (51 m<sup>2</sup>/ha) in basal area, 504 cypress and 103 swamp tupelo trees per acre (1,245 and 255 per hectare, respectively), and 6,356 and 1,423 ft<sup>3</sup>/acre (445 and 100 m<sup>3</sup>/ha, respectively) (Dicke and Toliver 1988). Keim et al. (2010) used published FIA data and 25-year-old results of a thinning study conducted at the Dicke and Toliver (1988) study site to identify maximum stand densities and density of incipient self-thinning in bald cypress. Results suggest a maximum stand density index (SDI) of 1200 (metric units [si] or 485 English units) should be used for bald cypress as a standard. SDI is directly related to the

quadratic mean diameter, and it can determine the maximum trees per acre desired; the higher the quadratic mean diameter, the fewer trees per acre desired. Thinning the bald cypress stand to  $\geq 58\%$  maximum SDI did not affect tree-level or stand-level growth, but thinning to 40% of maximum SDI increased diameter increment and net volume growth. These findings suggest that stand density-growth relationships of bald cypress and mixed cypress-tupelo stands appear to be similar to many other species, indicating that bald cypress does not attain the very high densities that are often thought possible.

In 1980, crown thinning treatments were applied in the above described stand to reduce basal area by 18, 36, and 54%. Dominant and codominant cypress trees in the upper crown level were favored for release with a goal of producing large high quality sawtimber trees. After five years, heavy thinning (54% of basal area) significantly increased diameter growth of the remaining dominant and codominant trees and appeared to increase sawtimber volume per tree, but not total stand volume. Volume growth of the stand averaged 716 ft<sup>3</sup>/acre (50 m<sup>3</sup>/ha) over the five-year period (Dicke and Toliver 1988, Wilhite and Toliver 1990). Analysis 20 years later (25 years after thinning) indicated that this trend continued. These studies suggest that thinning productive natural stands is an option if the major goal includes growing large trees, but thinning is not warranted if simple volume production is desired (Keim et al. 2010).

#### ***2.1.5.3 Desired Stocking Levels***

The body of **published literature concerning cypress timber stand management is limited**, but the following discussion should provide general guidance to aid in timber management decisions such as timing and degree of thinnings for various management objectives.

Putnam et al. (1960) developed a stocking and yield table for well-managed even-aged tupelos on average or better sites. This table could be approximately adjusted for bald cypress by increasing numbers of trees and basal areas by 10% and volumes by 15%. The table described characteristics of the harvested and residual components of a typical stand allowed to increase 4 inches (10 cm) in d.b.h. between thinnings, expected to be about every 10 years on average. Timber stand improvement was presumed to be the objective of each thinning, i.e., removing smaller, lower-quality stems and leaving the larger, more vigorous stems. Pre-harvest basal areas at each thinning ranged from 131 – 205 ft<sup>2</sup>/acre (30 – 47 m<sup>2</sup>/ha), and post-harvest basal areas ranged from 56 – 158 ft<sup>2</sup>/acre (13 – 36 m<sup>2</sup>/ha), with 45 – 75 ft<sup>2</sup>/acre (10 – 17 m<sup>2</sup>/ha) removed at each harvest.

Williston et al. (1980) provided a general rule of thumb for managing cypress stands, suggesting that thinning to a residual basal area of 100 ft<sup>2</sup>/acre (23 m<sup>2</sup>/ha) would provide good results for timber production objectives. This is within the range of the earlier recommendations of Putnam et al. (1960) as described above.

Goelz (1995) utilized the above data of Putnam et al. (1960) to develop equations for estimating stocking percentage in even-aged bald cypress stands. The percentage of full stocking can be estimated for cypress stands using the following equation:

$$\text{Full stocking \%} = 0.00112N + 0.01488NDq + 0.00273N(Dq^2)$$

where  $N$  = cypress trees per acre and  $Dq$  = quadratic mean diameter, i.e., the diameter of the tree of average basal area. A stocking value of 100% can be interpreted as full stocking, i.e., the stocking above which mortality from self-thinning would begin to occur in the stand.

Goelz (1995) also provided an equation to estimate the minimum cypress stocking needed for full site utilization. The percentage of the minimum stocking an average site should contain can be estimated using the following equation:

$$\text{Minimum stocking \%} = 0.08879N + 0.04120NDq + 0.00251N(Dq^2)$$

where  $N$  = cypress trees per acre and  $Dq$  = quadratic mean diameter. A stocking value of 100% can be interpreted as a desired residual thinning level at a given  $N$  and  $Dq$ . It should be noted however, that although the use of Putnam's et al. (1960) estimates and Williston's et al. (1980) reporting of other's fieldwork cannot be considered rigorous research, it does provide the basis for a management scheme that will have to be adapted to local site conditions and landowner objectives regardless.

SDI provides another method for evaluating cypress stocking levels. In its most commonly-used form as proposed by Reineke (1933), SDI is a measure of site occupancy in relation to a reference stand with a quadratic mean diameter of 10 inches (25 cm). The general form of the SDI equation in English units is:

$$SDI = N(Dq/10)^{1.605}$$

where SDI = stand density index,  $N$  = trees per acre, and  $Dq$  = quadratic mean diameter.

Keim et al. (2010) incorporated the Goelz (1995) results and other publications, FIA data, and the Dicke and Toliver (1988) cypress thinning study to develop SDI values for bald cypress as noted above. The authors found that well stocked stands will reach a maximum SDI of approximately 1,200 si (485 English units) as a standard for bald cypress. Cypress stands are considered to be fully stocked at an SDI of 660 si (265 English units) which is the level at which self-thinning would begin to occur. This corresponds approximately to the Putnam et al. (1960) and Goelz (1995) estimates of full stocking. Thinning a bald cypress stand to 58% of maximum SDI did not affect tree-level or stand-level growth, but thinning to 40% of maximum SDI increased diameter increment and net volume increment in the first 25 years after thinning. Thus 40% of maximum SDI represents an appropriate residual thinning level for timber stand improvement, and corresponds well with the Putnam et al. (1960) and Goelz (1995) estimates of the minimum cypress stocking needed for adequate site utilization.

## **2.2 Determination of Productive Cypress Soils in Coastal Louisiana**

Cypress can be found on many soils and topographic positions in Louisiana. In horticultural applications it can be grown even on upland soils, and it is often seen in cities as a shade tree or ornamental (Wilhite and Toliver 1990). For land managers, however, it is helpful to understand which soils are more or less suitable for cypress in a forested setting. The following summarizes an analysis conducted for this report by Dr. Terry Clason (USDA Natural Resources Conservation Service (NRCS) Louisiana Technical Forester, retired) to assess the productivity of soils in coastal Louisiana for sustainable cypress growth and management.

### **2.2.1 Background**

More than 90% of natural bald cypress stands in the southern U.S. are on flat topography or in slight depressions at elevations of less than 100 ft (30 m) above sea level. The upper limit of its growth in the Mississippi Valley is at an elevation of about 500 ft (150 m). A few isolated stands occur at elevations of 1,000 to 1,750 ft (300 to 533 m) bordering deep hollows on the Edwards Plateau of Texas (Southeastern Forest Experiment Station 1969). Because bald cypress usually grows on nearly flat topography, little is known about its growth in relation to topographic factors. However, even though these swamps are areas of very low topographic relief, slight changes in elevation (a few feet) produce quite different hydrologic conditions, soils, and plant communities (Brown 1981).

Normally, bald cypress is found on intermittently flooded and very poorly drained phases of Spodosols, Ultisols, Inceptisols, Alfisols, and Entisols (Southeastern Forest Experiment Station 1969). The native range of the species is in the thermic and hyperthermic soil temperature regimes. In Louisiana, there is no Spodosols soil order, and FIA data indicate that bald cypress could be found on

Alfisols, Entisols, Histosols, Inceptisols, Mollisols, Ultisols, and Vertisols soil orders. The Louisiana coastal parish soil orders are shown in Figure 2-1 below.

### **2.2.2 Methods**

To determine the suitability of soils for cypress management in Louisiana, cypress growth potential was evaluated by soil mapping unit within a study area comprising the following 24 Louisiana coastal parishes: Acadia, Ascension, Assumption, Calcasieu, Cameron, Iberia, Iberville, Jefferson Davis, Jefferson, Lafayette, Lafourche, Livingston, Orleans, Plaquemines, St. Bernard, St. Charles, St. James, St. John, St. Martin, St. Mary, St. Tammany, Tangipahoa, Terrebonne, and Vermillion. These parishes correspond to the LASAF area of interest as described in the Introduction to this report.

The objective was to categorize each soil mapping unit into one of the following cypress productivity classes:

- 1) Class A: Productive Cypress Soils – soils that exhibit a potential for establishing and supporting the growth and development of naturally regenerated cypress stands;
- 2) Class B: Manageable Cypress Soils – soils that exhibit a potential for establishing and supporting the growth and development of artificially regenerated cypress stands with intensive management; and
- 3) Class C: Low-productivity Cypress Soils – mucky soils which would require hydrological restoration to establish and support the growth and development of artificially regenerated cypress stands.

The list of soils to be considered was developed based on actual occurrence of cypress stocking across the study area. Cypress stocking data by soil mapping unit was determined by combining a bald cypress stocking GIS layer developed by the USDA Forest Service, Forest Health Technology Enterprise

Team (Ellenwood et al. 2009) with digitized NRCS National Soil Information System (NASIS) parish soil layers. The resulting layer identified all soil mapping units in the study area with bald cypress stocking of at least 30 ft<sup>2</sup>/acre (7 m<sup>2</sup>/ha), the NASIS threshold for woodland productivity. The intent was to include all soils exhibiting at least minimal cypress growth potential and to exclude soils apparently incompatible with cypress establishment or growth.

Next, a set of 16 geographic and soil characteristics related to cypress establishment and growth was selected from the NASIS tabular data for the soils under consideration. These characteristics included Louisiana Level 4 Eco-Regions (Daigle et al. 2006), soil order, flooding frequency, flooding duration, flooding occurrence, ponding frequency, ponding duration, ponding depth, ponding occurrence, salinity level, subsidence, hydrologic group, drainage, elevation, landscape class, and landform class. A key was developed to classify the possible values for each characteristic into the three cypress soil productivity classes noted above. The key was then used to initially assign each soil in the study area into one of the three cypress productivity classes.

An iterative process was then used to verify the initial productivity class assignments and make reassignments where necessary. First, the NASIS data were queried to determine which soils identified cypress as a recommended species for commercial woodland management. These soils were assumed by definition to be included in (or comprise) Class A, Productive Cypress Soils. Next, the NASIS data were queried to determine which soils were identified as mucky non-productive forest soils. These soils were assumed by definition to be included in (or comprise) Class C, Low-productivity Cypress Soils. The remaining soils retained their initial productivity classification, the majority of which were Class B, Manageable Cypress Soils. The revised cypress productivity class assignments were entered into the soil mapping unit GIS layer for soils under consideration in the study area.

As a final check, the cypress stocking GIS layer was compared with the layer identifying cypress productivity class by soil mapping unit. The general rationale was that cypress occurrence should be

most common across the study area for soils in Class A, less common for soils in Class B, and least common for soils in Class C. Soils that did not fit this general pattern were examined individually and final productivity class adjustments were made on a case-by-case basis.

### 2.2.3 Results

Bald cypress was found within seven soil orders in the 24 parishes: Alfisols, Entisols, Histosols, Inceptisols, Mollisols, Ultisols, and Vertisols. However, the Ultisols was a very minor component representing less than 1% of all acreage of bald cypress in the 24 coastal parishes. Potential bald cypress soil acreage within the six predominant soil orders was estimated by using the NASIS tree productivity interpretation data and is shown in Table 2-1. A map of cypress soil productivity classes in coastal Louisiana derived from the above-described analysis is depicted in Figure 2-2.

**Class A: Productive Cypress Soils** – soils that exhibit a potential for establishing and supporting the growth and development of naturally regenerated cypress stands are listed in Appendix A-1. There are 20 discrete mapping units encompassing four soil orders: Alfisols (3), Entisols (3), Inceptisols (6), and Vertisols (8).

**Class B: Manageable Cypress Soils** – soils that exhibit a potential for establishing and supporting the growth and development of artificially regenerated cypress stands with intensive management are listed in Appendix A-2. There are 37 discrete mapping units encompassing seven soil orders: Alfisols (16), Entisols (4), Histosols (2), Inceptisols (7), Mollisols (2), Utisols (1), and Vertisols (5).

**Class C: Low-productivity Cypress Soils** – mucky soils which would require hydrological restoration to establish and support the growth and development of artificially regenerated stands are listed in Appendix A-3. There are 18 discrete mapping units encompassing four soil orders: Entisols (6), Histosols (10), Inceptisols (1), and Mollisols (1).



#### 2.2.4 Discussion

The soils identified as Class A soils generally are fine textured soils subjected to hydrological cycling patterns that should support the natural growth and development of cypress. At the local level, however, many of these soils may suffer from long-term water inundation, particularly long durations of ponding, which negatively affects or prevents natural development.

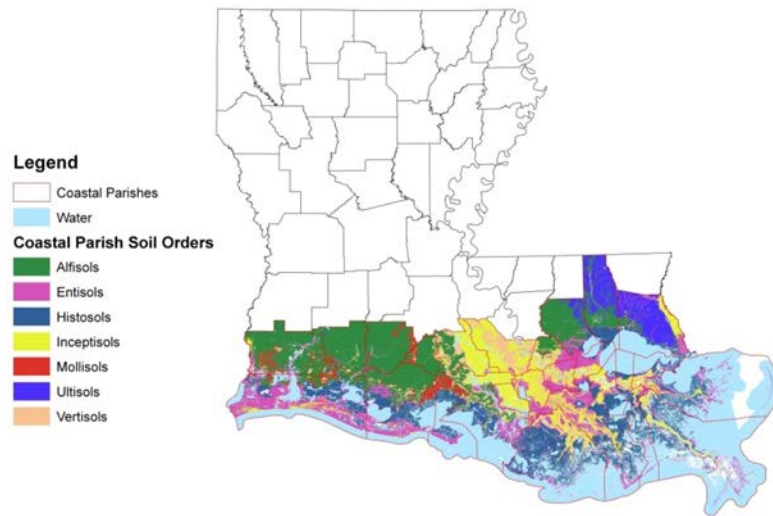
The soils identified as Class B soils exhibit the potential to manage cypress growth outside areas that provide adequate hydrological cycling, i.e., where cypress will not withstand competition from other species without considerable effort. Artificial regeneration and planned competition reduction interventions will be required to attain suitable growth. Generally, these are fine textured soils found in floodplains, stream terraces, and depressions subject to rare, occasional, and short duration frequent flooding.

Although NASIS classifies the soils in Class C as non-productive forest soils, the Ellenwood et al. (2009) bald cypress stocking GIS layer suggests that the map units in this category may support cypress at various locations in coastal Louisiana. Declining bald cypress stands have been observed on Rita mucky clay, Kenner muck, and Maurepas muck frequently flooded map units. The soils in this category are either organic or have a surface mineral layer over organic matter and are found in depressions and swamps along the coast. Many of these soils are subjected to long-duration ponding, either natural or man-made. Future cypress management would require extensive hydrological restoration efforts.

### 2.2.5 Conclusion

**The classification analysis described above should be viewed as a starting point** or general guide as to which soils may be more or less suitable for cypress management, and a couple of caveats should be kept in mind. First, though the soils are separated into three seemingly distinct productivity classes, in practice they should be viewed as a spectrum of soil types that may exhibit overlapping characteristics. Second, all soil mapping units contain embedded acreage of alternate soil mapping units within the larger polygons, thus on-site verification of soil type is recommended.

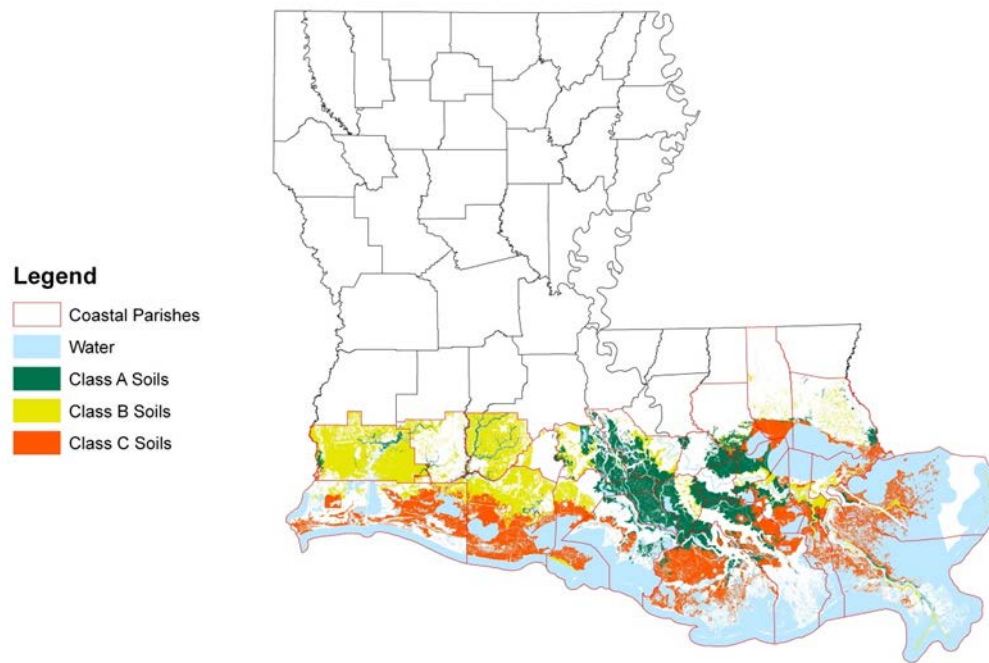
Most importantly, **soil type alone does not determine the suitability of a site for cypress management**. Rather, it is a first step in evaluating the potential of a site for cypress sustainability. If the hydrological system of a subject site has not been significantly altered, the productivity classifications described herein should provide some useful guidance. However, due to the widespread alterations that have occurred to the hydrologic systems in south Louisiana, it is likely that the hydrology of a given site will prove to be functioning differently than would be indicated by the underlying soil type. Hence it is imperative that a number of additional factors be taken into account to determine sustainability of a site for cypress management, as described later in Section 3, Sustainability Determination Methodology.



**Figure 2-1.** Soil orders in Louisiana coastal parishes. Source: NRCS National Soil Information System (NASIS).

**Table 2-1.** Estimated acres of potential bald cypress soils by soil order in Louisiana coastal parishes. Source: NRCS National Soil Information System (NASIS).

SOIL ORDER	ACRES	PERCENT
Alfisols	940,033	19%
Entisols	1,181,888	24%
Histosols	1,549,368	32%
Inceptisols	610,119	12%
Mollisols	143,222	3%
Vertisols	410,015	8%



**Figure 2-2.** Cypress soil productivity classes in coastal Louisiana. Source: analysis of USDA Forest Service, Forest Health Technology Enterprise Team (Ellenwood et al. 2009) and NRCS National Soil Information System (NASIS) data.

## 2.3 Operations in Forested Wetlands

Forest management activities in wetland areas involve unique legal requirements and present significant operational challenges. This section begins with a synopsis of overarching regulations and voluntary guidelines related to forested wetland operations in Louisiana. Next follows a discussion of timber harvesting systems common in Louisiana and their related water quality effects.

### 2.3.1 Regulatory Background

Prior to initiating management activities in forested wetlands, the **land manager should become thoroughly familiar with all relevant federal and state statutes and regulations**, as well as any voluntary guidelines promulgated for these purposes. Below is a brief synopsis of key legal requirements and voluntary guidelines related to forest management operations in wetlands of Louisiana. **The reader is encouraged to follow up with additional research** if needed to gain a thorough understanding of this important subject.

#### 2.3.1.1 *Clean Water Act*

Section 404 of the Clean Water Act (CWA) regulates the discharge of dredged or fill material into waters of the United States, including wetlands. Normal forestry operations in wetlands are exempt from permit requirements under Section 404(f)(1) of the CWA Amendments of 1977, as long as the activity: 1) qualifies as “normal silviculture,” 2) is part of an “established” silvicultural operation, 3) does not support the purpose of converting a water of the United States to a use to which it was not previously subject, and 4) does not impair the flow or circulation of navigable waters or reduce the reach of such waters. In addition, the silvicultural activity should follow the 15 mandatory Best

Management Practices (BMPs) for road construction and the six mandatory BMPs for site preparation. There should also be no toxic pollutant listed under Section 307 of the CWA or dredge or fill materials discharged into waters of the United States without permit.

Section 404(f)(1)(A) of the CWA exempts normal forestry activities from permitting (for example, bedding, seeding, harvesting, and minor drainage) that are part of an established, ongoing forestry operation. A forest operation ceases to be “established” when the area in which it was conducted has been converted to another use or has lain idle so long that modifications to the hydrological regime are necessary to resume operations (40 CFR Part 232.3(c)(1)(ii)(B) (EPA) and 404(f)(1)(A) (CWA)). A definition of the phrase “ongoing forestry” in bottomland hardwood and cypress swamps has been developed by the Southern Group of State Foresters for the EPA (Southern Group of State Foresters 2009). In this document, nine criteria were identified that would indicate a plan for ongoing forestry on a site:

- 1) The property is occupied by a predominance of bottomland hardwood or cypress trees (except for recently harvested parcels).
- 2) The landowner is engaged in some type of forest management activity(s) such as boundary maintenance, firebreak construction and maintenance, invasive plant, insect, or disease control, or timber stand improvement.
- 3) The forest management plan includes timber harvesting and reforestation (either by natural or artificial means), which is being implemented.
- 4) The forest in question is enrolled in a third party certification program, i.e., Tree Farm, Forest Stewardship Council, Sustainable Forestry Initiative, etc., or is enrolled in agricultural-use tax status.
- 5) Where harvesting has recently occurred, the tree stumps are left in place to sprout.

- 6) Intensive mechanical site preparation techniques such as shearing and root raking have not been employed in the reforestation effort, except on sites where afforestation or restoration of bottomland hardwood or cypress swamps is being conducted.
- 7) Low ground-pressure equipment or mat logging techniques have been used on especially wet sites to minimize ground disturbance and soil compaction and to facilitate natural regeneration.
  - a) Mat logging should incorporate acceptable techniques that maximize the facilitation of natural regeneration (e.g., attachment).
  - b) Skid trails should be minimized and follow applicable state approved BMPs for logging operations.
- 8) Evidence of prior management activities, such as stumps from earlier harvests, or aerial photos indicating past activity or other such records of past tree establishment, cultivation or utilization.
- 9) Forest roads serving forest management purposes should be constructed in accordance with state approved road BMPs, road BMPs listed in Section 404 of the CWA, and be consistent with the practice and purpose of forestry.
  - a) Forest roads are typically narrow, low-cost, and minimally spaced as to be practical and economically feasible.

Further information on silvicultural practices commonly used in bottomland hardwood and cypress swamps can be found in the report by the Southern Group of State Foresters (2009), and it may supplement recommendations provided herein.

Clean Water Act statutes are cited as follows: Federal Water Pollution Control Act (33 U.S.C 1251 et seq., amended 1977, amended through P.L. 107 – 303, November 2002) and commonly referred to as the “Clean Water Act”; Section 404; Title 33 – Navigation and Navigable Waters; Chapter 26 Water

Pollution Prevention and Control; Subchapter IV – Permits and Licenses, Sec. 1344 – Permits for dredged or fill material.

#### ***2.3.1.2 Rivers and Harbors Act***

Section 10 of the Rivers and Harbors Act of 1899 (33 USC Sec 403, Chapter 9, Subchapter I) prohibits the unauthorized obstruction or alteration of any “navigable water of the United States” unless a permit has been issued by the U.S. Army Corps of Engineers (USACE). The definition of navigable waters of the United States and related jurisdictional limits of the USACE are contained in 33 CFR 329, “Definition of Navigable Waters of the United States.” The general definition in 33 CFR 329.4 states that navigable waters of the United States are “those waters that are subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce. A determination of navigability, once made, applies laterally over the entire surface of the waterbody, and is not extinguished by later actions or events which impede or destroy navigable capacity.”

USACE geographic and jurisdictional limits on non-tidal rivers and lakes are defined in 33 CFR 329.11 as follows: “Federal regulatory jurisdiction, and powers of improvement for navigation, extend laterally to the entire water surface and bed of a navigable waterbody, which includes all the land and water below the ordinary high water mark (OHWM). Jurisdiction thus extends to the edge (as defined above) of all such water bodies, even though portions of the water body may be extremely shallow, or obstructed by shoals, vegetation or other barriers. Marshlands and similar areas are thus considered navigable in law, but only so far as the area is subject to inundation by the ordinary high waters.”

Federal regulations define the OHWM as “that line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank,



shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas.” Under Section 404 of the CWA, the OHWM defines the lateral extent of federal jurisdiction in non-tidal waters of the United States in the absence of adjacent wetlands. Thus, consistent, repeatable, and defensible OHWM delineation practices are essential for proper implementation of the CWA.

Similarly, USACE geographic and jurisdictional limits in coastal areas and tidal waters are defined in 33 CFR 329.12 as follows: “Regulatory jurisdiction in coastal areas extends to the line on the shore reached by the plane of the mean (average) high water,” and for bays and estuaries, “Regulatory jurisdiction extends to the entire surface and bed of all waterbodies subject to tidal action. Jurisdiction thus extends to the edge (as defined above) of all such waterbodies, even though portions of the waterbody may be extremely shallow, or obstructed by shoals, vegetation or other barriers. Marshlands and similar areas are thus considered navigable in law, but only so far as the area is subject to inundation by the mean high waters.”

For purposes of cypress management, the **land manager should be aware that the USACE considers its jurisdiction under Section 10 of the Rivers and Harbors Act of 1899 to include silvicultural activities that lies between the lateral extents of navigable waters which may require USACE authorization**; for example, marshes and forested wetlands that lie between the waterbody and the mean high water line or OHWM. Unlike the CWA, there is **no silvicultural exemption under Section 10** for regulated work within navigable waters of the United States. Examples of work associated with silvicultural activities that may require Section 10 permits if they occur within navigable waters include: deposition or redistribution of fill material associated with the construction of logging roads and staging areas; construction or placement of structures such as timber mats and loading or offloading ramps; stockpiling of timber; and excavating or dredging for any reason (SWG 2005).

### ***2.3.1.3 Louisiana State Regulations***

Forest management activities in the Louisiana Coastal Zone may require a coastal use permit from the Louisiana Coastal Resources Program in certain situations. The Louisiana Administrative Code (Title 43, Part I, Chapter 7, Section 723.B.7) states that “Agricultural, forestry and aquacultural activities on lands consistently used in the past for such activities shall not require a coastal use permit provided that (i.) the activity is located on lands or in waters which have been used on an ongoing basis for such purposes, consistent with normal practices, prior to the effective date of [The State and Local Coastal Resources Management Act] SLCRMA (Act 361 of 1978), (ii.) the activity does not require a permit from the U.S. Army Corps of Engineers and meets federal requirements for such exempted activities, and (iii.) the activity is not intended to, nor will it result in, changing the agricultural, forestry, or aquacultural use for which the land has been consistently used for in the past to another use.” Thus **if USACE determines that a permit for the activity would be required under Section 404 of the CWA or Section 10 of the Rivers and Harbors Act, the land manager should be aware that a Louisiana coastal use permit will also be required.**

### ***2.3.1.4 Louisiana Best Management Practices***

In addition to the above federal and state regulations, all forest management operations should follow the voluntary Recommended Forestry BMPs for Louisiana. A copy of the Louisiana BMP Manual can be obtained at the following URL:

<http://www.ldaf.state.la.us/wp-content/uploads/2014/04/BMP.pdf>.

The Louisiana BMPs discuss specific management activities that may take place in forested wetlands, and should be consulted regularly when operating in cypress forests.

### **2.3.2 Harvesting Systems**

With a thorough understanding of the regulatory background described above, consideration should be given to the type of harvesting system to be employed at the site. Harvesting should be done with consideration to season, stand composition, soil type, soil moisture, and the type of equipment that is used. When done correctly on the right sites, harvesting can benefit site productivity for future forests, improve regeneration, and benefit the overall hydrologic function of a wetland site.

#### ***2.3.2.1 Common Harvesting Systems in Louisiana***

The information on harvesting systems below is adapted from the North Carolina state forestry BMP manual (North Carolina Forest Service 2006). The proper selection of a harvesting system involves consideration of many different conditions:

- Slope and terrain
- Type of water resources and wet areas present
- Skidding distance
- Weather
- Soils
- Tree size and volume per acre
- Size of tract
- Cost of road construction
- Cost of logging
- Productivity goals

Below is a basic description of the most common harvesting systems used in forested wetlands of Louisiana. Potential water quality issues are provided in bulleted text for each system.

**Skidder:** A skidder is a tractor that uses a cable, grapple, or both, to secure and drag the felled logs or trees to a loading deck. Skidders may be mounted on tracks or tires. Skidders are the most common logging system in Louisiana, and their use is appropriate for most of the site conditions found in the State.

- When not used properly, skidders can severely affect water quality and lead to conditions that may degrade long-term site productivity.
- Skidders that are mounted on tracks, extra-wide tires, or dual tires can further minimize intensive soil disturbance in some cases and allow operations to continue during adverse conditions.

**Shovel Logging (Mat Logging):** This is a term used to describe a log or tree loader that is mounted on self-propelled tracks. These machines can construct a homemade mat trail made up of logs that other equipment then travels upon, instead of traveling directly on the ground. This mat trail is then removed as skidding is completed. Shovel systems are usually limited to total harvests due to the need to use tree or log material for the mat trail.

- Shovel systems are able to work effectively in wetter areas than a skidder system because they move timber with the reach and swing of the shovel-arm rather than the traffic movement of a wheeled or tracked machine.
- Shovel systems allow logging on extremely wet-natured sites while minimizing site disturbance.
- Due to the ability of this equipment to operate in saturated soil conditions, care must be exercised to ensure sufficient streamside management zones (SMZs) are established, marked, and maintained.

**Track-Mounted Equipment:** These are machines mounted on rubber or metal tracks instead of rubber tires. Track-mounted machines are available for tree cutting, skidding, processing, loading or roadwork.

- When compared to rubber-tired equipment, track machines protect soil better due to the increased “footprint” area of the tracks. This decreases the ground pressure of the unit.
- Tracked machines minimize soil compaction, especially on wet soil conditions. Due to the ability of this equipment to operate in saturated soil conditions, care must be exercised to ensure sufficient SMZs are established, marked, and maintained.

**Forwarders:** These machines are rubber tired tractors equipped with a self-contained log loader and a log bunk that can transport logs completely off the ground. Forwarders can reduce the number of forest roads needed since logs can be carried for longer distances from the woods to the deck.

- Forest road construction is minimized, which helps reduce the potential for sedimentation.
- However, if operations are conducted under wet conditions, soil compaction and site productivity degradation can occur. The use of wider tires or add-on track cleats can help minimize this potential problem.

**Helicopter:** Helicopters can completely lift cut timber from the woods and fly it to the loading deck.

- Ground disturbance is minimized, and the need for skid trails is reduced or eliminated.
- The need for forest roads is reduced, and those forest roads that are needed may be located farther from waterbodies than what may be possible with other systems.
- Due to the inherent high costs of operations, this logging system is usually only economical for extremely valuable high-quality timber.

### ***2.3.2.2 Harvesting System Effects***

Protection of soils from rutting during harvesting operations is a major consideration in forested wetlands. The use of low p.s.i. (pounds per square inch) equipment is recommended. Rutting is caused by high pressure applied to a limited area, such as narrow wheels, where all the weight of the equipment is focused on the small cross-section that actually touches the ground at one point. Spreading the weight out over a wider surface area reduces p.s.i., and consequently, ruts. Wide tires or dual tires are one way of reducing p.s.i. by increasing the area touching the ground (U.S. Environmental Protection Agency, Office of Water Quality 2005).

Temporarily placing mats or organic debris in the path of the equipment is also very effective at reducing p.s.i. A recent Florida study found mat-logging reduced the depth of skid trails by half compared to traditional bottom-logging. In addition, microtopography following mat-logging was more similar to reference conditions than following traditional bottom-logging practices (Bohn and Cohen 2011).

The EPA and USDA Forest Service recommend using mats when crossing wetlands (Blinn et al. 1998, U.S. Forest Service 1999). The EPA list of recommendations for controlling non-point source pollution from forestry operations in wetlands includes using low p.s.i. equipment in conjunction with adequate root or slash mat to provide additional support (U.S. Environmental Protection Agency, Office of Water Quality 2005).

Though studies in cypress forests are limited, the felling method used does not appear to affect cypress regeneration success. In a study conducted in two bald cypress-water tupelo ponds in the Mobile-Tensaw River Delta of Alabama, early establishment of bald cypress and water tupelo regeneration did not differ significantly between mechanized felling and chainsaw felling (Gardiner et al. 1995).

Few studies have directly compared the effects of different harvesting systems in cypress forests, but Aust et al. (2006) did examine the effects of helicopter and skidder timber harvesting on the regeneration, growth, and development of a naturally regenerated cypress-tupelo forest in the Mobile-Tensaw River Delta of Alabama. At stand age 16 years, both treatments had well-stocked, vigorously growing stands composed of stump-regenerated water tupelo, Carolina ash (*Fraxinus caroliniana*), bald cypress, and seed-origin black willow. Stand growth parameters suggested that both treatments would produce stands similar to the previous stand in terms of species and volumes. Recovery was speeded by annual inputs of nutrient rich sediment, the shrink-swell nature of the soil, and rapid growth of stump sprouts.

### 3 Sustainability Determination Methodology

The SWG (2005) recommended that “before harvesting SWG Condition Class I and II sites, a written forest management plan with specific plans for regeneration must be reviewed by a state-approved entity so appropriate practices can be suggested based on local site conditions. The intent is to ensure that cypress-tupelo regeneration and long-term establishment take place and that species or wetland type conversion does not occur.”

This section outlines a proposed methodology for land managers to determine the potential of a site to support sustainable cypress management in coastal areas of Louisiana. For the purposes of this report, **sustainability is defined as the capability of a site, with proper management, to support successive stands of cypress via natural or artificial regeneration.**

The sustainability determination methodology presented herein is designed for **immediate implementation** by meeting three readiness criteria. First, the methodology relies on **established field techniques** based on existing scientific knowledge; future research may streamline the methodology but is not necessary for immediate implementation. Second, it utilizes **off-the-shelf equipment and technology** readily available in the marketplace. Finally, the methodology is designed to be **implemented by a team of qualified natural resource professionals** contributing expertise routinely provided to landowners and land managers in Louisiana.

At the conclusion of the process, the land manager should have a well-documented analysis of the data collected and conclusions reached in classifying the site into one of several sustainability categories that are patterned after the SWG RCCs (SWG 2005). Based on the sustainability determination, site-appropriate management recommendations are provided in the next section to support development of a comprehensive management plan for the site.



LASAF encourages regulatory agencies to consider adopting the sustainability determination methodology and associated management recommendations provided herein as a blueprint for evaluating whether forest management activities proposed for a cypress site are subject to federal and state wetland permitting requirements. This would allow protection of Class III sites while providing a path forward for landowners interested in resuming active management on sustainable Class I and II sites.

**Note:** The methodology described below presumes familiarity with the concepts and background information presented in the Essential Knowledge for Land Managers section of this report.

The general factors involved in determining the potential of a site to support sustainable cypress management include the soil types, hydrologic regime of the site, and the salinity of soil and water on the site. Thus the field evaluation will seek to obtain as much information on these factors as is reasonably practical in order to develop a sustainability determination and resulting management alternatives. The general process is as follows:

- 1) Determine the potential of the **soils** on the site to produce sustainable cypress stands.
- 2) Evaluate the **vegetation** on the site as an indicator of hydrologic regime.
- 3) If vegetation analysis is inconclusive, conduct on-site **water level monitoring** to develop an understanding of hydrology at the site. Where available, employ river gage data analysis or documentation of hydrology by qualified natural resource professionals familiar with the site to reduce or eliminate the actual monitoring needed.
- 4) Assess the **salinity** levels of soil and water at the site.
- 5) Evaluate all of the above information to classify the site into one of several **sustainability categories**.

Based on the sustainability determination, site-appropriate management recommendations are provided in the next section to support development of a comprehensive management plan. Each of the steps in the sustainability determination is described in further detail below.

### 3.1 Soils

The productivity of soils in coastal Louisiana for sustainable cypress growth and management was classified in the analysis described in the Essential Knowledge for Land Managers section of this document. These Cypress Soil Productivity Classes are designed to assist in determining if a particular area should be considered for cypress forest management. Though **soil type alone does not determine the suitability of a site for cypress management**, it is a first step in evaluating the potential of a site for cypress sustainability. If the hydrological system of a subject site has not been significantly altered, the productivity classes should provide useful guidance. However, due to the widespread alterations that have occurred to the hydrologic systems in south Louisiana, it is likely that the hydrology of a given site will prove to be functioning differently than would be indicated by the underlying soil type. Thus it is important that additional factors be taken into account to determine sustainability of a site for cypress management, as described in later sections.

The first step is to identify the soil type on the property. Soil types can be identified by collecting samples and using the following information sources:

- Soil Samples – contact your local office of the Louisiana Cooperative Extension Service  
[www.lsuagcenter.com](http://www.lsuagcenter.com)
- Web-based GIS – Natural Resource Conservation Service, Web Soil Survey  
<http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm>

Next refer to the Cypress Soil Productivity Class Tables in Appendix A to determine the classification of cypress growth with which the soil type is associated. For example, if the predominant soil type is Barbary Muck Association (BA), it is considered a Class A soil: soils that exhibit a potential for establishing and supporting the growth and development of naturally regenerated cypress stands.

If the predominant soil category of the site is Class A (Productive Cypress Soils) or Class B (Manageable Cypress Soils), field evaluation should proceed to the next step of examining the vegetation of the site. However, if the predominant soil type is a Class C (Low-productivity Cypress Soils), field evaluation should not proceed any further. These are considered non-productive soils for cypress growth, and forest management should probably not be considered without extensive hydrological modifications.

If the site is located on soils not listed in any of the tables, it is probably not suited for cypress. However, cypress and tupelo may be a part of mixed hardwood stands on those soils.

### **3.2 Vegetation Indicators**

Although plant species association is determined by a number of interacting environmental factors, it is generally agreed that flooding is the dominant factor at work in bottomland forests (Wharton et al. 1982). Thus the hydrologic regime of a site, (i.e., the seasonality, frequency, depth, and duration of flooding) is one of the most important influences on the vegetation of the site (Lugo et al. 1990) and its consequent potential for sustainable cypress management.

In bottomland hardwood systems, plant communities tend to segregate along the topographic gradient from the open water of the river to the upland transitional areas (Guilfoyle 2001). Using this natural separation, Larson et al. (1981) devised a classification of floodplain forests based on the zonation of plant communities and their location along the hydrologic gradient (see Figure 3-1). In

general, Zone 1 refers to river channels, oxbow lakes, and permanently inundated backsloughs; Zones 2 and 3 refer to bald cypress swamps and swales; Zone 4 refers to flats and backswamps; Zone 5 refers to levees, relict levees, and terraces; and Zone 6 refers to the floodplain-upland transitional area that links bottomlands to terrestrial ecosystems. While this classification may be an oversimplification of bottomland systems, it has been found to be useful in describing many forested wetlands in the Southeast and provides an important tool in establishing management guidelines locally and regionally (Wharton et al. 1982).

Although various studies have demonstrated that frequency and duration of inundation or saturation exert a controlling influence on the composition, structure, and distribution of wetland plant communities, there have been few studies describing the relationship between plant species distribution and specific hydrologic regimes in bottomland forests. To address this need, the USACE Waterways Experiment Station in Vicksburg, Mississippi conducted a study to develop flood tolerance indices (FTI's) for common species in southeastern U.S. bottomland forests, to be used as a surrogate for quantitative hydrologic information on a given site (Theriot 1993).

The investigators in the Theriot (1993) study examined seventeen sites across the southeastern U.S. for which detailed quantitative hydrologic information was available from nearby river gage stations. These gage data allowed the researchers to estimate inundation levels on the sites at various stages and thereby delineate the hydrologic zones on the ground. Sample plots were located in each zone to identify species present in the overstory, midstory, and understory strata. The weighted average importance value of each species in each zone was used to calculate the FTI of the species. The FTI is expressed as a value indicating the species' optimum position along the hydrologic zone gradient for each vegetation stratum. So for example, bald cypress was found to have a mean FTI of 2.97 in the overstory, indicating that its optimum position is near the boundary between Zones II and III.

For field application of FTI's on a subject site, Theriot and Sanders (1986) recommend that the land manager subjectively estimate the five dominant plant species in a given vegetation stratum, average the corresponding FTI numbers, and calculate a site FTI number. FTI values for common Louisiana bottomland plant species by vegetation stratum can be found in Appendix B of this document.

As an example, suppose that inspection of a site indicates that the five dominant overstory species are eastern swampprivet, water hickory, boxelder, overcup oak, and sugarberry (scientific names included in Appendix B). The site FTI would be calculated as follows:

<u>Dominant Species</u>	<u>Species FTI Number</u>
Eastern swampprivet	3.48
Water hickory	3.54
Boxelder	4.83
Overcup oak	3.73
Sugarberry	<u>4.84</u>
Total	20.42
Site FTI Number	$20.42 / 5 = 4.08$

The site FTI of 4.08 in this example indicates that the area is in hydrologic Zone IV, which would typically be inundated or saturated 12.5% to 25% of the growing season, and inundated at least every other year on average (Figure 3-1).

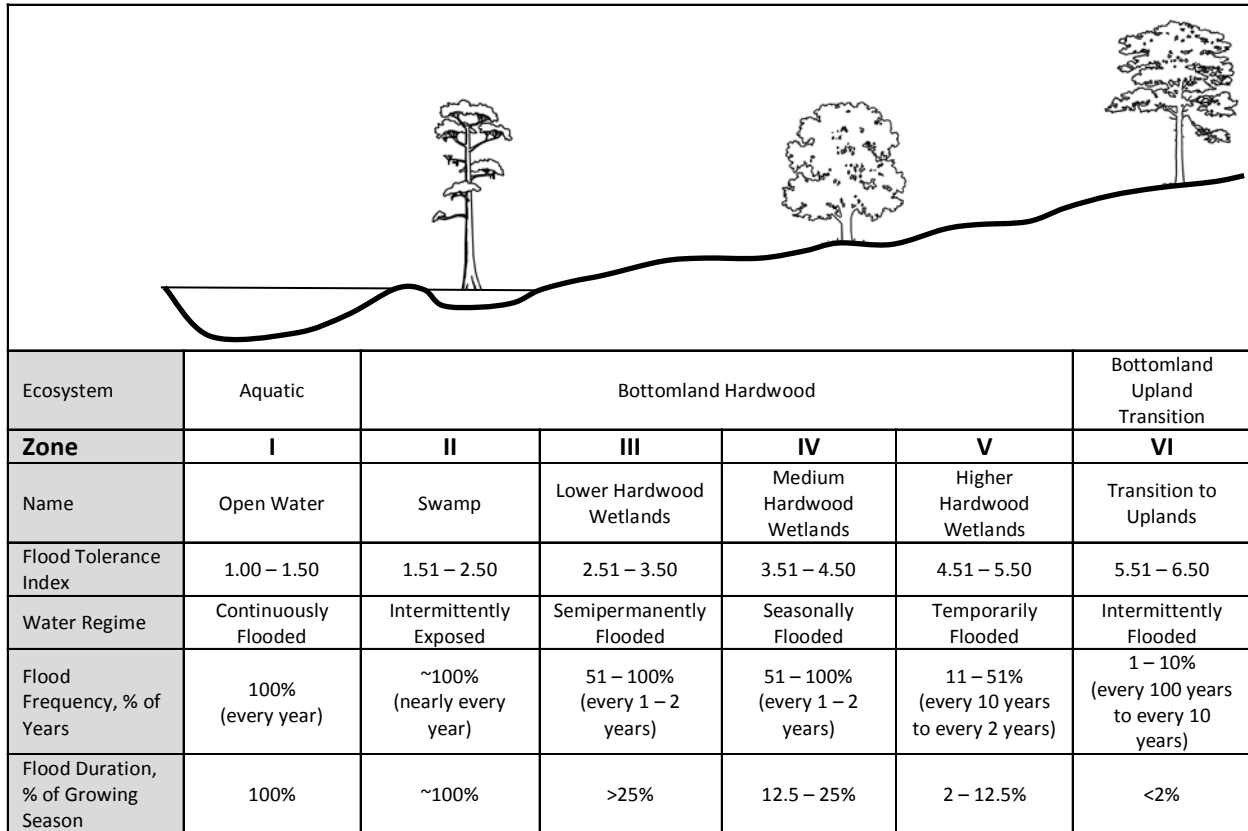
The FTI should be calculated from the highest vegetation stratum present on the site, preferably the overstory, as this provides the best indication of the site's long-term hydrologic regime. Where overstory is not present, midstory values may be used with good results. Where no overstory or

midstory is present, understory values should be used with the understanding that the resulting site FTI may reflect only the more recent hydrologic history of the site.

**Selection of the preferred vegetation strata for calculation of FTI may be complicated by past hydrologic alterations.** For instance, in the example above, the FTI value of 4.08 may mean that the site was previously in Zone IV, and that recent changes in hydrology have moved the site into a different zone not revealed by the existing overstory. If hydrologic alterations are evident or known to have occurred, FTI values from lower strata may best reflect the current hydrology of the site. A general rule of thumb would be to calculate FTI using the highest vegetation stratum available that has been established subsequent to the most recent significant hydrologic alteration(s).

Further, as with any sampling procedure, **sample size should be carefully considered** in vegetation indicator analysis. Theriot (1993) notes that FTI's for species with few stems per acre or low basal area per acre may be unreliable. If this appears to be the case on the subject site, lower vegetation strata should be employed for the species in question or for the stand as a whole.

Finally, taking all of these factors into account, a decision should be made by the land manager as to whether vegetation analysis provides a reliable indication of the hydrologic zone on the subject site. On some sites, suitable vegetation strata reflective of current hydrology may be available, and the hydrology of the site will be reasonably apparent. On other sites, however, absence of vegetation, recent hydrologic changes, or other factors may preclude use of FTI's to predict hydrologic zone. In those cases, water level monitoring will be needed to ascertain site hydrology, as described in the following subsection.



**Figure 3-1.** Hydrologic zones in bottomland hardwood forests (adapted from Larson et al. 1981).

### 3.3 Water Level Monitoring

Hydrologic regime is one of the most important influences on the vegetation of the site (Lugo et al. 1990), and understanding the seasonality, frequency, depth, and duration of flooding of a subject site is essential in determining its potential for sustainable cypress management. Vegetation indicator analysis can provide important insights about hydrologic regime, but has limitations as previously described. Where vegetation indicator analysis proves inconclusive, water level monitoring conducted for a sufficient period of time can provide an accurate assessment of the hydrology of a site.

On-site water level measurement has the advantage of providing data specific to the site, but requires a significant investment of time as **multiple years of monitoring are needed for purposes of cypress sustainability determination**. Monitoring for one year may provide a record of that year's water levels, but will not establish the annual frequency of flooding, a key determinant of cypress site suitability. Thus monitoring should be conducted for at least three years to develop a complete picture of the site's hydrologic regime. If the prevailing climate during that time is considered significantly outside historical norms (e.g., extended drought, extreme temperature, or precipitation), an additional year or two of monitoring may be advised. Also, if hydrologic alterations are occurring that significantly affect the subject site, monitoring may need to be delayed or extended for a sufficient time to allow conditions to stabilize and reflect expected future hydrology.

#### 3.3.1 Alternatives to On-Site Monitoring

Before proceeding with the time and expense involved in on-site water level monitoring, consideration should be given as to whether alternative sources of suitable hydrologic information are available for the subject site. These sources include 1) historical river gage data and 2) documentation by qualified professional(s) familiar with the site.



#### 3.3.1.1 *River Gage Data*

Historical river gage data may be a suitable alternative to on-site water level monitoring under certain very limited circumstances. The U.S. Geological Survey and USACE maintain river gages at dozens of sites across coastal Louisiana, many with records going back for several decades. The gage data can be downloaded from the agencies' websites and analyzed to provide a long-term picture of an area's hydrology, using a procedure similar to that employed by Keim et al. (2006) to assess hydrology for two sites in the Atchafalaya Basin. In this way, an extended period of on-site water level data collection may not be needed, allowing the hydrologic analysis to be completed in a much shorter time frame.

However, for this method to be applicable, 1) there must be a suitable river gage in the vicinity of the site, 2) the river gage must be hydrologically connected to the site being examined, and 3) a mathematical relationship can be established between the river gage data and the corresponding levels of water on the site. Even if these conditions are met, developing a model of this sort can be very complex and will likely require the expertise of a qualified hydrologist or other appropriate consultant.

#### 3.3.1.2 *Documentation by Qualified Professional(s)*

In some instances, knowledgeable natural resource professionals may have observed the subject site over time or collected hydrologic data pertinent to the site. If so, documentation of this information may reduce or eliminate the on-site water monitoring effort needed. The documentation should be provided in writing and signed by the appropriate professional. Qualified individuals for this purpose would typically include experienced natural resources professionals with hydrologic expertise employed

by state and federal agencies, private consulting firms, or university researchers . The professional and his or her employer should be demonstrably independent of the landowner and the management team in order to ensure objectivity in reporting the hydrologic data, results, and conclusions.

To the extent that data are available, the report should contain a detailed discussion of the factors critical in determining the cypress regeneration potential of a site, i.e., seasonality, depth, duration, and frequency of flooding (see “Hydrologic Characteristics to Consider” subsection below). If only a portion of these factors can be addressed, the on-site water level monitoring effort may be reduced accordingly. If all of the critical factors can be adequately addressed, and conclusions reached that are comparable to those that would be derived from actual on-site water level monitoring (see “Data Collection and Analysis” subsection below), then on-site monitoring may be eliminated altogether.

If historical river gage data analysis is conducted for the subject site, or if documentation by qualified professional(s) precludes the need for on-site water level monitoring, sustainability determination can then continue to the next section on salinity assessment. Otherwise, the land manager should proceed with water level monitoring as described below.

### **3.3.2 Hydrologic Characteristics to Consider**

The objective of obtaining and analyzing water level data is to calculate parameters describing the hydrologic regime of the site; specifically the seasonality, depth, duration, and frequency of flooding. These factors are critical in determining the cypress regeneration potential of the site (Keim et al. 2006).

Seasonality refers to the time of year in which flooding occurs. For the purposes of this report we are most interested in inundation levels during the growing season (generally April through October) and the planting season (generally December through February). Growing season flooding is important for several reasons. On one hand, extended flooding during the growing season can limit the potential

for natural bald cypress regeneration which requires exposed soil for germination (Demaree 1932). Additionally, bald cypress seedlings typically cannot survive being overtopped by floodwaters for more than 45 consecutive days during the growing season (Souther and Shaffer 2000). On the other hand, some periodic growing season flooding is necessary to create conditions favorable for bald cypress by reducing competition from other bottomland hardwood species (Mattoon 1915).

Planting season flooding becomes important if the forester or land manager determines that natural regeneration is not likely to be successful, whether due to hydrologic factors or lack of seed source. In that event, artificial regeneration will be necessary to establish or supplement the stand, and the land manager will need to know whether planting is operationally feasible on the site. Artificial regeneration can be practical and successful if seedlings are planted in permanently flooded waters up to 20 inches (51 cm) deep during the planting season (Peters and Holcombe 1951).

Depth and duration of flooding are interrelated in their effect on cypress regeneration. The combination of excessive depth (i.e., above seedling height) and extended duration during the growing season leads to seedling mortality (Conner et al. 1986). Also, depth and duration of flooding during the planting season have operational implications for artificial regeneration as mentioned above.

Frequency of flooding for this discussion refers primarily to the proportion of years during which the site experiences growing season inundation. Water levels on a given site over time may range from fairly consistent to highly variable, depending on such factors as local hydrology, geomorphology, and annual weather patterns. Natural regeneration of bald cypress would be considered more likely to be successful if the site is seasonally inundated, but not permanently flooded during every growing season (Wilhite and Toliver 1990).

Thus analysis of hydrologic data is intended to address the following questions:

- Does the site experience growing season flooding often enough over time to reduce competition from other bottomland hardwood species?

- Is the soil exposed during the growing season often enough over time to allow for natural seed dispersal and germination?
- If germination takes place, can seedlings tolerate the depth and duration of flooding the site typically experiences during the growing season?
- If conditions are not favorable for natural regeneration, would planted seedlings be able to tolerate the expected depth and duration of growing season flooding?
- Is artificial regeneration operationally feasible given the expected depth and duration of planting season flooding?

### 3.3.3 Data Collection and Analysis

Depending on the data needed, collection and analysis of hydrologic data can range from fairly straightforward to very complex. **If the project is likely to be outside the expertise of the land manager, consideration should be given to obtaining the services of a qualified hydrologist or other appropriate consultant** to provide the needed expertise.

To begin, a visual examination of the site and reference to topographic maps will help determine the proper locations for monitoring. Note any hydrologic modifications to the site such as dikes, canals, dams, dredge spoils, pipelines, impoundments, and beaver activity, as these structures will affect the location and direction of water flow on the site. Also note the location of sources of water ingress and egress and the extent of areas that may be inundated when water is present. The objective here should be to develop a sketch of the site that identifies its general hydrologic zones so that monitoring can be conducted as needed in each unique area.

Once these critical locations for monitoring are identified, one or more monitoring points should be established in each area that is relevant to cypress management. The number and location of

monitoring points should be based on the professional judgment of the land manager evaluating the site, and they should be sufficient to provide the information needed to determine sustainability in combination with other available site information. Monitoring points should be physically established by installing a permanent marker such as PVC pipe at the desired location(s). GPS readings should be taken at each point for ease of location during re-measurements and also to re-establish posts that may be removed or destroyed.

If the site is readily accessible and personnel are available to frequently collect data, a simple monitoring equipment setup may be adequate. This may require little more than a U.S. Geological Survey staff gage attached to a post, tree or other structure allowing visual reading of water depth at the monitoring point. (The readings should be documented by digital photos stamped with date and time.) The staff gage data can be supplemented by water depths collected at nearby hydrologically connected locations by use of a weighted sounding reel or similar device.

During the monitoring period, the site should be visited for data collection as often as necessary based on relevant weather and climate events such as significant rainfall, extended droughts, and nearby river crests. Keep a record of dates visited and water depths measured, along with notations of recent local conditions that may be related to the hydrology of the site. Also make note of natural indicators such as water lines or lichen lines that can be used to estimate high water levels. If all or a portion of the site becomes inundated, continue to visit the site periodically to determine the depth and duration of the inundation event.

If the site is not readily accessible, or frequent visitation is impractical, an automated water level recorder system may be preferred. There are a number of suppliers furnishing such equipment, but the general setup often includes the water level sensor unit, a data logger to continuously store information, a transmitter to send data periodically via satellite or cellular networks, a battery charged by a solar panel, and a shelter to protect the equipment. These systems can be considerably more expensive than

manually-read equipment, but can operate unattended for extended periods and can send data directly to a computer for analysis.

When the monitoring period is concluded, data analysis should follow the suggested outline below:

- 1) Calculate the following average annual values for the site:
  - a) Depth, duration, and timing (early, mid, or late growing season) of each growing season flood event
  - b) Annual frequency of flooding, i.e., number of years the site experienced growing season flooding divided by total years during the monitoring period
  - c) Number of consecutive unflooded days during the growing season (Apr 1 – Oct 31)
  - d) Number of days flooded to a depth of 1 ft or less during planting season (Dec 1 – Feb 28).
- 2) Calculate the expected height of newly germinated cypress seedlings after one growing season, based on the number of consecutive unflooded days and an average growth rate of 1 ft (30 cm) per growing season (Williston et al. 1980).
- 3) Compare the expected seedling height with the depth, duration, and timing of growing season flooding to determine whether seedlings would be overtopped for less than 45 consecutive days during the following growing season (Souther and Shaffer 2000); if this is true for at least half of the growing seasons in the monitoring period, natural regeneration may be feasible.
- 4) Calculate the percentage of the planting season that flooding is 1 ft or less; if percentage is at least 50%, planting may be operationally feasible.
- 5) Use duration of growing season flooding and annual frequency of flooding to determine the hydrologic zone of the site (see Figure 3-1).

The results of the above analysis will be used as part of the sustainability determination described later in this section.

### 3.4 Salinity

Salinity is a measure of the amount of soluble salts in soil or water. Many salts can be found in soils, including calcium, magnesium, potassium, sodium, chloride, sulfate, carbonate, and nitrate. Some of these salts are necessary for healthy plant growth and development, while others such as sodium and chloride can become toxic at high concentrations (Saichuk et al. 2009).

Coastal wetlands in Louisiana have in recent decades been exposed to increases in flooding or salinity stress, or both, as a result of a combination of natural processes (e.g., land subsidence) and man-induced alterations of hydrology and sedimentation. Cypress is considered to be more tolerant of flooding compared to other local tree species. However, it is only moderately salt-tolerant, particularly at the seedling stage, which carries implications for regeneration and sustainability in areas where saltwater intrusion occurs. Studies have shown that a combination of flooding and salinity is considerably more detrimental to bald cypress seedlings than the effect of either stress alone, and the detrimental effects of a combination of flooding and salinity increase with increasing salinity (Conner 1994). Wicker et al. (1981) concluded that bald cypress wetlands are often limited to areas where salinity does not exceed 2.0 parts per thousand (p.p.t.) for more than 50% of the time that the trees are exposed to inundation or soil saturation. Similarly, a variety of studies have shown that bald cypress growth decreases substantially in areas where salinity levels remain above 2.0 p.p.t. for extended periods, resulting in eventual transition from bald cypress forest to brackish marsh (Krauss et al. 2009).

To assess the level of salinity on the subject site, begin by examining recent topographic maps, aerial photos, and NRCS soil survey data to determine whether the site appears likely to be affected by tidal influences, saltwater intrusion, subsidence, storm surge, and other sources of salinity. Tide and river gage data can also provide insight regarding seasonal water level variations and long-term trends in overall water levels of the surrounding watershed that may provide opportunities for salinity levels to increase on the site.

If a salinity problem is suspected, a preliminary estimate of salinity levels can be obtained by visual inspection of the site. Indicators of high salinity can include the following:

- Absence of fresh water vegetation
- Presence of brackish water vegetation, e.g., black needlerush (*Juncus roemerianus*), smooth cordgrass (*Spartina alterniflora*)
- Stunted trees with small crowns
- Lack of cypress seedling distribution
- Chlorotic foliage discoloration
- Low overall tree basal area
- Presence of cypress or tupelo snags
- Presence of marine animal species, e.g., crabs, barnacles
- White crusts on soil surface when dry

The presence of these indicators should be documented for the site and recorded by digital photos or other appropriate means. In some cases, these indicators alone can be enough to establish whether salinity levels are acceptable for cypress survival and growth.

Where further confirmation is needed, tests of surface water and soil salinity should be conducted. Surface water salinity is typically tested with an electrical conductivity meter, readily available through forestry and environmental equipment suppliers. Soil salinity can be tested for a nominal fee by sending a sample to the LSU AgCenter; see [www.lsuagcenter.com](http://www.lsuagcenter.com) or contact your local county agent for testing fees and sample collection procedures.

If the site appears to experience cyclical or periodic pulses of saltwater rather than consistent salinity levels, it may be necessary to monitor the salinity of the site for a sufficient period of time to determine the range and duration of salinity on the site. This can be accomplished by establishing shallow monitoring wells consisting of slotted PVC pipe, screened on the bottom, inserted in the soil to a



depth of 2 ft (61 cm), and capped. When data are to be collected, the pipe should be emptied of standing water and then allowed to fill with pore water from the surrounding soil (Krauss et al. 2009). The salinity can then be measured with an electrical conductivity meter. This process should be repeated monthly or as needed based on site conditions including rain events, drought, and storm surges.

Taking all these indicators and testing into account, the objective should be to determine whether salinity levels on the site routinely exceed 2.0 p.p.t. for more than 50% of the time the site is exposed to inundation during the growing season. If this is the case, sustainable cypress management may be limited by excess salinity unless hydrologic restoration can be conducted to ameliorate these effects.

### **3.5 Sustainability Determination**

Upon completion of the site evaluation process as described above, the land manager should now have a thorough understanding of the subject site, along with a significant amount of essential information regarding soils, vegetation, hydrology, and salinity. The reasons for collecting all of these data are to 1) make a determination regarding the potential of the site to support sustainable cypress management and 2) identify appropriate forest management alternatives.

The set of possible classifications for sustainability potential are based on the SWG RCCs (SWG 2005), i.e., sustainable by natural regeneration (Class 1), sustainable by artificial regeneration (Class 2), and not sustainable due to incompatible hydrology or excess salinity (Class 3). For our purposes we further subdivide Class 2 and Class 3 to specify the source of the determination. Thus our sustainability determination categories are:

- 1) **Category RCC-1:** sustainable by natural regeneration. This category is characterized by favorable inundation cycles, an available cypress seed source, and acceptable water depth during growing season to allow natural seedling survival.
- 2) **Category RCC-2a:** sustainable only by artificial regeneration due to shallow prolonged flooding. This category is characterized by extended flooding, acceptable planting conditions, and acceptable depth during the growing season to allow planted seedling survival.
- 3) **Category RCC-2b:** sustainable only by artificial regeneration due to brief infrequent flooding. This category is characterized by infrequent flooding (allowing greater competition from less flood-tolerant hardwood species) but acceptable cypress planting conditions.
- 4) **Category RCC-3a:** not sustainable due to deep prolonged flooding. This category is characterized by extended flooding and excessive depth during the growing season, preventing seedling survival.
- 5) **Category RCC-3b:** not sustainable due to excessive salinity. This category is characterized by frequent flooding combined with high salinity levels.

The **land manager should take into account the totality of evidence** obtained from soils, vegetation indicators, on-site hydrologic monitoring, and salinity to classify the sustainability of the site into one of the above categories, to the best of his or her professional judgment. To aid in this classification, the tables in Appendix C summarize the typical characteristics of each cypress sustainability category.

## 4 Management Recommendations

At the conclusion of the sustainability determination process described above, the land manager should have a well-documented analysis of the data collected and conclusions reached in classifying the site into one of several sustainability categories that are patterned after the RCCs listed in SWG (2005). Based on the sustainability determination, site-appropriate management recommendations are herein provided to support development of a comprehensive management plan for the site. Topics discussed below include recommendations based on site sustainability, techniques for successful regeneration, intermediate stand management, and guidelines for operations in forested wetlands.

These recommendations emphasize forest management activities on sites where bald cypress is the current or historically predominant tree species. (As mentioned in the Introduction, the word “cypress” will be used when referring in general to bald cypress, bald cypress-tupelo, and pond cypress-blackgum forest types; more specific terms such as “bald cypress” will be used when it is necessary to denote a particular species.) These sites may contain a variety of associated species. The presumption is that management recommendations for cypress will also be generally appropriate for associated species, and that management needs for these species will be taken into account in tract-specific forest management plans.

The recommendations are believed to be consistent with applicable federal and state regulatory requirements and voluntary guidelines for forest management in Louisiana. However, **the land manager should always use professional judgment in deciding whether a particular activity is appropriate for a specific site, and seek additional scientific and legal guidance whenever necessary.**

**Note:** The methodology described below presumes familiarity with the concepts and background information presented in the Essential Knowledge for Land Managers section of this report.

## 4.1 Recommendations by Sustainability Category

Based on the sustainability determination outlined above, the overall management recommendations for each sustainability category are as follows:

1) Category RCC-1: sustainable by natural regeneration

- The site may be sustainably managed for cypress using natural regeneration
- Harvesting in established stands should be designed to encourage natural regeneration
- Artificial regeneration may also be used to supplement natural regeneration if planting is operationally feasible

2) Category RCC-2a: sustainable only by artificial regeneration due to shallow prolonged flooding

- Artificial regeneration must be used if the site is to be sustainably managed for cypress
- Once established, cypress would tend to persist as a primary component of the stand
- Normal silvicultural management of existing stands can be conducted if artificial regeneration is planned following harvest. Long-term establishment must be secured and monitored or conversion to marsh or open water will occur.

3) Category RCC-2b: sustainable only by artificial regeneration due to brief infrequent flooding

- The hydrology of the site favors less flood-tolerant species
- Without intensive management, harvest of existing cypress would tend to reduce the cypress component of the site over time due to competition from other vegetation
- Artificial regeneration must be used if the site is to be sustainably managed for cypress

## 4) Category RCC-3a: not sustainable due to deep prolonged flooding

- The hydrology of the site prohibits both natural and artificial regeneration
- Established cypress would tend to persist as a primary component of the stand
- Harvest of existing cypress would not be sustainable without restoration to reestablish favorable hydrologic conditions.

## 5) Category RCC-3b: not sustainable due to excessive salinity

- High salinity levels on the site prohibit both natural and artificial regeneration
- Established cypress may need to be harvested if capture of anticipated mortality is desired
- Harvest of existing cypress would not be sustainable without restoration to ameliorate the effects of salinity on the site.

The remainder of this section provides further detail on recommended regeneration practices and management of established cypress stands.

## 4.2 Regeneration

Successful cypress regeneration techniques vary depending on the hydrology and other characteristics of the subject site. The following discussion and associated Table 4-1 will outline suggested regeneration techniques for each RCC sustainability category.

**Category RCC-1 sites:** sustainable by natural regeneration. Generally connected to a fresh water source and are flooded annually for some period of time while also experiencing dry cycles during the

year. These sites are usually suitable for both natural and artificial regeneration. Natural regeneration can develop from seed or seedlings in place. Stump sprouting is possible if trees are less than 12 inches (30 cm) in basal diameter, but it is very unpredictable and unreliable. Hence, we recommend it as a potential for supplemental regeneration only. Group Selection or whole stand clearcuts are most effective for encouraging cypress regeneration, which is moderately shade intolerant. Based on observation of cutover stands, seed tree and shelterwood methods have potential, but the leave tress require reentry into the stand for final harvest which can be expensive and difficult to execute in wetlands. Artificial regeneration can be accomplished by planting seedlings. On some sites, with more limited flooding, competition control may be necessary.

**Category RCC-2a sites:** sustainable only by artificial regeneration due to shallow prolonged flooding. These sites are not suitable for natural regeneration because seed either cannot germinate or is overtopped by water after germination. Artificial regeneration by planting seedlings tall enough to maintain at least 50% of the crown above water is the best option for regeneration. Harvest cuts should result in full sunlight to encourage cypress seedling height growth and development.

**Category RCC-2b sites:** sustainable only by artificial regeneration due to brief infrequent flooding. These somewhat drier sites are not suitable for natural regeneration because seedlings will not survive competition from less flood-tolerant species. Intensive management including mechanical and chemical site preparation along with artificial regeneration may be necessary to establish cypress on these sites.

**Category RCC-3a sites:** not sustainable due to deep prolonged flooding. These sites are not suitable for natural or artificial regeneration.

**Category RCC-3b sites:** not sustainable due to excessive salinity. These sites are not suitable for natural or artificial regeneration.

Below are additional factors to consider when planning for cypress regeneration:

- 1) Management plan should evaluate regeneration options prior to harvest.
- 2) On sites suitable for management that can be reliably regenerated naturally, schedule ground-based harvesting in late fall or early winter. This is typically the driest time of the year which will minimize soil disturbance. During this time of year seed fall has occurred and stump sprout vigor peaks, perhaps resulting in better sprouting, but sprouts will most likely be an unreliable and minor component of the resulting regeneration. Clearcutting with reliance on stump-sprout regeneration is not recommended for sustainable cypress management. Sprouts may provide a supplemental source of natural regeneration in intermediate harvests, but only where stump diameter is small and harvests provide substantial light for rapid growth. This method is untested for coastal Louisiana conditions and needs further research. Research suggests stump-sprout regeneration is unreliable in stands of moderate and larger size bald cypress.
- 3) For artificial regeneration, completely harvest standing stems of all species to allow maximum sunlight into the regenerating stand (by group selection, strip clearcuts, or typical clearcuts). Cypress is an early successional species and is moderately shade intolerant. On otherwise favorable sites, intermediate harvests will likely favor hardwood species that are more shade tolerant.
- 4) Direct seeding is not recommended for artificial regeneration of cypress. Nursery-grown seedlings may be bare-root or containerized. Bare-root seedlings should be at least 12 inches (30 cm) in height with a root collar diameter of at least  $\frac{1}{4}$  inch (6 mm), and should be undercut at about 6 to 8 inches (15 to 20 cm) in the nursery beds.
- 5) Cypress seedlings are usually hand-planted. Densities of 436 to 680 trees per acre (1,077 to 1,680/ha) are common for wood products objectives, but lower densities may be suitable for wildlife or ecological purposes. On sites where nutria predation is expected, seedling protectors should be installed.

- 6) Regeneration success should be evaluated at years 1, 3, and 5 after harvest to ensure sufficient regeneration. For wood products objectives, LASAF recommends having a minimum of 300 to 400 stems per acre (740 to 990 stems/ha) of well-established 3 to 5 ft tall (0.9 to 1.5 m) cypress or tupelo somewhat uniformly distributed across the site. For wildlife or ecological purposes, or where timber management is not the primary use, 80 to 100 stems per acre (198 to 247 stems/ha) should be sufficient to establish a minimal cypress stand.
- 7) In all regeneration harvests, retain any species of tree 36 inches in diameter (91 cm) or greater with visible cavities as den trees for the Louisiana black bear (*Ursus americanus luteolus*). Although Louisiana black bears are known to utilize any species of tree with large cavities in wetland sites as den sites, the Endangered Species Act rule only legally protects cypress and tupelo with visible cavities, and occurring in or along rivers, lakes, streams, bayous, sloughs, or other waterbodies. “Actual den tree” refers to any tree used by a denning bear during the winter and early spring seasons.



**Table 4-1.** Recommended cypress regeneration systems.

Site Category	Natural Regeneration			Artificial Regeneration
	Group Selection	Strip Clearcut	Seed Tree	Clearcut and other methods
RCC-1 – favorable hydrology	A	A	C	A
RCC-2a – shallow prolonged flooding	D	D	D	A
RCC-2b – infrequent flooding	D	D	D	B
RCC-3a – deep prolonged flooding	D	D	D	D
RCC-3b – excess salinity	D	D	D	D

A – Highly effective

B – Effective

C – Untested, but probably less effective

D – Not recommended

### 4.3 Intermediate Stand Management

Once a cypress stand is established according to the regeneration guidelines described above, subsequent management of the stand will be dictated in large part by the landowner's objectives for the property. Where timber production is contemplated, decisions regarding levels of harvest and their effect on stand characteristics can be aided by previous studies on cypress thinning and stocking as described in the Silvics and Silviculture section of this document.

As described previously, Putnam et al. (1960) developed a stocking and yield guide for well-managed even-aged tupelos on average or better sites. Also provided were average diameter growth rates by species as well as adjustment factors by which bald cypress data could be derived from the tupelo data. Using this information, a stocking guide can be developed for bald cypress as shown in Table 4-2.

Each column of the table describes the characteristics of the stand as a whole, at the time the stand has attained the average diameter shown in the heading. Following a growth period during which the average stand diameter increases by 4 inches (10 cm), the resulting stand characteristics are shown in the next column. The duration of each growth period will vary with size of leave trees, site, species composition, and other factors. However, estimates of the approximate age of the stand at the end of each growth period are shown for unmanaged average sites and well-managed better sites to give an idea of the range of likely growth rates. Stand improvement is assumed to be the goal of each thinning, i.e., cut trees are the smaller, lower-quality stems and leave trees are the larger, more vigorous stems.

Stand density index (SDI) provides another method for evaluating cypress stocking levels. In its most commonly-used form as proposed by Reineke (1933), SDI is a measure of site occupancy in relation to a reference stand with a quadratic mean diameter of 10 inches (25 cm). The general form of the SDI equation in English units is:

$$SDI = N(Dq/10)^{1.605}$$

where SDI = stand density index,  $N$  = trees per acre, and  $Dq$  = quadratic mean diameter. So for example, if  $N = 200$  and  $Dq = 10$ , SDI will be 200, i.e., the same as the number of trees per acre because the stand diameter is equal to the reference diameter of 10. If  $N$  remains at 200 and  $Dq$  is increased to 14, SDI will become 343; this can be interpreted that a stand with an average diameter of 14 inches (36 cm) and 200 trees per acre (494 trees/ha) is equivalent in density to the reference stand (average diameter of 10 inches (25 cm)) at 343 trees per acre (848 trees/ha).

SDI expressed in metric units can be divided by 2.47 to obtain an approximate value for SDI in English units. Using this conversion factor, the maximum cypress SDI of 1,200 (metric units or si) reported by Keim et al. (2010) would equate to an SDI of approximately 485 in English units. This can be interpreted to mean that a cypress stand with an average diameter of 10 inches (25 cm) would support a maximum of 485 trees per acre (1,198 trees/ha). Similarly, the fully-stocked cypress SDI of 660 si noted above would equate to an SDI of approximately 265 in English units. This can be interpreted to mean that a cypress stand with an average diameter of 10 inches (25 cm) could support up to 265 trees per acre (655 trees/ha) before self-thinning would begin to occur. Thinning to 40% of maximum SDI (480 si) as described by Keim et al. (2010) above would indicate a target residual SDI of 195 in English units.

Keim et al. (2010) found that well stocked cypress stands will reach a maximum SDI of approximately 1,200 si as a standard, which appears to be similar to many other species. Cypress stands are considered to be fully stocked (the level at which self-thinning would begin to occur) at an SDI of 660 si, which corresponds approximately to the Putnam et al. (1960) and Goelz (1995) estimates of full stocking. Thinning to 40% of maximum SDI was found to increase diameter and net volume increment. The 40% level can be viewed as a residual stand target for timber stand improvement, and corresponds well with the Putnam et al. (1960) and Goelz (1995) estimates of the minimum cypress stocking needed for adequate site utilization.

A residual SDI of 480 si corresponds closely with the leave-tree recommendations for each diameter class shown in Table 4-2. Thus for practical purposes, cypress harvest levels can be guided either by target SDI levels or by referring to Table 4-2, whichever is preferable to the land manager.

The above information regarding intermediate stand management can be illustrated by way of example. Outlined below are example guidelines for two management regimes – intensive stand management emphasizing timber production and limited stand management emphasizing ecological objectives. Though there can be considerable overlap between the two regimes, with timber production providing significant ecological benefits and vice versa, the regimes are intended to highlight key differences in silvicultural practices as well as tradeoffs that may need to be considered. These contrasting examples encompass the spectrum of cypress management scenarios likely to be encountered in practice. **Actual management plans for a specific site should be guided by applicable regulations, landowner objectives, consultation with natural resource managers, sustainability considerations, and numerous other factors as described throughout this report.**

### **Intensive Stand Management**

Management goal: Maximize and accelerate the growth of large diameter trees for sawtimber or aesthetics; capture future loss due to mortality.

1. Let stand develop to a full stocking of SDI 660 si (265 English units) or to the basal area appropriate for average stand diameter per Table 4-2.
2. Thin stand to SDI 480 si (40% of maximum SDI) or as suggested by Table 4-2, favoring dominant and codominant trees for retention. A more intensive approach that would result in larger diameter trees would be to thin the stand to SDI 300 si or 25% of the maximum SDI of 1,200 si.
3. Continue periodic harvests as dictated by stand growth and development.

4. As stand approaches economic maturity, conduct an updated sustainability analysis to determine regeneration potential.
5. If the site still meets RCC-1 or RCC-2 sustainability categories, refer to regeneration guidelines for natural or artificial regeneration best practices.

### **Limited Stand Management**

Management Goal: Perpetuate stand in a natural condition for aesthetics and ecosystem health; no capture of mortality.

1. Let stand develop naturally over time. As stand exceeds full stocking at SDI of 660 sj, self-thinning of suppressed and intermediate trees will occur, and dominant and codominant trees will continue to grow at a slower rate.
2. If encouragement of uneven-aged structure is desired, conduct an updated sustainability analysis to determine regeneration potential.
3. If the site still meets RCC-1 or RCC-2 sustainability categories, conduct timber harvest to reduce number of dominant and codominant trees to open up the stand.
4. Optionally, leave felled trees on site to provide ancillary ecological benefits.
5. Refer to regeneration guidelines for natural or artificial regeneration best practices.

**Table 4-2.** Stocking and harvest per acre for even-aged bald cypress at the end of successive diameter growth periods.<sup>1</sup>

Average Stand Diameter ( <i>in.</i> )		6	10	14	18	22	26	30	34	38	42
Diameter growth rate <sup>2</sup>	Unmanaged	2.3	2.3	2.6	2.6	3.2	3.2	2.7	2.7	2.7	2.7
	Intensively managed <sup>3</sup>	3.0	3.0	3.4	3.4	4.2	4.2	3.5	3.5	3.5	3.5
Age <sup>4</sup>	Unmanaged	26	43	61	76	92	104	117	131	146	161
	Intensively managed	20	33	47	59	70	80	90	101	113	124
Before harvest	Number of trees	666	285	161	105	74	55	42	32	24	19
	Basal area ( <i>sq.ft.</i> )	131	155	172	184	194	201	205	202	197	183
	Stand density index <sup>5</sup>	293	285	276	268	261	255	244	227	206	187
	Sawtimber volume ( <i>mbf</i> )	0.0	0.0	3.8	10.3	15.9	20.5	24.4	28.3	32.2	36.0
	Pulpwood volume ( <i>cds</i> )	16.8	29.8	26.1	7.5	6.3	6.7	5.9	5.7	4.4	2.8
Cut trees	Number of trees	381	124	56	31	19	13	10	7	6	19
	Basal area ( <i>sq.ft.</i> )	75	68	60	54	50	48	47	45	47	183
	Sawtimber volume ( <i>mbf</i> )	0.0	0.0	0.0	1.2	2.5	3.2	3.8	4.1	4.8	36.0
	Pulpwood volume ( <i>cds</i> )	6.4	8.2	21.2	0.9	1.0	1.0	0.9	0.8	0.7	2.8
After harvest	Number of trees	285	161	105	74	55	42	32	25	19	0
	Basal area ( <i>sq.ft.</i> )	56	87	112	130	144	153	158	157	150	0
	Stand density index <sup>5</sup>	126	161	180	190	195	195	187	178	162	0
	Sawtimber volume ( <i>mbf</i> )	0.0	0.0	3.8	9.1	13.4	17.3	20.6	24.2	27.4	0.0
	Pulpwood volume ( <i>cds</i> )	10.4	21.6	4.9	6.6	5.3	5.7	5.0	4.9	3.7	0.0

<sup>1</sup>Adapted from Putnam et al. (1960)<sup>2</sup>Ten-year average diameter growth rate for bald cypress stands by diameter class (Putnam et al. 1960)<sup>3</sup>Assumes 30% improvement in diameter growth rate for intensively managed stands (Putnam et al. 1960)<sup>4</sup>Approximate stand age calculated from ten-year diameter growth rates<sup>5</sup>In English units per Reineke's (1933) formula

#### 4.4 Guidelines for Operations in Wetlands

Prior to initiating management activities in forested wetlands, the **land manager should become thoroughly familiar with all relevant federal and state statutes and regulations**, as well as any voluntary guidelines promulgated for these purposes. Consideration should also be given to the type of harvesting system to be employed and its related water quality effects. A summary of applicable regulations and harvesting systems is provided in the Essential Knowledge for Land Managers section of this report.

The operational guidelines presented in the remainder of this subsection represent a compilation of applicable provisions adapted from the Louisiana, Mississippi, and Florida state forestry BMP manuals (Louisiana Department of Agriculture and Forestry 2000, Mississippi Forestry Commission 2008, Florida Department of Agriculture and Consumer Services 2011).

##### 4.4.1 General Guidelines

The following are general guidelines applicable to most operations:

- To the greatest extent possible, ground-based forestry operations in wetlands that exhibit seasonal inundation or saturation should be limited to dry conditions, and forestry operations in wetlands that are continually saturated or inundated should be limited to low-water conditions and to sites that can and will be regenerated.
- When excessively wet harvesting conditions are unavoidable, low ground pressure equipment such as dual-tire skidders, tracked machines or special techniques such as “mat-logging” or “shovel-logging” should be employed where practical and economically feasible.
- Use low pressure and high flotation tires or wide tracks where possible, so that excessive damage to residual stand will not occur.

- Fell trees away from watercourses if possible.
- After harvesting, remove any obstructions in channels resulting from harvesting operations.
- Limit operations on sensitive sites and in SMZs during periods of wet weather.

#### **4.4.2 Forest Roads**

As mandated by Amendments to the CWA, forest roads in jurisdictional wetlands including “waters of the United States” must be constructed and maintained in accordance with the 15 federally mandated BMPs to retain Section 404 exemption status. Construction and maintenance of all roads, whether permanent or temporary, must follow these BMPs. In addition to the 15 federally mandated BMPs for roads in wetlands, the following guidelines are also suggested:

- Locate, design, and construct forest roads according to pre-harvest planning.
- Use temporary roads whenever possible in forested wetlands.
- Construct permanent roads only to serve large and frequently used areas, as approaches to watercourse crossings, or to provide access for long-term fire protection.
- Construct fill roads only when absolutely necessary for access since fill roads have the potential to restrict natural flow patterns. Provide adequate cross drainage to maintain the natural surface and subsurface flow of the wetland.
- Where feasible, construct roads at natural ground level to minimize the potential to restrict flowing water.
- Minimize use of roads during excessively wet periods.
- Where possible, minimize rutting and soil compaction.
- Repair roads prior to leaving the tract.



In general, a road is used for transport of equipment and forest products to and from locations other than the current work site.

#### **4.4.3 Skid Trails**

Skid trails provide temporary access for movement of wood within the harvest area. When properly used and maintained, skid trails will have minimal affect on water quality, hydrology, and other wetland functions. Skid trails are different from roads, and they are used to transfer harvested forest products within the site. Use of skid trails is generally limited to off-road vehicles and equipment.

##### **Guidelines for Skidding in Wetlands**

- Minimize use of skidders or other heavy equipment during wet conditions to reduce widespread excessive soil rutting, if possible.
- When wet harvesting conditions are unavoidable due to permanent flooding, low ground pressure equipment such as dual-tire skidders, tracked machines, or special techniques such as “mat-logging” or “shovel-logging” should be employed where practical and economically feasible to reduce rutting.
- When skidding in wetlands with organic soils, concentrate skid trails to as small an area as possible and minimize the number of trails on a given site.
- Keep skidder loads light when rutting is evident.
- To minimize effects, wet areas that must be crossed with equipment can be stabilized by using mats. There are a variety of mat types that are commonly used to cross wet areas. If multiple layers of mats are necessary, they should be limited to no more than 3 layers.

- When using mat or shovel logging, minimize the width of skid trail mats. Mats should not exceed 20 ft (6 m) in width on average, except for sections of the trail where it is necessary for equipment to pass. In these sections the maximum width may be doubled to 40 ft (12 m).
- Also minimize the number of skid trail mats. Typically, trails should not be spaced closer than 200 ft (61 m) on average. Where conditions prohibit tracked machines from operating off the mat, spacing may be reduced to 50 ft (15 m) in order to minimize site disturbance. However, under no conditions should skid trail mats exceed 25% of the harvest area.
- If timber is used for skid trail mats, it should be laid down in the direction of the trail under normal conditions. Use only one layer of timber for skid trail mats, except where multiple layers are necessary to minimize site disturbance. Where multiple layers of timber are necessary to construct the skid trail mat, the bottom layer may be laid down perpendicular to the trail, and it may exceed 20 ft (6 m) in width to maximize weight distribution.
- Merchantable material in skid trail mats should be removed after the logging operation is complete.
- Ruts should not be present to the extent that they impede, restrict, or change natural water flows and drainages. The determination of excessive rutting is highly subjective and must be made only by a forester or other qualified individual who evaluates rutting extent, depth, soil type, direction and position, and other local factors.

Table 4-3 below summarizes some of the more common skid trail materials that can be used in wetland situations.

**Table 4-3.** Skid trail materials for use in wetlands. Adapted from Louisiana, Mississippi, and Florida state forestry BMP manuals (Louisiana Department of Agriculture and Forestry 2000, Mississippi Forestry Commission 2008, Florida Department of Agriculture and Consumer Services 2011).

Material	Description
Wood Mats	Individual cants strung together with cables to make a single layer crossing.
Wood planks & panels	Wood planks or panels are constructed using lumber planking to create a two-layered mat. Parallel runners are laid down on each side where tires will pass.
Wood pallets	Wood pallet mats are sturdy and commercially available.
Bridge decking	Timber bridge decking can be used to cross small wet areas.
Expanded metal grating	Relatively light and offers some traction.
PVC or HDPE Pipe	A PVC and HDPE pipe mat is constructed using at least 4-inch (10 cm) diameter pipes that are tightly connected using steel cables.
Tire Mats	Used tire sidewalls fastened together to form mats suitable for crossing wet areas.
Corduroy	Small brush and logs cut from non-commercial trees on site and placed perpendicular to the direction of travel.
Pole Rails	Similar to corduroy mat, but poles or logs are laid parallel to direction of travel.
Alternating layers	Brush or logs are layered in perpendicular layers to create a sturdy travel surface.

#### 4.4.4 Canals

Because canals are often connected to streams, lakes or other waterbodies, forestry activities adjacent to canals have the potential to affect water quality through such connections. For the purposes of these guidelines, the term canal does not include natural streams that have been hydrologically modified by dredging or straightening to enhance their efficiency to transport water. Although such “modified streams” may have been significantly altered, they are still geographically located to receive and transport storm water and thus are connected directly to other waters. In most cases, they continue to perform important natural stream functions particularly if they have associated wetlands. BMPs for modified streams (including SMZ criteria) are identical to those for any other naturally occurring perennial or intermittent stream, except for maintenance activities. Canals, for the purposes of these guidelines, are totally man-made and generally independent from natural drainage features. As artificial systems, canals exhibit only periodic and limited characteristics of natural streams and usually receive periodic maintenance. Canals do not include forestry road-side ditches or upland field ditches.

The following guidelines are recommended when operating near canals in wetlands:

- A minimum buffer of 50 ft (15 m) on either side of a channel, oxbow, or flow-way is recommended to trap sediment and logging debris, preventing downstream effects.
- During normal silvicultural operations, do not operate heavy equipment within canals or in such a manner as to result in damage to the canal bank.
- Avoid canal crossings when possible. Where necessary, construct crossings in accordance with the Stream Crossings section of publication “Recommended Forestry Best Management Practices for Louisiana.”

- Do not conduct bedding, chopping or other site preparation activities in such a way that results in direct surface water discharge into a canal.
- Avoid dropping logging slash in canals; remove significant amounts of logging slash from canals.
- Do not discharge pesticides not approved for aquatic use, fertilizer, or other pollutants into canals. Do not dispose of chemical containers or equipment rinse water in canal waters.
- Maintenance for modified streams and canals should be minimized. When necessary, conduct canal re-dredging during periods of low flow. Minimize disturbance to canal banks and retain as much “streamside” vegetation as possible.
- Use appropriate erosion, sediment, and turbidity control practices to reduce sediment transport.

## 5 Conclusions and Research Needs

A substantial amount of what is known about the ecology and management of cypress is based on field experience rather than rigorous research, and therefore, the species has not been studied in nearly as much detail as other commercially valuable southern U.S. trees. In addition, the native habitat of the species (i.e., frequently flooded wetland areas) creates operational challenges for routine management activities. Stewardship of cypress forests in Louisiana would be facilitated by additional research related to soil productivity, effectiveness of regeneration methods, growth and yield, harvest regimes for various management objectives, improvement of techniques for equipment access and operation, and effect of forest management activities on other ecological attributes.

The sustainability determination methodology presented herein is designed for immediate implementation by relying on existing scientific knowledge, currently available equipment and technology, and expertise readily available from qualified natural resource professionals. A drawback of this approach is that completion of the sustainability determination on a site may require a substantial investment of time, particularly if extended water level monitoring is required. The process could be greatly facilitated by research into rapid assessment techniques including testing of field evaluation criteria, refinement of vegetation and salinity indicators and sampling methods, and remote sensing and spatial analysis of hydrology at tract-level scales.

The cypress management recommendations and wetland operational guidelines developed for this report are based on the best available information consistent with applicable regulatory requirements. As knowledge improves and regulations change over time, management plans should incorporate these new developments. The best approach is to practice adaptive management, creating a circular process that includes plan development, implementation, monitoring, and feedback into revised plans. In this

way, continual improvement in stewardship of our treasured cypress resources in Louisiana can be assured for future generations to come.

Cypress has played an important role in the ecology, economy, and culture of Louisiana, but these forests are much reduced from their former extent. In light of the exacting regeneration requirements of the species, and given the many challenges posed by altered hydrology in coastal Louisiana, restoration and stewardship of our cypress forests will require a sustained, collective effort among a broad community of stakeholders if long-term success is to be achieved.

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## **Appendices**

### **Appendix A: Cypress Soils by Productivity Class**

(Tables begin on next page.)

**Appendix A-1: Class A – Productive Cypress Soils**

Soils that exhibit a potential for establishing and supporting the growth and development of naturally regenerated cypress stands. Source: analysis of USDA Forest Service, Forest Health Technology Enterprise Team (Ellenwood et al. 2009) and NRCS National Soil Information System (NASIS) data.

<b>Parish Map Unit Symbol</b>	<b>Map Unit Name</b>	<b>Soil Order</b>
AR, ARA	Arat mucky silt loam	Entisol
BA, BAA, BB, BBA, BRA	Barbary muck association, frequently flooded, 0 to 1 % slopes	Entisol
BB	Basile and Guyton silt loams, frequently flooded	Alfisol
BEA	Basile and Casilla silt loams, frequently flooded	Alfisol
BSA	Basile and Brule soils, 0 to 3 % slopes, frequently flooded	Alfisol
CH	Carville-Barbary association	Inceptisol
CN	Carville and Schriever soils, undulating, frequently flooded	Vertisol
CS	Cancienne and Schriever soils, frequently flooded	Vertisol
CV	Carville, Cancienne, and Schriever soils, frequently flooded	Vertisol
DO, DW	Dowling association, frequently flooded	Inceptisol
FA, FAA	Fausse association, frequently flooded	Inceptisol
FC	Fausse-Carville association	Inceptisol
FE	Fausse soils	Inceptisol
Hf	Harahan clay, frequently flooded	Inceptisol
HYA, CVA, GW	Hydraquents, Carville, and Glenwild soils, undulating, flooded	Entisol
Se , Sv	Schriever clay, frequently flooded	Vertisol
SF	Schriever-Fausse soils	Vertisol
Sf , Sk, SkA	Sharkey clay, frequently flooded	Vertisol
Sh, SIA, Sk, Sm	Schriever clay, frequently flooded	Vertisol
SY	Sharkey and Fausse soils	Vertisol



**Appendix A-2: Class B – Manageable Cypress Soils (p. 1 of 2)**

Soils that exhibit a potential for establishing and supporting the growth and development of artificially regenerated cypress stands with intensive management. Source: analysis of USDA Forest Service, Forest Health Technology Enterprise Team (Ellenwood et al. 2009) and NRCS National Soil Information System data.

Parish Map Unit Symbol	Map Unit Name	Soil Order
AD, AT	Aquents, dredged, frequently flooded	Entisol
At	Alligator soils, frequently flooded	Vertisol
Cd	Caddo-Messer silt loams	Alfisol
Cm	Cancienne silt loam	Inceptisol
Cn	Cancienne silty clay loam, frequently flooded	Inceptisol
CO	Convent soils, frequently flooded	Inceptisol
CR, CT	Cancienne and Carville soils, frequently flooded	Inceptisol
Cr, Cw	Crowley-Vidrine silt loams	Alfisol
CrB	Crowley silt loam, 1 to 3 % slopes	Alfisol
Cy	Crowley-Patoutville silt loams	Alfisol
Cy	Colyell-Springfield silt loams, frequently flooded	Histosol
DE	Delcomb muck association	Histosol
FA	Fausse muck, saline	Inceptisol
FE	Felicity loamy fine sand, frequently flooded	Entisol
Fo, Fr	Frost silt loam, occasionally flooded	Alfisol
GB, GDA, GE	Ged mucky clay	Alfisol
Go, Gy	Guyton silt loam, occasionally flooded	Alfisol
GU, GUA	Guyton and bienville soils frequently flooded	Alfisol
Ha, HpA	Harahan clay	Inceptisol
Ib, IEA	Iberia silty clay	Vertisol
Ja, JeA	Jeanerette silt loam	Mollisol
Jd, JdA, Ju	Judice silty clay loam	Vertisol
Ka, Kd	Kaplan silt loam	Alfisol
Kd, KrA	Kinder-Messer silt loams	Alfisol
KvA	Kinder-Vidrine silt loams, 0 to 1 % slopes	Alfisol
Lt, LtA	Leton silt loam, occasionally flooded	Alfisol
Mn	Midland silty clay loam	Alfisol
Mr	Morey loam	Mollisol

Continued on next page

## Appendix A-2, continued (p. 2 of 2):

Parish Map Unit Symbol	Map Unit Name	Soil Order
Mt, MtA	Mowata-Vidrine silt loams	Alfisol
My	Myatt fine sandy loam, frequently flooded	Ultisol
Pa, PaA	Patoutville silt loam, 0 to 1 % slopes	Alfisol
PC	Placedo association	Entisol
PcA	Patoutville-Crowley silt loams, 0 to 1 % slopes	Alfisol
Sh, Sg, SS	Sharkey clay	Vertisol
Sh, SkA, Sr	Schriever clay	Vertisol
UN	Una silty clay loam, frequently flooded	Inceptisol
Ww	Westwego clay	Entisol

**Appendix A-3: Class C – Low-Productivity Cypress Soils**

Mucky soils which would require hydrological restoration to establish and support the growth and development of artificially regenerated cypress stands. Source: analysis of USDA Forest Service, Forest Health Technology Enterprise Team (Ellenwood et al. 2009) and NRCS National Soil Information System data.

<b>Parish Map Unit Symbol</b>	<b>Map Unit Name</b>	<b>Soil Order</b>
AC, AD, Ad, AE, Ae, AEA, AR	Allemands muck	Histosol
AG, AY	Andry muck	Mollisol
AN	Allemands-Larose association	Histosol
ARA	Allemands and Carlin soils, very frequently flooded	Histosol
BA	Bancker muck	Entisol
BE, BP, BSA	Bellpass muck	Histosol
CE CKA ,CL, CV, CYA	Clovelly muck	Histosol
CR	Creole mucky clay	Entisol
Gy	Gueydan muck	Entisol
KE, KEA	Kenner muck	Histosol
LA	Lafitte-Clovelly association	Histosol
LAA, LF	Lafitte muck, very frequently flooded, slightly saline, tidal	Histosol
LE, LR, LRA	Larose mucky clay	Entisol
LEA	Larose muck, very frequently flooded	Histosol
MA, MAA, MP	Maurepas muck, frequently flooded	Histosol
Ra	Rita mucky clay	Inceptisol
SC	Scatlake mucky clay	Entisol
TM	Timbalier muck	Entisol

**Appendix B: Flood Tolerance Index Numbers by Vegetation Stratum (p. 1 of 3)**

Flood Tolerance Index (FTI) numbers of species commonly occurring in Louisiana bottomland forests and associated terraces and old ridges (adapted from Theriot 1993).

Scientific Name	Common Name	Overstory		Midstory		Understory	
		FTI Mean	+/- Std Dev	FTI Mean	+/- Std Dev	FTI Mean	+/- Std Dev
<i>Acer negundo</i>	boxelder	4.83	0.47	5.20	0.99	5.58	0.96
<i>Acer rubrum</i>	red maple	4.21	0.68	4.96	0.94	4.63	1.10
<i>Acer rubrum</i> var <i>drummondii</i>	Drummond's maple	3.48	0.12	3.68	0.57	3.64	0.19
<i>Acer saccharinum</i>	silver maple	3.75	0.36	3.50	0.00		
<i>Amelanchier arborea</i>	common serviceberry			6.50	0.00		
<i>Amorpha fruticosa</i>	false indigo bush			4.08	0.59	3.78	0.00
<i>Aralia spinosa</i>	devil's walkingstick			6.50	0.00	6.50	0.00
<i>Arundinaria gigantea</i>	giant cane			5.41	1.66	5.34	1.42
<i>Asimina parviflora</i>	smallflower pawpaw			6.50	0.00		
<i>Asimina triloba</i>	pawpaw			6.50	0.00		
<i>Betula nigra</i>	river birch	4.01	1.73	4.50	2.00	4.50	0.00
<i>Bumelia lanuginosa</i>	gum bully	6.50	0.00				
<i>Bumelia lycoides</i>	buckthorn bully	4.50	0.00				
<i>Callicarpa americana</i>	American beautyberry			6.39	0.20	6.39	0.22
<i>Carpinus caroliniana</i>	American hornbeam	4.84	0.61	5.07	0.43	4.84	0.35
<i>Carya alba</i>	mockernut hickory			6.50	0.00	6.50	0.00
<i>Carya aquatica</i>	water hickory	3.54	0.34	3.70	0.38	3.69	0.52
<i>Carya cordiformis</i>	bitternut hickory	6.50	0.00				
<i>Carya glabra</i>	pignut hickory			6.50	0.00	6.50	0.00
<i>Carya illinoensis</i>	pecan	5.57	1.01	5.00	0.71	6.50	0.00
<i>Carya tomentosa</i>	mockernut hickory	6.50	0.00				
<i>Castanea pumila</i>	chinkapin			6.50	0.00	6.50	0.00
<i>Celtis laevigata</i>	sugarberry	4.84	0.56	4.37	0.38	4.77	0.81
<i>Cephalanthus occidentalis</i>	common buttonbush	2.83	0.52	3.13	0.44	3.18	0.49
<i>Cercis canadensis</i>	eastern redbud	5.50	1.40	6.37	0.22	6.50	0.00
<i>Chionanthus virginicus</i>	white fringetree			6.50	0.00	6.50	0.00
<i>Clethra alnifolia</i>	sweetpepperbush			5.32	1.67	5.50	1.41
<i>Cornus drummondii</i>	roughleaf dogwood	4.50	0.00	5.69	0.90	5.73	0.00
<i>Cornus florida</i>	flowering dogwood	6.50	0.00	6.50	0.00	6.50	0.00
<i>Cornus foemina</i>	stiff dogwood	5.50	0.00	4.70	0.90	5.25	0.98
<i>Crataegus aestivalis</i>	may hawthorn	3.00	0.70	2.98	0.15	3.50	1.41
<i>Crataegus flava</i>	yellowleaf hawthorn			6.50	0.00		
<i>Crataegus marshallii</i>	parsley hawthorn			5.37	1.63	6.50	0.00
<i>Crataegus viridis</i>	green hawthorn	4.52	0.58	4.46	0.65	4.09	0.77
<i>Cyrilla racemiflora</i>	swamp titi	3.50	0.00	3.72	0.00	3.79	0.00
<i>Diospyros virginiana</i>	common persimmon	4.13	0.82	5.08	1.18	4.59	0.94
<i>Fagus grandifolia</i>	American beech	6.50	0.00	6.50	0.00	6.50	0.00
<i>Forestiera acuminata</i>	eastern swampprivet	3.48	0.50	3.57	0.54	3.32	0.36
<i>Fraxinus americana</i>	white ash	6.50	0.00	6.50	0.00		
<i>Fraxinus caroliniana</i>	Carolina ash	2.87	0.41	2.91	0.33	3.00	0.45

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## Appendix B, continued (p. 2 of 3):

Scientific Name	Common Name	Overstory		Midstory		Understory	
		FTI Mean	+/- Std Dev	FTI Mean	+/- Std Dev	FTI Mean	+/- Std Dev
<i>Fraxinus pennsylvanica</i>	green ash	4.44	0.67	4.27	0.70	4.00	1.29
<i>Fraxinus profunda</i>	pumpkin ash	3.87	1.41	2.91	0.33	3.00	0.45
<i>Gleditsia aquatica</i>	water locust	3.50	0.00	3.15	0.49	3.27	0.00
<i>Gleditsia triacanthos</i>	honeylocust			6.50	0.00		
<i>Gordonia lasianthus</i>	loblolly bay	4.50	0.00	4.50	0.00		
<i>Halesia carolina</i>	Carolina silverbell	6.50	0.00	6.50	0.00		
<i>Halesia diptera</i>	silverbell	6.19	0.43	6.09	0.57	6.50	0.00
<i>Hamamelis virginiana</i>	American witchhazel			6.50	0.00	6.50	0.00
<i>Hypericum galioides</i>	St. John's wort			4.30	0.00	4.53	0.00
<i>Hypericum hypericoides</i>	St. Andrew's cross			6.50	0.00	5.25	1.50
<i>Ilex amelanchier</i>	sarvis holly			2.50	0.00		
<i>Ilex coriacea</i>	large gallberry			4.58	0.00	5.50	1.41
<i>Ilex decidua</i>	possumhaw	4.35	0.83	4.57	0.73		
<i>Ilex glabra</i>	inkberry			6.50	0.00		
<i>Ilex myrtifolia</i>	myrtle dahoon	3.50	0.00			4.46	0.89
<i>Ilex opaca</i>	American holly	5.79	0.72	5.96	0.61	6.09	0.51
<i>Ilex verticillata</i>	common winterberry			2.56	0.00		
<i>Ilex vomitoria</i>	yaupon			6.50	0.00	6.50	0.00
<i>Itea virginica</i>	Virginia sweetspire			2.83	0.35	4.03	0.50
<i>Juglans nigra</i>	black walnut	6.50	0.00	6.50	0.00	6.50	0.00
<i>Juniperus virginiana</i>	eastern redcedar	6.50	0.00	6.50	0.00		
<i>Leucothoe racemosa</i>	swamp doghobble			4.06	1.17	4.50	0.00
<i>Lindera benzoin</i>	northern spicebush			5.82	0.00	6.23	0.00
<i>Liquidambar styraciflua</i>	sweetgum	5.03	0.65	5.52	0.76	4.87	0.75
<i>Lyonia lucida</i>	fetterbush lyonia			3.71	0.00		
<i>Magnolia grandiflora</i>	southern magnolia			5.43	0.09		
<i>Magnolia virginiana</i>	sweetbay			5.50	1.41		
<i>Malus angustifolia</i>	southern crab apple	6.50	0.00	6.50	0.00	6.50	0.00
<i>Malus coronaria</i>	sweet crabapple			6.50	0.00	6.50	0.00
<i>Melia azedarach</i>	Chinaberrytree	5.54	0.00	6.21	0.00	4.50	0.00
<i>Morus rubra</i>	red mulberry	5.75	0.96	6.25	0.50	5.70	0.84
<i>Myrica cerifera</i>	wax myrtle			6.19	0.43	6.50	0.00
<i>Nyssa aquatica</i>	water tupelo	2.62	0.20	3.25	0.50	2.93	0.79
<i>Nyssa biflora</i>	swamp tupelo	3.04	0.47	3.50	0.00	3.42	0.12
<i>Nyssa sylvatica</i>	blackgum	5.27	0.65	5.80	0.69	4.99	1.47
<i>Ostrya virginiana</i>	hophornbeam	6.50	0.00	6.50	0.00	6.50	0.00
<i>Persea borbonia</i>	redbay			4.78	1.23	5.29	0.00
<i>Pinus echinata</i>	shortleaf pine	6.50	0.00				
<i>Pinus elliotii</i>	slash pine	5.50	0.00				
<i>Pinus glabra</i>	spruce pine	6.24	0.37				
<i>Pinus taeda</i>	loblolly pine	6.41	0.14	6.50	0.00	6.50	0.00
<i>Planera aquatic</i>	planertree	3.12	0.68	3.01	0.64	3.07	0.56

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## Appendix B, continued (p. 3 of 3):

Scientific Name	Common Name	Overstory		Midstory		Understory	
		FTI Mean	+/- Std Dev	FTI Mean	+/- Std Dev	FTI Mean	+/- Std Dev
<i>Platanus occidentalis</i>	American sycamore	5.18	0.00	5.05	0.00		
<i>Poncirus trifoliata</i>	hardy orange			6.50	0.00	6.50	0.00
<i>Prunus serotina</i>	black cherry			6.26	0.47	6.50	0.00
<i>Prunus umbellata</i>	hog plum			6.50	0.00	6.50	0.00
<i>Quercus alba</i>	white oak	6.50	0.00	6.50	0.00	6.50	0.00
<i>Quercus falcata</i>	southern red oak	6.50	0.00	6.50	0.00		
<i>Quercus laurifolia</i>	laurel oak	3.89	0.38	4.39	0.00	3.81	0.45
<i>Quercus lyrata</i>	overcup oak	3.73	0.68	3.99	1.00	3.80	1.01
<i>Quercus marilandica</i>	blackjack oak			6.50	0.00		
<i>Quercus michauxii</i>	swamp chestnut oak	4.81	0.61	5.34	0.33	5.00	1.00
<i>Quercus nigra</i>	water oak	5.73	0.69	5.92	0.49	5.85	0.70
<i>Quercus nuttallii</i>	Nuttall oak	4.50	0.00	4.50	0.00	4.50	0.00
<i>Quercus pagoda</i>	cherrybark oak	6.39	0.31	6.50	0.00	6.50	0.00
<i>Quercus phellos</i>	willow oak	4.81	1.07	5.29	1.18	5.43	1.07
<i>Quercus shumardii</i>	Shumard oak	5.50	0.00	5.50	0.00	5.77	0.00
<i>Quercus stellata</i>	post oak	6.50	0.00	6.50	0.00	6.50	0.00
<i>Quercus velutina</i>	black oak	6.50	0.00	6.50	0.00	6.50	0.00
<i>Quercus virginiana</i>	live oak	6.50	0.00	5.85	0.92	6.50	0.00
<i>Rhododendron canescens</i>	mountain azalea			6.50	0.00	6.50	0.00
<i>Rhus copallinum</i>	winged sumac			6.50	0.00	6.50	0.00
<i>Rhus glabra</i>	smooth sumac			6.50	0.00		
<i>Sabal minor</i>	dwarf palmetto			4.50	0.00	5.01	0.77
<i>Salix nigra</i>	black willow	2.83	0.58	2.85	0.58	2.50	0.00
<i>Sambucus canadensis</i>	elderberry			5.95	0.77	5.85	0.94
<i>Sassafras albidum</i>	sassafras	6.50	0.00	6.50	0.00	6.07	1.13
<i>Sebastiania fruticosa</i>	Gulf Sebastian-bus			4.45	0.67	5.26	1.16
<i>Sideroxylon lanuginosum</i>	gum bully			5.91	0.00		
<i>Styrax americanus</i>	American snowbell			3.41	0.64	3.29	0.86
<i>Symplocos tinctoria</i>	common sweetleaf	5.54	0.00	6.40	0.17	6.18	0.46
<i>Taxodium ascendens</i>	pond cypress	2.97	0.61	3.33	0.71	3.09	0.66
<i>Taxodium distichum</i>	bald cypress	2.97	0.61	3.33	0.71	3.09	0.66
<i>Triodica sebifera</i>	Chinese tallow			3.50	0.00	3.50	0.00
<i>Ulmus alata</i>	winged elm	6.43	0.13	6.24	0.34	5.66	0.84
<i>Ulmus americana</i>	American elm	4.46	0.62	4.81	0.74	4.35	0.59
<i>Ulmus crassifolia</i>	cedar elm			6.50	0.00	6.50	0.00
<i>Ulmus rubra</i>	slippery elm	5.50	0.00	5.75	0.50	6.50	0.00
<i>Vaccinium arboreum</i>	farkleberry	6.50	0.00	6.45	0.13	6.50	0.00
<i>Vaccinium corymbosum</i>	highbush blueberry			6.50	0.00	4.50	0.00
<i>Vaccinium elliotii</i>	Elliott's blueberry			5.82	0.96	6.06	0.53
<i>Vaccinium fuscum</i>	black highbush blueberry			4.50	0.00		
<i>Viburnum dentatum</i>	southern arrowwood			4.87	1.24	6.05	0.78
<i>Viburnum obovatum</i>	small-leaf arrowwood			4.50	0.00	6.50	0.00
<i>Viburnum rufidulum</i>	rusty blackhaw			6.50	0.00	6.50	0.00

## **Appendix C: Site Characteristics by Cypress Sustainability Category**

(Tables begin on next page.)

**Appendix C-1: Site Characteristics of Cypress Sustainability Category RCC-1**

Sustainable by natural regeneration. This category is characterized by favorable inundation cycles, an available cypress seed source, and acceptable water depth during growing season to allow natural seedling survival. A cypress site in this category should exhibit the following typical characteristics:

Characteristic	Condition	Measure	Rationale
Soils	Soils that exhibit a potential for establishing and supporting the growth and development of naturally regenerated cypress stands	“Class A” soil; predominant soil type of the site is among those listed in Appendix A-1	Potentially sustainable, if local hydrologic alterations do not supersede
Hydrologic Zone	Theriot (1993) Zone III (lower hardwood wetlands) or Zone IV (medium hardwood wetlands)	Flood Tolerance Index 2.51 – 4.50	Optimum position for cypress along hydrologic gradient
Duration of Growing Season Flooding	Seasonally to semi-permanently flooded	Greater than 12.5% of growing season, but substantially less than 100% of growing season	Indicates annual dry periods for regeneration to occur
Annual Frequency of Growing Season Flooding	Frequent	At least every other year	Reduces competition over time from less flood-tolerant species
Depth of Growing Season Flooding for Seedling Survival	Acceptable	Seedlings overtopped less than 45 consecutive days during growing season	Allows survival of natural and planted seedlings if salinity is acceptable
Cypress Seed Source	Available in sufficient amounts	Present either on site, via hydrochory, or by planting	See <i>Silvics</i> section for further details
Salinity Levels	Acceptable	Less than 2.0 p.p.t. for at least 50% of duration of growing season inundation	A low level of salinity can be tolerated for extended periods, but if salinity exceeds 2.0 p.p.t., it should do so for relatively short durations
Operational Feasibility of Planting	NA	NA	However, if feasible, planting could be used to supplement natural regeneration



**Appendix C-2: Site Characteristics of Cypress Sustainability Category RCC-2a**

Sustainable only by artificial regeneration due to shallow prolonged flooding. This category is characterized by extended flooding, acceptable planting conditions, and acceptable depth during the growing season to allow planted seedling survival. A cypress site in this category should exhibit the following typical characteristics:

Characteristic	Condition	Value	Rationale
Soils	Soils that exhibit potential for establishing and supporting the growth and development of naturally regenerated cypress stands	"Class A" soil; predominant soil type of the site is one of those listed in Appendix A-1	An indication of management potential
Hydrologic Zone	Theriot (1993) Zone I (open water) or Zone II (swamp)	Flood Tolerance Index 1.00 – 2.50	Zones where natural regeneration would not be successful due to prolonged flooding with shallow water
Duration of Growing Season Flooding	Intermittently exposed to continuously flooded	Near 100% of growing season	Artificial regeneration can be successful under prolonged flooding if depth and salinity are acceptable as described in text
Annual Frequency of Growing Season Flooding	Very frequent	Nearly every year	Prohibits natural regeneration over time
Depth of Growing Season Flooding for Seedling Survival	Acceptable	Seedlings overtopped less than 45 consecutive days during growing season	Allows survival of natural and planted seedlings if salinity is acceptable
Cypress Seed Source	NA	NA	Even if present, hydrology prevents seedling establishment
Salinity Levels	Acceptable	Less than 2.0 p.p.t. for at least 50% of duration of growing season inundation	A low level of salinity can be tolerated for extended periods, but if salinity exceeds 2.0 p.p.t., it does so for relatively short durations
Operational Feasibility of Planting	Feasible	Less than 1-foot water depth for at least 50% of planting season	Allows adequate periods when flooding is shallow enough to implement planting activities

**Appendix C-3: Site Characteristics of Cypress Sustainability Category RCC-2b**

Sustainable only by artificial regeneration due to brief infrequent flooding. This category is characterized by infrequent flooding (allowing greater competition from less flood-tolerant hardwood species), but acceptable cypress planting conditions. A cypress site in this category should exhibit the following typical characteristics:

Characteristic	Condition	Measure	Rationale
Soils	Soils that exhibit potential for establishing and supporting the growth and development of artificially regenerated cypress stands with intensive management	"Class B" soil; predominant soil type of the site is one of those listed in Appendix A-2	Wetland forest management potential, but cypress may be subject to competition from less flood-tolerant species
Hydrologic Zone	Zone V (higher hardwood wetlands)	Flood Tolerance Index 4.51 – 5.50	Zone where natural regeneration would not be successful due to infrequent inundation allowing competition from less flood-tolerant species
Duration of Growing Season Flooding	Temporarily flooded	2 – 12.5 % of growing season	Favors moderately flood tolerant species unless managed intensively for cypress
Annual Frequency of Growing Season Flooding	Infrequent	Once every 2 to 10 years	Favors moderately flood tolerant species unless managed intensively for cypress
Depth of Growing Season Flooding for Seedling Survival	NA	NA	Flood duration insufficient to cause seedling mortality
Cypress Seed Source	NA	NA	Even if present, interspecies competition prevents natural and planted seedling establishment unless site is intensively managed
Salinity Levels	NA	NA	Duration/frequency of flooding insufficient to allow substantial saltwater intrusion
Operational Feasibility of Planting	Feasible	Flooded less than 1 ft depth for at least 50% of planting season	Allows adequate periods when flooding is shallow enough to implement planting activities

**Appendix C-4: Site Characteristics of Cypress Sustainability Category RCC-3a**

Not sustainable due to deep prolonged flooding. This category is characterized by extended flooding and excessive depth during the growing season, preventing seedling survival. A cypress site in this category should exhibit the following typical characteristics:

Characteristic	Condition	Value	Rationale
Soils	Soils that exhibit potential for establishing and supporting the growth and development of naturally regenerated cypress stands	“Class A” soil; predominant soil type of the site is one of those listed in Appendix A-1	Even if soils were suitable historically, local hydrologic conditions determine feasible management options
Hydrologic Zone	Zone I (open water) through Zone IV (medium hardwood wetlands)	Flood Tolerance Index 1.00 – 4.50	Zones where significant flooding could occur during early growing season or throughout growing season
Duration of Growing Season Flooding	Seasonally flooded to continuously flooded	12.5 - 100% of growing season	Flooding occurs during early growing season or throughout growing season
Annual Frequency of Growing Season Flooding	Frequent to very frequent	Every 1 – 2 years	Prohibits natural regeneration; if seedlings germinate they will not establish over time
Depth of Growing Season Flooding for Seedling Survival	Unacceptable	Seedlings overtopped more than 45 consecutive days during growing season	Prohibits natural and artificial regeneration
Cypress Seed Source	NA	NA	Even if present, hydrology prevents seedling establishment
Salinity Levels	NA	NA	Even if acceptable, hydrology prevents sustainable management
Operational Feasibility of Planting	NA	NA	Even if feasible, hydrology prevents seedling survival

**Appendix C-5: Site Characteristics of Cypress Sustainability Category RCC-3b**

Not sustainable due to excessive salinity. This category is characterized by frequent flooding combined with excessive salinity. A cypress site in this category should exhibit the following typical characteristics:

Characteristic	Condition	Value	Rationale
Soils	Soils that historically supported bald cypress	"Class A," "Class B," or "Class C" soils; predominant soil type of the site is one of those listed in Appendix A-1, A-2, or A-3	Regardless of the ability of the soil to support bald cypress growth, salinity conditions may prohibit management entirely
Hydrologic Zone	Zone I (open water) through Zone IV (medium hardwood wetlands)	Flood Tolerance Index 1.00 – 4.50	Zones where sites could be subjected to at least occasional saltwater intrusion
Duration of Growing Season Flooding	Seasonally to continuously flooded	12.5 - 100% of growing season	Allows sufficient time for saltwater intrusion within a given year
Annual Frequency of Growing Season Flooding	Frequent to very frequent	Every 1-2 years	Prohibits reduction in salinity levels over time
Depth of Growing Season Flooding for Seedling Survival	NA	NA	Even if acceptable, excessive salinity prevents seedling survival
Cypress Seed Source	NA	NA	Even if present, excessive salinity prevents seedling establishment
Salinity Levels	Unacceptable	Greater than 2.0 p.p.t. for at least 50% of duration of growing season inundation	Prohibits cypress survival especially at seedling stage
Operational Feasibility of Planting	NA	NA	Even if feasible, excessive salinity prevents seedling survival