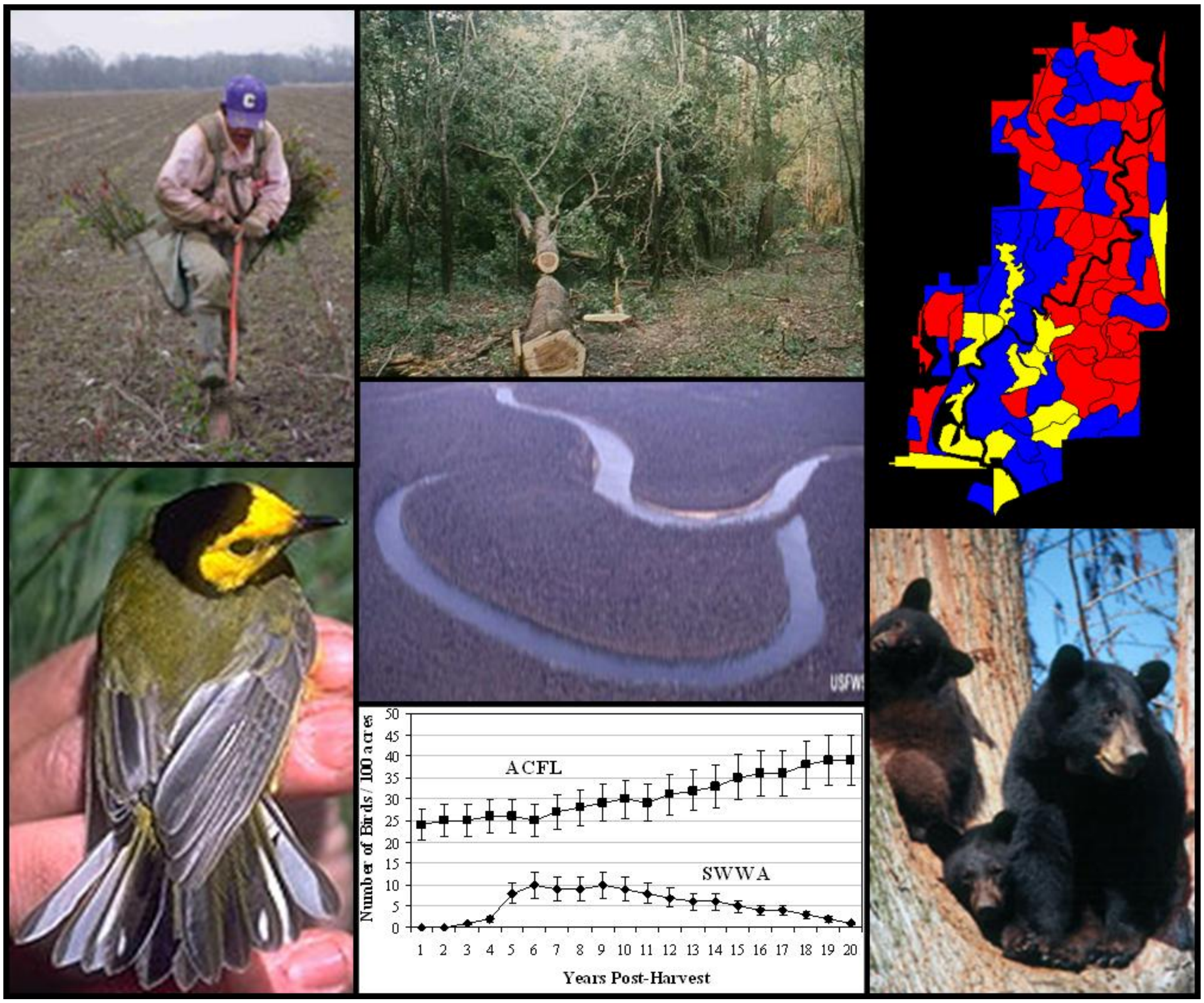
Restoration, Management, and Monitoring of Forest Resources in the Mississippi Alluvial Valley: Recommendations for Enhancing Wildlife Habitat



FINAL REPORT -- 2007

Lower Mississippi Valley Joint Venture

Forest Resource Conservation Working Group

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--- Final Report ---

Restoration, Management and Monitoring of Forest Resources in the Mississippi Alluvial Valley: Recommendations for Enhancing Wildlife Habitat

Edited by: Randy Wilson, Kenny Ribbeck, Sammy King and Dan Twedt

Version 5.2

--- June 2007 ---

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EXECUTIVE SUMMARY

The **conservation objective in the Mississippi Alluvial Valley is to provide forested habitat capable of supporting sustainable populations of all forest dependant wildlife species.** However, forest loss, fragmentation, and hydrological change has markedly altered habitat conditions within bottomland forests such that some species of concern (e.g., ivory-billed woodpecker (*Campephilus principalis*), Louisiana black bear (*Ursus americanus luteolus*), and some migratory songbirds) have been severely impacted. To provide habitat for these and other priority wildlife species, **we advocate forest conditions that are conducive to the continued viability of this suite of priority wildlife species.**

Forest-dependent (silvicolous) wildlife is responsive to habitat conditions at multiple spatial scales (e.g., **landscape quality** and **site quality)**. To address this issue, we define ***Desired Forest Conditions*** as those forested landscapes that meet both Desired Landscape Conditions and Desired Stand Conditions. Traditional forest management has focused on production of forest products (i.e., lumber or pulp) through silviculture that promotes optimal growth and vigorous health of economically desirable tree species. Often these traditional silvicultural methods are not optimal for silvicolous wildlife. Indeed, quality habitat for priority wildlife species likely requires some sacrifice in timber production and the retention of less healthy trees. Even so, **commercially viable, wildlife-oriented silviculture (i.e., Wildlife Forestry)** employing variable retention harvests can be used in conjunction with forest restoration, regeneration, and natural processes to achieve Desired Forest Conditions within bottomland hardwood forests.

To address landscape scale habitat needs of priority wildlife species, we advocate local **landscapes of >10,000 acres that are extensively forested** in a matrix of large blocks of contiguous forest and closely associated smaller forest fragments. Where possible, forest corridors should link these forested landscapes. Within each landscape, **5-30% of the forest area should be passively managed** (i.e., set-aside as "unmanaged" controls). However, to ensure development of "Desired Stand Conditions" **≥70% of forest area should be actively managed using Wildlife Forestry silviculture**. Regeneration harvests of areas >7 acres (i.e., clear-cuts) should be restricted to ≤10% of local landscapes and management should ensure the availability of some (≤5% of area) early successional (i.e., shrub-scrub) habitat.

Size, structure, and composition of forest vegetation are important parameters for predicting the suitability of forest habitat for priority silvicolous wildlife. Many **priority wildlife species favor structurally diverse and species rich forests which harbor large trees and frequent canopy gaps.** These conditions provide suitable habitat for foraging and cover within all dimensions of the forest and provide a desirable blend of regeneration, maturity, and senescence of forest trees. **Distribution and abundance of suitable forest habitat is largely dependent on disturbance.** Historically, disturbances resulted from flood, fire, tornadoes, etc. Under current conditions however, many former disturbances are spatially and temporally restricted. Reduced levels of disturbance acting in concert with unsustainable forest management practices have resulted in homogeneous, closed canopy forests with little structural diversity or understory vegetation. **We advocate the use of wildlife forestry silvicultural practices to induce disturbance within bottomland hardwood forests and thereby stimulate development of Desired Stand Conditions.**

The habitat conditions that result from wildlife forestry silvicultural prescriptions will vary among sites and forest types. For many forests, **desired stand conditions are:** an average of **60-70% overstory canopy cover** which is heterogeneously distributed, a **basal area of 60-70 ft^2 per acre**, and **60-70% stocking**. Desired **midstory and understory cover are between 25-40%, respectively.** At least 2 dominant trees (emergents) per acre should be retained. Some cavity trees (small and large) as well as **dead and/or stressed trees should be retained**. These stems will eventually contribute to coarse woody debris which should average >200 ft^3 per acre. To ensure future merchantability of stands, **shade-intolerant regeneration should be present on 30-40% of the area.**

Extensive forest restoration in the Mississippi Alluvial Valley has advanced progress towards desired landscape conditions. However, previous restoration methods may not readily result in desired stand conditions. Therefore, **we recommend that future restoration efforts place greater emphasis on the geomorphic setting and hydrologic conditions of the site,** as well as on **plant multiple tree species at densities of 435 seedlings per acre** combining shade-intolerant, early successional, and shade-tolerant species with **hard-mast producing trees accounting for 30-60% of stock**. Plantings, and natural colonization, **should result in an average of >300 trees per acre within 3 years** – preferably in a **matrix of high stem density patches and gaps** with sparse stem density.

We advocate improving forest management and restoration prescriptions through adaptive management. As such, it is imperative that the impact of forest management decisions be evaluated with regard to habitat conditions and wildlife response. **We recommend extensive inventories of forest within local landscapes (e.g., a refuge or management area) to assess existing habitat conditions** and aide in formulating and prioritizing silvicultural treatments. **To assess forest change and region-wide progress towards desired forest conditions, we recommend use of a regional continuous forest inventory (CFI) network** that is monitored at 5 to 10 year intervals. Finally, **we recommend the design and implementation of coordinated monitoring programs to evaluate wildlife use of forest stands following prescribed wildlife forestry treatments** to ensure hypothesized wildlife responses are achieved.

PREAMBLE

The history of bottomland forest conservation and management in the Mississippi Alluvial Valley (MAV) is in many respects one of exploitation and conversion of an internationally significant forest resource to agricultural land uses. Yet it is also one of dedicated natural resource managers and forest landowners, both public and private, seeking to better understand the art, science, and practice of bottomland hardwood forest management to provide habitat for the wildlife species that depend upon it for their existence.

This document has been prepared to further the conservation goals and objectives of the Lower Mississippi Valley Joint Venture (LMVJV). The LMVJV is a self-directed, non-regulatory partnership that exists for the purpose of implementing the national and international plans of the North American Bird Conservation Initiative. Its members include private, state, and federal conservation organizations that by virtue of mission or legislated authority share in the commitment to conserving wildlife species and their habitats. The LMVJV partnership operates on the basis of a population-based, multi-scale conservation framework that emphasizes an adaptive approach to ecosystem management. The focus of this conservation framework is on the development and refinement of goals expressed as measurable biological outcomes that are linked across multiple spatial scales. The LMVJV partnership focuses primarily on the MAV and West Gulf Coastal Plain (WGCP) Bird Conservation Regions (Fig. 1) as defined by the North American Bird Conservation Initiative. Within both of these regions, forest restoration and management is central to achieving the goals and objectives of Joint Venture partners.

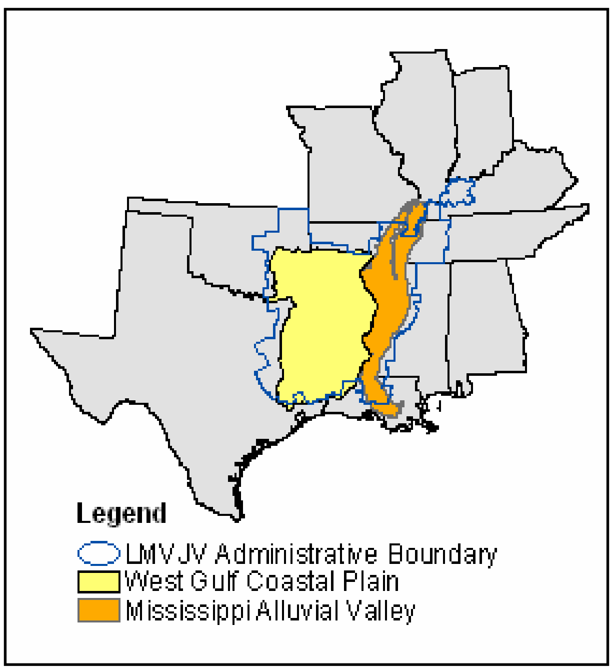


Figure 1. Administrative boundary of the Lower Mississippi Valley Joint Venture and Bird Conservation Region therein.

More specifically, this document is a product of the LMVJV's Forest Resource Conservation Working Group. This Working Group was chartered by the LMVJV Management Board to serve as the technical forum for Joint Venture partners on matters pertaining to the reestablishment and management of forest resources with a specific mission to "*ensure the conservation actions and programs of Joint Venture partners reflect reforestation and forest management prescriptions and practices that sustain populations of priority birds and other forest-dependent wildlife in concert with sustainable forestry*." The Working Group draws its participants (Appendix 1) from both the forestry and wildlife disciplines and includes members experienced in on-the-ground management and applied research.

PURPOSE OF DOCUMENT

Over the last 18 years, Joint Venture partners have established objectives for conserving, restoring, and managing bottomland hardwood forests in the context of two overarching goals: (1) conserve and restore the ability of the MAV and WGCP to sustain birds of national and international conservation concern; and (2) maintain and restore the wetland functions and values associated with forested floodplains. In addressing these goals, information on forest restoration and management is integral to the progressive refinement of Joint Venture goals and objectives.

To provide the LMVJV partnership with information on the restoration and management of bottomland forests, this document is intended to meet three specific needs: (1) to define desired forest conditions that result from management of bottomland hardwood forests where the primary objective is the conservation of wildlife; (2) to provide technical recommendations for the restoration of bottomland hardwood forest on areas that have been converted to non-forested land uses (e.g., agriculture) that reflect the cumulative knowledge and experiences of land managers and researchers from the past decades of active reforestation; and (3) to recommend protocols and procedures for coordinated inventory and monitoring of forest resources on public lands managed for wildlife conservation such that restoration and management can be implemented in an adaptive manner.

The recommendations contained within this report were developed to specifically address issues surrounding restoration, management, and monitoring of forest resources in the MAV. However, the working group believes that these recommendations are applicable to other bottomland hardwood systems across the southeastern United States provided users consider differences in geomorphology, soils, and hydrology where applicable.

USE AND REFINEMENT OF TECHNICAL RECOMMENDATIONS

This document provides technical guidance for the restoration and management of bottomland hardwood forests where conservation of wildlife resources is a central purpose and objective. As such, the document integrates habitat conditions for priority wildlife with technical recommendations for the restoration and management of bottomland hardwood forests. To achieve these habitat conditions requires managers to reassess traditional methods of silviculture, placing greater emphasis on retaining and promoting forest structure and senescence to benefit priority wildlife.

We envision these recommendations will aid on-the-ground managers and program managers responsible for managing forest resources in implementing forest management strategies for wildlife conservation. Furthermore, we anticipate that these recommendations will be instructive to private landowners targeting wildlife conservation as part of their overall land stewardship objectives; especially on lands under conservation easement. To that extent, all data are presented in English units throughout the document but tables with equivalent metric data are presented in Appendix 3.

These recommendations are not intended to be regulatory or administratively prescriptive, or to conflict with partner's ability to meet overarching (legislative or proprietary) mandates. Because these recommendations reflect the collective technical judgment and experiences of many biologists, foresters, and researchers, they have been developed with the expectation of being incorporated into the forest management programs and forest conservation efforts of LMVJV partners. Finally, although these recommendations reflect our current knowledge and experience, refinement and modifications are expected as we increase our knowledge, understanding, and experience in the science of bottomland hardwood forest restoration and management.

CHAPTER I

THE MISSISSIPPI ALLUVIAL VALLEY

INTRODUCTION

The MAV is located along the course of the Mississippi River, including portions of 7 states (Illinois, Missouri, Kentucky, Tennessee, Arkansas, Mississippi, and Louisiana), extending south from Cairo, Illinois to the Gulf Coast of Louisiana. The Mississippi River flows southward through the central United States and drains roughly 41% (approximately 79 million acres) of the conterminous United States (Klimas et al. 2004, Gardiner and Oliver 2005). The MAV is made up of 6 drainage sub-basins including the St. Francis, Western Lowlands, Arkansas Lowlands, Yazoo, Boeuf, and Tensas Basins, with major tributaries to the Mississippi River including the St. Francis, Arkansas, White, Bayou Bartholomew, and Yazoo Rivers (Saucier 1994). The rich alluvial soils of this 25-million acre floodplain have historically supported vast expanses of mixed-species, deciduous forests (Gardiner and Oliver 2005), known as the bottomland forests of the MAV.

The MAV was formed by geologic downwarping, and shaped by riverine processes of erosion and sediment deposition. The valley is bounded by older, higher uplands and is characterized by deep alluvial fill that overlies deeper Coastal Plain formations. A combination of alternating braided stream and meandering stream processes during the Pleistocene and Holocene Periods shaped the MAV into a broad and complex network of natural communities related to varying elevations, hydrologic regimes, soils, and vegetative types (Saucier 1994).

The MAV is a highly productive environment as a result of abundant water and the substrate of alluvial deposits high in mineral and organic nutrients. Bottomland hardwood systems are described as among the most productive and diverse ecosystems in North America (Klimas et al. 2004). They are maintained by the natural hydrologic regime of alternating wet and dry periods and historically these forests served as an integrated system linked by flood waters to import, store, cycle, and export nutrients (Wharton et al. 1982, Klimas et al. 2004). These bottomland hardwood forests contain a diversity of overstory species, are characteristically rich in woody vines and shrubs and may feature an understory with large monocots such as cane (*Arundinaria gigantea*) and palmetto (*Sabal minor*) (Wharton et al. 1982, Klimas et al. 2004, Gardiner and Oliver 2005). Natural regeneration within bottomland hardwood stands is typically initiated by localized damage to overstory trees such as single tree snapping or wind throw (Johnson and Deen 1993, King and Antrobus 2001), periodic catastrophic fire or windstorm damage or prolonged growing season flood inundation (Dickson 1991). Seasonally wet oak-hardwood woodlands reach an 'old-growth' condition with a multi-layered overstory and tree age ≥150 years. Reproduction occurs in openings created by dead trees or wind throws (Kennedy and Nowacki 1997) and down woody debris is rapidly decomposed by high temperatures and humidity (Harmon et al. 1986). Forest types are associated with distinctive landforms resulting from the interaction of species specific physiological requirements of vegetative components and site characteristics (Gardiner and Oliver 2005).

A gradient of increasingly fine soil textures (coarse sands to fine clays) from high-energy to low-energy deposition environments has resulted in characteristic soil types often associated with distinctive landforms. Finer soils have higher soil organic matter content, increasing cation exchange capacity, and decreasing permeability (Smith and Klimas 2002, Klimas et al. 2004). The bottomland hardwood forests have historically included a wide range of species and community types which can tolerate inundation or soil saturation for at least some portion of the growing season (Wharton et al. 1982), resulting in a complex mosaic of community types that reflect differences in the alluvial and hydrologic environment (Smith and Klimas 2002).

GEOMORPHOLOGY

By considering the relationships between landform (geomorphology) and source, duration and frequency of inundation (hydrology), we can better understand the composition and functions of wetland communities. This approach is known as hydrogeomorphic (HGM) classification and assessment. It was developed to quantify the loss of wetland functions caused by wetland destruction and the potential gain of wetland function resulting from wetland restoration (Brinson 1993). Guidebooks have been produced to facilitate hydrogeomorphic analysis of sites across the MAV (Smith and Klimas 2002, Klimas et al. 2004). For portions of Arkansas, this approach has been extended by using maps of geomorphology (Saucier 1994) and flood frequency created by the U. S. Army Corps of Engineers and sometimes augmented by soil maps to delineate the distribution of wetland communities across entire landscapes (Klimas et al. 2004, 2005). Such maps display both existing naturally vegetated wetland communities and restoration potentials of currently cleared wetlands.

Across the MAV, meandering streams and rivers (primarily during periods between glacial advances) have created distinct riverine landforms including point bars with alternating well-drained ridges and poorly-drained swales; high, well-drained natural levees; and poorly-drained backswamps. As the rivers have cut off bends and abandoned channels, they have created meander scar or oxbow lakes that gradually fill to form shallow sloughs. During glacial advances and particularly glacial retreats, the major rivers, particularly the Mississippi and Ohio, became sediment-rich and changed to braided-stream configuration. Under these conditions they left unsorted deposits of mixed particle sizes, often on relatively featureless plains, referred to as glacial outwash. As a result of varying relationships among stream gradient, sediment load, channel patterns and later removal of deposits, glacial outwash deposits remaining today are often at higher elevations than currently active floodplains, and form high terraces that are seldom or never flooded (Saucier 1994; Figure 2).

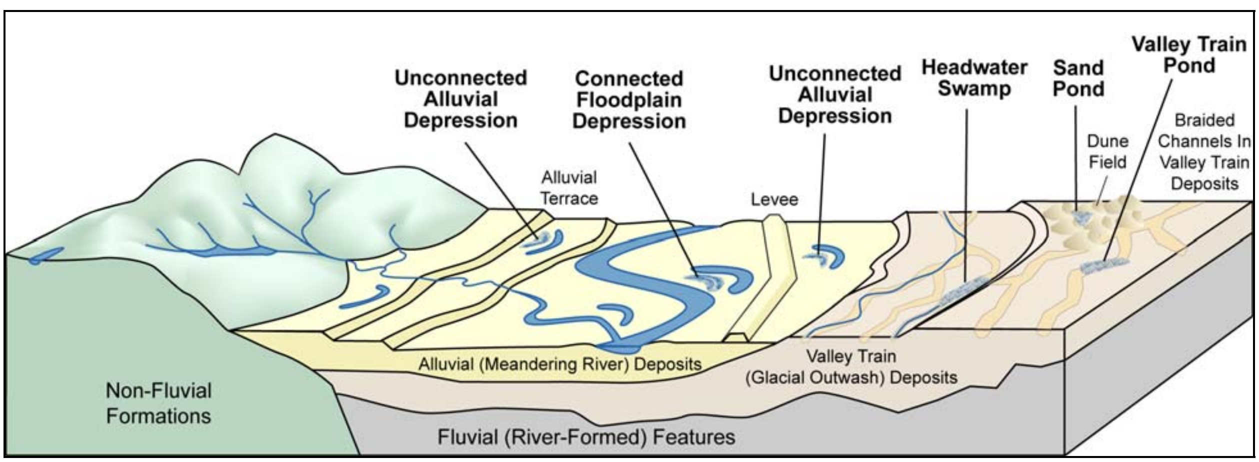


Figure 2. Placement of hydrogeomorphic depressional communities within the Mississippi Alluvial Valley (Adapted from Klimas et al 2004, by Elizabeth Murray, Arkansas Muti-Agency Wetland Planning Team).

Hydrologic processes underlie the natural plant communities of the MAV (Hodges 1997). In its pre-European settlement condition, the relatively flat MAV landscape as a whole was subject to various combinations of: (1) prolonged, extensive ponding during the winter wet season of most years; (2) localized, short-term ponding due to precipitation events at any time during most years; (3) headwater inundation of tributary basins due to precipitation in most years; (4) backwater flooding of tributary basins during flood events on the Mississippi River; and (5) occasional large-scale inundation over most of the valley due to overbank flow of the Mississippi River (Smith and Klimas 2002, Klimas et al. 2004).

TREE DISTRIBUTION

Within a given stream bottomland, similar variations of topography and hydrology tend to occur, however there can be differences with an area. Streamside point bars and natural levees in riverine overbank areas flood frequently (usually more often than every five years) by flowing, headwater floods. Soils on these sites are relatively sandy and well-drained, and plant communities vary with micro-site characteristics. Black willow (*Salix nigra*) and cottonwood (*Populus deltoides*) typically dominate newly-deposited sand bars. American sycamore (*Platanus occidentalis*), sugarberry (*Celtis laevigata*), American elm (*Ulmus americana*), cedar elm (*Ulmus crassifolia*), along with green ash (*Fraxinus pennsylvanica*) become more abundant on slightly older and higher sites. In a hydrogeomorphic classification these 'first bottom forests' (Figure 3) are referred to as riverine overbank wetlands.

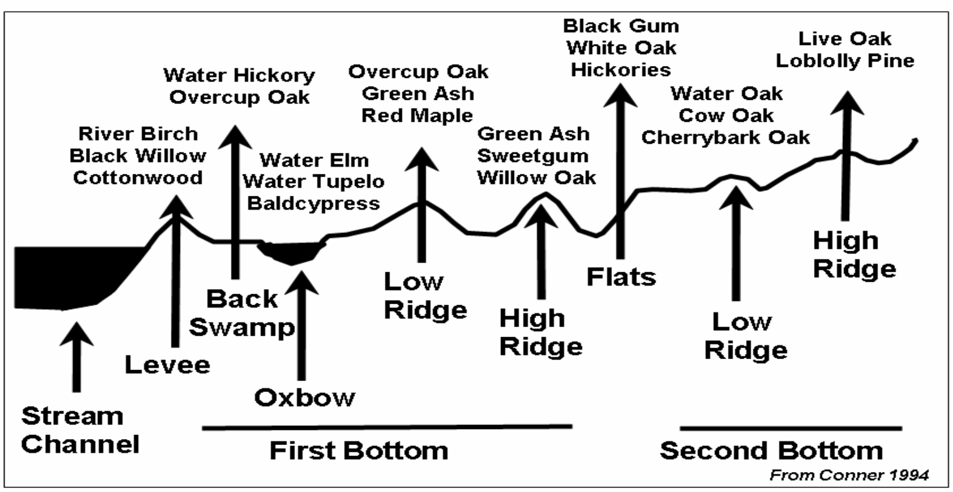


Figure 3. Distribution of tree species along hydrologic gradient (from Conner 1994).

In contrast, riverine backwater areas, often consisting of low backswamps behind natural levees, are typically flooded more frequently than every five years by sluggish or still waters. Overcup oak (*Quercus lyrata*) and bitter pecan (a.k.a., water hickory - *Carya aquatica*) are the typical dominant species on these sites, but occasionally species of higher sites such as Nuttall oak (*Quercus nuttallii*) or willow oak (*Quercus phellos*) may be found on drier parts of these sites.

Depressions, such as those formed by abandoned river or stream channels (e.g., oxbows, Figure 3) can hold water permanently or semi-permanently and be dominated by baldcypress (*Taxodium distichum*) and water tupelo (*Nyssa aquatica*). Large oxbow lakes may have expanses of open water with a lacustrine fringe of baldcypress and water tupelo. If depressions are flooded by an adjacent river more frequently than every five years they are classed as connected depressions, otherwise they are called unconnected (Figure 2; Klimas et al. 2004).

Higher bottomlands are typically classed as flats (second bottom, Figure 3). These flats are usually flooded by the river less frequently than every five years, and are therefore hydrologically influenced more by precipitation. Forests of these sites are typically dominated by willow oak, cherrybark oak (*Quercus pagoda*) and swamp chestnut (a.k.a. cow oak - *Quercus michauxii*), pin oak (*Quercus palustris*) and/or Nuttall oak.

The hydrology of glacial outwash terraces (valley train deposits, Figure 2) is primarily affected by precipitation rather than flooding by an adjacent stream. Terrace wetlands (alluvial deposits, Figure 2) typically exhibit flat terrain that has poor surface drainage, and are underlain by soils with poor internal drainage. Therefore, these terrace wetlands are characteristically different in composition, structure and function than floodplain wetlands. There is little storage of water in the shallow soils, so these sites are often extremely wet during the winter and spring and extremely dry during summer and fall, a hydropattern referred to as hydroxeric. During the dry season these wetlands burn frequently, leading to a more open tree canopy and increased herbaceous ground cover, which consequently further increases fire frequency. Tree species adapted to low wetlands may germinate on these sites during wet cycles, and tree species adapted to high wetlands or uplands may germinate during dry cycles, so the tree species composition can be very diverse. Thus, fire and drought conditions add to the diversity of these sites.

Therefore forests of outwash plains (valley train deposits [Figure 2] or second bottoms [Figure 3]), although they are considered hydrogeomorphic flats and are sometimes referred to as flatwoods, are quite different from those of floodplain flats (alluvial deposits [Figure 2] or first bottoms [Figure 3]). Wet flatwoods may be dominated by willow oak and dry flatwoods by post oak, but these may also be intermixed.

ANTHROPOGENIC IMPACTS

Anthropogenic effects began as early as 5,000 ybp when Native American cultures permanently or semi-permanently resided in the MAV. These cultures likely modified the landscape by clearing and burning the vegetation and through subsequent cultivation (Gardiner and Oliver 2005). Even so, early European explorers to the area, prior to 1700, described it as a vast and largely pristine wilderness with scattered Native American communities and clearings (King et al. 2005). A dramatic reduction in Native American populations from the 1500's through the 1700's muted Native American anthropogenic impacts on the landscape, resulting in abandoned agricultural fields regenerating with forest and cane. Impacts from the new European populations at this time included clearing of lands for small farms, largely along natural levees and point bar deposits which provided well drained and fertile soils and access to river travel routes (Fredrickson 2005, King et al. 2005).

As settlements became established, land clearing and alteration of hydrology increased in scope and intensity. Local communities cleared, ditched, and drained lands for agriculture and utilized the river systems for travel and transport. The late 1800's brought the railroad system to the MAV and made large scale commercial timber harvest, market hunting, and settlement possible (Smith and Klimas 2002, Fredrickson 2005, King et al. 2005). Following the great flood of 1927, the United States Congress passed the 1928 Flood Control Act, which placed flood control under Federal authority. Consequently, landscape-scale flood control of the Mississippi River was initiated by the U.S. Army Corps of Engineers and has ultimately resulted in over 3,700 miles of levees on the Mississippi River and its tributaries (IFMRC 1994).

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 MAV in the 1960's and1970'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 (Creasman et al. 1992, Haynes 2004). Subsequent legislation authorized the Wetland Reserve Program and other private land conservation programs that encouraged restoration of bottomland forests. According to Haynes (2004), these new conservation programs, combined with the land acquisition and reforestation activities by numerous state and federal agencies, resulted in approximately 450,000 to 550,000 acres of bottomland hardwood restoration in the MAV.

The modern MAV forests are a highly fragmented patchwork interspersed across a predominantly open, agricultural landscape. This patchwork is weighted with increasing density of forested lands southward within the seven state area, with 94% of the remaining forested lands within Arkansas, Louisiana and Mississippi. Forested fragments throughout the MAV tend to be small and finely dispersed (circa 38,000 discrete patches of forest), with larger fragments centralized along the major river systems (Twedt and Loesch 1999).

Forest loss has occurred disproportionately, with well drained and higher sites converted first and maintained through the present; these lands are now the prime agricultural lands of the MAV. Lower, poorly drained sites were converted last, if at all. In recent years some of these areas have been allowed to revert or have been restored to forested lands. Even with vast acreage of reforestation, the landscape supports less forest than historically, with forest communities adapted to poorly drained sites occupying a greater percentage of the landscape than they historically did. Thus, overall habitat for forest-dependent wildlife species has not only decreased dramatically but habitat for species that use well-drained community types (e.g., sycamore/sugarberry/elm/ash and cane thickets of natural levee fronts and point-bar deposits, and Nuttall/willow/cherrybark/swamp chestnut oaks of seasonally flooded forests) is limited beyond its historic representation in the forest landscape. More than a century of commercial timber harvest has also influenced forest composition, as commercially preferred species such as baldcypress and oaks were removed disproportionately, leaving forests heavy in shade-tolerant and low commercial value tree species (Conner and Sharitz 2005, Fredrickson 2005).

Additionally, the remaining forests are impacted by anthropogenic change to their formative systems. Modifications to hydrology (e.g., levee systems, ditching and draining, land leveling, flood control, and hydropower dams) altered the processes that structure these communities and determine wetland function (Fredrickson 2005, King et al. 2005). Increased drainage associated with agricultural areas, cessation of seasonal sheet flooding outside of levees, increased depth and duration of flooding inside of levees, and increased river slope and power are profound resultant changes to the hydrologic system (Biedenharn et al. 2000, Gardiner and Oliver 2005). Levee systems have altered the timing, duration, depth, frequency, and velocity of flood events and have functionally disconnected remnant bottomland forests from the natural processes of flooding and sediment deposition which maintained them. These changes in hydrologic and depositional processes affect factors such as nutrient and sediment recharge and distribution, and subsurface water availability and aquifer recharge. Such modifications to the form and function of the land subsequently affects plant and animal distributions, as species respond to change and thrive only in areas suitable to their biological needs.

SUMMARY

The once vast expanse of bottomland forests in the MAV are now a shadow of their historic presence. The human forces exerted in the MAV, particularly since European settlement, have changed the system and the remaining forested habitat. Restoration and maintenance of bottomland hardwood forests in the MAV are important to maintain their biological integrity and recover wildlife populations that are held in trust for future generations of Americans. Recognition of the natural forms and functions of bottomland forests in the MAV, as well as understanding the tremendous changes that have occurred, sets the stage for wise planning, restoration, and stewardship of these forests in the future.

CHAPTER II

PRIORITY WILDLIFE SPECIES AND HABITAT OBJECTIVES

PRIORITY WILDLIFE SPECIES

Alteration of the forest condition within the MAV has impacted the wildlife species that are dependent upon these forests. Fragmentation has resulted in smaller forest fragments that suffer more human perturbations (e.g., livestock, non-biodegradable refuse, buildings, etc.) than do larger fragments (Rudis 1995) and have high edge to area ratios with little interior forest that is far from agricultural and urban influences. Although some large tracts of bottomland forest remain in the MAV, they are often dominated by flood-prone forest types (Rudis 1995, Twedt and Loesch 1999). As a result, species that are dependent upon large expanses of bottomland forest at a landscape scale and complex forest structure within forest stands have declined.

Forest-dependent wildlife species that are of conservation concern within this ecoregion have been identified through Regional, National, and International conservation planning. For example, species specific plans have been developed for the recovery of threatened and endangered species such as Louisiana black bear ([*Ursus americanus luteolus*], U. S. Fish and Wildlife Service 1995) and ivory-billed woodpecker (*Campephilus principalis*], U. S. Fish and Wildlife Service 2006). Conservation plans for more relatively abundant species that are of conservation concern have been addressed via habitat conservation plans: birds (Twedt et al. 1999, Rich et al. 2004), reptiles and amphibians (Gibbons et al. 2000, Semlitsch 2003, Bailey et al. 2006), and bats (North American Bat Conservation Partnership 2006, Mississippi Department of Wildlife, Fisheries, and Parks 2005; Anderson 2006). Other species remain abundant, such as mallards (*Anas platyrhynchos*), wood ducks (*Aix sponsa*) and American woodcock (*Scolopax minor*), but are of management concern for annual harvest (North America Waterfowl Management Plan 1986, 2004; Kelly and Rau 2006). Not surprisingly, nearly all of these species are dependent upon large expanses of bottomland forest at a landscape scale and complex forest structure within forest stands for all or part of their annual life cycle. We believe these priority species may function as umbrellas for other bottomland wildlife species, wherein meeting their habitat needs provides habitat for many other species.

Louisiana Black Bear

The Louisiana black bear was listed as a threatened species under the Endangered Species Act due to extensive habitat reduction and fragmentation and declining populations (U. S. Fish and Wildlife Service 1992). Clearing of forest for agriculture has fragmented and reduced the area of suitable habitat by more than 80% in the MAV (U. S. Fish and Wildlife Service 1995). Because bears occupy large home ranges, landscape considerations are especially important. Forest area, connectivity, and juxtaposition are all important factors as each influences movement patterns of black bears and their ability to secure mates and food, as illustrated through the successes experienced in the Louisiana black bear repatriation efforts in Louisiana and Mississippi to date.

Within forest stands, black bears benefit from diversity in forest species and structure. Forage is provided via numerous hard mast [e.g., oaks and sweet pecan (*Carya illinoinensis*] and soft mast [e.g., pawpaw (*Asimina triloba*), mulberry (*Morus* spp.) and plum (*Prunus* spp.)] producing trees as well as fruiting understory plants and shrubs such as blackberries and dewberries (R*ubus* spp.), Hercules club (*Aralia spinosa*), pokeweed (*Phytolacca americana*), elderberry (*Sambucus canadensis*) and palmetto. Black bears use large, >36 inch diameter at breast height (dbh) trees with visible cavities that occur along rivers or other water bodies as den sites (Black Bear Conservation Committee 2005). Excavated and natural depressions under tree roots, stumps, and fallen logs are also used as den sites and daybeds, particularly in areas that are not subject to flooding. Additionally, dense understory that limits visibility, such as that provided by cane, palmetto, or thickets of shrubs and saplings, also provide ground den sites and serves as important escape cover.

Ivory-billed Woodpecker

The rediscovery of the ivory-billed woodpecker in Arkansas (Fitzpatrick et al. 2005) brought a heightened awareness of bottomland hardwood forests in the MAV and across the southeastern United States. Available literature on habitat characteristics favored by the ivory-billed woodpecker creates the impression that it was associated with expansive patches of "virgin" or uncut forests with a relatively high proportion of very large and old trees that supported a high proportion of dead and dying stems. However, the importance of virgin uncut forests may be only part of the equation based upon reviews and new interpretations of the older literature.

Large patches of standing dead and/or dying wood appear to be an important habitat component, thus forests that have recently experienced large catastrophic events (e.g., storms, drought, fire), including silvicultural treatments, are likely of importance to this species. Based on this interpretation, the ivory-billed woodpecker may be more appropriately described as a species that requires forest disturbance of substantial size to complete its lifecycle (Hunter et al. unpublished data).

Although little is known about the specific habitat requirements of ivory-billed woodpeckers, Tanner (1942) suggested that the species requires vast acreages of habitat to meet its annual needs due to its foraging behavior of (presumably) feeding extensively on wood-boring beetle larvae found within recently dead trees (≤ 1-3 years). Most foraging activity (84%) occurred on 12-36 inch dbh sweetgum (*Liquidambar styraciflua)*, Nuttall oak, and sugarberry trees (Tanner 1942).

Forest Interior Songbirds

Occupancy and vital rates (e.g., nest success) of songbirds within bottomland forests are influenced by both vegetation characteristics within forest stands (Heltzel and Leberg 2006) and by landscape conditions (Robinson et al. 1995). As with the Louisiana black bear, loss of bottomland hardwood forest and fragmentation due to land conversion for agriculture has presumably led to the decline of some songbirds (Andrén 1994). In small patches, forest birds are subjected to: (1) more competition with other species (Kerpez and Smith 1990), (2) increased parasitism from brown-headed cowbirds (*Molothrus ater*; Robinson and Wilcove 1994), (3) increased likelihood of predation (Andrén and Angelstam 1988; Marzluff and Restani 1999), (4) greater disturbance from human activities (Knight and Gutzwiller 1995), and (5) increased isolation and inhibition of dispersal (Doak et al. 1992; Matthysen and Currie 1996).

Although specific habitat requirements vary among species, silvicolous bird species share broad overlapping habitat requirements. For example, many of the priority forest interior songbirds (e.g., Swainson's warbler (*Limnothlypis swainsonii)*, cerulean warbler (*Dendroica cerulea*) require complex vertical and horizontal structure for nesting and foraging. For example, Hamel (2000) suggested that for nest sites and foraging substrates, cerulean warblers need canopy gaps intermixed with dominant, shade-intolerant trees with expansive, long-limbed crowns that overtop large, individual, shade-tolerant trees. Similarly, "classic" Swainson's warbler habitat is found in canebrakes associated with canopy gaps within bottomland hardwood forests (Meanly 1971). More recent research suggests that this species exploits disturbance gaps that are characterized by high densities of saplings, shrubs, and vines for nest sites in the absence of cane (Graves 2001, 2002, Somershoe et al. 2003, Bednarz et al. 2005). Unfortunately, many of the extant bottomland forests in the MAV have homogeneous closed canopies with little vertical or horizontal diversity.

Waterfowl

Use of forested wetlands by waterfowl species is dynamic, varying among seasons, and flood conditions with the availability of water, food, and cover (Reinecke et al. 1989). Priority waterfowl include mallards, wood ducks, hooded mergansers (*Mergus cucullatus*), gadwalls (*Anas strepera*), green-winged teal (*A. carolinensis*), and ring-necked ducks (*Aythya collaris*). Fredrickson and Heitmeyer (1988) reviewed the habitat use and requirements of these species: some species (e.g., mallards) use forested wetlands in the MAV only during migration and winter, whereas residents (e.g., wood ducks) are present year-round. Because hard mast from forests (i.e., acorns) is an important source of energy (Kaminski et al. 2003), flooded red oaks are especially important. However, other forested and shrub wetlands provide aquatic invertebrates (Heitmeyer 1988, 2006) and herbaceous seeds (Kaminski et al. 2003) as well as protective cover. Wood ducks and hooded mergansers require relatively large cavities for nesting with future cavities dependent upon large or stressed trees, especially American sycamore, oaks, elms, and baldcypress. Samaras of red maple (*Acer rubrum*) and elms are important foods for wood ducks in spring.

In the past, managers attempted to obtain more benefits from forested wetlands for waterfowl and hunters by constructing greentree reservoirs to ensure flooding occurred. However, several decades of experience has shown that early flooding, annual flooding, and delayed spring drawdown can result in decreased acorn production, increased tree mortality, and gradual replacement of seasonally flooded oak stands with species that are more water-tolerant but produce less food for waterfowl. Fredrickson et al. (2005) address the ecology and management of greentree reservoirs, but we note current guidelines for management recommend alternate year and variable flooding. Construction and operating costs combined with degradation of forested wetlands argue against developing new greentree reservoirs. Acknowledging the potential benefits of GTRs, we recommend proper management following recommendations of King and Frederickson (1998).

American Woodcock

Unlike most of its shorebird relatives, the American woodcock is a bird of forested habitats. As such, forest loss has likely contributed to the species' declining population trends (Krementz and Jackson 1999) resulting in it being listed as species of high concern within the U. S. Shorebird Conservation Plan (Brown et al. 2001). Found within the MAV mostly during winter, this species favors young, second-growth hardwoods (e.g., clear cuts) and "mature" hardwood stands with a relatively open canopy for diurnal cover (Roberts 1993). These habitats are typically characterized by high densities of saplings, shrubs, cane, and/or vines that facilitate predator avoidance. Conversely, nocturnal habitat of American woodcock tends towards open fields where they forage and conduct courtship activities (Krementz and Jackson 1999). Because American woodcock use temporally distinct habitats, specific landscape characteristics (i.e., juxtaposition of habitats) are required for this species.

Reptiles and Amphibians

Amphibians and reptiles have received little attention in the MAV and very little is known about their population status or habitat requirements. Over the last several years amphibians and reptiles have experienced worldwide population declines that have been related to numerous factors, including disease and pathogens, global climate change, invasive species, commercial trade, and interactions of multiple factors (Hayes and Jennings 1986, Blaustein et al. 1994, Lips 1998, Wake 1998, Alford and Richards 1999, Carey et al. 2001, Gibbons et al. 2000). Amphibians need both terrestrial and aquatic/wetland habitats within close proximity of each other to complete their life cycle (Beebee 1985, Hecnar and M'Closkey 1996, Pope et al. 2000, Semlitsch 2005). In general, reptiles have relatively large home ranges and they have diverse habitat needs that can include forest, wetland, and aquatic habitats (Dundee and Rossman 1989, Ernst and Ernst 2003). Thus, providing wetland/forest complexes at appropriate spatial scales is important for the conservation of these species (Petranka and Holbrook 2006). At a local scale, wetland management should address hydroperiod requirements and the development of diverse wetland plant structure. For many reptiles and amphibians, abundant coarse woody debris in bottomland hardwood forests and wetlands is an important habitat component and should be a target of forest management.

Bats

Several species of bats, including two species of concern – the southeastern myotis (*Myotis austroriparius*) and Rafinesque's big-eared bat (*Corynorhinus rafinesquii*) – utilize hollow trees for roost sites (Cochran 1999, Hoffman 1999, Gooding and Langford 2004, Loeb and O'Keefe 2006). Rafinesque's big-eared bat frequently uses hollow water tupelo trees that are characteristic of older baldcypress / water tupelo forests (Mirowsky 1998, Cochran 1999, Hoffman 1999, Gooding and Langford 2004). Although other species of trees, including baldcypress, may be used as roost trees, water tupelo and blackgum (*Nyssa sylvatica*) appear to be most important to this species in the MAV (Cochran 1999, Lance et al. 2001, Gooding and Langford 2004). Southeastern myotis have been found roosting in sweetgum, Nuttall oak, and water hickory (Wilf 2004). Gooding and Langford (2004) found that the average size of water tupelo trees used as roosts in Northeast Louisiana was 47 inches in diameter (4. 5 feet above ground) while Cochran (1999) found roost trees in Arkansas to average 61inches in diameter (4. 5 feet above ground). Rafinesque's big-eared bats in several studies were associated with mature bottomland hardwood forest, abundant roost trees, and relatively close proximity to permanent water (Cochran 1999, Lance et al. 2001, Gooding and Langford 2004). These results suggest that protection of existing (large) roost trees, regeneration of water tupelo and blackgum for future roost trees, and management for mature bottomland hardwood forests are important for this species (Gooding and Langford 2004, Wilhide et al. 2005). However, it is worth noting, that Menzel et al. (2001) found Rafinesque's big-eared bats roosting in abandoned structures in upland habitats, and males commonly foraged among sapling stage pines. Thus, our understanding of habitat needs and the short- and long-term effects of forest management on this species is incomplete.

HABITAT OBJECTIVES

Within any restoration program, it is useful to establish objectives at suitable scales (Gardiner et al. 2002, Wilson et al. 2005). The use of a hierarchical approach may be required for wetland restoration, because no wetland can maximize all potential functions. The functions and values of wetlands are scale-dependent, thus the area, spatial distribution, and type of wetlands that support one taxonomic group or wetland function may not be sufficient to support another taxonomic group or wetland function (Laughban et al. 2005). For example, site location and restoration techniques necessary to enhance water quality may be very different from those necessary to enhance breeding songbird habitat.

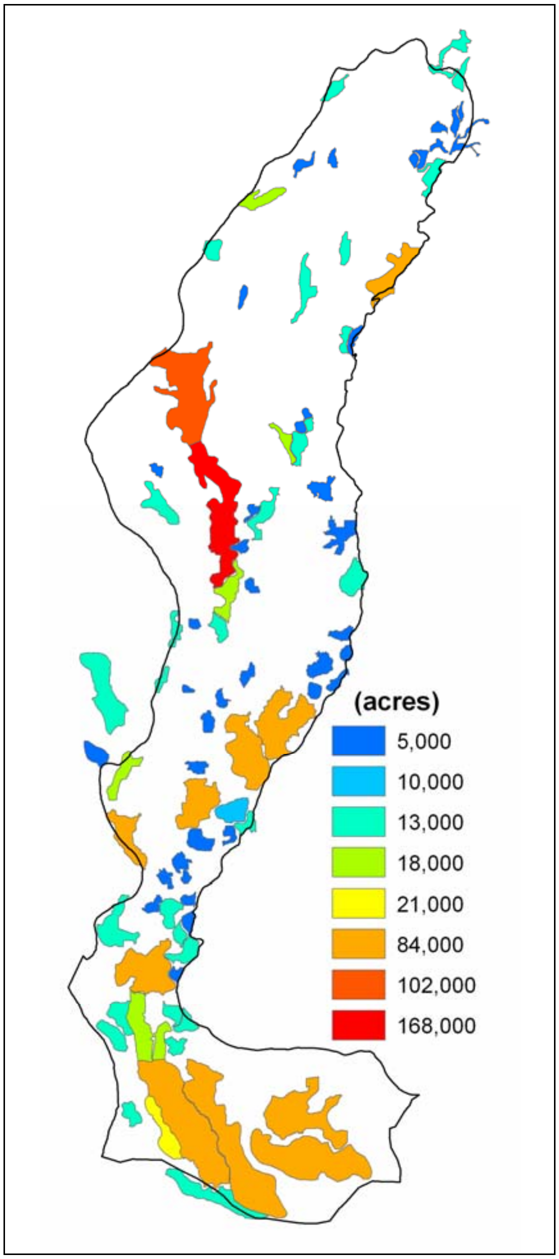
One of the first attempts to quantify forest habitat objectives for the MAV was within the framework of the landmark North American Waterfowl Management Plan (1986). Specifically, the Lower Mississippi Valley Joint Venture Management Board (1990) recommended restoration of historic forested wetlands for wintering waterfowl and other wetland functions. However, this plan did not recommend specific locations nor did it suggest any particular spatial distribution based on the assumption that waterfowl distribute themselves on the wintering grounds under an ideal-free distribution. That is, wintering waterfowl are not area dependent and can exploit any resource made available to them.

Similarly, the Partners In Flight (PIF) Bird Conservation Plan for the MAV (Twedt et al. 1999) suggested that sustainable source populations of breeding songbirds required >3.7 million acres of forested wetlands. In contrast to recommendations for waterfowl, songbird conservation planning efforts recommended that forest be distributed among 101 patches [13 patches >100,000 acres, 36 patches >20,000 acres, and 52 patches >10,000 acres] distributed among 87 local landscapes (i.e., Bird Conservation Areas). Specific geographic locations were identified based on extant forest conditions and expert opinion on forest restoration potential (Figure 4).

Several biological assumptions were made in the development of the PIF conservation goals. It was assumed that silvicolous bird populations in forest cores (>3,280 ft from “hostile” edges) are relatively free from deleterious edge effects of predation and nest parasitism (Batary and Baldi 2004). Similarly, local landscapes that were >60% forested were assumed to be conducive to successful reproduction of silvicolous birds (Robinson et al. 1995). Finally, forest core areas >5,200 acres were assumed to support self-sustaining (i.e., source) populations of >500 pairs of birds when they occur at high densities whereas core areas of >13,000 acres were required for species distributed at low densities.

Small, isolated forest patches attract few forest breeding birds (Robbins et al. 1989, Mancke and Gavin 2000) and often support low reproductive rates for breeding birds (Burke and Nol 2000, Nott 2000). Thus, restoration that increases the area of forest core and increases the proportion of forest within local landscapes is strongly encouraged (Twedt et al. 2006). Recent studies on avian productivity within reforested areas of the MAV support the merit of this approach (Twedt et al., unpublished data). By prioritizing reforestation proximate to existing forest (Huxel and Hastings 1999), restricting reforestation to within 6 mi of existing forest cores (Robinson et al. 1995), and targeting areas that increase forest in local (124 mi^2) landscapes to 70%, about 50 target areas have been identified that would result in the creation of forest cores >5,000 acres and 50 additional areas that target creation of forest cores >12,500 acres. A geographic information system (GIS) data layer developed from this decision support model for forest bird conservation (Twedt et al. 2006) depicts these restoration priorities at 100 ft (30 m) resolution (Figure 5, online at: http://www.lmvjv.org/GIS_data.htm).

Habitat objectives for birds overlap broadly with conservation recommendations for bats and bears. Rafinesque's big-eared bats are reluctant to cross large open areas (Clark 2000), making fragmented habitat unsuitable for this species. Black bears have large home ranges of up to 26 square miles (Marchinton 1995, White 1996, Anderson 1997, Benson 2005). Thus high levels of landscape connectivity are needed to allow movement of bats and bears among forest patches. To mitigate detrimental effects associated with small forest patches and sparsely forested landscapes, some reforestation programs have focused on establishment of corridors among forest patches (Sieving et al. 2000) and buffering forest patches to increase their size and interior area (Marzluff and Ewing 2001). Specifically, habitat restoration for the Louisiana black bear has utilized conservation priority areas (Figure 6) to target reforestation near existing blocks of bottomland hardwood forest and to reestablish forested corridors that connect inhabited areas within the southern portion of the MAV.



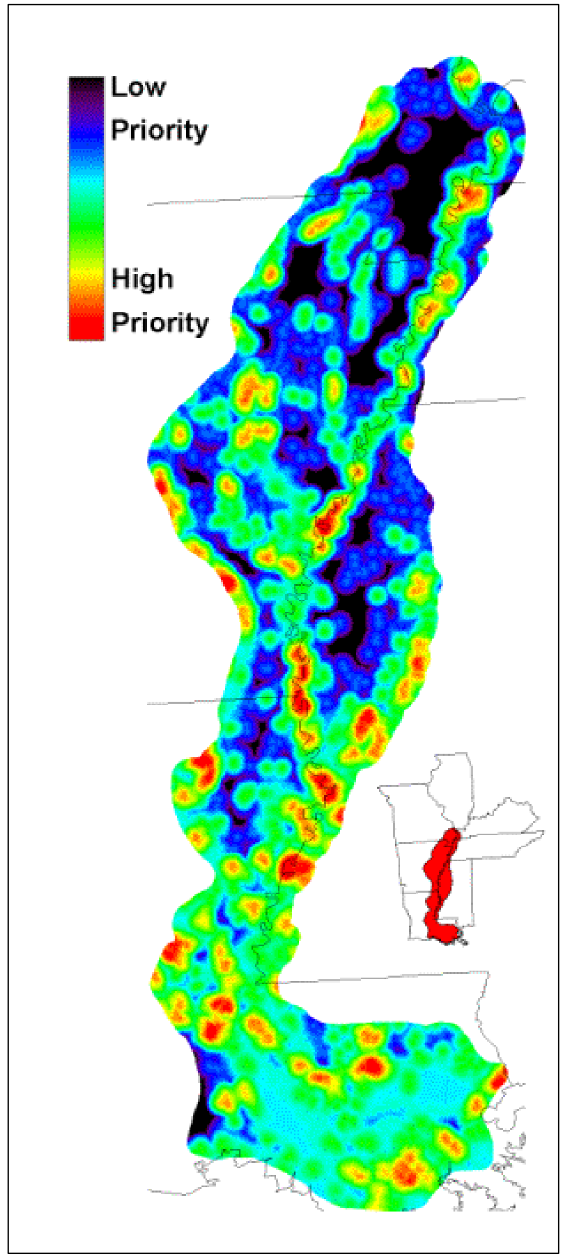


Figure 4. Geographic locations (Bird Conservation Areas) identified for potential forest restoration based on extant forest conditions and expert opinion (Twedt et al. 1999).

Figure 5. Forest restoration priority areas intended to create larger forest core area and more forested landscapes within the Mississippi Alluvial Valley (Twedt et al. 2006)

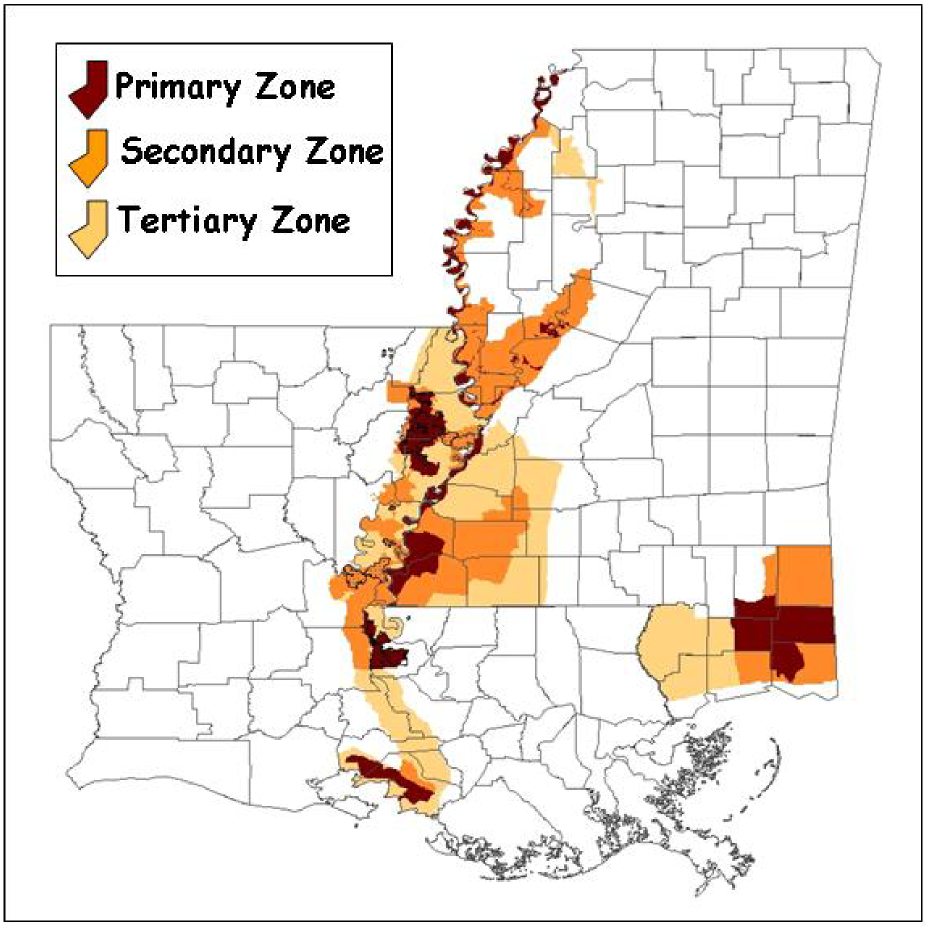


Figure 6. Conservation priority areas designed to facilitate forest restoration in support of Louisiana black bear conservation in the Mississippi and Louisiana.

DESIRED LANDSCAPE CONDITIONS

The continuity and juxtaposition of forested habitat within and among local landscapes has been shown to influence vital demographic rates (Robinson et al. 1995) and occupancy rates (Robbins et al. 1989) of many forest interior species. Undesirable landscape characteristics (e.g., forest edge) can result in poor reproduction of some silvicolous species within forest stands that are otherwise structurally suitable. Furthermore, many forest species benefit from a matrix of habitat types (e.g., shrub-scrub, complex canopy forests, etc.) within an appropriate spatial scale to fulfill all or part of their life cycle needs: bears (Weaver et al. 1990, Anderson 1997, Van Why 2003, Benson 2005), American woodcock (Krementz and Jackson 1999), and wood thrush (*Hylocichla mustelina*)(Vega Rivera 1999).

Landscape level management is difficult when ownership is distributed among many parties with diverse and often conflicting management objectives. In some areas of the MAV, government entities and large private ownerships (e.g., timber companies) own a substantial percentage of existing forested area. Even so, management on adjacent private lands may impact management decisions on public lands because landscape conditions influence suitability of habitat for priority wildlife. It should be noted that this does not imply a need for regulation of habitat conditions on private lands but many private landowners may choose to implement our recommendations for management of bottomland hardwood forest stands (Chapter III).

To address landscape scale habitat needs of priority wildlife species in the MAV, we advocate that local landscapes (≥10,000 acres) be extensively forested with large contiguous patches of forest (Table 1). However, we recognize that these conditions could benefit landscapes smaller than 10,000 acres. We also recognize that current stand conditions may not be optimal for priority wildlife species, as they are deficient in structural heterogeneity. To achieve greater structural diversity likely requires disturbance – one way to achieve this disturbance is through silvicultural manipulations. Therefore, we recommend 70 – 95% of forests within these landscapes be under active silvicultural management to insure regeneration and development of desired habitat conditions. The remaining 5 – 30% of forests would be under passive management (e.g., set-asides, wilderness, etc.). Within the forests under active management, we recommend a small proportion (<5%) of this area should be in shrub-scrub habitat. However, no more than 10% of any local landscape should be in large (>7 acre) regenerating forests (i.e., clearcuts less than 1/3 their site dependant height [Table 1]).

Managers should strive to ensure that 35 – 50% of all forested habitat is within desired stand conditions at any point in time (Figure 7, Table 2). If these landscape conditions are achieved, habitat conditions should reflect a sustainable continuum with (1) habitat conditions that warrant management, (2) habitat conditions that reflect optimum stand conditions, and (3) habitat conditions that are not optimal but for which management is not warranted. These landscape characteristics are designed to ensure that within and among local landscapes, a matrix of habitat conditions is available to fulfill the annual requirements of priority species, as well as, to guarantee a sustainable supply of habitat through time.

Table 1. Desired landscape (forest) conditions within the Mississippi Alluvial Valley. See Glossary for definition of terms.

Habitat Type	Percent of Area	Description
Forest Cover	70 – 100 %	Large (>10,000 acre) contiguous forested areas are desired. At any point in time, a minimum 35% and optimum 50% of the forest should meet the desired stand structure conditions (Chapter III, Table 2).
Actively Managed Forest	70 – 95 %	Forests that are managed via prescribed silvicultural treatments to meet desired stand conditions.
• **Regenerating Forest**	≤10 %	Forest regeneration on areas > 7 acres (e.g., clearcuts where >80% of overstory has been removed) or forest restoration on agricultural lands (i.e., reforestation). However, achieving increased forest cover via reforestation overrides the 10% limitation.
• **Shrub/Scrub**	≤5 %	Thamnic woody vegetation (hydric or mesic) within bottomland forests, including forests in early seral (successional) stages.
Passively Managed Forest	5 – 30 %	Forest areas that are not subjected to silvicultural manipulation (e.g., no-cut, wilderness, set-aside, and natural areas).

Although passively managed forests in the MAV are currently limited in area, we believe these areas are important as they serve as experimental controls against which to measure results of silvicultural treatments. To serve as appropriate controls, passively managed areas should be representative of various forest types and topographic positions. Thus, these passively managed areas should not be limited to small, linear areas (e.g., streamside management zones) or locations that are “inoperable” due to their hydrology (e.g., swamps). We suspect that the older seral stages of passively managed forests will exhibit a diverse forest structure. However, the lack of widespread, extensive flooding, river meandering, large fires, and other disturbances have altered processes that were once important and necessary to maintain diverse forest tree species. Furthermore, natural regeneration process in general are unpredictable, sporadic, of limited scope, and favor shade-tolerant species, thus habitat conditions within passively managed forests may be inconsistent (Johnson 1988, Johnson and Deen 1993, Battaglia and Sharitz 2005). Additionally, extended periods of time may be necessary to achieve diverse older seral conditions. Thus, we believe forest management is warranted to facilitate the achievement of conditions similar to those within diverse older seral forests.

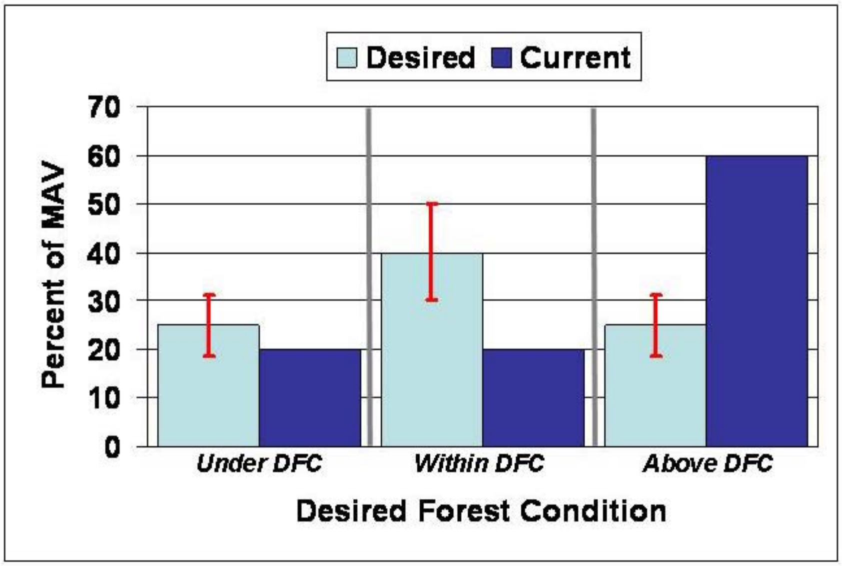


Figure 7. Hypothetical distribution of current and desired forest condition (Table 2) within bottomland hardwood forest stands in the Mississippi Alluvial Valley. Note desired conditions contain error bars representing the range of acceptable values.

To provide habitat for species requiring larger patches of early successional habitat (Annand and Thompson 1997), up to 5% of local landscapes may be maintained in early successional, shrub-scrub habitat. Various thamnic habitats are found within bottomland forests (Thompson and DeGraaf. 2001) but semi-permanent, hydric shrub habitat (e.g., buttonbush [*Cephalanthus occidentalis*] and swamp privet [*Forestiera acuminata*]) generally support different wildlife species than does mesic shrub habitat with herbaceous groundcover (Hunter et al. 2001). Some species such as Bell's vireo (*Vireo bellii*) and painted bunting (*Passerina ciris)* may require larger patches of shrub-scrub to maintain their populations. If shrub-scrub habitat is of high importance and limited availability in a local landscape, we recommend focused, active management to achieve these conditions. On hydric sites shrubby conditions may persist for many years whereas conditions on most mesic sites are ephemeral and will likely require periodic disturbance (e.g., mowing, burning, etc.) to be retained. Alternatively, early successional habitat can be temporally and spatially distributed across landscapes via prescribed silviculture such as that achieved on large (>7 acres) forest regeneration areas (i.e., clearcuts). However, ≤10% of any local landscape should be comprised of these large regenerating forest areas that are <1/3 of their site-dependent forest height. The limited area within each landscape coupled with this height constraint should; (1) insure reproductive sustainability of regenerated forest, (2) minimize predation and brood parasitism rates sometimes associated with these forest conditions, (3) alleviate concerns regarding widespread clearcutting on public lands, and (4) allow managers the flexibility to use clearcuts to achieve management objectives.

SUMMARY

Priority wildlife species within the MAV are often dependent on habitat characteristics obtained from extensive forest conditions, forest connectivity, higher site forests and forest disturbance events. The extensive manipulation of bottomland forests within the Mississippi Alluvial Valley since European settlement, and especially since the advent of a stronger national flood control policy and ensuing agricultural development, have resulted in a serious degradation of those habitat characteristics. The remaining sub-quality habitat has effectively resulted in declining populations of many wildlife species associated with these forest resources, thus heightening our awareness and accelerating their stature to “priority”.

Characteristics exhibited in mature bottomland hardwood forests also provide particular habitat variables important to many priority species such as dens, cavities, canopy gaps, species diversity, vegetative diversity, and natural senescence. However, the MAV forest resources have historically been extracted for forest products with only slight consideration for their regeneration and even less for wildlife habitat. More recent awareness of the importance of these forest resources to our nation has encouraged sustainable management of these forests for wildlife as well as forest products.

Chapter III

MANAGEMENT OF BOTTOMLAND HARDWOOD FORESTS

INTRODUCTION

For forest dwelling wildlife, the size, structure, and composition of forests are as important as the abundance and spatial distribution of forests within the landscape. To ensure hard mast production for consumption by Louisiana black bear and some species of waterfowl, it is important to maintain some proportion of forest stands in oaks or sweet pecan. However, for large woodpeckers, such as the ivory-billed woodpecker, large-diameter senescent trees are a key habitat component. Additionally, large (>36 inch) diameter trees are important for bats and the Louisiana black bear, especially baldcypress, water tupelo, blackgum and overcup oak for den and roosting sites (Hightower et al. 2002, Benson 2005, Cochran 1999, Hoffman 1999, Gooding and Langford 2004). Clearly, when manipulating habitat within stands managers must consider a variety of habitat factors (e.g., size, structure, and composition) to address the habitat needs of priority species.

Moreover, within-stand successional patterns results in a shifting mosaic of patches of various ages and sizes across the landscape. At any given point in time, a particular stand may not provide desired conditions, but at a different stage of stand succession it may be crucial for providing habitat for priority wildlife species. Ideal habitat conditions for any given species are transient and the presence and abundance of species will vary temporally according to the successional stage of the stand and the surrounding landscape. In forested systems, the timeframe necessary to achieve desired conditions within a stand for a given species may be decades. Thus strategic long-term planning is necessary to achieve forest habitat goals.

HISTORIC IMPLEMENTATION

The distribution and abundance of suitable habitat often depends upon the temporal and spatial characteristics of disturbance (Hobbs and Huenneke 1992). In bottomland hardwood forests of the MAV, disturbances include tornadoes, hurricanes, ice storms, floods, fire, and wind throws, as well as the size, type, frequency, and abundance of timber harvest (King et al. 2005). Little quantitative data are available on disturbance regimes in the MAV, but the system of levees, channelization, and other activities that have restricted the meandering of the Mississippi River and its major tributaries have markedly reduced the frequency of large-scale disturbances. The effects of altered disturbance regimes and the loss of bottomland hardwood forests have affected the structure and composition of bottomland hardwood forests (Chapter I). Over the last century, activities detrimental to forest habitat have included clearing land for agriculture and homesteads and indiscriminate, large-scale clearcutting and high-grading of forests to exploit their timber resources. More recently, sound silvicultural practices have been utilized in management of the MAV forests, targeting sustainable timber production (King et al. 2005). Concomitant with this push for sustainable forestry has been a desire to relate forest management actions to habitat needs of priority fish and wildlife species. Indeed, even as the area of bottomland hardwood forest has diminished, the proportion of these lands being managed primarily for wildlife has vastly increased. Ideally, wildlife management in bottomland hardwood forests should follow an ecosystem approach, focusing on wildlife species of conservation concern and the implementation of management activities at multiple spatial scales.

On private lands, the 1990 Farm Security and Rural Investment Act which authorized the U. S. Department of Agriculture's Wetland Reserve Program (WRP) placed increased emphasis on wildlife habitat. The voluntary WRP provided financial incentives to restore wetlands through retirement of lands from agricultural production. According to the act, the Secretary of Agriculture "*... in consultation with the Secretary of the Interior, shall place priority on acquiring easements based on the value of the easement for protecting and enhancing habitat for migratory birds and other wildlife*" (United States Congress 1990). This program has greatly altered the landscape of the MAV, as over 680,000 acres have been enrolled in WRP as of September 30, 2005 (King et al. 2006). Although easements have targeted restoration of forest and wetland cover to retired agricultural land, some easements have included tracts of extant bottomland forest. As the legislative language mandated that any management on WRP lands enhance habitat for migratory birds and other priority wildlife, the USDA Natural Resource Conservation Service identified forest management activities that were compatible with this objective. Similarly, state and federal wildlife resource agencies have mandates to protect, restore and enhance habitat for fish and wildlife species (Pittman-Robertson Wildlife Restoration Act, as amended through P. L. 106-580, 29 December 2000).

Although it has long been recognized that forest management, including some component of passive management, impacts wildlife habitat, only recently have forest management objectives been articulated that explicitly address priority wildlife needs in bottomland forests. Specifically, the Natural Resource Conservation Service in conjunction with the U. S. Fish and Wildlife Service and input from researchers, practicing foresters, and wildlife biologists addressed habitat needs through the development of *General Guidelines for Hardwood Forest Management to Improve Wildlife Habitat* (B. Strader, unpublished manuscript, U. S. Fish and Wildlife Service, Jackson, Mississippi) and *Wetland Reserve Program – Forest Land Compatible Use Guidelines* (Anderson et al. 2004). These documents provided forest metrics that identified habitat conditions presumed to be favorable for priority wildlife species. However, some foresters and biologists raised concerns pertaining to the long-term sustainability of forests using these recommended forest metrics. To facilitate and further these discussions, the LMVJV Forest Resource Conservation Working Group took on the challenge of refining these forest management guidelines to better reflect habitat needs of priority wildlife species and long-term forest sustainability. Specifically, the objective was to develop recommendations to clearly articulate desired forest conditions that meet the habitat requirements of priority wildlife species at multiple spatial scales.

DESIRED STAND CONDITIONS

Forests within suitable landscapes (Chapter II) should provide vertical and horizontal structural diversity in terms of tree species, size and age classes, and growth forms (e.g., trees, shrubs, and vines) within a heterogeneous forest canopy comprised of gaps and a complex layering (i.e., desired stand conditions, Table 2). As many forest interior wildlife species flourish under habitat conditions associated with these complex forest structures, we emphasize the need to increase the availability of these forest conditions. Although little empirical data exist upon which to draw (Mitchell and Beese 2002), we believe that desired stand structures can be achieved via the use of silvicultural practices (Beggs 2004).

Table 2. Desired stand conditions for bottomland hardwood forests within the Mississippi Alluvial Valley.

Forest variables [1]	Desired stand structure	Conditions that may warrant management
Primary Management Factors		
Overstory canopy cover	60 – 70 %	>80%
Midstory cover	25 – 40 %	<20% or >50%
Basal area	60 – 70 ft^2 / acre with ≥25% in older age classes[2]	>90ft^2 / acre or ≥60% in older age classes
Tree stocking	60 – 70 %	<50% or >90%
Secondary Management Factors		
Dominant trees[3]	>2 / acre	<1 / acre
Understory cover	25 – 40%	<20%
Regeneration[4]	30 – 40% of area	<20% of area
Coarse woody debris (>10 inch diameter)	≥200 ft^3 / acres	<100ft^3 / acre
Small cavities (<10 inch diameter)	>4 visible holes / acre **or** >4 "snag" stems ≥4 inch dbh **or** ≥2 stems >20 inch dbh	<2 visible holes / acre **or** <2 snags ≥4 inch dbh **or** <1 stem ≥20 inch dbh
Den trees/large cavities[5] (>10 inch diameter)	1 visible hole / 10 acres **or** ≥2 stems ≥26 inch dbh (≥8 ft^2 BA ≥26 inch dbh)	0 visible holes / 10 acres **or** <1 stem ≥26 inch dbh (<4 ft^2 BA ≥ 26 inch dbh)
Standing dead and/or stressed trees[5]	>6 stems / acre ≥10 inch dbh **or** ≥2 stems ≥20 inch dbh (>4 ft^2 BA ≥ 10 inch dbh)	<4 stems ≥10 inch dbh / acre **or** <1 stem ≥20 inch dbh (<2 ft^2 BA ≥ 10 inch dbh)

Table 2. Continued.

[1] Promotion of species and structural diversity within stands is the underlying principle of management. Management should promote vines, cane, and Spanish moss within site limitations.

[2] "Older age class" stems are those approaching biological maturity, (i.e., senescence). We do not advocate aging individual trees but use of species-site-size relationships as a practical surrogate to discern age.

[3] Dominants (a.k.a. emergents) should have stronger consideration on more diverse sites, such as ridges and first bottoms.

[4] Advanced regeneration of shade-intolerant trees in sufficient numbers (circa 400/acre) to ensure their succession to forest canopy. Areas lacking canopy (i.e., group cuts) should be restricted to <20% of stand area.

[5] Utilizing BA parameters allows the forest manager to maintain this variable in size classes that are most suitable for the stand instead of using specific size classes noted.

By focusing management actions on forest stand conditions, managers are able to ensure that prescribed treatments address habitat needs of priority wildlife. Within a forest stand, managers historically have used a set of primary forest metrics (e.g., basal area, tree stocking) to define forest management needs in terms of forest density, health (Nebeker et al. 2005) and economic quality. We have employed these primary forest metrics and a suite of additional (secondary) forest metrics (e.g., tree cavity and standing dead tree densities) to guide managers in discerning the need for forest treatments to sustain important wildlife habitat characteristics (Table 2). These forest metrics are listed as *primary* or *secondary management factors* based on their presumed impact on forest structure and contribution to wildlife habitat needs, as well as the perceived ability of management to impact these conditions.

Recognizing that it is impractical to identify exact values for these metrics, each management factor is represented by a range of values, as well as, the extent of deviation from these desired conditions that may warrant prescribed forest management. It should be noted that prescribed management actions may temporarily result in stand conditions below the recommended range of stand conditions. This condition will maximize the time that stand conditions are maintained within a recommended range by accounting for the vegetative response in some systems and allowing for the full range of values to be experienced post-treatment.

We advocate use of silvicultural prescriptions that result in: (1) reduced basal area and tree stocking; (2) multi-layered canopies; and (3) increased midstory development, thereby addressing primary management factors. Additionally, secondary management factors can be addressed through management by ensuring that prescribed treatments promote the development of dominant trees, cavity retention, understory development, and shade-intolerant regeneration.

Achievement of desired stand conditions is dependent upon a multitude of factors including but not limited to site index, frequency and duration of flooding, and existing stand condition. As such, we acknowledge that there is no “silver bullet” prescription. Instead, we envision a range of desirable stand conditions that are broad enough to accommodate different management objectives, while maintaining sufficient rigidity to guide management towards stand conditions beneficial to priority wildlife species.

Attaining desired stand conditions requires disturbance. Disturbance may be initiated by land managers through silvicultural treatments that address appropriate change in primary management factors. For example, stands with basal area of >90 ft^2/acre should be reduced to a basal area of 60-70 ft^2/acre. Although there is not a one-to-one relationship, this reduced basal area should concurrently target a reduction in canopy cover to 60 – 70%. Canopy cover of <50% should be avoided except within areas that target regeneration of shade-intolerant trees. Similarly, we caution against use of traditional harvest prescriptions designed to solely optimize timber production, recommending instead prescriptions wherein trees are retained to meet ecological objectives, especially provision of habitat for priority wildlife (Mitchell and Beese 2002).

IMPLICATIONS FOR PRIORITY WILDLIFE SPECIES

Management should favor the creation of a naturally diverse canopy, as well as floristic diversity within the forest midstory and understory. Furthermore, we caution against the tendency to harvest primarily trees of higher economic value and managers should likewise guard against favoring retention of species based solely on their economic value at harvest.

Diverse tree species composition in bottomland hardwood forest is important because it can provide heterogeneous vertical structure, a variety of hard and soft mast, and greater insect abundance. Evidence of avian dependence on specific tree species is sparse (Gabbe et al. 2002), but some species such as baldcypress, American sycamore, sweetgum, and willows (*Salix* spp.) have indications of substantial use. Most tree species exhibit unique phenologies of seasonal development. As such, they have different temporal development of flowering and fruiting (Reynolds-Hogland et al. 2006). Additionally, trees attract different insects (primarily as hosts for insects that consume their leaves) at different times. Some insects are unique to specific tree species. Because most birds are insectivorous during the breeding season, maintaining diversity of tree species likely buffers against "boom and bust" cycles in the insect forage base available to birds. Additionally, some tree species are more prone to cavity development or they may be closely linked with the distribution of specific wildlife species (e.g., *Nyssa* spp. and Rafinesque's big-eared bats (Burns and Honkala 1990, Mirowsky 1998). A diverse forest also supports trees that mature and senesce at different rates thus allowing for more continuous input of snags, canopy gaps, and coarse woody debris (Harmon et al. 1986, King and Antrobus 2005).

To maintain and encourage vertical structure development, treatments should leave 2 to 4 trees/acre of species and individuals that will maintain or rapidly attain dominant crown positions. Because of their propensity to become dominant or emergent trees, residual species should include oaks, baldcypress, cottonwood, and sweetgum. These future emergent / dominant residual trees should be identified before marking timber for harvest such that subsequent timber harvest can be used to encourage lateral growth via increased sunlight and/or encourage vertical growth via competition with neighboring residual trees.

Tree size is also an important component of forest structure. Stem size is influenced by a variety of factors including tree age, the species of tree, site productivity, the amount of competition and other factors. Analysis of forest inventory data from 1991-1995 revealed 56% of bottomland hardwood forests in the MAV had <20% of their basal area occupied by stems with >20 inch diameters (Rudis 2001a). A general, but often false, assumption is that large trees are older than smaller trees. Data from bottomland hardwood forests do not unequivocally support this assumption, particularly when comparing among different species or among different sites (S. King unpublished data). In central Louisiana for example, willow oaks that were 33 – 67 years old developed large diameters relative to other species that attained similar or even smaller diameters at greater age [green ash (70-88 years), bitter pecan (82-90 yrs), overcup oak (66-170 yrs) (K. Ribbeck, personal observation).

Tree size is important to a number of wildlife species. For example, large diameter trees are the only trees suitable for black bear den sites and preferred roost trees for Rafinesqe's big-eared bats. Furthermore, Tanner (1942) found that ivory-billed woodpeckers foraged disproportionately more on larger stems relative to their presence in the forest. A total of 35% of observed foraging occurred on stems $\geq$24 inch in diameter even though stems in that size class accounted for only 5% of stems in the forest. Thus, large tree size is included within the primary management factors as a percentage of older age class trees within the basal area metric and is also considered in the secondary management factors within three different categories (Table 2). Although we believe it desirable to retain large diameter, older age class trees, excessive representation of these trees (>60%) will likely impede regeneration of shade-intolerant species, especially oaks (Hodges 1989).

In addition to large trees, cavities are important to many wildlife species for roosting, denning, and nesting sites. Trees containing or likely to develop cavities are recommended for retention within stands. Care should be taken to minimize damage to cavity trees during harvest operations. When possible, prescribed treatments should retain 4 to 6 cavity or cavity-potential trees (e.g., unsound culls) per acre. The availability of several suitable cavity trees within a given area is important to bats, especially females with young, which tend to frequently switch roost sites. Additionally, some of the stressed and/or dying trees that traditional silviculture would remove to improve forest health, should be retained for recruitment of future cavities.

Although reduced canopy stimulates beneficial development of herbaceous understory, reduction of the canopy to <50% may cause displacement of many forest birds and extensive colonization by shrub-scrub birds. At this disturbance intensity, nest success of canopy and midstory nesting species will likely decline for several years. However, failure to reduce the overstory to <80% canopy cover will likely result in rapid canopy closure and negligible increases in the abundance of high priority species that depend on the forest understory (e.g., Swainson's warbler). A reduction of the forest overstory to 60% -70% canopy cover will likely improve long-term habitat conditions for understory bird species but not cause dramatic changes in the overstory bird species composition within bottomland forests.

Silvicultural treatments could also be used to influence species composition and improve growing conditions on restored sites (e.g., reforested stands; Chapter IV) entering "stem-exclusion" conditions when canopy closure occurs and reduces understory vegetation. No definitive silvicultural prescriptions currently exist to guide stand development towards desired stand conditions or to promote wildlife habitat (Meadows 1996). However, Goelz (1995) provides stocking recommendations for timber production under an even-aged management scheme that may provide a foundation for management decisions. This guide is based on hypothetical stocking levels provided by Putnam et al. (1960) for bottomland hardwood stands but no residual stocking levels have been experimentally validated. Alternatively, management actions (e.g., group cuts) could be undertaken within these stands to ensure areas of sunlight penetration to the forest floor within parts of the stand. This will encourage diverse vegetation and increased horizontal structure. Additionally, these treatments should consider retention of dense areas within the plantations to allow natural senescence for deadwood development.

Because they increase vertical and horizontal cover, regeneration harvests of limited areas likely benefit many priority wildlife species. The size of openings necessary to regenerate shade-intolerant tree species, however, must be balanced against the potential negative effects of increased brood parasitism of songbird nests by brown-headed cowbirds in larger openings, the time required for harvested areas to regain forest canopies, and the even greater time required to attain desired stand structure. Because brown-headed cowbirds appear to be ubiquitous within bottomland hardwood forest patches of <25,000 acres in the MAV, increased nest parasitism within forest openings may have a negative impact on breeding birds (R. J. Cooper, University of Georgia, unpublished data). This is important, as gaps of 1 to 3 acres may be essential for regeneration of some shade-intolerant tree species (e.g., oaks and sweetgum). Despite potential impacts on breeding birds, a small proportion (<20%) of many forest stands should target regeneration of shade-intolerant tree species through small, silvicultural induced gaps – even at the risk of slightly elevated rates of nest parasitism. However, as defined by desired landscape conditions (Chapter II), regenerating forests >7 acres should represent ≤10% of the landscape. To the extent possible, large areas of forest regeneration (i.e., clearcuts) should be positioned to create maximum benefit for species of concern while minimizing the negative impacts often associated with these large, temporary openings. We believe that limited use of larger regeneration harvests, combined with smaller openings within variable retention harvests, will provide sufficient shade-intolerant regeneration, including oaks (Oliver 2005).

An additional concern associated with large disturbances within forests is the potential for invasion by vegetation that has a negative impact on priority wildlife. Of particular concern are exotic species (e.g., Chinese tallow [*Triadica sebiferum*], trifoliate orange [*Ponicirus trifoliate*]) that may aggressively invade bottomland forests following silviculture operations and/or the abandonment of agricultural lands (Renne et al. 2000). Notably, Chinese tallow has commandeered numerous sites within the southern MAV, to the detriment of native plant species (Bruce et al. 1997). As such, managers will need to give extra consideration to the implication of disturbance within forests where these exotics are likely to invade (e.g., several years of Chinese tallow chemical control will likely be required on most Gulf Coast sites following silvicultural treatments).

Finally, some non-woody vegetation has been associated with increased use by priority wildlife species. Three centuries ago canebrakes were widespread throughout the MAV (Harper 1958). However, the canebrake ecosystem has declined by 98%, and this once prominent feature of bottomland forests is now considered a critically endangered ecosystem (Noss et al. 1995). When present in forest stands, silvicultural prescriptions should minimize damage to and encourage proliferation of cane. Creation of gaps surrounding cane patches may encourage their development by providing additional sunlight (Gagnon 2006, Appendix 2). Spanish moss (*Tillandsia usneoides*) is another vegetation component often associated with specific bottomland forest species (Gooding 1998). Unfortunately, management actions to encourage expansion of Spanish moss are unknown.

Silvicultural treatments should optimally occur between 1 August and 28 February, but care should be taken to avoid bear denning locations during the winter (Linnel et al. 2000, Hightower et al. 2002). Disturbance should be minimized during the peak-breeding season for birds and bats -- between 1 March and 31 July (this period may differ slightly within the MAV based on latitude). However, wet ground conditions often restrict access during late fall and winter. Thus, forest management that improves habitat may be undertaken between 1 March and 31 July when the alternative is undertaking no habitat improvement actions.

The length of time between stand entries should be related to the intensity of treatment – that is, habitat enhancements persist longer in stands subjected to more intense disturbance. Thus, desired stand conditions should prevail for longer duration. Because desirable habitat conditions are likely to persist for >10 years after harvest, subsequent entry for additional disturbance should not be warranted for at least 15 years unless the original prescription recommended follow up treatments. Moreover, it is important to note that we are not promoting a specific (e.g., 15 year) "cutting cycle," instead we are recommending an "evaluation cycle". That is, every 10-15 years (based on site characteristics), the area in question will be evaluated for the need of additional treatments to maintain desired forest conditions. In many cases, the management decision will likely be to defer treatment in this area until a future time, unless the control of exotic invaders indicates otherwise.

SUMMARY

As more emphasis is placed on drawing a clearer linkage between forest management activities and habitat needs of priority forest wildlife species, it is imperative that biologists and foresters work together. To that extent, we have identified landscape and stand level parameters intended to guide and facilitate management actions that result in desired forest conditions beneficial to priority wildlife species. These parameters reflect a combination of published reports and the collective knowledge of experienced managers, thereby representing what we believe to be realistic, long-term sustainable forest conditions. Parameters are represented as a range of values, thereby providing flexibility to modify prescriptions to meet overriding habitat needs within local landscapes and among different forest types.

Forest managers have historically emphasized maintaining forest health and productivity. However, wildlife managers recognize the benefits conferred to certain species through unhealthy or less productive components of a forest. For example, dead and stressed trees and coarse woody debris provide food for the lower organisms in the food chain (e.g., invertebrates) which in turn provide forage for subsequent links in the food chain (e.g., skinks, woodpeckers, bears, etc.). These processes also serve important functions in recycling nutrients thereby promoting sustainable forest conditions. Unfortunately, the normal practice of silviculture attempts to remove dead or stressed trees before they can be recycled within the forest system. Similarly, traditional timber harvest is undertaken, in part, to: (1) maximize the growth of retained stems; and (2) promote overall forest health. As such, we recognize that to attain our recommended desired forest conditions, land managers must alter forest management prescriptions to retain some non-merchantable forest components and maintain less than maximum sustained tree growth. Even so, we believe that these management recommendations will provide a sustainable forest that is economically viable, produces quality timber products, and maintains sustainable populations of priority silvicolous wildlife.

CHAPTER IV

RESTORATION OF BOTTOMLAND HARDWOOD FORESTS

INTRODUCTION

As early as the 1960s land managers within the MAV expressed concerns over the degradation of forested habitats due to hydrologic and geomorphic alterations to river systems and widespread clearing of bottomland hardwood forests. Although little information was available on reforestation techniques, these land managers began a trial and error process to plant trees on abandoned agricultural land (Tim Wilkins, Yazoo NWR, personal communication, Savage et al. 1989). In most cases, available land consisted of heavy clay soils that flooded too frequently to be profitable for agriculture. More serious efforts to restore forest cover on lands converted to agriculture began in the mid-1980s (Allen and Burkett 1996) when the U. S. Fish and Wildlife Service, Arkansas Game and Fish Commission, Louisiana Department of Wildlife and Fisheries and Tennessee Wildlife Resource Agency increased their tree planting efforts (Savage et al. 1989, Newling 1990). These efforts were furthered through contacts and field review meetings of the Southern Hardwood Forestry Group with input from researchers at the U. S. Forest Service's Center for Bottomland Hardwood Research in Stoneville, Mississippi (M. Blaney, personal communication). In most cases, the sole activity was to plant two or three species of trees with little monitoring of vegetation or wildlife response.

Since 1987, public agencies and private interests have reforested circa 1,000,000 acres (R. Wilson, personal communication), with suggested restoration targets of >2 million acres (Haynes 2004). Numerous state and federal agencies have contributed to these totals, but the advent of the USDA's Wetland Reserve Program greatly accelerated reforestation efforts (King et al. 2006). The 1990 Farm Bill established the WRP, a voluntary program that provides technical and financial assistance to eligible landowners to restore wildlife habitat on wetlands through planting of vegetation and limited hydrologic restoration. Haynes (2004) stated that *"The Wetland Reserve Program is perhaps the most significant and effective wetland restoration program in the world, and has provided a tremendous opportunity to restore forested wetlands"*. As of September 2004, nationwide there were 7,831 projects on 1,470,998 acres enrolled in the

Wetland Reserve Program. Through 2005, > 680,000 acres have been enrolled in Louisiana, Arkansas, and Mississippi (King et al. 2006).

HISTORICAL PERSPECTIVE

Historically, hardwood forest restoration was intended to create diverse forest habitat for wildlife and a sustainable timber harvest (Wilson and Twedt 2005). Unfortunately, most of the early restoration occurred opportunistically, resulting in isolated blocks of restored forest (i.e., little contribution to the reduction of forest fragmentation). Additionally, many of the restored sites had relatively low topography (i.e., flood–prone sites), coupled with a failure to properly match tree species with site conditions (Stanturf et al. 2001) that resulted in poor tree survival. These mismatches of tree species and site conditions are less frequent in current practice.

Despite high diversity of tree species in bottomland forests (Allen 1997), plantings on bottomland sites have historically focused only on a few species of slower-growing, hard-mast producing trees. The species selected for restoration are typically based on their mast-production, their seed dispersal method (e.g., heavy-seeded, poorly dispersed species were favored), and their value as timber. Indeed, one study (King and Keeland 1999) indicated that within the MAV >80% of all planted species have been oaks or sweet pecan, although the diversity of plantings has increased more recently.

Few guidelines exist regarding optimal planting densities (Lamb 1999). Historically, a density of 302 seedlings / acre (12 x12 ft spacing) has been used in most bottomland forest restoration in the MAV (King and Keeland 1999). Early restorations often employed direct seeding due to the low cost of acorns and sowing (Johnson and Krinard 1987, Haynes et al. 1995). However, unpredictable survival within direct seeded restorations (due to seed and/or planting qualities) has prompted greater reliance on planting bare-root seedlings despite greater cost.

DESIRED FOREST CONDITIONS

Forest restoration is the most important method by which we can achieve largely forested landscapes. However, reforestation has historically been extensive with an intent to “plant as many acres as possible,” despite a lack of clearly defined site-specific objectives linked to succinct landscape objectives (Wilson et al. 2005). Although this approach may have been initially warranted, it fails to recognize important components of successful ecosystem restoration (e.g., succinct objectives linked to wildlife population response [Young 2000]). Obviously, the establishment of clearly defined focal areas and restoration priorities is necessary to effectively meet landscape conservation objectives (Chapter II; Table 1) (Llewellyn et al. 1996, Twedt et al. 2006). Over the last 5-10 years, conservation objectives have been used more effectively in prioritizing bottomland hardwood restoration (e.g., use of songbird [Fig. 4 and 5] and black bear [Fig. 6] decision support tools in the ranking of WRP).

Concurrently, the "one-size-fits-all" approach has often been used for restoration within sites, as evidenced by commonly planting few species (primarily oaks) at a standard density of 302 seedlings / acre (12 x 12 ft spacing). Evaluation of the subsequent development of these plantings suggests that many have failed to attain a diverse species composition or structural complexity, in the absence of additional site invasion by native species. Furthermore, it appears that many planted stems are unlikely to develop characteristics that will lead to quality timber production, thereby limiting forest management options to meet DFCs. Thus, site development following historical restoration methods appears unlikely to provide Desired Stand Conditions (Chapter III) without additional silvicultural manipulations or extended periods of time. Below we articulate recommendations for bottomland restoration that target attainment of both Desired Landscape Conditions and development of Desired Stand Conditions.

LANDSCAPE SCALE CONSIDERATIONS

Many priority wildlife species are dependent upon large, forested landscapes that harbor contiguous bottomland hardwood forests. Thus, in general, our primary landscape conservation goal is to establish and maintain extensive areas of contiguous bottomland forest within distinct local landscapes (Chapter II; Wilson et al. 2005).

Although small isolated, or long linear tracts may provide important wildlife habitat (e.g., as bear movement corridors), these sites are likely of lesser value to forest-breeding songbirds. An alternative management strategy for these sites may be to plant and maintain these areas in shrubby, early successional habitat (see below). Depending on topographic diversity, these sites may also be important for reptiles and amphibians. Both environmental and spatial variables influence amphibian assemblages (Parris 2004, Loehle et al. 2005) but Burbrink et al. (1998) noted that patch size was less important than topographic diversity for these species.

When planning restoration at the landscape scale, sites with higher elevations should be considered as they have been underrepresented in previous restoration activities. As historic opportunity for restoration has largely been on flood-prone sites, higher elevation bottomland sites (e.g., ridges and second bottoms; Fig. 3) have rarely been restored. Indeed, most extant bottomland forests in the MAV are on lower sites (Twedt and Loesch 1999, Rudis 2001b) whereas higher elevation sites remain in agricultural production. Functionally, higher sites provide unique habitat resources that are unavailable or limited on lower sites. For example, during major flood events, many forest interior species (e.g., ground foraging songbirds, deer, turkey, etc.) must find alternative habitat when displaced from flooded forests. Furthermore, higher elevation sites often have temporary, fishless wetlands that are important for many species of amphibians (Burbrink et al. 1998).

Restoration of these higher sites should be a priority, but there are economic, social and political challenges. Economically, these sites are more productive agricultural areas and the costs of acquiring these sites will be considerably higher than marginally productive agricultural areas. Socially and politically, the loss of agricultural revenues from rural communities is a concern and will likely be met with resistance (R. Wilson, personal observation). Loss of farming activities can further impact rural communities as the need for services supporting this practice is diminished. The lag time between reforestation and forest harvesting can be hard on the local economies currently dependent on farming activities. These and other concerns must be appropriately addressed.

Opportunities may exist to gain substantial benefits from concurrent functions when they are considered in the selection process. These “secondary” functions can potentially enhance the success of restorations. For example, selecting sites for restoration that are known sediment sources or that are important sediment sinks may enhance the long-term condition of existing forests in a watershed.

Conversely, there may be conflicting landscape-based forest restoration objectives among priority wildlife species. For example, managers may have to choose between forest restorations or herbaceous moist soil intended for waterfowl. In these situations, the potential benefit of reduction in forest fragmentation will have to be balanced against maintaining non-forest habitat (e.g., moist soil units or managed agricultural areas) that benefit waterfowl and other waterbirds. The effect of landscape position on other wetland functions (e.g., carbon sequestration, water quality enhancement) and other species of wildlife (e.g., amphibians and reptiles) should also be considered.

STAND LEVEL CONSIDERATIONS

Site Limitations

Forest composition within the MAV is highly correlated with hydrogeomorphic setting (Klimas et al 2005). Thus, we suggest that forest restoration is likely to be most successful when restoration accounts for the effects of micro-topography, hydrology, soils, and geomorphic setting on plant species composition. To that extent, most, if not all restoration sites have undergone hydrological changes/alterations. Although restoration of original hydrologic conditions may not be possible because of physical land use changes and/or socioeconomic constraints, restoring or emulating local hydrologic processes through re-contouring of lands or through active wetland management is encouraged. Flooding was and is a critical component of forested wetlands with ecosystem productivity and life cycles of many organisms linked to these hydrologic processes. Thus, restorationists should evaluate opportunities for hydrologic restoration or rehabilitation prior to selecting plant species for restoration.

Differences in soils and hydrology, among and within restoration sites, mandate that for optimal tree growth and survival, species selections must be compatible with site conditions (Baker and Broadfoot 1979, Patterson and Adams 2003, Lockhart et al. 2006). On sites with varied topography (e.g., ridge and swale), matching species with site conditions should result in increased heterogeneity of species and structure (Groninger 2005). However, on sites that are often inundated, soil with uniform topography or with homogeneous soils, planting only a few site-compatible species may be warranted.

Species diversity

The high diversity of tree species found within bottomland forests (Allen 1997) provides a great variety of wildlife habitat. However, previous restoration has focused on ensuring establishment of hard-mast producing trees, primarily oaks with the assumption that diversity would result from naturally colonizing light-seeded trees. Assessment of established restorations sites has indicated that diversity is often dependent upon distance from existing forest stands (Allen et al. 1998, Battaglia et al. 2002, Twedt 2004, Wilson and Twedt 2005).

Due to limited natural invasion, including a greater diversity of tree and shrub species in reforestation plantings (i.e., mixed-species plantings) is important for successfully attaining long-term conservation goals. Mixed-species plantings have numerous benefits including greater diversity and broader temporal availability of mast and insects, greater structural diversity, higher timber quality and yield, increased non-timber and timber products, improved soil health, enhanced natural regeneration, and increased carbon sequestration (B. Lockhart, U.S. Forest Service, personal communication).

Restored forests that are diverse in woody species provide benefits to priority wildlife by distributing food and shelter resources across space and time. A stable supply of insects is important for the diverse assemblage of forest dwelling bats, all of which are insectivorous. Most migratory birds forage primarily on insects rather than mast during spring and summer, and nestlings are provisioned almost exclusively with insects, especially caterpillars. Many of these caterpillar species exhibit preferences among host tree species (Twedt and Best 2004). Thus, in forests that are depauperate in tree species diversity, some caterpillar species may be rare or absent. Furthermore, the abundance of insects and species-specific fruit (mast) production vary temporally. Black bears have an omnivorous diet that shifts in space and time to exploit available food sources (Stransky and Roese 1984, Rode and Robbins 2000, Benson and Chamberlain 2006). Thus, species rich forests buffer temporal variability resulting in a more stable supply of insects and mast.

A multitude of woody species also provides many growth forms and phenologies that provide varied and seasonally dynamic structural niches. Mixed-species stands also allow for greater structural diversity, and often at a much faster rate than would occur with plantations of primarily heavy-seeded species (Twedt 2004). Mixed species stands can create interspecific competition that can improve timber quality, particularly of oaks, and increase management options in the future (Oswalt and Clatterbuck, 2006, Lockhart et al, 2006).

Restorations that incorporate fast-growing tree species promote rapid colonization by silvicolous birds (Twedt et al. 2002, Hamel 2003). For example, eastern cottonwood interplanted with oaks on appropriate sites have proven to be successful in achieving rapid development of vertical structure and providing economic benefits to landowners (Twedt and Portwood 1997, Gardiner et al. 2004, Twedt and Best 2004). Sweetgum interplanted with oaks have also been recommended for providing more rapid development of forest structure. In early stages, sweetgum will outgrow the oaks, but at about 25 years the oaks will attain dominance within planted stands (Lockhart et al. 2006). Additional conceptual models of compatible bottomland species, targeting improved timber quality of oaks, have been proposed for use in establishing multi-species restorations (B. Lockhart, unpublished manuscript).

Although mixed-species plantings are recommended on most sites, another method used to provide rapid height development of trees is to plant plantations exclusively of fast-growing hardwood trees. Plantation forests have been successfully used to achieve diverse forest conditions (Keenan et al. 1997, Lamb 1998). Plantations facilitate forest succession in their understories through modification of both physical and biological site conditions, changing light, temperature, and moisture conditions at the soil surface (Lugo 1997). These changes enable germination and growth of seeds transported to the site by wildlife and other vectors (Parrotta et al. 1997, Joslin and Schoenholtz 1998). That these physical changes occur within the understory implies that plantation trees have rapid development of a forest canopy. Diversification of these forests can be further hastened by “under-planting” a mixture of slower-growing and understory tree species, shrubs and vines (Twedt and Portwood 1997, Gardiner et al. 2004), although Allen et al. (2006) identified limitations to this approach (e.g., reduced survival and growth due to low light conditions). As such, these species should be included in the initial planting stock.

Regardless of how achieved, to ensure rapid colonization of a restored site by priority wildlife, trees with rapid growth characteristics must occur on the reforested site. Although there remains a perception that forest diversity, particularly colonization of light-seeded species, will result from natural colonization, it is often necessary to plant several species to ensure species diversity on restored sites. Flooding (i.e., over-topping seedlings) impacts natural colonization of trees but colonization may be restricted by distance from existing seed sources or harsh site conditions (e.g., drought) for seed establishment. When restoration sites are far (>660 ft) from seed sources, natural colonization by woody species may be sparse (Allen 1990, McCoy et al. 2002, Twedt 2004, Wilson and Twedt 2005).

There is no set number of species to be planted per field or project. Forest restoration within some ecosystems, such as rainforests in Australia (Tucker and Murphy 1997) and thamnic forests in Texas (Twedt and Best 2004), have successfully planted up to 80 species at densities of up to 1,215 stems/acre to promote restoration of diversity. While large numbers of species would be beneficial in many areas, in some cases, such as an old baldcypress brake, it might be appropriate to plant only one or two species, baldcypress and button bush. Conversely, in a field with ridge and swale topography, it might be appropriate to plant numerous species. Species found within adjacent forests can be used to guide species selection (i.e., reference sites) for restoration within site limitations. If non-traditional species are candidates for restoration, limited past demand may reduce the availability of planting stock. Thus, land managers may need to communicate planting stock needs with nurseries well in advance (>1 year) of anticipated planting dates.

Stem Density

Some forest resource managers have determined that the planting rate used by most agencies, 302 trees per acre, is sufficient to create habitat beneficial to silvicolous birds (Wilson et al. 2005). However, Stanturf et al. (2001) suggested that the standard currently used to define restoration success, 125 – 225 trees per acre at or before the third year after planting, is not sufficient to produce commercial timber and recommend survival of 250 – 450 trees / acre. Historically, it has been assumed that natural colonization of light-seeded species will ensure restored forests are both diverse and stocked at densities >250 trees / acre. However, as with diversity, natural colonization cannot be relied upon to produce densely stocked stands when sites are far (>660 ft) from existing forests (Allen 1990, Allen et al. 1998, McCoy et al. 2002, Twedt and Wilson 2002, Twedt 2004). Thus, planting at higher densities may be required to initiate stands at high densities.

High densities of trees and shrubs provide benefits to wildlife by rapidly achieving 'forest-like' habitat conditions. Furthermore, these dense, shrub-like habitats often provide important food sources for priority wildlife, in the form of soft, fleshy fruits and small hard seeds. Wunderle (1997) found that sites with greater availability of perches, structurally complex vegetation, and food (fruit and insects) resources attract seed dispersers, thereby increasing within site diversity. Some birds of management concern (e.g., Bell's vireo, orchard oriole [*Icterus spurius*], and painted bunting) preferentially breed in shrub-scrub habitats provided by "thickets" of invading trees, whereas other priority wildlife species use these thamnic areas for post-breeding cover and foraging (Kilgo et al. 1999, Vega Rivera et al. 1999). In areas where species using shrubby habitat are high priority, mangers are encouraged to maintain thamnic habitat through periodic manipulation of vegetation (e.g., burning, disking, chaining, or mowing).

Densely stocked stands promote early canopy closure, encouraging vertical development of trees. In addition to the positive correlation between tree height and colonization of sites by silvicolous birds, high sapling densities stimulate development of dominant or emergent trees within stands due to the "shepherd tree" effect that inhibits lateral growth while encouraging apical growth (Gómez-Aparicio et al. 2004, Lockhart et al. 2006). Emergent trees within a multilayered forest canopy provide preferred nest and perch sites for some priority bird species (Hamel 2000).

However, densely stocked stands that allow little sunlight penetration to the forest floor generally harbor few priority wildlife species. Indeed, wildlife would benefit from silvicultural treatments that introduce disturbance and increase structural heterogeneity even in relatively young restored forests. Unfortunately, such silvicultural treatments are not commercially viable and thus are unlikely to occur. A potential alternative to commercial operations is via the acquisition of shared harvesting equipment (e.g., a feller-buncher) capable of felling small diameter trees.

Although the cost of such equipment could likely not be justified by a single management area, harvesting units that are regionally based and jointly operated may be feasible.

Impediments to increasing density of woody species on restored bottomland sites are both logistic and economic. Increasing the density of planted seedlings markedly increases the cost of restoration. For example, moving from 12 ft spacing (302 seedlings/acre) to 8 ft spacing (680 seedlings/acre) more than doubles the planting stock and labor required for restoration. On the other hand, an increase to 435 seedlings/acre (10ft spacing) only increases the cost by about 50% and may provide a much preferred basis for attaining DFCs. Although initial costs are higher, planting higher densities of seedlings will likely improve timber quality (e.g., merchantability), as well as enhancing wildlife habitat.

To minimize costs in some situations, the planting rate can be reduced along field margins within 100-660 feet of adjacent forests, where increased rates of natural colonization is likely. Another alternative to reduce costs is the use of direct seeding. Seeds of woody plants cost a fraction of seedlings and can be planted with relatively little time and expense (Allen et al. 2001). Furthermore, Twedt and Wilson (2002) suggested that wildlife (birds) benefit more from direct seeding acorns than from restorations of planted oak seedlings, owing to increased species and structural diversity attained within these sites. Additionally, some land managers have found that direct seeded acorns survive periods of drought or prolonged flooding whereas planted seedlings suffered high mortality under these adverse conditions. However, there are also disadvantages of direct seeding: (1) direct seeding has been proven reliable only for large seeded species, such as oaks, (2) development of direct seeded oaks is generally slower than that of planted seedlings, and (3) rodents may eat sown acorns reducing survival (Savage et al. 1996).

Other woody species and cane have been successfully restored by directly sowing seeds (Holt 1998a, 1998b, Snell and Brooks 1998, Camargo et al. 2002). Unfortunately, little information is available on the methodology or success of directly sown non-hard mast seeds on bottomland sites (Herman et al. 2003, Lof et al. 2004), although Gagnon (2006, Appendix 2) provides recommendations for cane restoration. Allen et al. (2001) and Twedt (2006a) indicated that direct-seeding of light-seeded species has been largely unsuccessful in the MAV. Where successful restorations from direct seeding have been reported, success has often been contingent upon control of weed competition (Herman et al. 2003, Twedt and Best 2004). Weed control also benefits growth of planted trees (Ezell 1995, Ezell and Catchot 1998, Rey Benayas et al. 2005). However, weedy cover can provide beneficial habitat for many wildlife species during these early forest developmental stages. Regardless, limited financial resources and lack of personnel have prevented weed control on most restoration sites. Because of their inability to provide weed control (or other pre-commercial silvicultural treatments; see Chapter III), many managers are reluctant to risk increased tree mortality by planting species that are susceptible to weed competition. Considerable challenges remain to ensure germination and successful establishment of diverse forests via direct seeding.

When high tree densities can be obtained, caution should be exercised as the resultant dense canopy cover within the maturing forest diminishes its suitability for many wildlife species. Thus, it is advisable to mix densely planted areas with sparse or unplanted areas. One option is to plant small areas or only part of a restoration site with fast growing tree species. These areas of rapid vertical growth potentially serve as ornithochory foci (Werner and Harbeck 1982, McClanahan and Wolfe 1993, Robinson and Handel 1993) that may result in increased diversity and density of trees, but this has not been experimentally proven in the MAV (B. Keeland personal communication). Similar areas of rapid vertical growth may be achieved by isolated trees (Guevara and Laborde 1993), small clumps of trees (Toh et al. 1999, Twedt, 2006b), or linear strips (Twedt and Portwood 2003). Even so, colonization by other woody species at these sites can be slow (Wunderle 1997) and survival poor (Toh et al. 1999), thus necessitating the need for multi-species plantings.

Few guidelines exist as to the relative planting densities of species within multi-species restorations. Historically, restoration has focused on long-lived, commercially valuable species. Even when planted at relatively low densities, intraspecific competition among these species may result in mortality of many of the planted individuals. Conversely, planting of multiple species promotes interspecific competition that results in improved stand development and enhanced wildlife habitat. This approach risks the possibility that some species may be overtopped by faster growing species but many of these species (e.g., oaks) can normally persist and eventually out-compete the faster growing pioneer species (Clatterbuck and Hodges 1988, Johnson and Krinard 1988, Lamb 1998, Lockhart et al. 2006). Moreover, specific mixed species plantings that combine early and late successional species or shade-tolerant and shade-intolerant species have been recommended for quality timber development and wildlife habitat (Ashton et al. 2001, Lockhart et al. unpublished manuscript).

SUMMARY AND RECOMMENDATIONS

Landscape Perspective

Future conservation efforts should clearly articulate goals and objectives that directly link habitat restoration and habitat needs of priority wildlife. Following direction provided by restoration objectives, existing decision support tools can be used to focus restoration so as to promote population sustainability of priority species. These support models exist or are in development for forest birds, hydrogeomorphology, and natural flooding. We encourage development of additional science based, biologically driven, landscape oriented models for other priority wildlife, particularly the threatened Louisiana black bear. Not only will clear articulation of goals and objectives guide restoration decisions, it will facilitate improvement of restoration efforts through evaluation of both programmatic and ecological success. These results can then be used to adjust management prescriptions via adaptive management.

Site Limitations

As discussed previously, forest distribution and composition are strongly linked to both the geomorphic setting and its associated hydrology. Furthermore, much of the MAV has undergone significant, hydrologic alterations due to flood control activities (e.g., levees) and farming practices (e.g., land-leveling). In an attempt to keep our "eye on the prize", restoration activities should strive to restore local hydrology and topography via re-contouring of land-leveled fields and the promotion of natural hydrologic events.

From the onset, we made a conscience decision not to address the many facets of site preparation, handling and storage of seeds/seedlings, etc.. due to the comprehensive nature of *"A Guide to Bottomland Hardwood Restoration"* (the reader is referred to [Allen et al. 2001] for more details). However, recent research and anecdotal observations in the use of no-till sub-soiling techniques and chemical weed control warrants further discussion. The use of sub-soiling (a.k.a. "ripping") has been shown to increase both growth and survival of planted species, as well as to facilitate planting efforts (Andy Ezell, personal communication). Additionally, the use of post-planting weed control (first-growing season) through the use chemical applications has also been shown to increase both growth and survival of planted species (Andy Ezell, personal communication) via reduced competition for resources (i.e., water). As such, we recommend that all restored sites be sub-soiled before planting and that post-planting chemical weed control during the first-growing season be considered where applicable (i.e., when weeds are presumed to be a problem).

Promotion of Vertical Stratification and Horizontal Structural Heterogeneity

Vertical stratification and increased horizontal heterogeneity within restored sites is only possible over time and with maturation of woody vegetation. As such, it seems somewhat premature to include these elements as objectives for initial restorations. However, attainment of desired stand conditions (Chapter III) is our ultimate objective regardless of the length of time it takes to be achieved. Thus, initial restoration decisions should target desired forest conditions, including increased species richness and greater structural diversity. Managers should bear in mind that increased diversity of species (including faster growing trees), higher densities of stems, and varied planting strategies (e.g., leaving patches [circa 1-2 acres] unplanted), not only represent a sound initial restoration strategy but also contributes to improved habitat conditions within maturing forests.

Recommended Planting/Survival Rates

To facilitate natural stand development processes (e.g., inter-specific competition) and to increase wildlife habitat, we recommend increasing the initial planting rate to 435 seedlings per acre (10 ft spacing), recognizing that 680 seedlings per acre (8 ft spacing) would be even better. On most sites, hard mast species, including multiple species of oak, sweet pecan, and other hickories (*Carya* spp.), should represent 30% to 60% of planted trees. These proportions are based on three assumptions: (1) that oak-hickory was part of the previous forest composition, (2) that >30% oak composition is needed to ensure an adequate abundance of oak in future stands to maintain high merchantability, thereby enhancing future management options, and (3) that sufficient hard mast production will occur for resident wildlife species [e.g., black bear, white-tailed deer (*Odocoileus viginianus*), wild turkey (*Meleagris gallopavo*)*,* squirrels (*Sciurus* spp.), as well as for migratory waterfowl (e.g., mallard and wood duck). The remaining 40% to 70% of the planted trees should represent a mixture of light seeded, soft mast, and fast growing species (e.g., red maple, persimmon *[Diospyros virginiana]*, elm*,* green ash, sweetgum, sugarberry, blackgum, American sycamore, and black willow) that would naturally occur on the site. Other trees that are native to many sites, such as honey locust (*Gleditsia triacanthos*)*,* ironwood (*Carpinus caroliniana*), swamp dogwood (*Cornus drummondii*) and boxelder (*Acer negundo*) should not be forgotten from the mix of available species.

Although wildlife managers on public lands are not striving for commercial products, planting appropriate species mixtures (Lockhart et al. unpublished manuscript) may promote development of merchantable timber and increase management options. Achieving stocking rates of >300 trees per acre three years post-planting, including 75 – 180 hard-mast producing trees per acre, will also promote these objectives. To increase density of trees, naturally colonizing species should be encouraged. Once established, species composition within these stands can be altered using prescribed silvicultural management. Not only does natural colonization increase species diversity and stem density, these benefits are incurred at essentially no additional cost. This cost savings can be enhanced through judicious planting, wherein locations within restoration sites that are likely to have considerable colonization (e.g., near forest edges) are not planted or selectively planted at lower densities.

CHAPTER V.

FOREST EVALUATION AND MONITORING

INTRODUCTION

How "success" of restoration and management of bottomland forests is measured depends on many factors, but stated objectives are essential (Ruiz-Jaen and Aide 2005). These may be the specific objectives established within this document or entirely different objectives determined by a landowner or manager. Indeed, objectives on private lands are usually different from those on public lands. Likewise, forests established for carbon storage or sediment retention may have similar or different objectives than those established for timber production or wildlife habitat. Regardless, determination of "success" requires a well defined, coordinated monitoring program with clearly stated objectives operating at multiple spatial and temporal scales.

On lands retired from agricultural production, it could be argued that high quality wildlife habitat is being provided by natural succession, independent of survival of planted trees – thus simply removing this land from agriculture production constitutes some level of success. Although many wildlife benefits are provided by simply removing land from agriculture, other benefits such as timber production and habitat for forest-dwelling wildlife species are lacking without trees. Clearly the benefits to wildlife are dependent upon the species, as some require early successional habitat whereas others require later seral stages. Consideration of temporal and spatial scales is therefore important when defining measures of success. Logistically, some measures of success must be established at the project scale and within a relatively short time interval. This information will allow managers, on a site specific basis, to: (1) evaluate the success (or failure) of their efforts, (2) determine if additional efforts are warranted, and (3) identify modifications that will facilitate attainment of objectives. This is a practical and necessary measure of project success, even though short-term assessments may be misleading – for example low seedling densities 2-4 years after planting may not be indicative of densities in later years (Allen 1990, Twedt and Wilson 2002). Furthermore, it is difficult to "scale up" from short-term measures of project success (e.g., the number of seedlings / acre, or change in percent canopy cover) to measures of successful implementation of Desired Forest Conditions across landscapes that support sustainable populations of priority wildlife species (e.g., biological success).

Although we can readily assess short-term changes within forests that are attributable to silvicultural treatments, long-term sustainability of desired stand conditions is not assured. As most public agencies do not have the personnel or financial resources to undertake prescribed treatments needed to attain desired forest conditions, ensuring continued merchantability of timber within sites will likely be required to attract commercial partners. Unfortunately, we still do not fully understand how to optimize planting densities (in restored stands) and silvicultural treatments to achieve the desired result (e.g., production of quality merchantable timber). However, we have learned that some activities do not consistently produce desired habitat objectives and these observations can be used to adaptively develop new recommendations for planting and treatments. Continuing research, evaluation, and monitoring are needed to test our assumptions, evaluate success, and assess progress toward conservation goals of maintaining forested landscapes capable of sustaining populations of priority wildlife through attainment of Desired Forest Conditions.

Even with the inherent uncertainty in measuring success, we propose to measure success against our overarching goal of establishing and maintaining forested landscapes capable of sustaining populations of priority wildlife in perpetuity. To achieve this goal will require: (1) strategic restoration of forest on lands retired from agricultural production to attain desired landscape conditions, (2) enhancement and maintenance of forest stand conditions to meet the habitat needs of priority wildlife, and (3) implementation of a coordinated, statistically sound monitoring program operating at multiple spatial and temporal scales such that management decisions can be made in an adaptive manner (i.e., learning from past management actions).

ADAPTIVE APPROACH TO MANAGEMENT

Our recommended forest metrics (Tables 2 and 3) may seem like an endpoint in achieving bottomland forest conservation goals and objectives within the MAV, but in the context of adaptive management they are only a beginning. Adaptive management is a systematic approach for implementing and improving resource management by learning from management outcomes so as to reduce uncertainty (Holling 1978, Walters 1986). Management actions are a series of experiments whose outcome is predicted with some level of uncertainty but the results of which can be evaluated. In that vein, adaptive management is a blend of management, research, and monitoring that together yield valuable information – the absence of any of these components weakens the effort substantially.

Most examples of successfully applied adaptive management have been in systems where management decisions (and therefore updating) occur frequently: for example, waterfowl harvests which occur annually (Williams and Johnson 1995) or prescribed burning of prairies which also occurs relatively frequently (Gibson 1988). Forest management is characterized by relatively infrequent management decisions within stands (circa 10-15 years) and outcomes from prescribed treatments that may not be fully realized for decades. Therefore, opportunities for updating management prescriptions are limited and may span generations of researchers and managers. Lack of opportunity in time, however, can be compensated for by replication in space, such that decisions made in one stand are informed by those made in another. Maintaining written records of management actions and subsequent monitoring is a critical step in the assessment process.

We have identified general management recommendations for bottomland forests, but in each case there will likely be several treatment alternatives that managers could consider regarding the type, species, number, and spatial distribution of trees removed. Other areas that are set aside for passive management serve as experimental controls, which is actually just another type of treatment. The results of the treatments evaluated (i.e., monitoring) can used to inform models that help to identify optimal management practices in bottomland forests (i.e., management).

A similar framework should be used for assessing forest restoration. For example, survival of planted trees should be evaluated the third year after planting. Trees that have survived until that time have a good chance of continued survival. Naturally established woody species should also be counted – at least those that could affect development of vertical structure. We recommend recording: (1) separate tallies of planted and naturally established seedlings, (2) the proportion of sample plots where stocking meets the desired objective, and (3) the proportion of sample plots that harbor target species (e.g., oaks). Spatial projection of these data may provide useful insight that can be used to identify supplemental treatments, if deemed necessary, and influence restoration approaches on subsequent sites (i.e., adaptive management).

Implementation of an adaptive approach in management of bottomland forests faces many challenges. There are many forest types and conditions in the MAV, so different site-specific models may need to be developed. Appropriate response variables must be determined as well. Even so, there are several attributes of this system that make it conducive to adaptive management: (1) many forest managers have made a commitment to manage this resource cooperatively, as evidenced by the production of this document, (2) a centralized, forest management database that allows continuous systematic updating of models is under development (see below), and (3) the large number of managed forest stands and reforested sites that are available for development and evaluation of models increases statistical power and compensates for infrequent visitation or updates within individual sites. These are significant attributes that must be taken advantage of to fully endorse an adaptive management approach to bottomland forest management in the MAV.

DEVELOPMENT OF A MONITORING PROGRAM

As previously stated, an important component of adaptive management is a comprehensive monitoring program that addresses clearly articulated goals and objectives at multiple spatial and temporal scales. That is, a comprehensive monitoring program should integrate the various ecological, temporal, spatial, and programmatic aspects of the system in addressing specific management-based objectives. If designed and implemented correctly, the sum of the parts will yield information more valuable than the individual components of the monitoring program (National Park Service, www.science.nature.nps.gov/im/monitoring.cfm).

It is important to clarify a few key terms (i.e., inventory, monitoring, and research). Although these terms are often used interchangeably, each has a strict definition that warrants discussion to clarify our use of the terms. An *inventory* is an effort to determine the location or condition of a parameter of interest (e.g., distribution, abundance) at a specific point in space and/or time, whereas *monitoring* addresses change in time – the collection and analyses of repeated observations to evaluate change and/or progress toward meeting management objectives (Elzinga et al. 1998). However cause and effect relationships are not typically identified through inventory and/or monitoring. Instead, *research* is usually required to fully explain cause and effect relationships underlying the documented changes observed through monitoring.

Before an inventory or monitoring system can be developed, several key elements must be considered for planning, implementation, analysis, and reporting (Bart 2005, Droege undated). Specifically, an inventory and/or monitoring effort needs to clearly articulate the: (1) survey objectives, (2) sampling frame (statistical population for inference), (3) data required, (4) appropriate sample size needed to achieve desired level of statistical confidence, (5) appropriate sampling scheme and method(s) of data collection, (6) protocols for storage and management of data, and (7) protocols for the analysis and reporting of results. It is beyond the scope of this document to present a detailed, comprehensive inventory and monitoring program that addresses each of the key elements with respect to each of our stated objectives. However, we do provide general recommendations and in places offer detailed insight into the development and implementation of specific inventory and monitoring programs designed to assess forest management, restoration efforts, and wildlife response. It is our hope and expectations that LMVJV partners will develop common inventory/monitoring protocols and contribute to a common database so as to facilitate adaptive management of forests within the MAV.

GENERAL RECOMMENDATIONS

Within the MAV, forest inventories are routinely conducted on most areas under federal, state, and forest industry ownership. Many of these land mangers collect similar data (e.g., trees per acre by species and diameter class) and report in similar terms (e.g., basal area, diameter distributions). However, forest parameters deemed important to priority wildlife species are usually not recorded (e.g., canopy cover, midstory cover, understory cover). Additionally, there is no central repository or standardized method for consolidating and conducting landscape analyses. Furthermore, long-term monitoring systems are either non-existent or of dissimilar nature (e.g., different methods and parameters collected), thereby limiting our ability to conduct comprehensive landscape analyses. Similarly, there are no coordinated wildlife monitoring programs (outside the realm of site-specific research projects) designed to assess wildlife abundance in relation to management actions (e.g., silvicultural treatments) in bottomland hardwood forests. As a first step in moving towards a coordinated, comprehensive monitoring program to assess forest management activities and progress towards achieving Desired Forest Conditions in the MAV, we offer the following recommendations.

As previously discussed, the most important element of any inventory or monitoring program is to have clearly defined objectives that facilitate achievement of the overarching goal. To that extent, our (LMVJV partnership's) overarching goal of establishing and maintaining forested landscapes capable of sustaining populations of priority wildlife in perpetuity should provide the framework for developing a comprehensive monitoring program. To measure progress (success) toward attaining this goal, we recommend the establishment of specific, realistic, and measurable objectives that address management needs. For example, the successful establishment of ≥300 stems per acre three years post-planting on restored sites, assessment of current forest conditions within management compartments (pre-treatment, post-treatment, and passively managed compartments) in relation to Desired Stand Condition parameters, assessment of Desired Forest Conditions at a landscape scale on 15 year intervals, and avian response to silvicultural treatments designed to achieve Desired Stand Conditions will facilitate measurement of success towards this stated goal.

Once objectives are clearly articulated, managers can then determine the appropriate data needed (e.g., parameters to be collected [Table 3]) and the amount of data needed (e.g., sample size). Sampling schemes are varied but the methods employed should be economical, minimizing both time and personnel required, and they must ultimately yield statistically valid information. We recommend the use of preliminary data to assess local variability which can be used to inform recommendations for sample sizes. Sampling design directly affects efficiency of data collection and should be carefully considered before implementation of data collection.
Data are often collected on paper forms, but use of electronic devices (e.g., hand-held field computers) may be more efficient and negates errors that occur during data transcription. Current forestry software can often be modified to include the additional forest parameters recommended here. To this extent, an effort is underway to customize forest inventory programs (e.g., TwoDog® and TCruise®) to accommodate these additional parameters and to facilitate

analysis and assessment of habitat conditions. Furthermore, we recommend that data be output from these programs and imported or linked to a Geographic Information System (e.g., ArcMap®) for spatial analysis and the development of decision-support tools.

Table 3. Recommended minimum forest parameters for site and landscape scale inventory and monitoring required to ascertain landscape condition (Chapter II, Table 1) and stand condition (Chapter III, Table 2). Parameter descriptions are provided in the Glossary and Appendix 4.

Forest Parameters	
Individual tree data	Trees by species
	Diameter at breast height (dbh)
	"Useable" length (dead or alive)
	Crown class (Dominant, Co-dominant, Intermediate, Suppressed)
	Tree Condition (healthy, stressed, standing dead, or down wood)
Plot level data	Overstory percent cover (10% increments)
	Midstory percent cover (10% increments)
	Understory percent cover (10% increments)
	Shade-intolerant regeneration
	Vines in overstory (None, Sparse, Moderate, Abundant)
	Cane (None, Sparse, Moderate, Abundant)
	Hydrologic-Forest Type (Table 4)

Analysis of data and reporting of results is of utmost importance. Reports should provide decision makers with adequate information to draw conclusions, or at least identify trends, regarding the status of Desired Forest Conditions. To accomplish this on a landscape scale, a central, GIS-linked data repository is required for data storage and access. Toward this end, the LMVJV office has developed a web-enabled database to track forest restoration (online at: http://www.lmvjv.org/rts_2ways.htm). Additionally, this office has begun development of a forest management database: thus, land managers need to coordinate with database developers to ensure inclusion of appropriate information pertaining to forest treatments, inventories, and monitoring. We recognize the proprietary nature of some data, but recommend that all partners: (1) work with LMVJV staff to design and implement a central data repository, (2) contribute data from long-term, permanent plots (monitoring plots), and (3) contribute appropriate data from site scale, habitat assessments (inventory plots) such that evaluations can be conducted at multiple spatial scales.

Table 4. General hydrologically defined bottomland forest types found within the Mississippi Alluvial Valley (after NRCS Missouri, June 2004, Bottomland Forest Information Sheet, IS-MO643F, online at: http://www.mo.nrcs.usda. gov/technical/forestry/out/Bottomland_Forest_IS_FINAL. pdf.).

Hydrologic-Forest Types	
Swamp forest	baldcypress, baldcypress-water tupelo
Wet bottomland forest	overcup oak-bitter pecan, black willow, laurel oak-red maple
Moist bottomland forest	sugarberry-elm-ash, oak-elm-ash, oak-sweetgum
Dry bottomland forest	cherrybark oak-cow oak, post oak-blackgum
Levee forest	cottonwood-sycamore, sweet pecan-boxelder

SPECIFIC RECOMMENDATIONS

Although numerous methods are available for sampling and data collection, each comes with its own positives and negatives. Nevertheless, we make specific recommendations regarding data collection and sampling of forest vegetation and silvicolous birds that we believe will enhance our understanding of bottomland forest dynamics and facilitate the implementation of adaptive management schemes in the MAV.

Habitat Assessments (Inventory Plots)

Land managers routinely conduct inventory plots to assess current conditions. Unfortunately, the majority of these inventories are focused on assessing forest merchantability, with little explicit recognition of wildlife habitat. To better focus these routine inventories in terms of assessing wildlife habitat conditions, we recommend that all stand level inventories include at a minimum, the parameters identified in Table 3. These parameters afford land managers the ability to assess current stand level habitat conditions and compare these with Desired Stand Conditions (Chapter III, Table 2). Furthermore, we recommend that habitat assessments be conducted within all management compartments and/or stands (i.e., areas subjected to similar, identifiable silvicultural actions – to include passively managed stands) within a given year, where logistically feasible. That is, the entirety of an area (e.g., National Wildlife Refuge or Wildlife Management Area) should be completely inventoried within a given year, on a circa 15 year basis. By doing so, managers will be able to make informed decisions and prioritize which stands require silvicultural treatment based on their status with regard to Desired Stand Conditions (Figure 8).

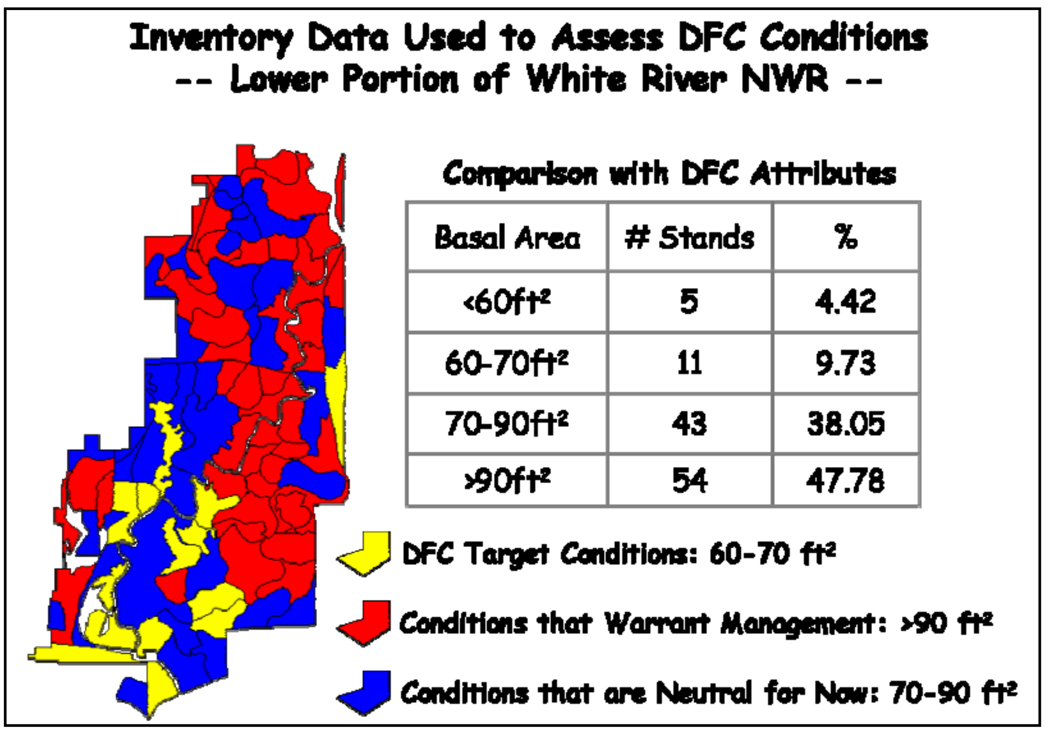


Figure 8. Spatial representation of basal area forest parameter that resulted from a 2005 inventory of 113 forested stands on White River National Wildlife Refuge, Arkansas.

After a comprehensive inventory is complete and habitat conditions are projected into the future, management decisions can be made and appropriate treatments prescribed. Management actions can also be prioritized to target stands in most need of habitat improvement. If additional data are needed, priority stands can be re-entered to conduct more detailed inventories in preparation for silvicultural treatments. Ideally, stands will be evaluated post-treatment (e.g., 1, 3, 5, 10, 15 years post-treatment) to document and assess vegetative response such that future prescriptions can be modified or adjusted accordingly. If logistical and monetary constraints preclude post-treatment evaluation of all treated stands, we recommend that a sub-set of treated stands be periodically re-evaluated.

To quantify current habitat conditions we recommend a clustered sampling design within which several "clusters" (e.g., plots along a transect) of sample plots are inventoried within each management unit (stand) – see Appendix 4 for example. Cluster sampling is typically more economical because it reduces the amount of travel between survey locations, as well as having greater statistical benefits than simple random sampling. The number of clusters should be determined *a priori* for local landscapes (e.g., a refuge or management area) through the analysis of pilot data to examine the distributional properties and the variability of the parameter(s) of interest. For example, on White River National Wildlife Refuge a test of the coefficient of variation (CV) for density of large trees (≥24 inches dbh) was conducted on pilot data that suggested four clusters, each harboring five $1/5^{th}$ acre plots achieved acceptable precision (i.e., low CV) at a reasonable cost for time and personnel (Appendix 4). At each plot, data should be collected for each of the DFC parameters identified in Table 4, as well as any additional information needed to meet other agency or management plan objectives (e.g., see Appendix 4). Once data are collected in the field, they should be summarized, entered into a data repository, and subsequently linked to spatially delineated polygons within a GIS to facilitate visual interpretation of the data (e.g., decision support tool). Further guidance on establishing a statistically sound inventory system is provided in a prospectus that outlines the ivory-billed woodpecker habitat assessment conducted in Arkansas during 2005 and 2006 (Appendix 4).

Continuous Habitat Monitoring (Monitoring Plots)

Because stand level inventories only reflect a single point in time at a specific location they are generally not suitable for assessing long-term changes in forest composition and structure at landscape scales. Furthermore, stand level inventories (e.g., single assessments) do not permit land managers to assess and project tree growth, decay, and mortality. Thus to provide the basis for a valid, region-wide assessment of Desired Forest Conditions, we recommend the installation, measurement, and systematic re-measurement of forest parameters on permanent Continuous Forest Inventory (CFI) plots established across all forested habitats on public lands in the MAV. We recognize many partners have already implemented some type of CFI. Therefore, we recommend the continued use of existing CFI plots, although partners may choose to re-distribute or add to these existing CFI plots to ensure representation of all forest types and ecological conditions. For partners that have not implemented a CFI, we recommend establishing new plots based on a stratified random sampling design (with forest type serving as strata).

As with stand level inventories, the number of plots needed to accurately reflect change and yield statistically valid estimates should be rooted in the variability of the system. Unfortunately, analyses to determine sample size for all forest parameters of interest have not been conducted across all landscapes. Based on anecdotal observations and preliminary analyses, we tentatively suggest that ≥1 CFI plot be established for every 300 – 500 forested acres. This would equate to approximately 20 to 30 plots per 10,000 acre landscape and should be within the realm of statistical validity as well as being logistically feasible for local land managers (i.e., 1-2 weeks worth of work). As CFI plots are designed to monitor change over time, CFI plots should be re-surveyed at 5 – 10 year intervals. Moreover, all Continuous Forest Inventory efforts should collect the minimum set of DFC parameters (Table 3; see Appendix 4 for an example data form) in addition to other agency/organization specific data needs.

Wildlife Response

Although we have emphasized the need for forest inventory and monitoring, our ultimate goal is to provide habitat for sustainable populations of wildlife. Throughout this document, we have made many assumptions regarding wildlife response to forest conditions. As such, it is imperative that we verify these assumptions by actually assessing wildlife response to Desired Forest Conditions, such that knowledge learned can be used to modify management actions accordingly (i.e., adaptive management).

Currently we know of no coordinated monitoring efforts designed to assess the impacts of forest management activities on priority wildlife species in the MAV, except for a few site-specific research projects focused on silvicolous songbirds (Twedt et al. 1999, Twedt et al. 2002, Wilson and Twedt 2005, R. J. Cooper unpublished data). As such, we recommend that the conservation community incorporate population monitoring into their day-to-day management activities. Specifically, population monitoring programs need to be designed following the general recommendations previously discussed, such that the direct impacts (both positive and negative) of forest management activities can be evaluated in a manner that facilitates the refinement of assumptions underlying conservation planning and delivery of conservation programs.

To that extent, we offer a detailed prospectus for the implementation of a coordinated monitoring program to evaluate forest breeding bird response to forest habitat conditions (Appendix 5). In brief, we propose region-wide monitoring within a temporally stratified subset of forest stands that have been subjected to silvicultural treatments (including untreated controls). In addition, the minimum vegetation parameters (Table 4) will be assessed within all stands that are monitored for birds. The National Point Count Database (http://www.pwrc.usgs.gov/point) will be used to store avian data, whereas forest vegetation parameters will be entered into the proposed forest management database maintained by the LMVJV office. This avian monitoring program should allow us to test many assumptions regarding wildlife response to Desired Forest Conditions.

Additionally, this avian monitoring program is consistent with the goals put forth by the North American Bird Conservation Initiative's monitoring subcommittee draft interim report (Opportunities for improving North American avian monitoring, http://www.nabci-us.org/aboutnabci/avianmonitoringdraft906.pdf, to improve the current state of bird monitoring in North America. Specifically, their report suggested that the conservation community should: (1) fully integrate monitoring with bird conservation and management to ensure that it is aligned with management priorities, (2) ensure monitoring programs are coordinated among institutions and integrated across spatial scales to effectively solve conservation or management problems, (3) increase the value of monitoring programs by improving their statistical design, and (4) maintain bird population monitoring data in up-to-date data management systems.

SUMMARY

Use of the above recommendations for inventory and monitoring of key forest attributes during habitat assessments within stands (inventory) and on permanent plots (monitoring) is essential for implementation and evaluation of Desired Forest Conditions. Within each management unit (stand), analysis of current conditions may be used to determine and prioritize the need for silvicultural treatments to enhance habitat conditions towards Desired Stand Conditions. At the landscape scale, the analysis of data from permanent plots will provide an assessment of the regional status and temporal change in Desired Forest Conditions.

Although it is outside the scope of this document to provide detailed monitoring recommendations for all suites of priority wildlife, we hope that information provided on monitoring silvicolous birds will serve as a catalyst for the development of monitoring programs to assess the impact of Desired Forest Conditions on other priority wildlife species.

CHAPTER VI

RECOMMENDATIONS AND CONCLUSION

The concept of wildlife forestry in bottomland hardwood forests is relatively new. Assessment of habitat-related parameters at scales that are appropriate to influence species' populations is complex but achievable. The science of forestry is evolving towards landscape planning and is furthering our understanding of the intricate relationships between forest structure and development. We are poised to make great advances in the restoration and management of bottomland hardwood forests and the diversity of wildlife species that require these forests. Furthermore, if the conservation community is to make strides in fulfilling the habitat needs of species dependent upon extant blocks of bottomland hardwood forest, it is imperative that land managers use their habitat needs to derive management prescriptions. It was our shared goal of population sustainability that led to the development of Desired Forest Conditions for forested wetlands in the MAV. Progress towards attaining this goal can best be achieved in an adaptive manner. As such, a detailed, coordinated monitoring program is imperative. With that goal in mind, we offer the following forest restoration, management, and monitoring recommendations to enhance wildlife habitat.

Specifically, we recommend:

- use of hydrogeomorphic models to guide forest restoration, especially hydrological restoration;
- restoring micro-topography of land-leveled agricultural fields as an integral part of forest restoration;
- use of biologically-based, spatially-explicit decision support tools to determine high priority areas for restoration;
- analysis of existing farm bill programs to improving farm conservation measures on high sites (non-flood prone lands);
- a greater focus on restoring higher bottomland sites to forest cover, while linking these sites with extant and restored forests;
- that all restored sites be sub-soiled prior to planting;

- mixed-species plantings of native hardwood trees (we do not support the use of invasive and/or exotic species) on most sites, with adjustments to single-species plantations where appropriate – especially to promote rapid height development of new forest structure.
- an initial planting density of 435 seedlings per acre, with hard mast species comprising 30 to 60% of the count, especially in areas not expected to have significant natural regeneration within the first 3 years post-planting;
- survival acceptance 3 years post planting be >300 trees per acre, with modified sampling procedures used to account for high density natural regeneration in limited portions of restored site;
- mixing densely planted areas with sparse or unplanted areas. Alternatively, management actions (e.g., group cuts) should be undertaken early in the development of a stand (e.g., circa year 15 post-planting) to ensure areas of sunlight penetration to the forest floor;
- use of the LMVJV's Reforestation Tracking System (online at: http://www.lmvjv.org/RTS_2ways.htm) to document and track reforestation events;
- that 70% to 95% of the forest area within local landscapes be actively managed via sustainable silvicultural practices to attain Desired Stand Conditions (Table 2);
- that 35-50% of forest lands under active management meet the Desired Stand Conditions (Table 2) at any given point in time;
- that emphasis be placed on recognizing specific site limitations relative to the presence and abundance of specific woody (e.g., oaks) and non-woody species (e.g., cane);
- implement overstory thinning or other methods of inducing larger canopy gaps or sparse overstory cover to encourage proliferation of cane on appropriate sites;
- identify areas for cane reintroduction and advance restoration techniques;
- retention within harvested stands of snags and a portion of stressed/dying trees that contain or are likely to develop cavities, with care taken to minimize damage to cavity trees during harvests;
- targeting a small proportion (<20%) of most forest stands for regeneration of shade-intolerant tree species through small, silvicultural induced gaps;
- leaving an average of 2 to 4 trees per acre of species and individuals that will most rapidly attain dominant crown position;

- up to 5% of the actively managed forest should be in shrub-scrub habitat with no more than 10% of the landscape comprised of regenerating forests (i.e., clearcuts <1/3rd site dependant height) (Table 2). An exception being reforestation of large agricultural tracts wherein the overall goal of achieving 70 – 95% forest within a landscape overrides the 10% limitation placed on regenerating forests;
- if shrub-scrub habitat is of high importance in your local landscape, use focused, active management (i.e., periodically set back succession via mowing, burning, etc.) on a specific site to maintain early successional habitat;
- 5 – 30% of the landscape encompassing a broad representation of forest types be passively managed to serve as experimental controls for management activities;
- land managers implement forest management prescriptions to attain, retain, and maintain Desired Stand Conditions (Table 2), while still operating in a sustainable manner that produces tangible benefits to silvicolous wildlife and quality timber products;
- use inventory and monitoring programs to ascertain current conditions of forests, guide prescription development, and assess temporal changes within forest and their associated wildlife and fisheries resources;
- standardizing primary monitoring methodologies to allow effective analysis of MAV forest conditions, based upon coordinated exchange of data across political boundaries and ownerships.

From the onset, our objectives were to: (1) define desired forest conditions that reflect the collective needs of priority wildlife species; (2) provide technical recommendations for the restoration of bottomland hardwood forest; and (3) recommend protocols and procedures for implementing coordinated inventory and monitoring programs, such that management actions can be evaluated in an adaptive manner. To accomplish these objectives, we have utilized a vast array of information published in scientific journals, as well as, the cumulative knowledge and experience of on-the-ground biologists, foresters, land managers, and researchers. It is our expectation, that these recommendations will facilitate continued discussions among biologists, foresters, land managers, administrators and academia that result in improved habitat conditions for priority wildlife species. Furthermore, we hope this document provides a framework that allows restoration and management to be implemented in an adaptive manner via implementation of forest management prescriptions that reflect DFC parameters, coordinated inventory and monitoring efforts and targeted research to address underlying assumptions and forest metrics that influence wildlife habitat suitability.

GLOSSARY

Actively Managed Forest: *Forests that are manipulated or have a history of manipulation to obtain forest products and/or provide wildlife habitat.*

Basal Area: *An area (ft^2, m^2) per unit area (acre, ha) measure of the "foot print" occupied by trees. Basal area (BA) alone is not an accurate indicator of forest structure. In most stands, BA levels >90 ft^2 / acre are generally relatively dense with trees having a closed overstory canopy. When communities exhibit large stem diameters but small, disintegrating crowns (e.g., baldcypress – water tupelo), higher ranges of BA may be appropriate. Conversely, in communities with large stem diameters and large spreading crowns (e.g., overcup oak – bitter pecan) a lower BA may be appropriate.*

Clearcut: *A treatment that results in the removal of ≥ 80% canopy cover over an area > 7 acres in size.*

Coarse Woody Debris: *Dead wood on forest floor measured in volume (ft^3) per unit area (acre) usually by diameter class. Diameters of >10 inches are preferred due to their longer retention within a stand and inhabitation by a more varied community of decomposers.*

Diameter: *Diameter at breast height (dbh); diameter of tree outside the bark measured at 4. 5 feet (1. 3 m) above ground on uphill side of tree.*

Dominant Trees: *Trees with full sunlight available to the top and portions of the sides of their crown; slightly (25% of the crown) above the general forest canopy (Dictionary of Forestry, J. A. Helms, SAF). Dominant trees are sometimes referred to as "emergent" trees by wildlife biologists, but emergent trees may not be possible in some community types without management efforts to express this attribute.*

Forest Cover: *In a landscape context, lands that are covered by forest vegetation at any seral stage. Society of American Foresters defines forest cover as having >25% tree crown coverage.*

Group Selection: *In an uneven-aged forest management system, a regeneration method that involves the clearing of forest in group cuts or corridors throughout the stand with a focus on providing sufficient light to stimulate development of understory vegetation and regeneration of* *shade–intolerant species. Although there is not an acreage or dimension specification on opening size, width of cuts generally do not exceed more than two times the height of the dominant forest.*

Landscape: *An area of ≥10,000 acres (≥4,000 ha). To support priority wildlife species, landscapes should be largely forested and harbor several forest community types. Landscapes are matrices of large forested areas, smaller forested parcels, and their intervening spaces.*

Large Cavities: *Sound or unsound stems with a cavity hole ≥10 inches (25 cm) in diameter.*

Midstory Cover: *The middle layer of the forest, generally between 10-60% of canopy height. Measure of the degree of horizontal occupancy of cover (volume in space noted as midstory) within forest midstory.*

Overstory Canopy Cover: *The uppermost canopy level of a forest comprised of tree crowns. Within a stand, overstory canopy cover is a measure of the degree of structure blocking light penetration to lower levels of the forest.*

Passively Managed Forest: *Passive management occurs on lands with limited anthropogenic manipulations (e.g., forest reserves, natural areas, wilderness areas, inoperable stands, etc.). Several different forest type communities should be represented in this acreage. When embedded within actively managed forests, narrow strips of "unmanaged" habitat (e.g., streamside management zones) are generally not considered to be passively managed.*

Regenerating Forest: *A component of the managed forest landscape that has been manipulated to promote forest regeneration (particularly of shade-intolerant species) through removal of >80% of forest canopy (i.e., clearcuts) or through restoration on agricultural lands. Forests are considered regenerating until canopy trees achieve >1/3 of their anticipated, site dependent height.*

Shade-intolerant Regeneration: *Because most forest communities succeed to more shade-tolerant species without perturbations that induce increased light penetration, management should strive to ensure continued advanced regeneration of shade-intolerant species in sufficient numbers (400 stems per acre, Hart et al. [1995]) across 30 – 40% of a stand to ensure retention* *of these species in future stands. A minimum of 40% of the regeneration stocking should be hard mast species, such as oaks and pecans.*

Shrub / Scrub: *Thamnic vegetation dominated by short woody plants. This structure may be ephemerally created through seral stage development within managed forests, maintained via periodic prescribed disturbance, or naturally occur as semi-permanent shrub-scrub habitats (e.g., buttonbush/swamp privet). However, hydric and mesic shrub-scrub habitats typically support different faunal communities.*

Small Cavities: *Cavities (holes) in sound or unsound stems that are ≥1 inch but <10 inches in diameter.*

Standing Dead / Stressed Trees: *Dead stems or stems that show signs of stress which suggest that they will die and "fall out" of the stand within 5-10 years.*

Tree Stocking: *A measure of the number of trees in relation to their size class. An average stocking level of 60 – 70% is appropriate but management should be implemented with stands below 50% or above 90%. Bottomland hardwood forest management experience is currently a better guide in determination of this variable than are published stocking guides*

Understory Cover: *Measure of cover (volume in space defined as understory) within forest understory between 0 – 10% of canopy height. Canopy cover is a measure of the degree of horizontal coverage through lower levels of the forest.*

Variable Retention Harvest: *Forest management that removes forest canopy through thinning and/or group selection harvests with the intensity of canopy removal differing spatially within a stand. Trees are retained to meet specific ecological objectives such as maintaining structural heterogeneity or protecting biological legacies (Mitchell and Beese 2002) and not solely to maximize their growth potential.*

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Appendix 1. Participants in the Lower Mississippi Valley Joint Venture's Forest Resource Conservation Working Group.

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Appendix 1. Continued.

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Appendix 1. Continued.

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Appendix 1. Continued.

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Appendix 2. Overview of cane ecology and management.

Management of Cane in Bottomland Hardwood Forests

Paul Gagnon, Louisiana State University

Canebrakes provide critical habitat for numerous bottomland hardwood forest species (Platt et al. 2001). A century ago, canebrakes were known as a last refuge for black bears, Florida panthers (*Puma concolor* subsp. *coryi*) and other game species (Roosevelt 1908). Canebrakes are still prime habitat for the threatened Louisiana black bear and several migratory birds including American Woodcock (*Scolopax minor*), Swainson's Warbler (*Limnothlypis swainsonii*) and Hooded Warbler (*Wilsonia citrina*) (Thomas et al. 1996, Moorman et al. 2002). The rare and possibly extinct Bachman's Warbler (*Vermivora bachmanii*) and at least six satyrine and skipper butterflies are also considered cane obligates (Remsen 1986, Brantley and Platt 2001).

Ecology of Canebrakes

Cane (*Arundinaria gigantea*) is the only bamboo native to the United States. Cane can be divided into two subspecies (Judziewicz et al. 1999). Switch cane (A. *gigantea tecta*) is the short-stature (typically < 2 m) subspecies found along the Atlantic and Gulf Coastal Plains. Giant cane or river cane (A. *gigantea gigantea*) is the larger subspecies, frequently producing culms 5 to 6 m tall and occasionally 8 m in fertile soils. Giant cane is found in bottomlands and along creeks and ravines throughout the southeastern United States including the Mississippi Alluvial Valley (MAV). Within the MAV, canebrakes occurred primarily on the highest ground along ridge-tops and levees (Platt and Brantley 1997). Today cane can be found growing on virtually any ground not subject to prolonged inundation (Marsh 1977). Cane attains its largest size on the most fertile soils, and common lore among early settlers was that the ground under the biggest cane grew the best crops (Platt and Brantley 1997).

Like many bamboos, cane grows clonally for years before it flowers and dies (Hughes 1951, Judziewicz et al. 1999). The time it takes for a cane seed to germinate, grow to full size, flower and die is unknown. The interval may be 20 years or more, which is typical of woody bamboos (Judziewicz et al. 1999). Cane can flower as individual culms, in small patches, or en masse.

Sparse or isolated flowering typically leads to little or no seed-set (Gagnon 2006). In contrast, large-scale flowering can produce millions of fertile grains, which sprout the same growing season they are produced, cane seedlings being inconspicuous and resembling many small understory grasses (Hughes 1951). Additionally, juvenile cane plants grow for several years before culms attain full-size (Gagnon 2006).

Like all bamboos, cane is a giant forest grass (Judziewicz et al. 1999). Stands of cane inevitably decline in the deep shade of closed forest canopy, although sparsely distributed stems can persist for years in such an environment. Cane stands need at least partial sunlight to maintain dense, canebrake-like structure; however culms of giant cane grow tallest in shade. Whereas, culms are shorter but grow more densely in full sunlight (Gagnon 2006). Hughes (1957) concluded that stands of switch cane in North Carolina gradually declined after several years of vigorous growth, and stands of giant cane in the MAV appear to follow a similar pattern. However, this decline can be avoided or reversed if cane is periodically burned (Hughes 1958, Gagnon 2006).

Ecological disturbances appear to dictate much about cane's clonal growth. Over ecological time, natural and human-caused disturbances were prevalent and diverse in the MAV. Tornadoes, hurricanes, violent thunderstorms and ice-storms all knocked down forest canopy. Flooding from the Mississippi River and its tributaries damaged forests, as did flooding from beaver dams. Fires (whether natural or anthropogenic) were also occasional disturbances. With its capacity for rapid clonal growth, ability to persist in shade, and preference for higher-light environments, cane could potentially exploit virtually any forest gap in the MAV on non-inundated land.

RESTORING CANEBRAKES

There are essentially three possible pathways for restoring canebrakes in the MAV. The first way is to restore already-present but sparsely growing cane. The second is via vegetative propagation – full-sized cane or rhizomes can be transplanted from another location. The third is to plant cane from seeds collected elsewhere.

Canebrake restoration can be straightforward when diffusely-growing cane is already present. The cane may only need a more favorable environment to form dense thickets. At least partial sunlight is critical for development of cane thickets. At best, cane growing in deep shade will persist for years as occasional, sparsely-distributed stems. In such cases, thinning the overstory can promote the growth of higher-density cane stands. Cane is somewhat shade tolerant, and on a favorable site it can grow into high-density patches in the forest gaps commonly left by uneven-aged silviculture. Expansive canebrakes, however, require large canopy gaps or a sparsely stocked overstory.

Increased light alone will not ensure the persistence of canebrakes. Hughes (1957) reported that stands of switch cane naturally senesced after a period of years, and a study of giant cane in the MAV yielded a similar result (Gagnon 2006). Hughes (1957) suggested burning stands of switch cane at intervals of 7 to 10 years to maintain them at high density. Giant cane in the MAV likewise benefits from this treatment (Gagnon 2006). Burning simultaneously stimulates vigorous sprouting of new cane culms, returns nutrients to the soil, and reduces competition from other plants. Where stand densities are too sparse for fire to spread naturally, or where natural fires are likely to be outside of management prescriptions, cane can be cut, dried in place for a week or two, and then burned. Where prescribed burning is not feasible for reasons of policy or logistics, cutting cane without burning it may offer some, though not all, of the benefits. However, this has not been tested experimentally. A combination of overstory thinning and periodic prescribed fires should maximize cane vigor and stand density.

Where cane is not already present on a site, it can be transplanted from elsewhere. This method of canebrake restoration has met with mixed results. One experienced source who has overseen both failed and successful cane transplantations suggests that rhizomes be transplanted as large root wads (30-45 cm in length) with as much intact soil as possible (Kelby Ouchley, personal communication). When transplanting root wads, Ouchley urges great care be taken to avoid introducing invasive competitors. Even well-established cane can be drought sensitive. Transplanted cane will survive and establish better if irrigated during dry periods. Reliable establishment from rhizomes may take 2 or more years. Ouchley speculates that difficulty establishing cane on reclaimed agriculture fields may result from the absence of some critical mycorrhizal symbiont. More research on this aspect of cane biology is needed.

One cane restoration project in Missouri used cane transplanted in two-gallon root wads. After two years, the cane had established and was spreading, despite substantial competition from vines (Shively et al. 2002). Each transplanted soil wad originally had 1-4 attached culms. Some were treated by cutting off all culms prior to transplanting. These produced fewer new culms and survived less frequently than those transplanted with culms intact. Cane growth accelerated in the year after a flood temporarily inundated it under as much as 4.5 m of water. The authors speculated that cane growth accelerated because the flood reduced vine competition.

Cane can be transplanted as individual rhizomes if treated appropriately. A series of studies in southern Illinois used cane rhizomes cut into lengths of 20-30 cm, planted into greenhouse pots and treated with a regimen of frequent water misting (Zaczek et al. 2004, Hartleb and Zaczek in press). After one month in the greenhouse, more than three-fourths had sprouted at least one culm. Rhizome segments with 10 or more nodes sprouted more culms than rhizome segments with fewer nodes. Rhizomes collected in early spring outperformed those collected in either fall or late winter, but fall- and winter-collected rhizomes still sprouted frequently. Transplanted to restoration sites, culms from these sprouted rhizomes had established and spread substantially after 3-4 years. Although competition from other plants influenced cane growth after transplantation, pre-treating the restoration site with herbicide to kill competitors did not improve cane success. In the study, establishment success varied significantly by both donor sites and transplantation sites. After testing several transplantation methods, the best was to plant each rhizome distal-end up with multiple nodes and buds above ground level and exposed to light. Using this method, sprouting rates exceeded two-thirds even for rhizomes stored for one month in moist refrigeration. Results suggested that successful transplantation is possible even without first sprouting rhizomes in a greenhouse (J. Zaczek, personal communication).

Successful establishment of transplants is only the first step toward full canebrake restoration. As described above, established cane requires at least partial sunlight and periodic disturbance to attain canebrake-like stand structure. Eventually, long-term re-establishment of cane on a given site will require successful flowering and seed production. Existing evidence suggests that out-crossing may be necessary for successful seed set. Long-term restoration success from transplanting may require that multiple genetic individuals eventually flower in-phase years later. Cane can be reintroduced from seed. Cane flowers infrequently, and procuring a large quantity of viable seeds may require some luck and good contacts where cane is abundant. With that said, cane flowers more frequently than a casual observer is likely to notice. Where cane is prevalent, widely scattered pockets of it may be flowering during any given spring or summer (Hughes 1951). Unfortunately, many of these scattered flowerings do not frequently set fertile seed (Gagnon 2006). Occasionally cane can be found flowering en masse. These events may produce millions of plump, fertile grains in the late spring. Instead of producing the usual flush of new leaves in the early spring, flowering cane will appear straw-brown as though dying. Upon closer inspection, flowering culms will be covered with inflorescences resembling heads of rice or wheat. In Louisiana, cane seeds ripen in late April or early May. This timing may be later farther north in the MAV. Cane seed-heads progress quickly from green to ripe. Once ripe, heads shatter easily and drop seeds in even a slight breeze (Hughes 1951), so frequent monitoring of flowering patches is necessary if collecting ripe seed is a goal.

Cane seeds can be planted by pressing them lightly into moist soil. Cane seeds have no dormancy, and the best germination rates result from planting soon after seeds are harvested. Even so, some seeds should remain viable for a year or more if sealed and refrigerated – in one instance 50% of seeds sprouted after18 months in refrigerated storage (M. Cirtain, unpublished data). Chances of success are maximized by planting seeds in moist, well-drained soils (Cirtain et al. 2004) under partial shade (Gagnon 2006). Seedlings can also be started in a greenhouse and then transplanted out the following growing season (Cirtain et al. 2004). Seedlings are susceptible to drought and do best in soil with an organic component. Accounts conflict whether cane seedlings benefit from fertilization (Hughes 1951, Cirtain 2004). Growth of cane seeds into adult plants is undocumented, but most bamboos require 3-7 years to reach full size (Judziewicz et al. 1999), and cane appears to follow a similar pattern (Hughes 1951, Gagnon 2006). Without careful monitoring, cane seedlings are inconspicuous, and positive results may require five or more years to manifest. Planting a large number of cane seeds may be the best way to ensure long-term canebrake restoration. The seedlings will grow up as a cohort and should be in-phase for flowering when that time comes years later. Cane seedlings are somewhat shade tolerant, but to attain dense stand structure they will need at least partial sunlight and periodic disturbance as they mature.

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Appendix 3. Desired forest conditions for bottomland hardwood forests within the Mississippi Alluvial Valley (metric units).

Forest variables [1]	Desired stand structure	Conditions that may warrant management
Primary Management Factors		
Overstory canopy cover	60 – 70 %	>80%
Midstory cover	25 – 40 %	<20% or >50%
Basal area	13.7 – 16 m^2/ha with ≥25% in older age classes[2]	>20.6 m^2/ha **or** ≥60% in older age classes
Tree stocking	60 – 70 %	<50% or >90%
Secondary Management Factors		
Dominant trees[3]	>5/ha	<2.5/ha
Understory cover	25 – 40%	<20%
Regeneration[4]	30 – 40% of area	<20% of area
Coarse woody debris (>25cm diameter)	≥14 m^3/ha	<7 m^3/ha
Small cavities (hole <25cm diameter)	>10 visible holes/ha **or** >10 "snag" stems/ha ≥ 10cm dbh **or** ≥5 stems/ha > 51cm dbh	<5 visible holes/ha **or** <5 snags/ha ≥ 10cm dbh **or** <2.5 stems/ha ≥ 51cm dbh
Den trees/large cavities[5] (hole >25cm diameter)	One visible hole/4 ha **or** ≥5 stems/ha ≥ 66cm dbh (≥1.8 m^2 BA/ha ≥ 66cm dbh)	No visible holes /4 ha **or** <2.5 stems/ha ≥ 66cm dbh (<0.9 m^2 BA/ha ≥ 66cm dbh)
Standing dead and/or stressed trees [5]	>15 stems/ha ≥ 25cm dbh **or** ≥5 stems/ha ≥ 51cm dbh (>0.9 m^2 BA/ha ≥ 25cm dbh)	<10 stems ≥25cm dbh/ha or <2.5 stems/ha ≥ 51cm dbh (<0.5m^2 BA/ha ≥ 25cm dbh)

Appendix 3. Continued.

[1] Promotion of species and structural diversity within stands is the underlying principle of management. Management actions should promote vines, cane and Spanish moss within site limitations.

[2] We view "older age class" as those stems approaching biological maturity. We do not advocate coring for defining age but instead using species/site/size relationships as practical surrogates to discern age.

[3] Dominants (a.k.a. emergents) should have stronger consideration on more diverse sites, such as ridges and first bottoms.

[4] Advanced regeneration of shade-intolerant trees in sufficient numbers (ca. 1,000/ha) to ensure their succession to forest canopy. Areas lacking overstory canopy (i.e. group cuts) should be restricted to <20% of stand area.

[5] Utilizing BA parameters allows the forest manager to maintain this variable in size classes most suitable for the stand, versus pinpointing specific size classes as noted.

Appendix 4. Example of a forest inventory designed to assess habitat conditions.

PROSPECTUS FOR IVORY-BILLED WOODPECKER HABITAT ASSESSMENT

Randy Wilson, Kenny Ribbeck, Jeff Denman, Eric Johnson, Martin Blaney, and Chuck Hunter with statistical assistance from Ken Reinecke

BACKGROUND: In 1942 James Tanner provided the most comprehensive life history account of the Ivory-billed Woodpecker (IBWO) throughout its historic range and the only in-depth, ecological investigation conducted on a population of IBWO. Tanner's observations of the Singer Tract population of IBWO led him to hypothesize that foraging habitat was the limiting factor of habitat occupancy and possibly of population growth. Tanner went on to describe foraging habitat as recently dead trees (<4 years) with 84% of the foraging observations occurring on trees 12-36 inches in diameter. Unfortunately, this is the only published work detailing habitat characteristics associated with the occupancy of IBWO.

Since Tanner's publication, there have been numerous reports of IBWO sightings across the southeast, but none have had the benefit of being confirmed by a series of "re-sightings" or by locating a "base-activity" site (i.e., roost or nest site). The confirmed rediscovery of the IBWO in the Cache/Lower White River basin of Arkansas has set in motion a series of conservation actions. Key among these activities is the continued search effort led by Cornell Lab of Ornithology. As the Cornell staff and their partners continue to search and document evidence (e.g., sightings and sound recordings), it is imperative that a concurrent habitat inventory and assessment be conducted to facilitate the search efforts and to document existing habitat conditions.

OBJECTIVE: The purpose of this inventory is to quantify current habitat conditions on public lands within proximity to recent Ivory-billed Woodpecker (IBWO) sightings and audio recordings and areas perceived to likely harbor IBWO based on local land manager knowledge. These data will then be used to: (1) develop a spatially-explicit decision support model to facilitate search efforts, (2) provide ground-truth data to enhance accuracy of remotely-sensed data, and (3) provide land managers with a basis for making management decisions.

STUDY AREAS: The areas to inventory include public lands in proximity to previous sightings and audio recordings in the Big Woods area of eastern Arkansas; which includes the Bayou DeView area of Cache River National Wildlife Refuge, Jacks Bay and Prairie Lake area of White River National Wildlife Refuge and the entirety of Dagmar Wildlife Management Area. Additionally, time and manpower permitting we propose to inventory additional areas perceived to be providing "suitable" IBWO habitat based on local land manager knowledge. These additional areas potentially include: other areas on White River National Wildlife Refuge and Cache River National Wildlife Refuge, Bayou Meto Wildlife Management Area, Wattensaw Wildlife Management Area, Rex Hancock/Black Swamp Wildlife Management Area, and Henry Gray/Hurricane Wildlife Management Area.

SAMPLING FRAMEWORK: This habitat inventory will cover bottomland hardwood forest (excluding reforestation and bodies of water [e.g., oxbow lakes]) within the boundaries of the individual Wildlife Management Areas and National Wildlife Refuges previously identified. Within these public lands, the inventory will focus primarily on areas with evidence of IBWO existence (e.g., sightings and or auditory recordings): Bayou DeView area (ca. 10,000ac) of Cache River NWR, Jack's Bay and Prairie Lakes region (ca. 60,000ac) of White River NWR, and the entirety of Dagmar WMA (ca. 10,000ac). However, additional areas (ca. 10-20,000ac) may also be assessed in a preemptive manner to facilitate search efforts to locate the bird(s).

Due to the large acreage of interest, the inventory will be sample-based. That is, sampling effort will be allocated and conducted in such a manner to reduce the amount of time, manpower cost, and potential disturbance, all the while maintaining a level of statistical precision in the data. To accomplish this, individual management compartments within the area of interest will be broken down into homogenous stands approximately 500 acres in size (Fig. 1). Each management compartment and stand will be digitized to create a GIS shapefile for use in the allocation process, as well as, in analysis of the data.

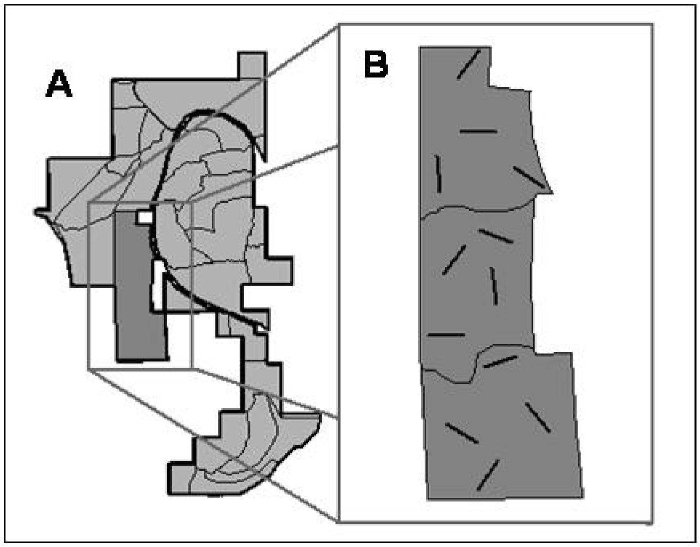

Figure 1. Schematic demonstrating: (A) the delineation of management compartments within a management area; and (B) the delineation and allocation of sampling units within stands across a management compartment.

SAMPLE SIZE DETERMINATION: As with any sampling effort, there are trade-offs in terms of cost (e.g., number of samples and manpower) and the reliability of the data. That is, collect too few samples and the data lack statistical power to provide precise parameter estimates. Whereas, on the other extreme, there is a point where no additional precision can be obtained regardless of the number of samples taken. One means of assessing these trade-offs is to examine pilot data collected from the area of interest to generate summary statistics that provide insight into distributional properties of the data. In particular, the coefficient of variation (CV) is the population quantity on which sample size depends when one desires to control the relative precision of the data (Thompson 1992; Sampling. John Wiley and Sons Inc. 343pp).
To facilitate the determination of sample size requirements for conducting habitat inventories for Ivory-billed Woodpeckers (e.g., the density of large diameter trees [≥24inches]; density of dead/dying trees), pilot data from White River NWR was subjected to sensitivity analyses to assess precision (i.e., stability of coefficient of variation values) under different sample sizes. To accomplish this, we subjected the pilot data (n=15 clusters of 5, 1/5th acre plots) to simulation models that randomly selected clusters of points at varying sample sizes and generated summary statistics for the parameter of interest (e.g., density of trees ≥24 inches in diameter at breast height [dbh]). In these simulations, CV values were calculated for sample sizes of 2, 3, 4, 5, 6, 8,

and 10 clusters by randomly selecting clusters and then replicating the procedure 10 times. Simulations resulted in the calculation of 10 CV values for each sample size (Fig. 2). The simulations revealed great variation in precision estimates (e.g., CV values) for sample sizes ≤3; whereas sample sizes ≥6 demonstrated little variation in the precision estimates (Fig. 2). Precision estimates calculated for sample sizes of 4 and 5 clusters were similar in the amount of variation expressed in the replicates and also produced acceptable levels of precision (i.e., none exceeded 15%).

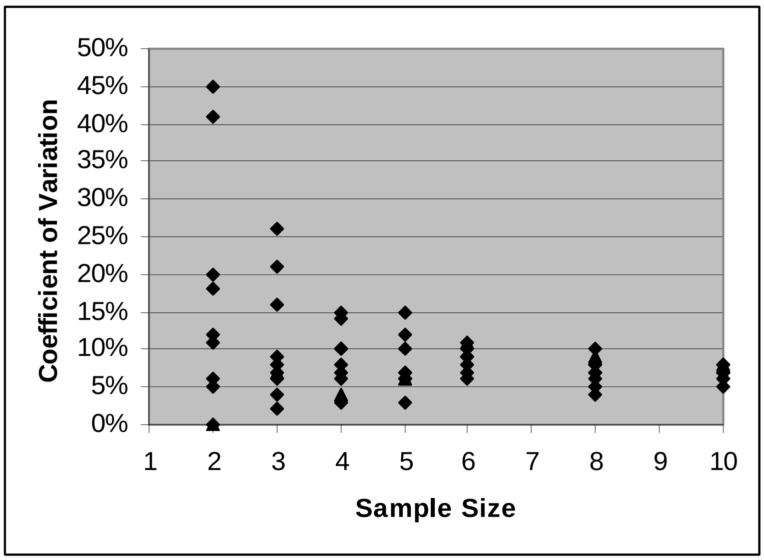

Figure 2. Sensitivity analysis to assess implications of sample size (e.g., number of clusters) on the coefficient of variation for density of large trees (≥24inches dbh) based on pilot data from White River NWR.

Given the current funding constraints, availability of manpower, the large area of interest in the Big Woods of Arkansas (Cache River NWR, White River NWR, and Dagmar WMA) and the desire to maintain an acceptable level of precision (i.e., low CV values) in parameter estimates, a sample size of 4 clusters per sampling unit (e.g., stand) appears to be the best option. That is, sample sizes of ≤3 clusters were not sufficient to consistently produce a high level of precision. Where as, sample sizes ≥4 clusters produced precise parameter estimates with sample sizes ≥6 clusters being very precise in the parameter estimates. Due to the constraints described above, it seems reasonable to opt for a sample size of 4 or 5 clusters given that both continuously produced acceptable levels of precision (e.g., CV ≤15%). A closer examination of CV values for these two sample sizes reveals nearly identical CV values produced during simulation analyses, suggesting that a sample size of four clusters is sufficient to maintain the desired level of precision in parameter estimates.

MARGIN OF ERROR: Although the final precision estimates will be determined by the larger, more comprehensive data set, sensitivity analyses of the pilot data set suggest that a sample size of 4 clusters could reasonably be expected to produce parameter estimates within 15% of the true mean 95% of the time when the sample CV=10% (Table 1). Alternatively, if the probability level was lowered to 90% (P=0.10), parameter estimates would approach a 10% margin of error with a CV of 10% (Table 1).

Table 1. Sample size in relation to margin of error and coefficient of variation (n=4; P=0.95).

Estimated Number of Clusters (Transects)*				
		P=0.05; CV=10%		
Strata	Area	Margin of Error ± 10%	Margin of Error ± 15%	Margin of Error ± 20%
x	~500 acres	8	4	2
		P=0.05; CV=15%		
Strata	Area	Margin of Error ± 10%	Margin of Error ± 15%	Margin of Error ± 20%
x	~500 acres	17	8	5
		P=0.10; CV=10%		
Strata	Area	Margin of Error ± 10%	Margin of Error ± 15%	Margin of Error ± 20%
x	~500 acres	5	2	1
		P=0.10; CV=15%		
Strata	Area	Margin of Error ± 10%	Margin of Error ± 15%	Margin of Error ± 20%
x	~500 acres	10	5	3

* Sample size calculated using the following formula: $((cv*t)/e)^2$ where cv=coefficient of variation; t=t-statistic based on 3 degrees of freedom; and e=the margin of error.

ALLOCATION OF SAMPLES: From the sensitivity analyses of pilot data, it was determined that cluster sampling yielded equivalent or higher levels of precision in parameter estimates than a simple random sampling scheme. Thus, we propose to allocate samples within a stand using cluster-sampling procedures. For example, plots will be allocated using point-transects where each transect contains five, 1/5th acre plots (52.7 ft radius) spaced four chains (264 ft) apart (Fig. 3) and each stand contains four randomly allocated point-transects (Fig. 1B). Additionally, the use of cluster sampling reduces the amount of travel time required to move from point to point, thus increasing the overall cost efficiency of the inventory. It is also important to note that these transects are flexible. That is, if at some point along the route a barrier is encountered (e.g., oxbow lake) the observer has the flexibility to randomly alter the route such that all plots are conducted.

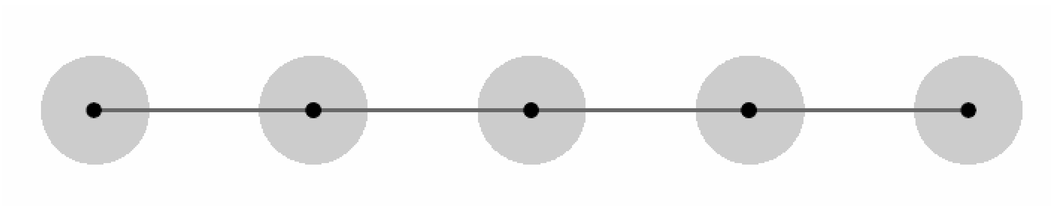

Figure 3. Schematic of a point-transect depicting a cluster of five, 1/5th acre plots spaced four chains (264 ft) apart upon which habitat metrics will be sampled.

PARAMETERS TO BE COLLECTED: Based on data provided in Tanner (1942) and discussions with Martjan Lammertink, (Cornell Lab of Ornithology Post-Doctorate Student), it is assumed that site-scale IBWO habitat occupancy is influenced by the density of large trees (≥24 inches dbh) and the amount of dead/dying wood often associated with high densities of larger diameter trees (e.g., crown dieback, over topped stressed trees). To inventory and assess habitat in the areas of interest (e.g., sightings and/or sound recordings) and other areas perceived to meet these criteria (as noted by local land managers) we propose to collect data on forest metrics listed in Table 2. It is believed that these metrics will provide both a quantitative estimate of parameters of interest, as well as, additional qualitative estimates that will facilitate the characterization of IBWO habitat, based on our limited knowledge. Furthermore, these data are also expected to provide additional benefits in terms of assessing habitat quality for other priority wildlife species (e.g., Swainson's Warbler).

DATA RECORDING AND PROCESSING: All data is to be collected on tally sheets (Table 3) in the field and subsequently entered into Microsoft Excel spreadsheets. Data must be correctly entered into Microsoft Excel spreadsheets following the desired formats. Upon completion of data entry and quality assurance checks, all data is to be promptly forwarded to the Lower Mississippi Valley Joint Venture Office for analysis. If data cannot be entered into Microsoft Excel spreadsheets for some reason, field observers should contact Randy Wilson (randy_wilson@fws.gov; 601.965.4903 ext 15) for assistance with data entry.

DATA ANALYSIS AND REPORTING: Data will be analyzed using SAS statistical software to generate summary statistics for all parameters. Parameter estimates will be generated for each stand, management compartment, and for the area of interest (e.g., entirety of Dagmar WMA, Bayou DeView area of Cache River NWR, Jacks Bay / Prairie Lakes region of White River NWR). After summary statistics are calculated, parameter estimates will be appended to GIS shapefiles depicting management compartments and stands to develop spatially explicit decision support models to facilitate search efforts. Summary reports will be provided to Arkansas Game and Fish Commission, Cache River NWR, White River NWR, Cornell Lab of Ornithology, U.S. Fish and Wildlife Service, Southeastern Regional Office and other entities as deemed appropriate.

Table 2. Parameters and definitions of metrics to be collected during the habitat inventory and assessment project in the Big Woods of Arkansas.

Parameter	Sample Area	Value	Comments
Tree Species	1/5th Acre	Alpha Code for Tree Species; Appendix 4	All trees ≥ 10" dbh
DBH	1/5th Acre	2" classes (9.0" – 10.9" = 10")	
Length in feet or # of logs	1/5th Acre	Dead or down wood: 5' increment. Cruiser option: 1 – 4.5 in half-log increments if sawlog, 5' increment for pulpwood.	Required for dead wood. *Cruiser option on # of logs*.
Crown Class	1/5th Acre	D = Dominant C = Co-dominant I = Intermediate S = Suppressed X = Dead	
Tree Condition	1/5th Acre	1 = No dieback (not very common) 2 = Lower crown dieback, natural pruning 3 = < 1/3 top crown dieback 4 = > 1/3 top crown dieback 5 = Recently dead, retains many twigs 6 = Dead, retains only large limbs 7 = Dead, only bole remains, ≥ 5' tall 8 = Down wood ≥ 8" @ 3' from base	
Stress Factor: Epicormic Branching	1/5th Acre	1 = Little to None (<20% of bole) 2 = Moderate (20% - 50% of bole) 3 = Heavy (≥ 50% of bole)	Bole is portion of tree beneath the crown.
Stress Factor: Bark Disfiguration: Ex: bleeds, tannin stains; bug holes; frass, conks	1/5th Acre	1 = Little to None (<20% of bole) 2 = Moderate (20% - 50% of bole) 3 = Heavy (≥ 50% of bole)	Ex: Red Oak w/ blocky bark; Ash w/ smooth bark; Rot; Bare wood from beaver, skinning, etc.
Overstory Canopy Cover	Visible Range	1 = < 50% 2 = 50% - 80% 3 = > 80%	Vertical sunlight blockage
Midstory Cover	Visible Range	1 = < 25% 2 = 25% - 60% 3 = > 60%	Horizontal vision blockage, 10' – 30' height
Understory Cover	Visible Range	1 = < 25% 2 = 25% - 60% 3 = > 60%	Horizontal vision blockage, < 10' height
Vines	Visible Range	1 = Sparse (<25% [1 of 4 overstory trees]) 2 = Moderate (25-50% [2 of 4 trees]) 3 = Heavy (>50% [3 of 4 overstory trees])	# of dominant or co-dominant trees with vines on the bole and/or canopy

Table 2. Continued…

Cane	Visible Range	1 = None 2 = Sparse (1% - 25% area coverage) 3 = Heavy (> 25% area coverage	
Station Option Shade-intolerant regeneration	Visible Range	Alpha Code for Tree Species; Appendix 4	Sufficient presence to occur if released
Potential IBWO cavity	Incidentally on Unlimited Area	A = very large irregular oval or rectangle, 4.5" x 5.5". Record tree species, DBH, height to cavity, face (north, west, etc.) and GPS coordinates (UTM, NAD 83).	Cavity size follows Cornell Lab of Ornithology.
Potential IBWO Bark Scaling	Incidentally on Unlimited Area	Extreme horizontal gouges of tight bark. Record tree species, DBH, height to cavity, face (north, west, etc.) and GPS coordinates (UTM, NAD 83).	
IBWO sighting or hearing of kent calls or double knocks	Incidentally on Unlimited Area	Record GPS coordinates UTM, NAD 83. Also direction and estimated distance to sighting or sound. ASAP contact inventory coordinator	

Table 3. Data sheet for collection of Desired Forest Condition parameters.

Location Data:

Date:_______________ Crew:_________________________
Location:____________ Unit:______________ Stand:_____ Line#:_____ Plot#:______
GPS Coordinates for the Plot:_______________________Hydro-Forest type: ______________

Plot-level Data:

Overstory	Midstory	Understory	Vines	Cane	Shade-intolerant regeneration
10% increments	10% increments	10% increments	0= None 1=Sparse <25% 2= Mod. 25-50% 3=Heavy >50%	0=None 1= Sparse <10% 2= Mod + >10%	

Tree Data: (≥9.5" dbh): 1/5th acre plot (r=52.7') (down wood diameter @ midpoint)

Species	DBH	Length / Height*	Crown Class	Tree Condition	Epicormic Branching	Bark Disfiguration

Codes.

*Length / height (only recorded for down dead wood and/or standing dead wood; merchantable height taken at discretion).

Crown Class
D=Dominant
C=Co-dominant
I=Intermediate
S= Suppressed
X= Dead
………………………………

Tree Condition
1 = No dieback
2 = Lower crown dieback
3 = <1/3 crown damage/top dieback
4 = >1/3 crown damage/top dieback
5 = Recently Dead, retains twigs
6 = Dead, retains large limbs
7 = Dead, only bole remains
8 = Down wood >8" diameter
………………………………

Epicormic Branching
1 = Little to None (<20%)
2 = Moderate (20-50%)
3 = Heavy (≥50%)
………………………………

Bark Disfiguration
1 = Little to None (<20%)
2 = Moderate (20-50%)
3 = Heavy (≥50%)
………………………………

Comments: ____

Appendix 5. Prospectus for implementing a forest breeding bird monitoring program to assess forest management activities.

ASSESSING FOREST BREEDING BIRD RESPONSE TO FOREST MANAGEMENT

Randy Wilson and Dan Twedt

Background: Many priority forest interior avian species in the Mississippi Alluvial Valley (MAV; Table 1) are disturbance dependent species (e.g., Swainson's Warbler, Kentucky Warbler). That is, these species require complex vegetative structure that typically results from disturbance to the forest canopy (e.g., increased light penetration resulting from tornadic events, tree mortality, or timber harvest). With only 24% of the once vast 24 million acre MAV remaining in bottomland forest, the expectation that habitat needs of these priority species can be met via successional events stemming from storm damage is questionable. Thus, silvicultural intervention will likely be integral to meeting their habitat needs. Conservation partners within the MAV have identified "Desired Forest Conditions" to guide forest management activities based on our current understanding of the habitat needs of priority species. As land managers implement forest management strategies to achieve "Desired Forest Conditions," it is imperative that we monitor the avian response so that forest management prescriptions can be modified following the principals of adaptive management.

Table 1. Priority Forest Breeding Birds in the Mississippi Alluvial Valley (Partners in Flight, 2005).

Species	Score	Action
Prothonotary Warbler	20	*Immediate Management*
Swainson's Warbler	20	*Immediate Management*
Cerulean Warbler	19	*Immediate Management*
Swallow-tailed Kite	18	*Immediate Management*
Mississippi Kite	18	*Management Attention*
Orchard Oriole	18	*Management Attention*
Northern Parula	16	*Management Attention*
Wood Thrush	16	*Management Attention*
Yellow-billed Cuckoo	15	*Management Attention*
White-eyed Vireo	15	*Management Attention*
Yellow-breasted Chat	15	*Management Attention*
Kentucky Warbler	15	*Management Attention*
Eastern Wood-Pewee	14	*Management Attention*
Acadian Flycatcher	14	*Management Attention*
Yellow-throated Warbler	14	*Management Attention*
Hooded Warbler	13	*Management Attention*

Goal: Obtain statistically valid estimates of the species-specific densities, along a temporal gradient (e.g., 1-20 years post-harvest), with respect to forest management strategies that target Desired Forest Conditions (see example in Fig. 1). Estimates for common species should be obtained within 2 years and estimates for all priority species (Table 1) should be obtained within 5 years.

Objective(s): Information is sparse regarding when priority species respond to forest management activities (e.g., 1-year, 2-years, 5-years post harvest, etc.) and the duration of optimal forest conditions. For example, when do Swainson's Warbler populations increase (if at all) and decrease following timber harvest? As such, the objective of this monitoring program is to generate species-specific density curves that reflect changes in abundance along a chronological gradient (e.g., years post-harvest). Furthermore, density estimates will be evaluated against "quasi-control stands" (e.g., stands >20 years post harvest), as well as, with "old-growth" stands (>100 years post harvest).

Quantitative Objective: From a statistical viewpoint, our objective is to generate density estimates corrected for detectability with coefficient of variation (CV) values of ≤20% within fixed time-treatment periods (e.g., 2 year or 3 year intervals post harvest). If this objective proves to be unattainable, time-treatment periods will be lumped into 2-3 year time-treatment periods (e.g., 5-7 years post harvest, etc.) to facilitate analyses. Over all time periods we are striving for a 10% margin of error at a 90% confidence level. Derivation of density estimates is based, in part, on the number of detections and good estimates require a minimum of 50 detections per species. Because species specific detections are likely to vary greatly among forest stands, we anticipate that 15-20 stands (90-120 counts) will be needed within each time-treatment interval to assess densities of common species. However, we anticipate that >600 point counts (100 stands) may be needed within each time-treatment interval to assess densities of priority species. As such, densities and their associated coefficients of variation (CV) will be assessed annually, with sample sizes (number of stands within time-treatment intervals) adjusted to achieve the desired levels of precision. Once a suitable CV level has been achieved (i.e., sufficient data acquired to answer the question) sampling within that time-treatment interval will be suspended.

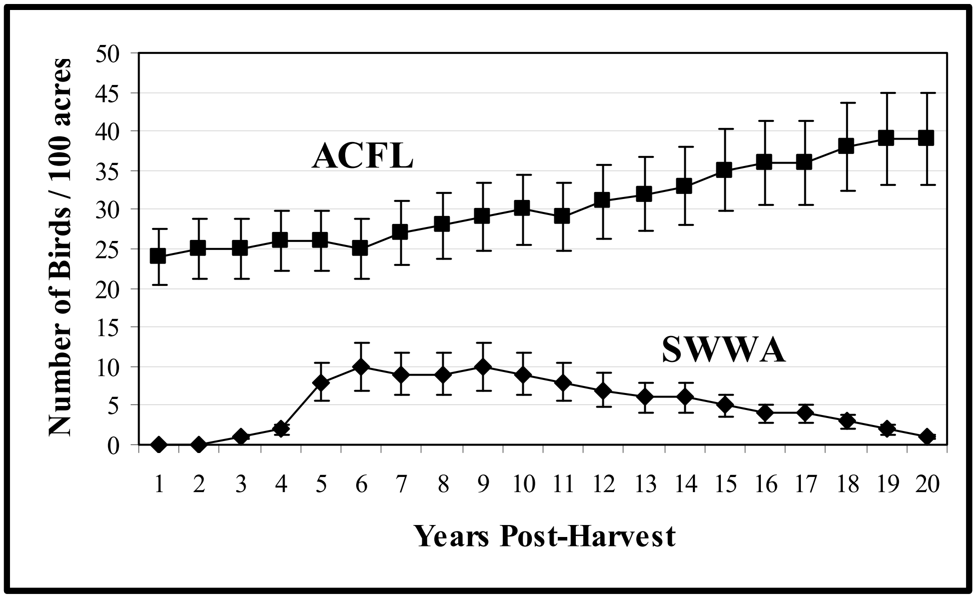

Figure 1. Schematic of hypothetical data demonstrating the expected product generated from this monitoring program.

Sampling Framework: Because our objective is to evaluate avian response to forest management that targets Desired Forest Conditions (or some wildlife-friendly derivation thereof) in bottomland forests of the MAV, the area sampled will focus on conservation lands (e.g., National Wildlife Refuges, State Wildlife Management Areas, and National Forests).. Data from all locations will be pooled to generate estimates applicable to the entirety of conservation lands within the MAV.

Avian surveys will be conducted within hardwood forest communities on conservation lands within the MAV and its associated bottomlands. Within these communities, forest management has historically been undertaken following uneven-aged management, although some even-aged management treatments have been applied. As discussed above, the “Desired Forest Conditions” being promoted in the MAV revolves around the achievement of stand-level characteristics resulting from thinnings and small group selection timber harvest. As such, this monitoring program will target stands subjected to treatments perceived to yield stand-level, target conditions prescribed for wildlife habitat improvement.

Ideally, stands monitored will be stratified among forest communities (e.g., cypress/tupelo, overcup oak/bitter pecan, Nuttall oak/sweetgum, etc.) and/or hydrologic gradients (e.g., wet vs. dry). However, anecdotal observations suggest that insufficient treatments exist to satisfy all these sample design requirements. As such, forest community types and hydrologic gradients will be used as covariates to help explain patterns of bird abundance.

Furthermore, most (if not all) bottomland forests in the MAV have been subjected to timber harvest at some point in the past. As such, we will treat all forest stands as if it they had been treated, with stands treated >20 years ago representing "quasi-controls". Additionally, we will locate and sample as many "old-growth" stands (e.g., areas with no known harvest for >100 years) as possible to "true-controls."

Sample Allocation: Within each forest stand (i.e., a defined area subjected to similar silvicultural treatment), we will allocate six point count locations. Points may be randomly or systematically located within each stand but should be at a minimum of 250 meters apart. Additionally, plots should be >100 meters from roads or agricultural edges. As a general "rule of thumb", a single point count with a 150 meter outer band represents approximately 7 hectares (ca. 18 acres). Thus, treated areas ≤ 40 hectares (ca. 100 acres) will be not be included in the survey.

Field Methods: Since the publication of "A Land Managers Guide to Point Counts of Birds in the Southeast (Hamel et al. 1996), several papers have been published suggesting that "unadjusted" point counts do not provide accurate estimates of bird abundance or estimates of density (see overview by Thompson [2002]). That is, some birds are not detected due to: (1) variables that affect the observers ability to detect and correctly identify birds (e.g., experience, hearing acuity); (2) environmental factors (e.g., wind, vegetation); and/or (3) physical and behavioral attributes of birds themselves (e.g., plumage coloration, singing rate). As a result, several methods, both methodological and analytical have been proposed for estimating detection probabilities that can be used to adjust abundances and thereby obtain density estimates from point count data. For example, Bart and Earnst (2002) suggested double sampling and Nichols et al. (2000) suggested double observer sampling. Both of these methods are modifications to field sampling and as their name suggest, they essentially double the amount of time personnel spend in the field. Other methods described by Farnsworth et al. (2002) and Rosenstock et al. (2002) utilize computer programs to analyze data that are recorded in temporal intervals and distance bands, respectively, to achieve estimates of detection probability.

Although we do not discount the need for or the importance of double sampling and the use of double observers, these methods are labor intensive and reduce the number of points that can be counted during a give year, thus reducing sample size. As such, we believe the most applicable method for estimating detection probabilities, while maintaining an adequate sample size, is through a temporal and spatial approach. That is, use of methods described by Farnsworth et al (2002) and/or Rosenstock et al. (2002) should permit the calculation of detection probabilities and not detract from sample size. Use of these methods requires only slight modifications to current point count protocols (Hamel et al. 1996). For example, point count duration must be 10 minutes with birds recorded separately for three distinct time intervals (0-3 min, 4-5 min, and 6-10 min). Also, the distance bands in which birds are recorded are set at (0-25 m, 25-50 m, 50-100 m, and 100-150 m). (Detections beyond 150 m and flyovers are recorded separately and not use to estimate detection probabilities). These modifications are compatible with past data collections and require only that data are collected in discrete time and distance intervals.

Below are step-by-step instructions for conducting the recommended 10 minute point counts, with birds recorded separately in three time periods (0-3 min, 4-5 min, and 6-10 min), as well as birds recorded in four distance intervals (0-25 m, 25-50 m, 50-100 m, and 100-150 m). Readers are referred to Hamel et al. (1996), "A Land Managers Guide to Point Counts of Birds in the Southeast" for details.

Standard Operating Procedure for Counting Birds:

1. Prior to the day of the counts, determine which points will be sampled and the order they are to be counted. Also, determine and upload the x,y coordinates for each point into a GPS.

2. Sampling will occur in the morning, beginning as soon as it is light enough to see a distance of 200 m and ending no later than 10 am. The observer should arrive at the first point while it is still dark so that the count can begin as soon as it is light enough to see. This is important

because singing rates for most species are highest near sunrise and then slowly decline over the morning.

3. Do not conduct the count during high winds or heavy rains. Counts should not be conducted if it is raining hard (rain code 4; Table 2) or if wind strength on the Beaufort Scale is a sustained 4 or greater (see Table 3). If these conditions are encountered, either wait until the weather improves or cancel the sampling for the day and reschedule.

4. Approach the location, noting any birds within 100 m of the counting station that are flushed, fly away, or retreat. Mark these birds in the appropriate distance band on a bull's-eye data sheet. Concentric circles on the data sheet indicate distances of 0-25 m, 25-50 m, and 50-100 m, record birds detected in the 100-150 m band in the margins outside the 100 m band.

5. Orient the bull's-eye data sheet to a fixed direction, record the wind and sky conditions (Tables 2 and 3), temperature, date, time, and observer.

6. Position a GPS unit and start it recording, if exact location is not already known.

7. As soon as possible, start the count. Use a pocket timer or watch to keep track of time.

8. Record each bird seen or heard with the appropriate species codes (Appendix C in Hamel et al. (1996). Count family groups of juveniles with a single adult as a single bird.

9. Mark birds on the data sheet in the appropriate distance band and approximate spatial location. Use standard coding symbols included on the data sheet to aid in separating individuals (4 letter species alpha codes can be found in Appendix C of Hamel et al. 1996).

10. Record data for different time intervals (0-3 min, 4-5 min, and 6-10 min) of the count in different ways. Some people like to use different color pens; alternatively, detections can be underlined or double underlined to indicate the different time periods. Be sure to record a legend of the chosen coding scheme on the data sheet for future reference.

11. Holding the sheet in a fixed position, spend part of the time facing in each of the cardinal directions in order to better detect birds.

12. Mark each bird once, using the mapped locations to judge whether subsequent songs are from new or already recorded individuals. All birds greater than 100 m from point center are recorded outside of the 100 m band; likewise, flyovers are recorded at the bottom of the page. The recorded distance should be the horizontal distance between the location a bird was first detected and the plot center. For species that occur in flocks, record the flock (e.g., species) and flock size in the appropriate distance band. There is no need to record each bird in a flock individually.

13. Do not record any birds believed to have been counted at previous stations.

14. At the end of 10 minutes, stop recording bird observations. Do not record any new birds seen or heard after the 10 minutes have passed.

15. Record the latitude and longitude coordinates from the GPS unit and mark the location.

16. Field notations from the bull's-eye data sheet can be transcribed to a point count summary form before they are entered into the National Point Count Database (www.pwrc.nbs.gov). The transcription process will facilitate data entry.

Procedures for Conducting Habitat Assessment:

At each point count location, complete the habitat data sheet (see below) at two spatial locations (one at the center of the point count and one at 100m from point center in the direction of travel to the next point count location). For example, there should be two habitat plots per point count location (point center and 100m). See Table 1 for variable descriptions.

1. For plot level data (i.e., the visible area around the point) record (circle) the appropriate categorical estimate listed on the datasheet for Vines, Cane, Overstory, Midstory, and

Understory. For clarification – overstory (i.e., canopy cover) is vertical cover of the upper canopy (>30ft), whereas midstory (10-30ft) and understory (<10ft) are measured on the horizontal plane.

2. For tree level data (i.e., individual trees) use a 10-factor prism* and record tree species and the number of trees by size category (4 – 9.5 dbh; 10 – 20 dbh; 20 – 30 dbh; and >30 dbh) that are considered to be "in" the plot.

*Procedural Note: When using a prism, the prism <u>must</u> stay over plot center with the user rotating around the prism.

All habitat parameters are based on forest metrics listed in Table 2 of the "Restoration, Management, and Monitoring of Forest Resources in the Mississippi Alluvial Valley: Recommendations for Enhancing Wildlife Habitat" document produced by the LMVJV Forest Resource Conservation Working Group, 2007.

Training: Bird identification workshops will be conducted annually by U.S. Fish and Wildlife Service's Migratory Bird Program and/or partners (e.g., Arkansas Game and Fish Commission). Workshops will expose participants to: (1) bird identification tips, techniques, and available resources; (2) bird/habitat relationships; and (3) key elements of bird monitoring programs.

Data Management: All data should be entered into the National Point Count Database as noted in step #16 of the standard operating procedure.

Data Analysis and Reporting: Data will be analyzed annually by Lower Mississippi Valley Joint Venture (LMVJV) Office staff and/or in conjunction with partners (e.g., U.S. Geological Survey scientists). Summary reports will be generated to assess progress and to facilitate revisions of sampling strategy. All reports will be circulated to partners and posted on the LMVJV web site.

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Rosenstock, S. S., D. R. Anderson, K. M. Giesen, T. Leukering, and M. F. Carter. 2002. Landbird counting techniques: current practices and an alternative. Auk 119: 46-53.

Thompson, W. L. 2002. Towards reliable bird surveys: accounting for individuals present but not detected. Auk 119:18-25.

Variable Circular Plot Point Count Summary Sheet

Date:	Observer:	Start:	End:

State:	Location:	Unit:	Compartment:	Stand:	Point:

Temp (F):	Wind:	Sky:	Cover Type:	Treatment:	Year of Treatment:

Species Alpha Code	0 – 25 m			25 –50 m			50 – 100 m			100 - 150 m		
	0-3 min	4-5 min	6-10 min	0-3 min	4-5 min	6-10 min	0-3 min	4-5 min	6-10 min	0-3 min	4-5 min	6-10 min

Flyovers:______________________________

Data Compiler:______________________________

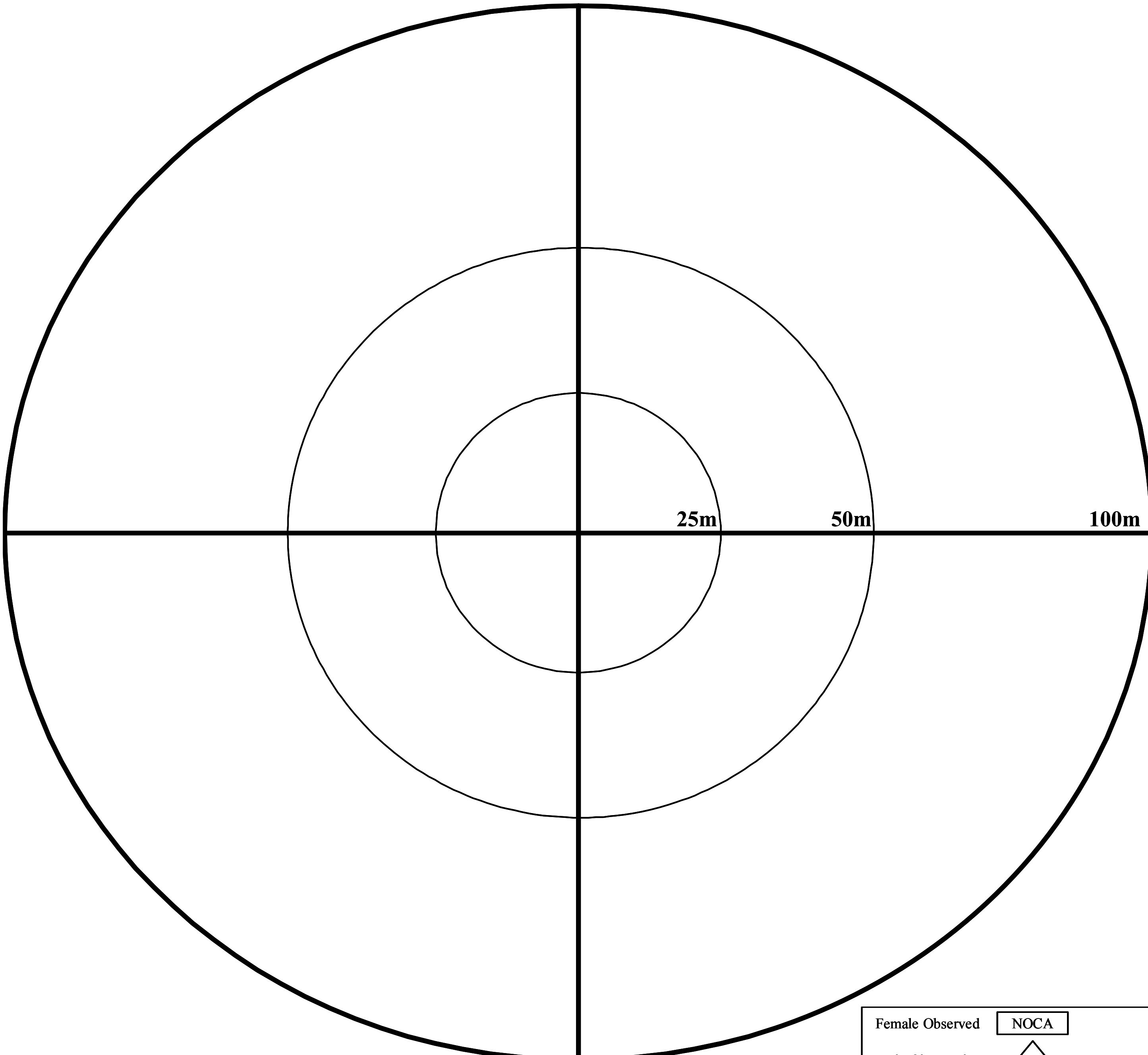
Comments:______________________________

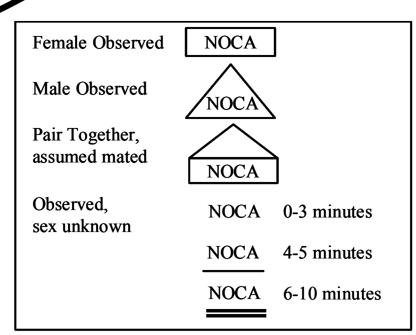
Variable Circular Plot Point Count Field Sheet

Date:	**Observer:**	**Start:**	**End:**

State:	**Location:**	**Unit:**	**Compartment:**	**Stand:**	**Point:**

Temp (F):	**Wind:**	**Sky:**	**Cover Type:**	**Treatment:**	**Year of Treatment:**





N-S Coordinate:____________ **E-W Coordinate:**____________ **Zone*:**_____

(N-S=Latitude; E-W=Longitude) *Zone = 0 for lat-long (geographic); else enter a UTM Zone.

Flyovers:____.

Habitat Data Associated with Forest Breeding Bird Point Counts

Date:	**Observer:**			
State:	**Location:**	**Unit:**	**Compartment:**	**Stand:**
Treatment:	**Year Treatment Implemented:**			
GPS Coordinates (*NAD83-UTM 15*):	**N-S:**	**E-W:**	**UTM Zone:**	

Point Count#_______ Habitat Plot#________

Plot-level Data: *visible area around plot*				
Vines	**Cane**	**Overstory** (>30ft)	**Mid-Story** (10-30ft)	**Understory** (<10ft)
1 = None *2 = Sparse (<25%)* *3 = Moderate (25-50%)* *4 = Heavy (>50%)*	*1 = None* *2= Sparse (<25%)* *3 = Moderate (25-50%)* *4 = Heavy (>50%)*	*1 = None* *2 = Sparse (<50%)* *3 = Moderate (50-80%)* *4 = Heavy (>80%)*	*1 = None* *2 = Sparse (<25%)* *3 = Moderate (25-60%)* *4 = Heavy (>60%)*	*1 = None* *2 = Sparse (<25%)* *3 = Moderate (25-60%)* *4 = Heavy (>60%)*

Tree Data: *plotless area using 10-factor prism*				
Tree Species	**Number Stems (dbh 4 - 9.5”)**	**Number Stems (dbh 10 - 20”)**	**Number Stems (dbh 20 - 30”)**	**Number Stems (dbh > 30”)**

****

Point Count#________ Habitat Plot#________

Plot-level Data: *visible area around plot*				
Vines	**Cane**	**Overstory** (>30ft)	**Mid-Story** (10-30ft)	**Understory** (<10ft)
1 = None *2 = Sparse (<25%)* *3 = Moderate (25-50%)* *4 = Heavy (>50%)*	*1 = None* *2= Sparse (<25%)* *3 = Moderate (25-50%)* *4 = Heavy (>50%)*	*1 = None* *2 = Sparse (<50%)* *3 = Moderate (50-80%)* *4 = Heavy (>80%)*	*1 = None* *2 = Sparse (<25%)* *3 = Moderate (25-60%)* *4 = Heavy (>60%)*	*1 = None* *2 = Sparse (<25%)* *3 = Moderate (25-60%)* *4 = Heavy (>60%)*

Tree Data: *plotless area using 10-factor prism*				
Tree Species	**Number Stems (dbh 4 - 9.5”)**	**Number Stems (dbh 10 - 20”)**	**Number Stems (dbh 20 - 30”)**	**Number Stems (dbh > 30”)**

Tree Species Codes

QUNU = Nuttall Oak
QUNI = Water Oak
QUPH = Willow Oak
QULY = Overcup Oak
QUPA = Cherrybark Oak
QUSH = Shumard Oak

CAIL = Sweet Pecan
CAAQ = Bitter Pecan

TADI = Cypress
NYAQ = Tupelo

ULAM = American Elm
ULCR = Cedar Elm

DIVI = Persimmon

PLOC = Sycamore
PODE = Cottonwood
LIST = Sweetgum

ACNE = Boxelder
ACRU = Red Maple

CELA = Sugarberry

FRPE = Green Ash

GLAQ = Water Locust
GLTR = Honey Locust

SNAG = Dead Trees

Table 1. Description of variables recorded at point count locations.

Variable	Description
Date	MM/DD/YYYY
Observer	Observer identification (e.g., initials).
Start Time	Time survey started.
End Time	Time survey ended.
State	State
Location	Name of forest, management area, refuge, etc...
Unit	Name of management unit within the location.
Compartment	Name of management compartment within the unit and/or location.
Stand	Name of management stand within the management compartment.
Point #	Number of the point within the compartment, unit, and/or station.
Temp (F)	Temperature in degrees Fahrenheit.
Wind	Wind speed from Beaufort scale (see Table 3).
Sky	Sky condition, combining cloud cover and precipitation (see Table 2).
Cover Type	Forest types follow Table 4 in the DFC Document, LMVJV Forest Resource Conservation Working Group 2007). *Swamp Forest – baldcypress, baldcypress-water tupelo* *Wet Bottomland Forest – overcup oak-bitter pecan, black willow* *Moist Bottomland Forest – sugarberry-elm-ash, oak-elm-ash* *Dry Bottomland Forest – cherrybark oak-cow oak* *Levee Forest – cottonwood-sycamore, sweet pecan-boxelder*
Treatment	Type of treatment (e.g., thinning, group selection, etc..)
Year of Treatment	Year treatment was implemented.
Flyovers	Birds observed flying over the plot.
N - S Coordinate	UTM (Northing - 7 digits) or latitude (DDMMSS) = (30°42'33").
E - W Coordinate	UTM (Easting - 6 digits) or longitude (DDMMSS) = (089°14'59").
Zone	UTM Zone or 0 if latitude / longitude recorded.
Comments	Notes and specific remarks about the count.

Table 2. Codes and descriptions for sky conditions (Weather Bureau Codes)[1].

Sky Conditions:		
Code #		**Description**
0		Clear or a few clouds
1		Partly cloudy (scattered)
2		Cloudy (broken) or overcast
4		Fog or Smoke
5		Drizzle
7		Snow
8		Showers

[1] These codes are the same codes used in the Breeding Bird Survey. Acceptable conditions for counting birds include a sky condition of 0,1, or 2 and wind speeds less than 20 km / h (12 mi/h), preferably less than 13 km / h (8 mi / h).

Table 3. Codes and descriptions for wind speeds (Beaufort Scale)[1].

Wind Speed Codes:						
Code #		**km / h**		**mi / h**		**Description**
0		< 2		< 1		Smoke rises vertically
1		2 to 5		1 to 3		Wind direction shown by smoke drift
2		6 to 11		4 to 7		Wind felt on face; leaves rustle
3		12 to 20		8 to 12		Leaves, small twigs in constant motion; light flag extended
4		21 to 32		13 to 18		Small branches are moved
5		33 to 30		19 to 24		Small trees begin to sway

[1] These codes are the same codes used in the Breeding Bird Survey. Acceptable conditions for counting birds include a sky condition of 0, 1, or 2 and wind speeds less than 20 km / h (12 mi/h), preferably less than 13 km / h (8 mi / h).

Appendix 6. Frequently asked questions and answers pertaining to *"Restoration, Management, and Monitoring of Forest Resources in the Mississippi Alluvial Valley: Recommendations for Enhancing Wildlife Habitat"*.

FREQUENTLY ASKED QUESTIONS

What is the purpose of this report? -- *The Lower Mississippi Valley Joint Venture Management Board chartered the forest resource conservation working group to serve as a technical forum for coordination among Joint Venture partners. Specifically, the working group was charged with the task of ensuring that conservation programs of Joint Venture partners reflect reforestation and forest management prescriptions and practices that sustain populations of priority birds and other forest-dependant wildlife in concert with sustainable forestry. To that extent, this report provides Joint Venture partners with contemporary recommendations based on the collective experience of on-the-ground managers, researchers, and published literature.*

What are desired forest conditions? -- *Desired forest conditions are intended to reflect some of the structural characteristics found in forests after long periods of natural perturbations. More specifically, desired forest conditions can be presented at multiple spatial scales (Table 1 and 2). For example, 70-100% of the area within local landscapes should be forested, with 70-95% of the forest under active management (i.e., 5-30% should be not be actively manipulated). At the stand scale, a series of primary management factors (e.g., canopy cover, mid-story, basal area) and secondary management factors (e.g., regeneration, cavities, coarse woody debris, etc.) represent the metrics for forest stand assessment and provide guidance for development of management prescriptions. Additionally, we note that desired forest conditions are* <u>*not*</u> *intended to be met on every acre within a stand or within a landscape. Instead, these forest metrics when measured within a stand should on average be within desired stand conditions. Moreover, desired stand conditions are only expected to be achieved on 30-50% of the stands within a landscape at any single point in time.*

Do desired forest conditions pertain to all bottomland hardwood forests? -- *Yes. Even though some tracts of bottomland hardwood forest are small and all priority species do not occur within all forest tracts of the Mississippi Alluvial Valley, we believe the implementation of desired forest condition recommendations has benefits to other wildlife (e.g., deer, turkey) as well as to overall forest conditions. Furthermore, we acknowledge that many of the conditions* *(e.g., increased understory) we are striving for will not be obtainable on all sites (e.g., bald cypress / water tupelo situations). However, we believe the recommended structural characteristics do not impose any negative constraints on these systems.*

Does the report put forth specific management prescriptions? -- *No. This report does not specify management prescriptions, although some past and current management practices have been identified as promoting development of desired stand conditions. Instead, recommendations are couched within specific habitat metrics (Table 2), such that local managers can evaluate site-dependant conditions and limitations to determine the most appropriate management prescriptions for achieving desired forest conditions.*

Do desired forest conditions promote regeneration of shade-intolerant species? --*Yes. Regeneration is encouraged through silvicultural treatments so as to establish advanced regeneration of shade-intolerant species on 30-40% of treated stands (Secondary Management Factor; Table 2). Although silvicultural practices that retain forest structure are necessary to achieve desired stand conditions, all silvicultural management tools are available to managers to manipulate forest structure as needed to regenerate and release established regeneration of shade-intolerant species. However, large (>7 acre) clearcuts should not represent more than 10% of any local landscape and group selection cuts (i.e., clearcuts <7 acres) should be limited to <20% of the area of treated stands.*

What is the justification for increasing reforestation stocking rates given its greater cost?
Much as the old commercial stated "pay me now or pay me later", we are recommending payment up front to insure a more species diverse and structurally complex forest is restored. Increasing diversity and potential upfront structural competition in the newly developing forests will promote more quality growth attributes of the trees leading to greater management options down the road. Additionally, if early treatments are not feasible, natural competition will allow greater natural mortality in the forests, providing an important secondary management factor (deadwood/coarse woody debris) normally absent in lesser stocked stands during the early stages of forest development.

How do reforested stands fit into desired forest conditions?
By our definition, reforested areas are considered regeneration areas. However, reforested stands are <u>*not*</u> *limited to 10% of the landscape as are regeneration harvests (e.g., >7 acre*

clearcuts). That is, achieving increased forest cover (i.e., reforestation) within the landscape overrides the 10% limitation placed on regeneration. Additionally, as restored stands develop, stand-level factors (i.e., midstory, overstory, vines, coarse woody debris, etc…) evolve, leading to development of structurally diverse forest systems that contribute to desired stand-level conditions (Table 2).

How will progress towards obtainment of desired forest conditions be measured?

This document puts forth recommendations for implementing both a forest monitoring program as well as a prospectus for monitoring the response of forest interior songbirds to management actions. Working collectively across agencies and organizations (through the LMVJV partnership) the conservation community should be able to implement monitoring programs, in a coordinated fashion, such that we can address management/conservation questions at multiple spatial scales following the principles of adaptive management. That is, these recommendations are intended to be dynamic and change as we learn more about forest developmental processes and within stand dynamics as it pertains to the structural characteristics of "Desired Forest Conditions" and the response of wildlife species. Furthermore, to achieve these monitoring recommendations will likely require a re-engineering of existing infrastructure in the form of roving teams and/or new job responsibilities for existing staff, as well as, new staff positions (e.g., biometrician, monitoring coordinator).