AN ASSESSMENT OF WETLAND MITIGATION IN TENNESSEE

by

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INTRODUCTION

The loss of wetland resources in the United States has been well documented by Mitsch and Gosselink (1986), Haynes and Moore (1988), Dahl (1990), and Dahl and Johnson (1991). The substantial losses of wetland resources in this country since settlement by Europeans have forced the development of legislation designed to slow or halt further wetland loss. Nationwide, the most important legislation of this type is the Federal Water Pollution Control Act, or Clean Water Act (CWA) of 1972, with amendments in 1977. The primary goal of the CWA is to restore and maintain chemical, physical, and biological integrity of the nation's surface waters, which includes wetlands. There are two primary sections of the CWA that deal with degradation of wetlands; Section 404 which regulates discharge of dredged and/or fill material into wetlands, and Section 401 which mandates that the fill not violate state water quality standards.

Specific to Tennessee, as of the early 1990s the state had lost over one half of the wetlands present historically (Dahl 1990). Legislation such as the Tennessee Water Quality Control Act serves in wetland protection by requiring 401 Water Quality Certification or state Aquatic Resources Alteration Permits (ARAP) be issued before waters of the state (including wetlands) are altered. Additionally, the latest update of Tennessee's Wetland Conservation Strategy (TDEC 1998) has established a goal of " no net loss" of wetland functions per hydrologic unit.

The protection of wetlands under Sections 401 and 404 is often less than effective however (Mitsch and Wilson 1996), with wetland losses still occurring regularly. As a result, the CWA also stipulates that wetlands lost as a result of fill or dredged material be mitigated if there is no plausible way the impact can be avoided or minimized. Unfortunately, in many cases it seems that compensatory mitigation takes place regardless of other options. As part of the goal of minimizing harm to the country's wetland resources, the U.S. Environmental protection Agency (EPA) and the U.S. Army Corps of Engineers (USACE) signed a memorandum of agreement (MOA) in 1989 regarding how permits for work in wetlands would be handled. The MOA specifies a sequence of steps that should be followed whenever the permitting agency

(USACE) receives an application regarding wetland alteration or filling. These steps which are intended to mitigate (lessen) the impacts of proposed projects involving wetlands are:

1. avoid impacting the wetland altogether if feasible alternatives are available,
2. minimize the impacts of the proposed action by reformulating the proposed work,
3. compensating for the loss of the wetland if no viable alternative to the proposed project can be found.

The last step typically involves creating a new wetland or restoring the hydrology to a former wetland to compensate for the loss of function performed by the altered or destroyed wetland. Other options that may be considered include enhancing degraded wetlands or purchasing and placing in public ownership existing wetlands (i.e., preservation) (Kruczynski 1990). Although there is no universal agreement as to the definitions of these terms (Lewis 1990), those used in Tennessee typically are those found in the second edition of the *Tennessee Wetlands Conservation Strategy* (TDEC 1996).

The concept of compensation provides flexibility in the decision-making process by allowing development that is in the public interest to proceed while at the same time protecting the overall wetland resource base. The use of compensation in the permitting arena was bolstered by studies conducted in the 1970s that showed some types of wetlands could be created successfully (Savage 1972, Woodhouse et al. 1972). Many regulatory agencies have accepted the concept of compensatory mitigation as having a role in the permit process and it now is common for permits allowing wetland loss to be issued contingent upon mitigation efforts. This practice is followed by both the primary regulatory agencies in Tennessee; the Memphis and Nashville Districts of the USACE and the Water Pollution Control Division of TDEC, and generally is accepted by EPA and the commenting agencies (i.e., the U.S. Fish and Wildlife Service and the Tennessee Wildlife Resources Agency (TWRA).

There are however, many issues and unanswered questions regarding compensatory mitigation; some have existed since the early 1980s. One consistent problem area has been defining "success" (Race 1985, Harvey and Josselyn 1986, Redmond 1992) and predicting how likely projects are to be "successful." Most wetland scientists maintain that success of a mitigation project should be based on the ecological role and "amount of function" the site is performing (Zedler 1996, Brinson 1993). The Wetland Evaluation Technique (WET) (Adamus 1987) was developed for such a purpose, but lack of validation and its inherent complexity resulted in limited use. Currently assessment models based in part on the Hydrogeomorphic Classification System (HGM) (Brinson 1993) are under development for many types of wetlands throughout the country. Only a few have been finalized however (personal communication, Ellis Clairain, USACE, 1999) , and it is anticipated that it will be several years before most are widely available. Until such models are available, there is no widely accepted protocol for quantitatively assessing the functions performed by mitigation wetlands.

Numerous wetland ecologists believe that even after more than a decade of practical experience involving wetland mitigation, we still lack the knowledge to effectively design and construct wetlands which are the equivalents of those destroyed (Kusler and Kentula 1990). Because of an inability to quantify function this concern remains, but a literature review for this study (Kentula et al. 1992, Sifneos et al. 1992, Atkinson et al. 1993, Reinartz and Warne 1993, and Erwin et al. 1994) suggested that recent wetland mitigation projects have tended to be somewhat more successful than earlier ones.

As compensatory mitigation projects have become commonplace throughout the country, most regulatory agencies including those in Tennessee simply measure the success of their programs on the basis of acreages lost and gained. The ratio of mitigation acreage to impacted acreage generally is determined by the state in which the impact occurs (Wilson and Mitsch 1996) and varies among categories (i.e., creation, preservation, etc.). In Tennessee, no formal policy regarding mitigation ratios has ever been established (personal communication, Robert Bay, USFWS, 1998).

An assumption agencies make is that the conditions of the permit will be followed and that a wetland of the type specified will be developed to compensate for the loss of the existing one. Unfortunately, a recent study of mitigation involving coastal wetlands in Florida (Roberts 1991) found that nearly one-third of the mitigation projects frequently did not succeed and in many cases were not even attempted. If a similar situation is occurring in Tennessee then the state's goal of "no overall net loss of wetland acreage and functions in each USGS hydrologic unit" (TDEC 1998) may not be realized.

The objectives of this study were to determine: (1) the number of mitigation projects which have been completed within the time stipulated in the permit, (2) if mitigation wetlands meet the conditions specified in the permit, and (3) the extent to which small, isolated wetland mitigation sites are used by vertebrate wildlife, especially amphibian and avian species.

The third objective was included because it is believed that most current wetland losses in Tennessee involve small acreages, often under 0.5 ha (personal communication, Daniel Eager, TDEC, 1996). Until recently, small wetlands such as these generally were considered to be of relatively little value. In fact, WET (Adamus 1987) almost always ranked wetlands less that 2.1 ha (5 ac) as being of low quality for most functions including wildlife habitat. New research has shown however that some species, especially amphibians, actually require the presence of small, isolated wetlands, and cannot exist without them (Moler and Franz 1987). Apparent reasons for this specificity include low dispersal abilities and a lack of fish predators in small ephemeral wetlands. Knowing how mitigation wetlands function to provide habitat for similar species in Tennessee may have a significant influence on how small wetlands are regulated in the future.

MATERIALS AND METHODS

Site Selection

One hundred Aquatic Resource Alteration Permit (ARAP) numbers were randomly selected from approximately 150 permits listed in the TDEC-WPC database. We used the ARAP permit database because it contained information about state as well as federally permitted activities (federal activities involved both the Nashville and Memphis Districts of the USACE). Permits issued at both the state and federal levels addressed the same general issues and contained similar information (i.e., replacement ratios, design plans, performance standards, monitoring requirements, etc.). Due to this similarity, we believe that results of this study apply to the USACE Districts regulatory program as well as to that administered by TDEC-WPC.

Wetland mitigation sites that corresponded to the numbers on the ARAP permits were visited to determine the status of each. Of 100 permitted mitigation sites visited, 53 were still under construction or had not been initiated. The remaining 47 permits represented 50 individual mitigation sites which were completed. These 50 sites served as the basis for the study.

Data Collection

Data which could be used to address the 3 objectives of the study were collected from each of the 50 sites. All sampling took place between 1 June and 31 October during both 1997 and 1998.

Wetland Area

To determine the amount of jurisdictional wetland area present at each site, the wetland boundary first had to be delineated utilizing the routine determination procedure described in the 1987 Wetland Delineation Manual (WDM) (USACE 1987). As part of the procedure, the presence or absence of wetland hydrology, hydric soils, and hydrophytic vegetation was determined based on indicators observed. At many of the projects, wetland boundary delineations were simple because the projects involved the excavation of basins, thus a distinctive boundary was present. The work at these sites centered on simply determining whether or not the excavated portion of the site could be considered jurisdictional wetland.

The boundary of the wetland area was marked and a 12 channel, Trimble Mark VI Global Positioning System (GPS) data logger was used to record the coordinates of the wetland boundary. Data were collected at one second intervals and downloaded to a personal computer. Processing and differential corrections of data positions were made using Pathfinder Series software and stationary files from base stations at the Big South Fork National Recreation Area, Oneida, Tenn. and the University of Kentucky, Lexington, Ky., for sites in eastern Tennessee, CADDUM Inc., Nashville, for sites in middle Tennessee, and the University of Memphis, Groundwater Institute, Memphis, for sites in western Tennessee. Data then were downloaded into ArcInfo and ArcView Geographic Information Systems and the acreage of each site was calculated using the equation:

$$\text{acreage} = \text{area}/43{,}560 \text{ sq. ft.}$$

Vegetation

Vegetation at each site was sampled by establishing 85 ft (25 m) transects through each of the communities present (i.e., stratified sampling). The number of transects at each site varied with the complexity of the plant communities, although at most sites 1-3 transects were required. The point-intercept technique (Raelson and McKee 1982) was employed whereby at 1.7 ft (0.5 m) intervals a meter stick was dropped directly in front of the researcher, and each plant species contacting its front edge was recorded. Identification was made to the lowest taxa possible (generally species), using Radford et al. (1968) and Godfrey and Wooten (1979, 1981). Height of the vegetation in the vicinity of the meter stick was recorded in centimeters. Sampling took place until it was judged that the sample accurately reflected the composition and density of vegetation within each distinct community. A list of all species present was generated for each site. Values for percent cover, mean height, and species richness were calculated. Wetland indicator status of all species identified was based on Reed (1988), and defined by the percentage of time each plant species occurs in wetlands. These categories were: obligate (OBL) (>99%), facultative wetland (FACW) (67 - 99%), facultative (FAC) (34 - 66%), facultative upland (FACU) (1 - 33%), and upland (UPL) (<1%).

Soils

Pits approximately 15 - 20 in (38 - 50 cm) deep were excavated throughout each site (generally distributed among each of the plant communities) to determine if soils were hydric. Soil characteristics recorded included: matrix color and chroma, mottle color and chroma based on a comparison with a standard Munsell color chart (Kollmorgen Corporation 1975), mottle abundance, presence of redoximorphic features such as soft masses of iron and manganese concretions, and the smell of hydrogen sulfide gas.

Hydrology

Wetland hydrology indicators were also documented at each of the sites. These included direct observations of inundation, saturation of the soil within the upper 10 in (25 cm), oxidized rhizospheres, water marks on trees or other vegetation, drift lines, water-stained leaves, and sediment deposits.

Wildlife Surveys

To determine if and which wildlife species were using the mitigation wetlands, surveys for both birds and frogs were conducted. Call count surveys for frogs were conducted using the methodology established for the Tennessee Amphibian Monitoring Program (TDEC 1996). Essentially this involved listening for calling males approximately 30 minutes after sunset, 5 minutes at each site. The avian species using these areas were determined using point counts following the methodology of Hamel et al. (1996). Each point count was 5 minutes in duration. All species seen or heard within a 100 m radius of the survey point were recorded. No systematic surveys were conducted to determine which mammals made use of mitigation sites, but all species that were seen, or that could be positively identified by tracks were recorded.

The Permit Process

The language contained in the ARAP permits and accompanying documentation dealing with project design, construction, monitoring, and remediation of problems, has a very significant influence on the success of wetland mitigation projects. To evaluate whether or not each applicant had followed procedures outlined in the permit, we carefully reviewed each of the permit packages. Categories of particular interest were: a description of the impacted wetland, the type of mitigation specified, the size of the mitigation project, design specifications, performance standards, monitoring requirements, and success criteria.

RESULTS

Wetland mitigation sites (n = 50) distributed among 30 counties from across the state were assessed during the study (Fig. 1). The distribution of study sites was relatively equal among the 3 geographic regions of the state. Nineteen wetland mitigation sites were located in both western and central Tennessee, while 14 sites were located in the eastern part of the state. Sites ranged in age from 1- 6 years, with the majority (n = 16) being 3 years old (Fig 2).

Applicants

Permit applications were placed into 1 of 4 groups based on the activity which resulted in the wetland impact. These groups included: private, commercial/industrial, city/county government, and state government. All in the latter category were issued to the Tennessee Department of Transportation (TDOT). Of the 47 permits, 27 (57%) were issued to TDOT for road construction. The remaining 20 permits involved commercial/industrial development (n = 14, 30%), private development (n = 4, 9%), and city/county governments (n = 2, 4%) (Fig. 3).

Mitigation Categories

Descriptions of projects in the permits and mitigation plans indicated that of the 4 currently accepted methods of wetland mitigation, creation was used most often (n = 30, 60%) followed by enhancement (n = 17, 34%), restoration (n = 13, 26%), and preservation (n = 9, 18%) (Fig 4.). It was common for many projects (n = 15, 30%), to specify that more than one form of compensatory mitigation (i.e., creation / enhancement or creation / restoration) take place at an individual site. Although the numbers and percentages of the mitigation types used by the 4 applicant groups varied, the order (i.e., most used to least used mitigation type) was similar among the groups. In some instances, field inspections suggested that the activities carried out at

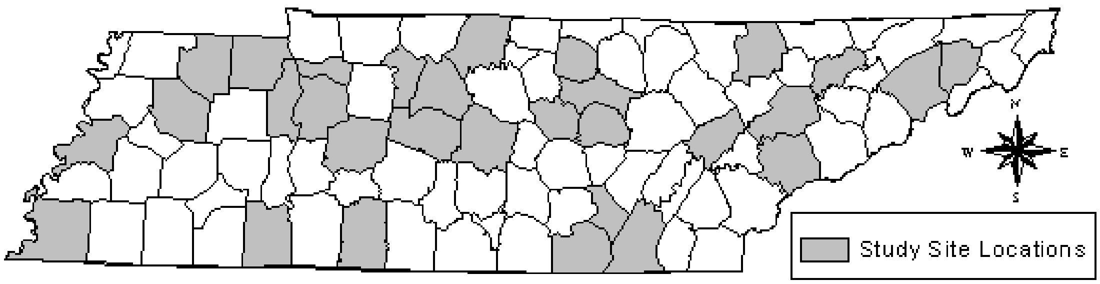

Figure 1. Map of Tennessee indicating distribution of study sites by county.

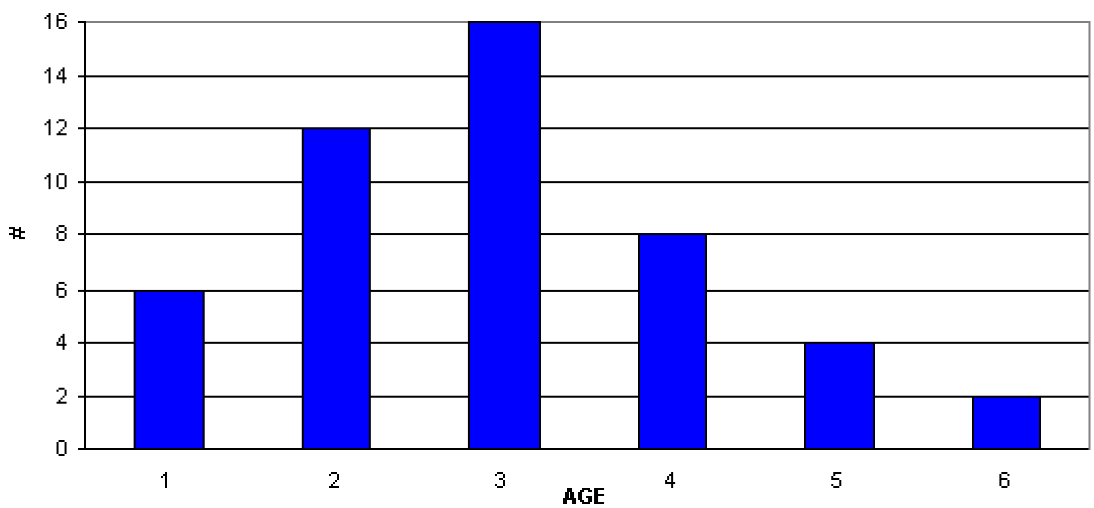

Figure 2. Age distribution of mitigation sites (n=50).

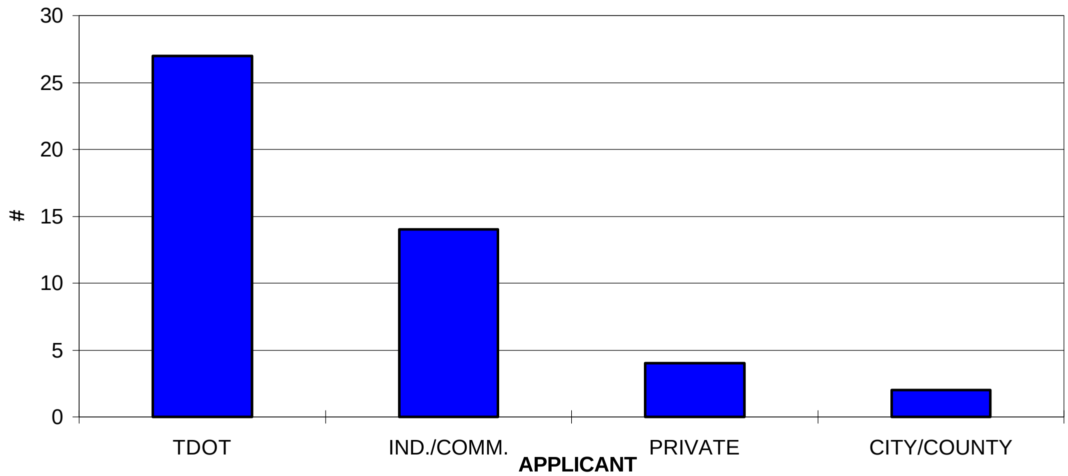

Figure 3. Permit applicants and number of permits used by each (n = 47).

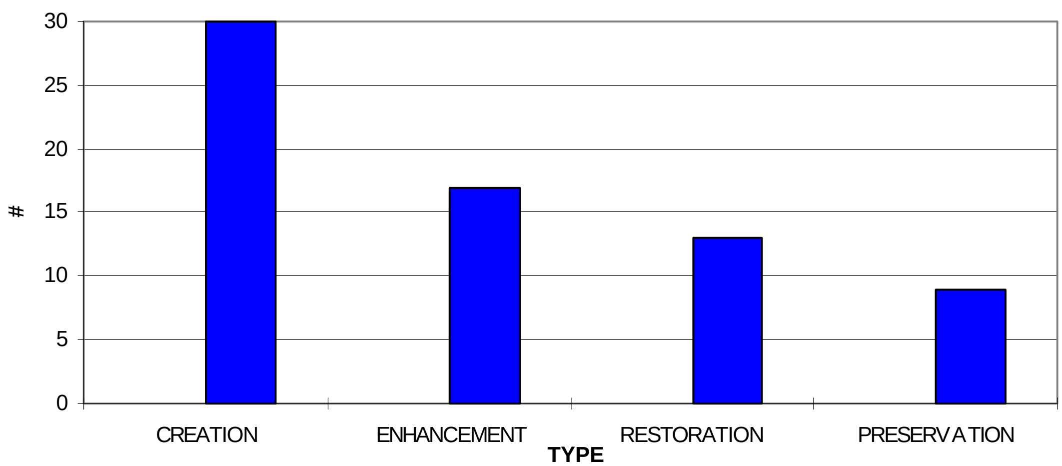

Figure 4. Types of mitigation and the number of each used (n = 50).

a site did not fit the description in the permit. This inappropriate categorization will be dealt with in the Discussion section.

Restoration projects entailed restoring hydrology to drained wetlands (sites #9 and #28) (Refer to Appendix A for information about site numbers), or in one instance, removing material from a filled wetland (site #41). The restoration of hydrology most often involved plugging drainage ditches.

Most creation projects were shallow basins excavated in upland landscapes in which wetlands had not previously existed (Figure 5). Their source of hydrology (besides direct precipitation) was local runoff and groundwater. Most were dominated by herbaceous vegetation such as soft rush (*Juncus effusus*), spicebush (*Eleocharis obtuse*), and various species of sedges (*Cyperus* spp). Tree seedlings of a variety of species were planted at nearly all sites as well. Sizable portions of 7 projects (sites #16, and #43), lacked rooted macrophytes and thus would be more accurately described as vegetated shallows or deepwater habitats, not wetlands (USACE 1987) (Fig.6).

At projects where enhancement was specified, the most common activity that had been implemented was the planting of tree seedlings, principally oaks (*Quercus* spp.). The majority of wetlands at which enhancement took place were dominated by herbaceous species, but 3 sites (#11, #13, and #19) already were dominated by trees. At 8 sites, tree planting took place in adjacent upland habitat as well. Surprisingly, the upland portion of the sites apparently was counted as mitigation acreage (#29 and #42). Two other enhancement activities were erecting wood duck (*Aix sponsa*) nest boxes (site #11) and developing snags (site #19) for use by cavity nesting animals.

Figure 5. Wetland creation projects were shallowly excavated depressions or basins.

Figure 6. Often creation projects contained too much water, resulting in deepwater habitat or vegetated shallows surrounded by only a fringe of jurisdictional wetland.

Eight of the 9 preservation sites in our study were forested or shrub-dominated. Of these, 6 were relatively mature (site #9) and were composed of a variety of species including sycamore (*Platanus occidentalis*), red maple (*Acer rubrum*), green ash (*Fraxinus pensylvanica*), and sweetgum (*Liquidambar styraciflua*), various oaks, and buttonbush (*Cephalanthus occidentalis*). Two sites (#33 and #36) were associated with oxbow lakes, and in portions were dominated by baldcypress (*Taxodium distichum*) and water tupelo (*Nyssa aquatica*). Site #48 was dominated by herbaceous species, but had a forested edge.

One of the larger areas of preservation (portion of site #9) did not meet the criteria for being considered a jurisdictional wetland. Except for a few shallow drainage ways; it consisted mostly of upland habitat (>75%). The incorrect determination that the majority of the site was wetland probably was caused by the soil being a light gray color (chroma 2) due to its parent material. There were no field indicators of hydric soils nor signs of wetland hydrology. The forest was composed mostly of FAC and FACU species such as white oak (*Q. alba*) and shagbark hickory (*Carya ovata*) which should have made the investigators question their decision.

Wetland Losses/Gains and Mitigation Ratios

The average size of the wetlands filled or drained as a result of the Section 404 or ARAP permit process was 1.87 ac. (0.75 ha). Sizes ranged from 0.009 ac - 12.17 ac (0.004 ha - 4.87 ha). Eighteen of the sites (36%) were smaller than 1.23 ac (0.5 ha). The total wetland acreage lost as a result of the projects for which the 47 permits were issued was 93.4 ac (37.8 ha). The target replacement acreage (calculated by summing the sizes of the mitigation projects specified in each of the permits) totaled 256.6 ac (103.9 ha). Thus, the mitigation ratio required by the regulatory agencies to compensate for wetland acreage lost was approximately 2.7:1.

Field verification of the amount of jurisdictional wetland acreage present at the mitigation projects revealed that most contained less acreage than had been specified in the permits. Only, 14 wetlands (28%) were the appropriate size while 36 (72%) were smaller than they were supposed to have been. The total wetland acreage present at the 50 project sites we studied was

173.3 ac (70 ha). When compared to the 93.4 ac (37.8 ha) lost, the actual replacement ratio (based on all accepted forms of compensatory mitigation) was approximately 1.9:1.

If however, we exclude projects involving preservation and/or enhancement (i.e. those sites at which wetlands already were present and thus did not contribute to an actual gain in wetland acreage), the total acreage produced by the mitigation process was only 82.3 ac (33.3 ha). Using this approach, the ratio of wetland acreage replaced to that lost through the permitting process is slightly below 0.88:1.

Jurisdictional Status

All of the sites but one (# 34) were found to contain some acreage of jurisdictional wetlands. More than one half (n = 27, 54%) were entirely wetland, though generally overall acreage was less than stipulated in the permit. A smaller number (n = 23, 46%) included uplands, deepwater habitat, or vegetated shallows habitat as well. It sometimes was not possible to separate the latter 2 categories and they are considered together in this report. The general composition of each site (i.e., % wetland, % upland, % deepwater habitat/vegetated shallows) is found in Appendix A.

In Kind vs. Out of Kind Mitigation

Although it was not always possible to determine the exact features of the wetlands that had been lost, we were able to characterize the vegetation at 43 sites. Based on the proposed mitigation plans for these sites, we concluded that 31 (72%) would have similar vegetation communities and would be considered as “in-kind” mitigation. The vegetation at nearly one-third of the impacted sites (n = 12, 28%) was to be replaced at least in part by another type. These sites, therefore constituted “out-of-kind” mitigation. The remaining 7 sites (16%) could not be assigned to one of these categories. Interestingly, each of the 12 sites considered “out-of-kind” involved the replacement of herbaceous vegetation with trees, which (presumably) will result in the site developing into a forested wetland. This would result in a net loss of herbaceous dominated wetlands. Because we seldom were able to find documentation of hydrology or soil characteristics of the impacted wetlands, we could not determine the "functional replacement" potential of the mitigation sites.

Characteristics of the Mitigation Sites

Hydrology

The primary type of hydrology present at most of the mitigation sites was that of water ponding within a closed depression. With only 1 exception, indicators of inundation or near-surface saturation were present at all the sites we studied. "Wetland hydrology" as defined by the WDM (USACE 1987) (i.e., inundation or saturation to the surface for a minimum of 5% of the growing season) was determined to be present throughout at 27 (54%)of the projects. Twenty-two projects (44%) had field indicators of "wetland hydrology" only in places.

Forty-five (90%) sites (or portions of them) were observed to be inundated or saturated within the upper 10 in (25 cm) of the soil profile, thus there was direct evidence of a hydrologic regime necessary to produce extended reducing conditions. A substantial number (n = 35, 70%) had visible oxidized rhizospheres, also a very strong indicator that the majority of the soil environment near the surface is anoxic for extended periods. Other indications of wetland hydrology recorded were water marks on trees and vegetation at 5 (10%) sites, drainage patterns through 4 (8%) sites, and sediment deposits at 2 (4%) sites.

Soils

Soils with visible hydric characteristics were present at 48 (96%) sites. Twenty five sites (50%) appeared to be hydric throughout, while 23 (46%) sites had hydric soil indicators only at some locations. The most commonly observed indicator of hydric soil conditions was a low chroma matrix (i.e., < 2), which occurred in at least portions of 48 (96%) of the sites. Soft masses (presumably manganese concentrations) were present at 21 (42%) sites. One site lacked any visible indicators, but was judged to be hydric based on documentation of prolonged ponding and the dominance of OBL and FACW vegetation. Two possible explanations for the lack of obvious hydric characteristics are: 1) they simply had not had time to develop and 2) the parent material of the soils prevented the development of the typical morphological features of hydric soils, particularly that of a low-chroma matrix.

Vegetation

A total of 143 individual species were identified at the mitigation sites (Appendix B). Twenty-eight (20%) species were trees or shrubs while 115 (80%) were herbaceous. Species that are considered "hydrophytic" dominated at least portions of 49 (98%) of the wetland mitigation sites. Based on the indicator status (Reed 1988) of the individual plant species, 80% were in the hydrophytic category (specifically 22% FAC, 29% FACW, and 29% OBL). The most common woody species were red maple, green ash, sweetgum, sycamore, black willow (*Salix nigra*), and buttonbush. The most common herbaceous species were common cattail (*Typha latifolia*), soft rush, and slender rush (*Juncus tenuis*).

The remaining 20% of the plants were non-hydrophytes and were classified either FACU (14%), or UPL (6%). The most common plants in these categories were Johnsongrass (*Sorgham halepense*), sericea lespedeza (*Lespedeza cuneatum*), and vetch (*Vicia* spp.); the latter 2 probably planted around the perimeters of some projects for erosion control.

Vegetation cover ranged from 0% at 1 site, to 100% coverage at 15 sites. Many sites had plant cover that varied from quite dense at some portions of the project to nearly bare in other portions. Mean vegetation cover for all sites was 88%. Herbaceous vegetation dominated most creation and restoration projects. Of the total plant cover present, herbaceous species accounted for the majority with an average of 68%. Cover by trees and shrubs was lower, averaging 12% and 8% respectively. At most sites, the trees present (both planted and volunteers) were saplings (< 10 cm dbh). There were portions of 11 projects (mostly preservation sites) at which larger, mature trees were common. At almost all the preservation sites, trees were the dominant form of vegetation present.

Planting of either bare root or containerized seedlings (n = 19 sites, 38%), or 1.5 in (3.8 cm) dbh, balled-and-burlapped trees (n = 18, 36 %) was done at almost all (n = 46, 92%) of the mitigation sites. Common species planted included hard mast-producing ones such as willow oak

(*Q. phellos*), water oak (*Q. nigra*), swamp chestnut oak (*Q. michauxii*), and baldcypress, as well as light-seeded ones such as green ash and black willow. All are native species and are characteristic of bottomland hardwood sites in Tennessee.

Survival overall was approximately 54%, and ranged between 0% - 95%. Only 22% of the sites met the minimum survival criteria (usually 75%) stipulated in the permit (Appendix C). Ten percent of the permits had no stated minimum survival criteria. Survival of seedlings (bare root and containerized) was 47% while that of larger balled-and-burlapped trees was 62%. There was no statistical difference in survival between the 2 groups (p 0.1). Attempts were made early in the study to identify species of dead trees to determine if survival of some species was better than that of others. This proved extremely difficult and time-consuming, and was discontinued.

<u>Buffer Areas</u>

A visual characterization of the areas surrounding the mitigation sites (approximately 100 m from the boundary and hereafter referred to as the buffer zone) revealed that most of the lands were at least partially vegetated and thus provided some protection from sediment deposition into the wetland. Forty-three (86%) of the sites had at least one side that adjoined a vegetated cover type which could be used by some wildlife species as habitat or as a travel corridor (heavily grazed pastures were not considered suitable).

Conditions at many projects however, were less than optimal for wildlife. Only 2 (4%) sites were completely surrounded by forest and although 31 (62%) were adjacent to forests, the patches generally were small (and therefore fragmented). “Natural” buffer zones adjacent to the remaining sites were either early succession “old fields” or some type of wetland. Residential or commercial/industrial development was adjacent to 28 (55%) of the sites and some form of intensive agricultural land use was adjacent to 25 (49%). Eleven sites (22%) were located next to major road systems (i.e., interstate highways and other heavily traveled roadways). Twelve sites (24%) had either intensive agriculture or commercial/industrial development on 3 sides. Two of the mitigation sites (4%) were completely surrounded by development. All these intensive land uses provide a formidable barrier to wildlife movement and drastically reduce their value as habitat for many species.

Wildlife Use of Mitigation Sites

Wildlife monitoring at each of the sites, while not intensive, resulted in documenting a total of 86 different species. They were distributed as birds (n = 67), amphibians (n = 10), and mammals (n = 9). A list of all species recorded is found in Appendices D, E, and F.

Some of the most frequently observed birds were the red-winged blackbird (*Agelaius phoenicius*), northern cardinal (*Cardinalis cardinalis*), bluejay (*Cyanocitta cristata*), and song sparrow (*Melospiza melodia*). Also seen, and of particular interest, were the king rail (*Rallus elegans*), American bittern (*Botaurus lentiginosis*), and great egret (*Casmerodius albus*), all relatively uncommon in Tennessee. We found a significant but weak correlation between the number of avian species (richness) and the size of the mitigation site ($r^2 = .21$, $p = 0.002$). Sites at which the most species were detected typically were those which had a combination of herbaceous, shrub, and forested habitat present. The 3 uncommon species mentioned above all were found in herbaceous-dominated wetlands (marshes).

Surveys for frogs (anurans) at the mitigation sites documented the presence of 10 species which represents approximately one-half of the 21 species known to occur regularly within the state. Some of the most common species were northern cricket frog (*Acris crepitans*), bullfrog (*Rana catesbeiana*), green frog (*Rana clamitans*), and southern leopard frog (*Rana utricularia*). There was no relationship between anuran species richness and size of mitigation sites ($r^2 = 0.002$, $p = 0.77$). It is noteworthy that 6 of the 28 sites (21%) that had a greater than average number of anuran species were 2.47 ac (1 ha)or less in size.

Mammals seldom were directly observed during field visits, but several species that had visited the site could be identified from tracks. The most common of these were white-tailed deer (*Odocoileus virginianus*), raccoon (*Procyon lotor*), and opossum (*Didelphis virginianus*). Small mammals (mice, voles, etc.) were not surveyed systematically by trapping and although tracks were seen at many sites, they could not be identified to species. Unconsumed remains of several small mammals including the genera *Sigmodon*, *Blarina*, and *Peromyscus* were observed, especially at sites adjacent to pastures or hayfields.

The Permit Process

Although the state and federal permits contained similar language, the accompanying documentation dealing with design, construction, monitoring, and other aspects of the project often varied substantially. The following sections deal with different areas of focus within the permit process.

Design Specifications

Specifications regarding how each wetland site was to be created, restored, or enhanced were found in all permit packages. Most of the permits that we examined contained general information about the characteristics of the mitigation wetland. A typical permit would include wording such as "construct a 1 ha basin with side slopes of 6:1;" "have a maximum depth of 1.5 m;" "seed construction site with perennial grasses to prevent erosion, etc." Most of the detailed information such as engineering drawings was included in supplemental documents. There was considerable variability among the permits in the amount of detail they contained relative to site design.

Performance Standards

Standards that would allow regulatory personnel to ascertain whether or not a mitigation project was developing as expected were present in all permits or accompanying mitigation plans. Eight categories of standards were recognized. Percentages of occurrence in the permits and/or mitigation plans are as follows: erosion control measures/water quality (100%), size (100%), "success" of the mitigation project based on "being able to delineate the area as a wetland by the best available means" (43%), minimum survival of vegetation (70%), species to be planted (96%), minimum vegetative cover (28%), maximum depth of water (20%), and wildlife use (6%).

Monitoring Report Characteristics

The submission of monitoring reports was stipulated in 42 (89%) of the permits examined. No such requirements could be found in the remaining 5 permits or in any of the accompanying documentation. Monitoring reports we reviewed typically contained information needed to confirm the presence of jurisdictional wetland conditions (i.e., wetland hydrology, hydric soils, and hydrophytic vegetation). Forty one (87%) of the permits stipulated that information describing these three parameters be included in the reports. Such information could be used in instances where applicable, to determine if the mitigation site had been "successful."

The majority of the permits (n = 43, 91%) included a time period through which annual monitoring reports were required. Specifically, 32 (68%) stated that reports were to be submitted annually for 5 years following completion of the project. Six (13%) required reports every 6 months for 1 - 2 years, then annually for the next 3 - 4 years. One (2%) required annual reports for 3 years. Three (6%) indicated that reports were to be submitted, but did not specify the length of the monitoring period.

Monitoring Report Compliance

It was difficult to determine exactly how many monitoring reports had been submitted for the 47 permits we reviewed, but the number apparently was quite small. A perusal of the files in the Nashville TDEC-WPC office in Fall 1997 resulted in only 16 monitoring reports that could be matched to one of the permits we had selected. It is possible that some were overlooked, but it is unlikely that the number would be significant. A copy of the TDEC mitigation database that we obtained contained confirmation of having received monitoring reports for only 18 of the 47 permits.

These figures are much lower than expected given that most projects were 2 - 4 years old and thus, the total number of monitoring reports received should have totaled between 125 and 150. Using the smaller of the 2 figures for illustrative purposes, the compliance rate for monitoring report submittal would be only 13%.

Overall Success

We did not attempt to derive a single statistic that could be used to measure success because of the variability in standards among the permits. If we used a minimal criteria such as number of sites "delineating as a wetland by the best available means," 14 (28%) were entirely jurisdictional and of the appropriate size. When other performance standards are considered, success rates decline. For example, when the standard related to tree survival is included along with simply delineating the area as a wetland, only 6 of the 14 projects (12%) would meet both standards. In spite of these low figures, we believe it is important to point out that with one exception, all but one of the mitigation efforts produced some jurisdictional wetland acreage. Thus, with the one exception they all could be considered at least "partially successful."

DISCUSSION

Assuming that our sample of 50 sites is representative of the wetland mitigation process in Tennessee, mitigation efforts have been sufficient to offset losses to unavoidable impacts only if preservation and enhancement acreage are included. Because creation, restoration, enhancement, and preservation are all considered acceptable forms of compensatory mitigation in Tennessee, we assume this is the appropriate way for the agencies involved in the mitigation process to determine how well their policies and the procedures they employ have worked. If we consider however, the State's recently revised goal dealing with "no net loss," to include acreage as well as function (TDEC 1998), we believe that it probably is more meaningful to use **actual** losses and gains (i.e., not counting enhancement or preservation) to evaluate the status of the wetland base. Viewed in this manner, the mitigation process overall has been less successful and has not quite produced enough wetland acreage to compensate for that lost, and significantly less than was required in the permits.

Most of the mitigation activities specified in the permits had been completed, so the lack of successful replacement was not due to applicants disregarding the requirement that they compensate for the wetland losses they caused. The principle reason for failing to replace lost acreage was that most projects were only "partially successful" as a result of inadequate design. Many were smaller than had been specified in the permits and most failed to achieve jurisdictional wetland conditions throughout.

It became evident over the 2 years of this study that improvements could be made in all of the major areas of the mitigation process including planning and design, permit writing, and monitoring/enforcement. If implemented, these changes should lead to a substantial improvement in our ability to compensate for unavoidable losses and help to achieve our "no net loss" goal.

Replacement Ratios and Types of Mitigation

Currently, there are only unofficial guidelines used by the regulatory (USACE, TDEC, and EPA) and commenting (Tennessee Wildlife Resources Agency (TWRA) and U.S. Fish and Wildlife Service (USFWS)) agencies regarding how many units of mitigation should be required for each unit of wetland filled or otherwise destroyed (personal communication, Robert Bay, USFWS, 1999). A document currently under review in Tennessee (May 1999) outlines suggestions for standardizing mitigation ratios. There is however, a general order that reflects agency preference (for the type of mitigation to be done) with restoration of existing wetlands having the lowest replacement ratio, creation of new wetlands an intermediate ratio, and enhancement and preservation of existing wetlands the highest ratios. Although mitigation involving creation, enhancement, and preservation requires greater replacement ratios than restoration, we found that all 3 types have been used routinely.

Restoration

Restoration (i.e., the reestablishment of a wetland in a location where it previously existed) generally is the preferred option for compensatory mitigation because it offers the highest probability of success (Kruczynski 1990, Kusler and Kentula 1990, USDA-SCS 1992). In Tennessee, projects that involve relatively simple activities to restore wetland hydrology (e.g., breaking levees or tiles, or plugging ditches) and which occur in areas with hydric soils can have replacement ratios as low as 2:1. In spite of the low ratio, restoration was not used as often as we would have expected; only 26% (n = 13) of the permits stated that restoration activities were to be done. When site visits were conducted and site managers described activities that took place, it became apparent even that this percentage was inflated. We believe that 2 of the 9 sites (#13 and #20) actually involved enhancement and or creation, not restoration.

We can only speculate as to why restoration was used as infrequently as it was, but a probable explanation was that permit applicants or their consultants were unable to obtain suitable acreage. The most suitable restoration sites are “prior converted” farmland and because sizable acreages are being restored under the Wetland Reserve Program (personal communication, Mike Zeman, 1998) sites available for compensatory mitigation may be limited. We recommend that agencies continue to encourage restoration by keeping replacement ratios lower than for other types of mitigation (2:1) and becoming more actively involved with applicants and landowners to identify candidate sites.

Creation

Because creating wetlands has proven to be less successful than restoring degraded ones (Kruczynski 1990) and requires more detailed engineering and construction costs, it normally is not a favored mitigation option. Due to the effort, cost, and uncertainty of such projects, Kruczynski (1990) recommended replacement ratios of at least 2:1 unless mitigation was done "up front." For these same reasons, ratios involving wetland creation in Tennessee have been approximately 4:1 in recent years. In spite of the high ratios and shortcomings of some creation projects in the past, it was the most common form of mitigation in our sample.

We found a great deal of variability in the quality of creation projects. A few such as site #2 and site #24 were well constructed and met most of the specifications in the permit. Most creation projects however, were only partially successful because they failed to develop wetland characteristics throughout (sites #3 and #12). Few actually met all the conditions specified in the permits. Problems with created wetlands were numerous and involved both site design and vegetation establishment. Both will be discussed in detail later.

We recommend that agencies consider wetland creation only when the likelihood of success is high (good source of hydrology, well designed mitigation plan, contractors with good track records, etc.) and when suitable restoration sites cannot be located. We also recommend replacement ratios of 4:1 (the ratio currently suggested by most agencies in Tennessee) for most creation projects. Higher ratios may be warranted depending on risk and the quality of the impacted site. Relatively high replacement ratios for wetland creation seem warranted given that we found projects yielded on average, approximately 1 ac (0.4 ha) for every 3 ac (1.2 ha) attempted.

Enhancement

Enhancement of existing wetlands is an acceptable mitigation practice because it improves the capacity of an existing (often severely degraded) wetland to perform certain functions. Sometimes replacement ratios involving enhancement alone can be as high as 10:1 (personal communication, Tim Merritt, USFWS, 1999); however, more commonly another type of mitigation also was specified at enhancement sites, resulting in lower replacement ratios. The most common enhancement activity was tree planting which can be very beneficial for wildlife if trees are lacking and conditions are favorable for their establishment. Several projects (e.g., sites #42 and #50) involved the planting of oaks and other species around the perimeter of the wetland and in adjacent uplands to enhance wildlife habitat and to provide a buffer. In these and similar projects we studied, the activity likely will enhance the value of the site in the future.

There were a few projects at which enhancement activities appeared to be not as well thought out. For example, at site #11, over 200 oak seedlings were planted beneath an existing canopy with generally poor results (reasons will be discussed later). At that same project, wood duck nest boxes were placed near several small steep-sided potholes that had been developed using explosives. It is assumed that each pothole was to serve as habitat for the young wood ducks when in fact, they lacked suitable cover and were much too small to be of any benefit. In reality, they probably were “ecological traps” as the likelihood of successfully rearing a brood there was minimal. Payne (1992) described quality wood duck brood cover and noted that areas less than 9.9 ac (4 ha) provide marginal habitat. A much better option would have been to attach the boxes to trees adjacent to Chattanooga Creek which bordered the site. Both tree planting and the installation of nest boxes can be very useful for improving habitat quality (Hunter 1990, Ridlehuber and Teaford 1986, Payne 1992), but at this project, they likely will result in little if any additional habitat value. If wildlife habitat enhancement is a goal, it is critical to understand the types of habitat required by animals for various portions of their life history. Bookout (1990) and Payne (1992) are excellent references for wildlife enhancement procedures.

We suggest that agencies carefully evaluate the use of enhancement as a mitigation option because it results in no new wetland acreage and there commonly is disagreement about whether or not the practice implemented actually enhances conditions at a site. This especially is significant when one considers the amount of time necessary for planted seedlings (the most common form of enhancement that targets wildlife) to reach the size necessary to produce a fundamental difference in the value of the site for most species. We agree with the currently accepted replacement ratios for enhancement beginning at 4:1 for projects with low risk and high short-term gains such as "improving" hydroperiods. We also recommend higher replacement ratios be required when the only enhancement activity planned is tree planting.

Preservation

Preservation of existing wetlands has been allowed as a form of compensatory mitigation in Tennessee, but is discouraged by some agencies, particularly the USFWS (personal communication, Tim Merritt, USFWS, 1999). Other agencies apparently view preservation differently and see it as a useful mitigation tool. We were surprised that in our random sample of 47 individual permits, there were 9 projects that allowed preservation of existing wetlands as mitigation (it was noted in the Results section that 1 preservation site consisted mostly of upland habitat). We presume this to be because sites suitable for other forms of mitigation (particularly restoration) could not be found. Of the preservation sites we studied, all but one were relatively mature forests, the wetland type most likely to be considered for preservation because of the high value as habitat, the fact that few old bottomland forests remain, and the lengthy time period needed for forest creation projects to mature. The other preservation site was dominated by herbaceous vegetation. Because we did not have information on the potential threats to these sites, we cannot judge the merits of their having been accepted as mitigation for other wetlands that were lost. Due to the nature of 3 of the sites however, (1 open water wetland, 2 oxbow lakes), their potential for loss seems low.

We believe preservation of existing wetlands can be a viable mitigation option, but only as a last resort. An example would be a mature, old growth forested wetland that would almost certainly be lost due to some proposed action. Other cases might involve rare or unique types of wetlands (e.g., bogs) or a type that is extremely difficult to create or restore (overbank flood-driven bottomland hardwoods). To identify such areas we suggest the development of specific criteria which can be used to evaluate an area and determine if it should be considered for preservation. Criteria for such an evaluation likely would include factors such as flood storage or conveyance capability, plant community type and age, surrounding land use, presence of rare, threatened, or endangered species, and degree of threat to the wetland. Such criteria would promote greater consistency in the selection of wetland areas proposed for preservation.

Kruczynski (1990) supported preservation under such conditions, particularly if anticipated wetland losses are likely to be minimal and benefits to the ecosystem from the preservation are substantial. He discouraged formalizing replacement ratios for mitigation and suggested instead that it be done on a case-by-case basis. We agree with this recommendation because of the wide range in the “quality” or “uniqueness” of wetlands that might be offered as candidates for preservation. Given the development of mitigation banks in several parts of the state in recent years, future preservation requests should be scrutinized carefully.

Mitigation Strategy to Prevent Net Loss

Enhancement and preservation projects were common in our study and their extensive use contributed to the actual acreage replacement ratio being less than 1:1. To counter this problem and to ensure that the state’s wetland base is maintained, we recommend agencies develop and implement strategies that encourage applicants to restore or create at least the wetland acreage lost when enhancement and/or preservation are used. As an example, if an applicant were to propose preservation of 10 acres of high quality wetland as the sole mitigation for 1 acre of wetlands lost, agencies might recommend instead that the mitigation involve the restoration of 1 acre and the preservation of a variable number of acres. Acceptance of such a proposal would result in no loss of actual wetland acreage and would place a sizeable block of existing high quality wetlands into public ownership. Scenarios involving other combinations of mitigation types also have potential for achieving the goal of minimizing preservation and enhancement projects and help achieve the goal of “no-net-loss of wetland acreage and function” in the latest version of the *Tennessee Wetlands Conservation Strategy* (TDEC 1998).

Site Selection

As land uses intensify, especially near urban areas, it is becoming increasingly difficult to find sites suitable for compensatory mitigation. In many instances, an applicant may be required to mitigate on-site, which alone limits the type of activity that can be done (i.e., restoration, enhancement, etc.). Such a requirement likely results in a much higher incidence of creation projects than might otherwise be done if mitigating off-site were an option. It generally is believed that on-site is preferable to off-site mitigation because the former helps to maintain the distribution of wetlands on the landscape in their historical context. Kruczynski (1990) discussed this and several other advantages to on-site mitigation. The State recognized the importance of this concept and included a goal of "achieving no net loss of wetland acreage or function in **each USGS hydrologic unit**" in the most recent version of the Wetlands Conservation Strategy (TDEC 1998). This desire to maintain the historical wetland distribution must however, be balanced against the likelihood of a proposed project's success. In many cases, it simply may not be possible to create the type of wetland desired given the site's soil type and watershed characteristics. In such instances, it would be more appropriate to mitigate off-site than to attempt a project that likely would not be successful. We support continuing to recommend on-site mitigation as a first option with the stipulation that the proposed project has a high probability of succeeding and does not require an excessive amount of effort (e.g., earthmoving) and expense.

The primary factors that most authors (e.g., Marble 1990, USDA-SCS 1992, and Denbow et al. 1996) suggest emphasizing when deciding where to locate a mitigation project are the available water sources and soil characteristics. If off-site mitigation is an option then **prior converted (PC)** farmland probably is the single best type of site to look for. These sites formerly were wetlands and many can be restored to wetland status with relatively minor activities such as filling in ditches or breaking subsurface drainage tiles. In western Tennessee where many wetlands were "driven" by overbank flooding, restoration of some types of PC areas is difficult due to channelization and downcutting of streambeds.

Another factor that also is critical to long-term success of mitigation projects that have wildlife utilization as a goal is the land use in the vicinity of the site. Although only a few of the sites we studied were completely surrounded by development, nearly 25% were located in areas in which development was extensive enough to either prevent use by sensitive wildlife or to have a deleterious effect on species using the site. At worst, sites such as #38 were in effect, wetland islands surrounded by development. Movements into and out of such sites by animals such as salamanders, frogs, turtles, and small mammals likely would be severely impeded. Buffer zones are required in some states (Denbow 1996) (they are not required in Tennessee) and can help protect the site in a variety of ways including filtering contaminants and acting as a shield for sensitive species. Most buffers are between 24.9 ft - 100 ft (7.6m - 30.5 m) wide (Denbow 1996) however, probably not large enough to have a significant moderating effect in highly developed landscapes. For example, Semlitsch (1999) surveyed the literature on amphibian habitat use beyond jurisdictional wetland boundaries and found that the average distance moved from the wetland itself was approximately 410 ft (125 m). Because many amphibians need forested habitat nearby their breeding sites to prevent dessication, he recommended that suitable habitat be developed or maintained within a similar radius of the wetland as a "zone of protection." We recognize that setting aside this amount of land as a buffer may not always be practical, but do recommend that agencies discourage mitigating at highly developed locations sites if alternatives are available.

Information on the location of a number of potential mitigation sites in Tennessee already has been compiled by Alley-Sykes and Duhl (1997) and currently is being expanded (personal communication, Mike Williams, TDEC, 1999). Sites were ranked according to criteria that reflected the suitability of the site for restoration and its potential value based on landscape considerations. The report and associated database is readily available and should be consulted anytime that off-site mitigation is to be done. Some of the sites in the database are PC wetlands, but there are many more that were not listed. The best source of information on the location of PC areas is the county NRCS District Conservationist.

Mitigation Site Development

<u>Using HGM as a Model</u>

For wetlands to be successfully created, restored, or enhanced on a consistent basis, it is essential that planners and construction personnel have a thorough understanding of the makeup of the type system they are working with.   A new approach to describing and classifying wetlands (Brinson 1993) has potential to become a powerful tool for use in designing wetland mitigation projects. The system, referred to as the Hydrogeomorphic Classification System or **HGM**, classifies wetlands in similar geomorphic settings and with similar sources of water and hydrodynamics into the same classes and subclasses. While HGM development efforts mostly have focused on producing assessment models for use within the regulatory arena, the concept of the classification itself has considerable utility as an aid in planning wetland creation and restoration projects. For example, by using the HGM system to classify the wetland that was impacted, its fundamental characteristics (i.e., landscape setting, primary source of water, and hydrodynamics) have to be identified. As a result, planners have a precise picture of how the mitigation wetland they will be creating or restoring should look (and function).

One of the HGM concepts that is an integral part of the assessment procedure and that also should be incorporated into the mitigation planning process is that of **reference standard** wetlands. In nature, there is a great deal of variability among wetlands even within an HGM class or subclass, but there are wetlands that most scientists would agree represent the highest quality within an area or region. These reference standard wetlands generally are the least disturbed by human activity and provide ideal models that created or restored wetlands can mimic. Thus, planners benefit not only conceptually from HGM, they have actual high-quality wetlands that they can visit and study to learn about their dimensions, bottom slopes, depths, water budgets, hydroperiods, soil characteristics, litter composition, plant communities, and any other characteristics that may be of interest. Essentially, the reference standard wetlands can be **natural models** upon which creation, restoration, or enhancement projects can be designed. We believe that every wetland creation or restoration project should have a natural model that it is patterned after. HGM can help mitigation planners formalize that concept. Projects based on natural models will be appropriate for the landscape setting they are in; in short, they will "fit."

The following example will illustrate how the HGM concept can be used as an aid in mitigation design. Because restoring a natural flooding regime to altered streams and rivers is very difficult, most of the created wetlands we studied were excavated basins that ponded water above a impermeable layer of soil. Wetlands such as these are found throughout Tennessee and would be classified in HGM as Class--Depression; Subclass--Perched. They may be completely closed systems (no outlet) or in the case of many headwater wetlands, they may be open with a gradual downslope movement of water (both as groundwater and aboveground as sheet flow). Depending on landscape position, they may be influenced primarily by local runoff, groundwater, overbank flooding, or by a combination of sources. In central and eastern Tennessee, such wetlands commonly are found in upland settings, often above the headwaters of streams.

One common soil series associated with wetlands in this HGM class and subclass in Tennessee is Guthrie. By examining the characteristics of Guthrie depressions, we can identify most, if not all, of the features we want to incorporate into the design of a wetland creation or restoration project. A good starting point is to obtain an up-to-date county soil survey from the local NRCS office. These s soil survey from the local NRCS office. These surveys list all the soils in the county (Guthrie in this example) and include information on landscape position, texture, permeability, horizon patterns, hydrologic regime (groundwater characteristics and depth and duration of ponding), and even the plant communities associated with the various soils. The following information mostly is from the DeKalb County soil survey (Moffitt et al. 1972). In it, Guthrie is described as "poorly drained, grayish soils that occur in level or depressional areas...These soils have a fragipan at a depth of about 76 cm" (approx. 30 in, varying from 20 in - 40 in). The subsoil is poorly aerated and slowly permeable....Runoff is very slow, and ponding is common in many places during wet periods." The soil horizons above the fragipan are silt loams while the fragipan itself is described as a heavy silt loam or a silty clay loam. Talley and Monteith (1994) describe Guthrie (ponded phase) as having a water table from 14 in (30 cm) below the surface to 24 in (60 cm) above the surface. That condition may exist from December to May. Trees commonly found in Guthrie depressions include willow oak, water oak, red maple, and sweetgum (Moffitt et al. 1972).

The above information provides planners a relatively complete profile of one of the common types of depressional wetlands found in central and eastern Tennessee. By designing a mitigation site with the geomorphic and hydrologic characteristics of a Guthrie depression, planners can enhance their likelihood of success. If properly constructed, the site should (over time) perform most of the functions (including having the appropriate plant and animal communities) of the natural model. Other types of wetlands (for example HGM Class--Riverine; Subclass--Low Gradient, Flats) can be created or restored using this same process.

Aspects of Design/Case Studies

This section includes examples of the most significant design and implementation flaws we identified and offers recommendations that should improve the process. Most of the discussion is in the context of wetland creation; however, the majority of the concepts and practices apply to restoration and enhancement projects as well.

The first feature to consider is the general type of wetland desired, which in HGM is defined foremost by the landscape setting (i.e., depression, flat, riverine, etc). As noted previously, most of the creation projects that we studied were excavated basins similar in concept to wetlands in the depression class. Intuitively, such wetlands should be relatively easy to create, but we found numerous problems with many projects that resulted in an undesirable plant community being present and in some instances, the site failing to attain wetland status.

Water Budgets

Certainly, the most significant design problem in a general sense was the failure to create the proper hydrologic regime. Overall, there were several reasons for not establishing the proper hydrology, but probably the most significant was the failure to calculate a **water budget**. This was a universal shortcoming as we could not find a single example of a water budget calculation in the files associated with any of the 50 projects we studied. Without such knowledge, it is impossible to determine with the degree of accuracy needed what water depths will be present at various portions of the site. This information in conjunction with the **hydroperiod** (i.e., the seasonal variability in inflow, outflow, and storage) is needed to determine the extent of flooding or ponding at a site. Most permit packages did include detailed drawings and engineering specifications and plans, but none dealt specifically with watershed size, land cover, and other factors in the context of an overall water budget. In fact, only 20% of the permit materials contained performance standards regarding water depth and other simple aspects of hydrology.

The primary text on wetlands today (Mitsch and Gosselink 1993) and almost all the references dealing with wetland design that we reviewed (some recommended ones are: Marble (1990), Payne (1992), USDA-SCS (1992), Kentula et al. (1993), Pierce (1994), Kent (1994), and Denbow et al. (1996)), emphasized the importance of hydrology. Mitsch and Gosselink (1993) and Bedford (1996) stated that hydrology is in fact **the** most important variable in the development and maintenance of a wetland system. When you consider that the goal of wetland mitigation really is to replace wetland function that has been lost, it is obvious that a mitigation project cannot be the functional equivalent of the impacted site unless it mimics its hydrologic regime.

Bedford (1996) suggested providing specific values in the mitigation plan or permit for such variables as flood frequency, duration, and timing of inundation and saturation at each mitigation site. Then, once the design to create the desired hydrologic regime has been specified, factors such as soils and the planting of vegetation could be addressed. This same logic and sequence of events is recommended directly or indirectly in most of the above-referenced documents and in the latest version of the *Tennessee Wetlands Conservation Strategy* (TDEC 1998).

In many cases, the consequences of not calculating a water budget resulted in neither average water depths nor hydroperiods developing as expected. These 2 factors are interrelated and together have a significant effect on the amount of oxygen that is present in the soil environment and the degree to which waterlogged sites ultimately become reduced (Mitsch and Gosselink 1993). This is an important concept relative to the success or failure of mitigation projects because plants exhibit varying degrees of tolerance to reduced environments (Mitsch and Gosselink 1993). The categories assigned to plants based on their affinity to wetlands (i.e., FAC, OBL, etc.) (Reed 1988) are related to their tolerance of anoxic conditions, but the relationships are not precisely defined. Although there are many exceptions, it is possible to generalize by stating that OBL species grow in areas with standing water for extended periods (moderately-to-highly-reduced) and FACU species in areas that experience little if any inundation and if so, only for brief periods (only slightly reduced if at all). The FACW and FAC categories have hydrologic regimes (and degrees of reduction) intermediate between these two.

In Tennessee, the portion of the bottomland hardwood community described by Wharton et al. (1982) as zones 4 and 5 is the desired end point of most creation or restoration projects. These zones are intermediate along the hydrologic gradient (composed primarily of FAC and FACW species such as willow oak, water oak, cherrybark oak, swamp chestnut oak, green ash, sweetgum, red maple, pignut hickory (*Carya glabra*), and associates) and normally have standing water early in the growing season. In most years, they dry out by mid-to-late spring. Mimicking this hydrologic regime is critical for allowing the plant communities associated with zones 4 and 5 to develop and persist.

Some of the created wetlands we studied simply ponded water for too long a period for many FAC and FACW species to survive well. For example, at sites #3 and #12, ponding that extended through the growing season resulted in almost complete mortality of planted stock (Fig 7). Only a few very tolerant species such as overcup oak, baldcypress, and water tupelo can withstand such prolonged inundation. We cannot say with certainty what the exact cause of prolonged inundation at these and other sites was, but indirectly at least, it can be attributed to the lack of a water budget. The probable cause at both sites was that they had been excavated too deep relative to their drainage area. Inspections by qualified engineers and hydrologists would be necessary to confirm the exact cause.

Besides using the HGM concept of mimicking the hydrologic regime of reference wetlands that serve as models for design, planners do have other sources of information. If wildlife habitat is a desired aspect of a mitigation wetland, probably the best recommendations for water depths and hydroperiod can be found in guidelines developed for greentree reservoirs. These impoundments are designed to provide a dependable source of habitat for waterfowl and normally contain the same forest communities targeted by creation or restoration projects (i.e., the mid-zone BLHs). Recommendations for water depths vary from as little as 1 in (2.5 cm)

Figure 7. Poor survival of planted trees was common, and at several sites mortality was 100%.

(USDA-SCS 1992) to a maximum of 35.4 in (90 cm) (Mitchell and Newling 1986). Typically, average depths should be between 6 in -18 in (15 cm - 45.7cm) (Huffstatler and Stewart 1997). All authors suggest that sites have variable water depths to facilitate the development of a diverse plant community and that sites be drained beginning in March or April to prevent stress to trees. These specifications and guidelines closely mimic the natural hydrologic regime of mid-zone southern BLHs (Wharton et al. 1982) and should be appropriate for mitigation wetlands. One obvious difference is that greentree reservoirs are managed systems with active water control while most mitigation wetlands are designed as self-sustaining and self-regulating systems. Thus, the importance of site design including a detailed water budget is even more critical for mitigation wetlands than for greentree reservoirs.

A failure to accurately predict the hydrologic response to planned actions also negatively affected the success of some restoration sites. The restoration projects we studied mostly involved plugging ditches at PC wetlands to restore hydrology (Fig. 8), but this action alone did not always produce the desired results. For example, at site # 9, where a series of approximately

2.5 ft (0.75 m) deep ditches had been used to lower the groundwater table, installing widely spaced rock plugs seemingly had little effect on the altered hydrology. It appeared that all the plugs did was to impede surface flow within the ditches and the majority of area between them showed no evidence of having wetland hydrology. Completely filling the ditches probably would have been necessary to restore the hydrology in groundwater driven systems such as this one. Hydrologists should be consulted for complex groundwater restoration projects.

Figure 9. Plugged ditches were often used in an attempt to restore hydrology to sites.

Basin Design

There were several projects at which the design of the basin itself contributed in failure to develop the desired wetland characteristics. In some instances (i.e. # 5, #16, and # 43), vegetated shallows or deepwater areas were created intentionally. Files for these projects contained design specifications showing the intention to construct basins with water depths of 3.28 ft - 6.6 ft (1m - 2 m). Most emergent plants will not grow in such areas, and as a result such basins generally would not be considered jurisdictional wetlands by definition. Compounding the problem at many of these projects was that the deepwater habitat/vegetated shallows made up a substantial portion of the total acreage present. Such areas lack the majority of characteristics and perform few of the functions of vegetated wetlands. The distinction between wetland and deepwater habitat/vegetated shallows has been discussed at length over the past several years, and TDOT has ceased to design such mitigation projects.

At several projects, we found very poor survival of planted trees. When we examined the permits, we found it was very common at creation sites to plant 5 - 7 “standard” wetland species from a list that included black willow, green ash, red maple, buttonbush, willow oak, cherrybark oak, overcup oak, and baldcypress. While these species are native to Tennessee and are appropriate for use in mitigation projects, many are quite specific in terms of their soil and hydrologic requirements. Of special significance is that they differ greatly in their tolerance to wetness.

We attributed much of the problem of excessive tree mortality to basin design; specifically to a failure to develop bottom contours in a manner that would produce the range of hydroperiods needed to ensure survival of all these species. Instead, a common practice illustrated by sites such as #12 and #22 was to construct the basins with virtually no relief. When the suite of species mentioned above was planted, the inevitable result was that only the ones adapted to the hydrologioc regime created by the basin design survived.

Except in unusual cases, created or restored wetlands should be designed with variable bottom elevations. This will increase habitat diversity (Fredrickson and Taylor 1982, and Marble

1990) and ensure that portions of the wetland can be de-watered. If marsh habitat is the desired goal of the project, ideal foraging conditions for waterfowl exists when depths vary from 6 in - 18 in (15 cm - 46 cm) (Weller 1990). Frederickson and Taylor (1982) presented an overview of how shallow impoundments can be designed with variable depths to provide habitat diversity and benefit waterfowl, wading birds, shorebirds, and dozens of other species.

Plant Community Establishment

While an HGM-like focus that emphasized site design and hydrology would have improved many of the projects we studied, other factors also were responsible for less-than-optimal results. One of the main factors was failing to consider the specific relationships that often exist between plants and the environments in which they live. These relationships which are an important aspect of the discipline of plant ecology must be integrated into the planning process before successful mitigation projects can consistently be developed.

Overall, we found poor survival of woody species that had been planted; in fact, in most cases survival was less than specified by the conditions included in the permits. Because the majority of mitigation projects were done with the goal of establishing a forested wetland, a lack of survival will only further delay an already lengthy process. Frequently, we could not determine why shrubs or trees had not survived, but at some sites, probable causes could be inferred. For example, buttonbush (*Cephalanthus occidentalis*), a wetland shrub, was planted at several sites (often in large numbers), but generally faired poorly. At sites #17 and #25 mortality was nearly 100%, and the reason was quite obvious. Buttonbush is a species that thrives in areas that pond water for extensive periods, yet at these sites, it was planted in locations that experienced little if any ponding. In some instances, it had even been planted in upland areas.

Given the above example and ones discussed in the previous sections dealing with water budgets and site design, it is apparent that neither many of the consultants nor planting crews recognized the significance of matching the desired species with site conditions and hydrologic regimes. We recommend that in addition to the general information on vegetation found in the county soil surveys, that the following sources for specific requirements of common wetland trees and shrubs be consulted: Johnson (1988), USDA Forest Service (1990), and Burns and Honkala 1990). The indicator status of all species found in wetlands in the Southeast (Reed 1988) also provides some insight into a plants probable hydrologic regime. For example, most obligate species typically occur in standing water, most facultative wetland species can tolerate some standing water, but not for as long a duration as obligate ones can. Facultative species typically are found in wetlands in which the duration of inundation or saturation is relatively brief.

We did see other factors that were responsible for poor tree survival and growth. Some as above seemed to indicate a lack of understanding of plant ecology and natural communities, while others were due simply to failing to implement the approved mitigation plan. Following is an example that likely involves both. At site #11 (an enhancement project in part), over 200 oak seedlings were planted beneath a canopy of mature maples and hackberry. The goal of increasing the abundance of mast-producing species at this site was a good one; however procedures for doing so were not carried out. Because most oaks are not very tolerant of shade (Dirr 1990), there had been over 50% mortality after only 2 years and only trees planted in canopy gaps had exhibited significant growth. Notes in the permit files indicated that portions of the canopy were to have been removed to allow seedlings to receive more direct sunlight, but evidence of this was not found. Even if it had, it is uncertain that small gaps created by removing a few trees would have been sufficient to allow the seedlings to grow into the canopy. The likely outcome would have been that the surrounding canopy would have quickly filled the gap and the planted trees would have been relegated to the midstory where they would remain for decades. Probably, a better approach would have been to cut relatively large 0.7 ac (0.3 ha) patches in the existing forest and plant the oaks in the openings.

Timing of planting likely was a factor that caused unnecessary mortality of plants at a few sites. Most permits stipulated that trees be planted during the dormant season; however, we found that some sites were planted during summer. For example, while collecting data at one of the study sites during Summer 1997, we observed that over 50 large, 10 ft - 14 ft (3 - 4 m) tall, balled-and-burlapped trees had been planted the previous day in an adjacent mitigation area.

Workers were watering the trees with large, high pressure hoses. A visit to the site one year later revealed that almost all of the trees had died. They simply had been planted at a time of the year when conditions were not favorable for success. Some wetland trees can be planted during summer, but moisture conditions must be favorable or steps taken to water the trees until they establish good root systems. If seedlings are planted during summer months, the tops should be removed to encourage the tree to concentrate its resources on root growth

(personal communication, Bob Johnson, U.S. Forest Service, retired, 1997). Agencies need to be aware that timing can significantly affect the success of vegetation establishment and neither require nor allow work to be done when low survival is inevitable.

Miscellaneous problems included failure of contractors to remove support cables from larger trees resulting in their eventually being girdled, and planting the wrong species. We noted a few instances of both. The former problem occurred at Sites #42 and #50, in which approximately one dozen trees were girdled. There were several instances of the wrong species being planted. For instance black willow was used in place of Virginia willow (*Itea virginica*) in at least one site (#31). A similar problem occurred at site #42 where sawtooth oak (*Q. acutissima*), an exotic, upland species had been planted although swamp chestnut oak (*Q. michauxii*) had been specified. Obvious problems such as this can only result from oversight by the contracting agency and regulatory personnel. The problem at the latter site apparently originated with the supplier, because the trees were labeled with metal tags identifying them (incorrectly) as swamp chestnut oak.

One practice that should be discouraged in most instances is that of planting substantial numbers of light-seeded species such as black willow (*Salix nigra*) and cottonwood (*Populus deltoides)* in and adjacent to mitigation areas. These and other species such as sweetgum (*Liquidambar styraciflua*) and red maple (*Acer rubrum)* are colonizers of early seral sites and in most cases will seed in on their own. This especially is true when a source of colonists is nearby.

Wilson and Twedt (1999) did however, recommend interplanting cottonwood with the principle species such as oaks, green ash, pecan, cypress, etc. to provide structure for forest birds more quickly than otherwise would occur. They reported that cottonwood will attain heights of 49.2 ft. (15 m) in 9 years, while oaks require 25 years to attain the same height. Besides providing habitat for forest wildlife sooner than would otherwise occur, other benefits they noted include more rapid development of litter, snags, and decomposition. One recommended option was to encourage landowners to implement this practice and harvest the cottonwood at 10 - 15 years, thus realizing a monetary gain much sooner than normal. Because of deed restrictions and ownership considerations, this practice may not be applicable to most small mitigation projects. If cottonwood is used in mitigation projects, one recommendation we favored is to plant several trees close together in clumps rather than positioning them throughout the project site (personal communication, Bob Johnson, U.S. Forest Service, retired, 1999).

Project planners should consider that wherever a mitigation project is adjacent to an existing forested area, planting may not be necessary at all. Even heavy-seeded trees such as oaks probably will become established on their own if mature seed-producers are present nearby. Most agencies do seem to favor some planting however, therefore, the following is a list of recommendations made by Johnson (1999): select species tolerant of site conditions and that are desirable for meeting certain goals (e.g., mast production for wildlife) plant bareroot seedlings 16 - 24 in (40 cm - 60 cm) tall, select planting stock from as close to the mitigation site as possible (ideally within a 50 mi (80 km) radius, plant during dormant season if at all possible, use proper planting techniques (e.g., place root collar below ground and close hole completely to eliminate air spaces), prune tops if growing-season planting is necessary, plant approximately 600 seedlings per acre (approx. 300 trees/ha) - allowing for 60% - 70% survival this will yield approximately 400 trees/ac (approx. 200 trees/ha), and plant 5 - 6 different species (most of the ones mentioned previously are common in Tennessee and are appropriate) including Nuttall’s oak (*Q. nuttallii*), shumard oak (*Q. shumardii*), sweet pecan (*Carya illinoensis*) and bitter pecan (*C. aquatica*). The latter recommendation regarding the number of species to plant might not be applicable at very small (e.g., < 0.1 ac (0.04 ha) sites where only a few trees would be needed and the hydrologic regime might be similar throughout.

As Built Documentation

Seldom do mitigation projects, especially ones involving creation of wetlands, turn out exactly as they had been designed (personal communication, Robin Lewis, Lewis Environmental, Inc., 1998). He noted that out of over 100 projects he had designed and built, only a "handful" matched the design specifications exactly. Although no "as-builts" were available for the projects we studied, we suspect that the same situation existed. Because problems due to unforseen conditions or failure of contractors to implement the proposed design are common, it is essential to check all wetland projects following construction to determine if they comply with the criteria for design and for agreement with permit conditions or project objectives (Kentula et al. 1993). These authors provided a detailed discussion with examples of how as-built documentation should be carried out and should be reviewed by the regulatory agencies. Implementation of this practice alone probably would have prevented many of the problems we found at the sites we studied.

Wildlife Considerations

Numerous species of wildlife used the mitigation sites. Probably the group that benefitted most from the mitigation areas was the amphibians. All of the sites were used by at least some members of this group and because most of the mitigation areas did not contain permanent water (and therefore no fish), survival of young amphibians should be relatively high. Small as well as large sites supported amphibian populations which supports a growing body of evidence that small wetlands distributed across the landscape provide high quality (and needed) habitat for many animal species.

The documentation of relatively uncommon birds using created marshes was surprising and noteworthy. Both the king rail and American bittern are not rare species, but both are uncommon in Tennessee (Nicholson 1997). Given the relative scarcity of marsh habitat throughout most of the state, we recommend that agencies give more consideration that they currently do to recommending the creation or restoration of marsh habitat within the mitigation process. Most of the agencies currently recommend the development of forested wetlands because that is the type most often impacted (personal communication, Robert Bay, USFWS, 1999). When, however, one considers the relative abundance of wetland habitats across the state, forested ones are much more common that herbaceous-dominated ones.

Two additional factors should be considered when recommendations regarding mitigation are made. First, marshes almost certainly were much more common historically than they currently are due to abundant beaver (*Castor canadensis*) populations prior to this century. Ponds created by beaver result in death of trees and their subsequent replacement for at least a decade by herbaceous and shrub habitat. The absence of beaver from much of the Tennessee landscape for the majority of this century has led to the notion that marshes never were common in Tennessee. We believe that not to be the case and that the creation or restoration of marsh habitat would far exceed the "value" of isolated forested mitigation sites that may in fact serve as "ecological traps" for some species. Given the relative ease with which marshes can be created and restored, and their rapid maturation time, mitigation of marsh habitat seems warranted.

Permit Process

During the early phase of the study, we encountered considerable difficulty obtaining the type of information we needed to make a thorough evaluation of how well the mitigation process was working. The following highlights some of the problems we encountered and some suggestions that would make the system more effective and user-friendly.

Files and Database Management

One of the first difficulties we encountered was simply finding the files for the sites we wanted to study. In a few instances the documents (i.e., permits, mitigation plans, etc.) were never found. The folders for these permits were in the proper place, but were empty. Subsequent attempts 2 and 3 weeks later to locate the information also were unsuccessful. There was no way of determining if the files in question were being used or had been lost. Because most information in both the TDEC and USACE offices was in paper instead of electronic format, there was no way of retrieving information on these permits. Storage in electronic form as well as hard copies would prevent such problems. Information could be retrieved quickly, easily exchanged among agencies, and in the event that hard copies become lost, could be reproduced.

Many of the files we did examine were incomplete, sometimes lacking what would seem to be essential information. We were surprised to find that there typically was little or no documentation concerning the impacted wetland. Generally, the information that was available was limited to size and the dominant vegetation present. There was little documentation of the functions performed, although it sometimes was implied that an analysis had been done. The primary purposes of compensatory mitigation is to replace lost acreage and function, and to determine if that has occurred information about the permitted wetland is required. Characteristics of the impacted site that should be included in the permit are: a general description including the HGM classification, acreage - total and by wetland type, surrounding land use, proximity to other wetlands, and data on hydrology, soils, and vegetation. Documentation of important functions using direct measurements or an approach such as an HGM model might be warranted in some instances.

Given the complex nature of wetland mitigation, the descriptions of the projects that were to be implemented commonly lacked the detail we expected to find. In over 25% of the files, only a very general reference was made to the mitigation activity that was to be carried out (e.g., “mitigation construction” or “constructed wetland”). Such vague descriptions could have referred to any type of project (i.e., creation, restoration, or enhancement), thus it was impossible for us to know exactly what was to be done. Determining what these projects entailed had to be done through direct communications with regulatory personnel or consultants.

We especially were surprised to find that one-third of the permit files did not contain **any** plans related to design, construction, and other critical aspects of mitigation projects, although all of the permits included language indicating that such plans existed. We also encountered a very different situation in that some files contained more than one mitigation plan. We could not determine why this happened, but assume that each was a different design that had been recommended during the review process. The problem we had in a few instances was determining which was the “final” approved design. In one permit file for example, 3 plans, all different were found. Although we assumed that the plan with the latest date was the “final,” it would have be preferable to know with certainty. A simple solution to this problem would be to assign a number to the final plan and cite that number in the permit (this was done in some permits).

Although there generally were directions to the wetland for which the permit was issued, the majority of the files lacked detailed directions to the mitigation site. An omission of such information presented a significant problem during this study and would to any person(s) not familiar with the project. To avoid such a problem, detailed directions should be included in the permit or the mitigation plan (or both). Directions should include the use of road and street names, key landmarks, mileage estimates, and latitude and longitude coordinates.

Wakeley (1989) developed a conceptual database for mitigation that should be considered for adoption by agencies in Tennessee. It was designed to provide information used by decision makers to evaluate impacts of permitted projects, to evaluate success of mitigation, to provide data on mitigation trends, and to provide documentation for public enquiries. We view the implementation of such a system as a necessity for ensuring the future success of the wetland regulatory process. The problem of tracking wetland losses and gains and keeping records on individual projects (including monitoring discussed in a following section) is likely to increase in complexity and magnitude as more and more ARAP and Section 404 permits are issued. A computerized database is the only way that agency personnel can manage such a comprehensive program effectively.

Mitigation Terminology

We had considerable difficulty in several cases with the terminology used in the permits to describe the various categories of mitigation (i.e., creation, enhancement, etc.). For example, in permits #19, #44, and #45 **restoration** was the term used to describe the proposed mitigation action, but in the attached plans, only tree planting was specified. Restoration as defined by Lewis (1990) is “returned from a disturbed or totally altered condition to a previously existing natural or altered condition by some action of man." TDEC (1998) includes a more comprehensive, but similar definition. Kruczynski (1990) used the term in the context of "reestablishing a wetland in an area where it historically existed," thus there is implied an emphasis on restoration of hydrology. We prefer this latter definition and recommend that it be restricted to projects that do involve hydrological restoration. In the context of the former 2 definitions, it may have been correct to use restoration to describe the above-mentioned projects, but probably, the more appropriate term would have been **enhancement**.

In other instances, we questioned whether the term **enhancement** was appropriate to describe the work that was done. Enhancement involves "improving the ability of an existing wetland to perform certain functions" (Lewis 1990, Kruczynski 1990, TDEC 1998) and always is discussed in the context of existing wetlands. We found however, several instances of projects at which so-called enhancement activities were done at wetland creation projects. For example, projects related to permits #23, #24, and #25 involved enhancement activities because trees were planted to improve (presumably the wildlife value) newly created wetlands. We believe that projects such as these should have been classified strictly as **creation**, because creating a wetland requires the 3 fundamental characteristics of wetland hydrology, hydric soils, and hydrophytic vegetation to be present in areas at which they did not previously exist. The presence of vegetation as a result of planting or natural establishment at new sites is simply a part of the wetland creation process. There was no "credit" given to these cases that reduced the acreage of wetlands that was to be created so it did not affect the compensation ratio. Instead, they further highlight the need for a standard terminology.

A more confusing situation occurred when terms were used interchangeably. As an example, the term **restoration** sometimes was used in one part of a permit, and the term **creation** in another part to describe the same activity. Two examples of permits in which this was done were #3 and #27.

More of a problem in a grammatical sense was the use of the term **re-create**. Lewis (1990) referred to the term as jargon and recommended that it not be used in mitigation permits.

Notwithstanding that such an activity cannot occur, re-create was mentioned in nearly 20% of the permits (or plans) examined. Further, it was used interchangeably to describe creation projects, and projects in which some combination of restoration, enhancement, and preservation had been used. Two examples include #8 and #10.

Consistent use of the proper terms within and throughout the permit process is essential for legal purposes and for making documents as easy to understand as possible. The problems we found are not a problem unique to Tennessee, as Lewis (1990) reported that these same terms have been used in a variety of ways depending on the personnel involved and the geographic region of the country. He noted that the definitions used differed not only among individual states, but also among counties and municipalities. We recommend that steps be taken to develop a definition for terms used in the mitigation process that are unambiguous and acceptable to all agencies involved. These definitions should be carefully worded in a way such that there is only one possible meaning for each term. Those recommended in Lewis (1990) and the *Tennessee Wetlands Conservation Strategy* (TDEC 1998) should be considered as a first step.

Monitoring Mitigation Projects

Monitoring reports are intended to characterize the soils, hydrology, and vegetation at mitigation sites to determine if wetland conditions have been developed and if various performance standards stipulated by the regulatory agencies are being met. Other requirements may include wildlife use and data related to various functions that are to be performed by the wetland. If properly prepared and accompanied by photographs that accurately depict the site, monitoring reports provide regulatory personnel with information to judge how a project is progressing and whether or not any remedial action is needed (Clewell and Lea 1990, Kentula et al. 1992). Because wetlands are systems that constantly are changing and sometimes are even destroyed by either natural or human-caused events, degradation of mitigation sites commonly occurs. During this study, we observed several completed mitigation projects that obviously were not properly constructed and others had been damaged by human activity (e.g., vandalism at sites # 6 and #42, solid waste dumping at site # 10, and heavy equipment damage at sites # 34 and

#38). Efficient monitoring would result in corrective action to “fix” design problems and would allow any human-caused damage to be corrected in a timely manner.

In spite of the importance of monitoring to the mitigation program, we found that little actually has been done in Tennessee. We noted several instances in which neither state or federal agencies had received **any** monitoring reports on projects that had been completed years previously (sites #24, and #25). This situation unfortunately, is not unusual; it is well documented that monitoring of mitigation wetlands after construction is rare (Brooks 1990, Gwin and Kentula 1990, Kusler and Kentula 1990).

Most of the monitoring reports we could find contained information on plant species composition and survival of planted stock, and some included lists of animal species that used the sites. None contained quantitative information on depth and extent of ponding, or of ground water parameters that is essential to a meaningful evaluation of the project. The length of the reports and amount of useful information they contained varied enormously. Some were brief with minimal data while others were lengthy documents with extensive verbage and numerous lists, tables, and color photographs. Much of the information found in several within the latter category would be classified as “**filler**.”

From an overall perspective, monitoring/enforcement probably is the part of the mitigation process that is in most need of improvement. Four aspects of the process that should be improved are: (1) compliance with requirement to submit monitoring reports on a regular basis, (2) enforcement of violations, (3) standardized data collection procedures, and (4) record keeping.

The failure of applicants to even submit monitoring reports probably is related to a lack of enforcement on the part of the regulatory agencies. Without enforcement of monitoring requirements and without follow-up visits to sites by regulatory personnel themselves, it is easy to see how a pattern of non-compliance on the part of applicants could develop. One possible solution to this problem would be for TDEC and the USACE to consolidate the responsibility of monitoring and enforcement within their offices. Instead of each staffer being responsible for his or her own projects, supervisors might designate 1 or 2 people to conduct monthly checks of files to determine if monitoring reports due have been received and if not to contact the applicants and find out why. These individuals also should conduct periodic site inspections themselves in late spring/early summer to determine if the reports submitted accurately portray site conditions.

Standardizing the monitoring protocol (i.e., data collection if required and format) would benefit all parties involved with the mitigation process. Agencies would be assured of obtaining meaningful information on which to judge how projects are progressing and applicants would know exactly what was required of them. Numerous authors (Clewell and Lea 1990, Erwin 1990, Kentula et al. 1992, Kent 1994, Denbow et al. 1996) have made recommendations or developed criteria for monitoring and should be consulted. We do not believe however that "standardizing" should necessarily mean that all projects must be monitored in exactly the same way. There probably is a need to develop 2 or 3 "standard" types of monitoring protocols that would be available for use as needed.

In some instances, reliable data on vegetation, soils, and especially hydrology is necessary to fully evaluate a project. In fact, the complexity of some projects may necessitate the installation of groundwater wells or other monitoring devices. Plant community composition or plant survival can be difficult to determine in some cases and very obvious in others. This variability highlights the need to tailor the monitoring program to the site. Effective monitoring can range from very detailed data collection to something as simple as having good photographic coverage of a site.

Regardless of the nature of the projects, we suggest that when the agencies formalize these monitoring protocols, each be made as **simple and cost effective** as possible. Based on our experiences in this project, we do not believe that monitoring of most sites should require more than one-half day of field work and that reports need not be more than 2 - 3 pages in length. Several of the reports we saw doubtless cost thousands of dollars and yet contained only very little meaningful information. Photographs are very important and should be taken from pre-selected reference points (selected at the time of construction by agency personnel to provide coverage of the entire site). We would prefer that the monitoring program be implemented exclusively or at least primary by agency personnel. If that cannot be done because of manpower constraints, we strongly recommend that **consultants responsible for site development not be allowed to submit the monitoring reports for their own projects**.

Length of Monitoring Period

One aspect of monitoring about which there is some disagreement is the period of time a site must be monitored after construction has been completed. Tennessee like most states, requires that most mitigation projects be monitored annually for 5 years. Although annual monitoring probably is adequate to detect significant changes in vegetation coverage and species composition, some researchers believe that monitoring for only 5 years is inadequate (Mitsch and Wilson 1996). They viewed a 5-year period as insufficient from an ecological perspective to evaluate the long-term stability of complex systems such as wetlands. This is especially true of mitigation sites dominated by trees (nearly all the sites in this study) that may take 50 years or more to mature. Clewell and Lea (1990) noted that 5 years might be adequate for monitoring some forested wetland projects, but a longer period might be necessary under certain conditions.

There is evidence from studies similar to this that monitoring for more extended periods is warranted. For example, Landin (personal communication 1994, in Mitsch and Wilson 1996) and Roberts (1991) documented the failure of mitigation wetlands years after they had been thought to be successfully established. For example, a man-made marsh in Virginia which was constructed in the mid - 1970s, was considered a success until 1986 when a major hydrologic change occurred at the site (Landin 1994 in Mitsch and Wilson 1996). Roberts (1991) reported several instances of established marshes failing due to natural events (erosion) and to human activity. He attributed most of the failures to poorly designed water-delivery systems.

It is recognized, that some reasonable “middle ground” must be achieved with regard to the time period that applicants will be held legally responsible for monitoring mitigation properties. However, a 5 year monitoring program may not be the best choice given the kinds of problems noted above. Alternatives which would not require significantly more total time or cost would be: 1) the submission of monitoring reports every other year for 10 years, 2) more reliance on rapid site inspections (not detailed data collection) by qualified agency personnel or consultants. A critical factor that should determine in large part how a project is monitored is how the project is developing relative to stated performance standards. It would be illogical to discontinue monitoring after 5 years if the site has not met stated performance standards. Regardless of procedures chosen, the emphasis of monitoring at most projects should be on the hydrologic regime and whether or not the hydrology is sustainable.

Mitigation Site Ownership

Another point of contention regarding mitigation wetland sites is the question of what happens to the sites after monitoring requirements have been met? Although it is clearly stated in the ARAP permits that each of these areas will be ..... “protected in perpetuity”...... through the use of conservation easements and/or deed restrictions, it is not clearly stated whom (if anyone) is responsible for them long-term. Initially the TWRA took the responsibility of some sites, but it is not clear if this always will be the case (especially with small disjunct wetland parcels). Agencies need to develop a policy regarding long-term ownership/oversight and implement it is soon as practical.

CONCLUSIONS

Compensatory mitigation of wetland resources has become an increasingly used management practice in Tennessee during the past decade. In spite of its widespread use here and elsewhere, many questions remain unanswered relative to its value. One of the most significant ones is whether or not mitigation (especially creation of new wetlands) actually compensates for losses of wetland acreage, functions, and the value of those functions. To answer this and other critical questions, meetings and symposia have been conducted; however, as Race and Fonseca (1996) noted, the majority of the findings never are submitted for peer reviewed publication. A

National Academy of Sciences study (NRC 1992) found little evidence that mitigation efforts actually duplicated wetland functional values or maintained biodiversity. Numerous other studies by Quammen (1986), Lewis (1992), and others generally show similar findings. Recent guidance on designing wetlands to perform certain functions (Marble 1990, Kent 1994, Denbow et al. 1996) have the potential for eliminating these problems in the future.

How then would we rate the effectiveness of Tennessee's wetland mitigation program? We found (assuming our sample of 50 sites is representative of the total) that the regulatory process has been effective enough to approximately offset losses when based on acreage of created and restored wetlands. If preservation and enhancement projects are included, the process would be viewed as more effective, but these categories of mitigation add nothing to the existing wetland base. We did not measure or estimate the extent to which these wetlands were functioning in the landscape except in regards to their use by selected groups of wildlife, so we cannot address the functional concerns mentioned above.

Notwithstanding our lack of information on function, we concluded that the regulatory programs administered by the USACE and TDEC-WPC overall have been successful. Nearly all the restoration and creation projects we studied resulted in the addition of some wetland acreage and several sites were very similar in appearance to natural wetlands nearby. There are however, areas in which improvements can be made more. In the process of assessing 50 mitigation sites, 47 permits and mitigation plans, and talking with agency personnel, a variety of concerns and problems similar to those observed in other studies were apparent. The primary recommendations we suggest include: discouraging the use of creation, enhancement, and preservation and emphasizing restoration; developing more consistency in the design of mitigation plans; emphasizing site fundamentals instead of vegetation survival; developing more relevant performance standards; developing more effective monitoring/enforcement programs; and modernizing the permit management system. These are discussed below.

We believe the agencies should emphasize restoration more than they currently do. Such projects have a high probability of success and increase the State's wetland base. Mitigation based on enhancement and preservation results in no actual acreage increase and in the case of enhancement especially may require decades before tangible benefits are realized. Working with Prior Converted Wetlands (PCs) offers the best chance for success and lists of available sites in each county or USGS hydrologic unit should be made available to project managers.

Significant improvement over some of the projects we studied could be achieved by making certain that design engineers understand exactly what the wetland “product” should be. This can be accomplished by having wetland scientists and biologists (who understand the importance of plant/hydrology relationships, landscape setting, and the habitat requirements of species that often are the focus of mitigation efforts) work closely with engineers to achieve specific site conditions. Because wetlands are functionally dependent on hydrology and geomorphic conditions, it seems logical to include more specific design goals and objectives relating to each. The HGM classification and functional assessment systems provide logical and “real” models in the form of reference standard wetlands. Of special importance is the need to have a water budget developed as part of the overall site design.

Performance standards currently used address some key concepts necessary for successful mitigation projects, but could be improved. The primary emphasis should be to incorporate specific hydrologic goals into the standards. If such standards are met, the likelihood of a successful project long-term should be quite high.

Monitoring and enforcement are the parts of the process probably in most need of improving. They are essential for determining if sites are progressing normally and for requiring remedial action if problems do occur. The fact that they have not been emphasized has produced an atmosphere in which some applicants apparently believe that they will not be held accountable for their projects. Agencies should make monitoring a high priority and consider devoting key, trained personnel to these tasks. Monitoring protocols should be developed for a variety of situations. We believe that monitoring can be structured so that in most instances, it is simple, rapid, and relatively inexpensive.

The permit management system used by both the USACE and TDEC could be improved. While some files have been computerized, many still have not. A digital database would make retrieval of information much more effective and would significantly improve the State's ability to assess future mitigation efforts and track wetland losses and gains.

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Appendix A. Compensatory wetland mitigation: Acreage characteristics and types.

Site Number	Permit # and County	Acres Filled	Wetland Acres Proposed	Wetland Acres Present	Vegetated Shallow Acres Present	Upland Acres Present	Net Gain / Loss (acres)*
01	93.849 Benton	2.10	Enhance - 3.0 Create - 3.30	Enhance - 3.0 Create - 2.0	0.50	0.80	-0.10
02	93.059 Blount	0.90	Create - 1.80	Create - 1.50	N/A	0.30	+0.60
03	94.631 Campbell	0.12	Create - 0.24	Create - 0.03	>0.21**	N/A	-0.09
04	93.402 Cheatham	0.76	Create - 1.6	Create - 0.70	N/A	0.90	-0.06
05	91.001 Davidson	1.80	Create - 3.80	Create - 1.50	0.62	1.68	-0.30
06	92.086 Dekalb	0.23	Create - 0.46	Create - 0.23	N/A	0.23	0
07	MFFDR-17 Gibson	1.80	Restore - 3.60	Restore - 3.10	N/A	0.50	+1.30
08	92.142 Grainger	0.92	Create - 3.0	Create - 0.76	N/A	2.24	-0.16
09	95.495 Greene	9.83	Restore - 12.98 Enhance - 6.37 Pres. - 20.16	Restore - 9.71 Enhance - 6.37 Pres. - 5.16	N/A	18.27	-0.12
10	92.046 Hamilton	0.60	Create - 2.20	Create - 1.50	N/A	0.70	+.90
11	93.304 Hamilton	1.0	Create - 1.0 Enh/Pres.- 22	Create - 0.50 Enh/Pres. - 22	N/A	0.50	-0.50
12	96.165 Hardin	1.0	Create - 4.20	Create - 2.93	N/A	1.27	+1.93
13	90.121 Henry	7.0	Enh. - 15.60	Enh. - 13.60	N/A	2.0	- 7.0
14	92.153 Hickman Williamson	2.23	Create - 4.59 Pres. 1.47	Create - 3.61 Pres. - 1.47	N/A	0.98	+1.38
15	95.450 Houston	0.01	Restore - 0.01	Restore - 0.01	N/A	N/A	0
16	92.049 Humphreys	1.60	Create - 2.50 Enhance - 4.0	Create - 0.80 Enhance - 4.0	1.70	N/A	-0.80
17	51.575 Jackson	2.0	Create - 2.0	Create - 2.0	N/A	N/A	0

Appendix A. (cont'd).

Site Number	Permit # and County	Acres Filled	Wetland Acres Proposed	Wetland Acres Present	Vegetated Shallow Acres Present	Upland Acres Present	Net Gain/ Loss (Acres)*
18	94.253 Knox	0.50	Enhance - 1.50	Enhance - 1.50	N/A	N/A	0.50
19	94.800 Lauderdale	0.36	Restore - 1.0	Restore - 1.0	N/A	N/A	0
20	92.114 Lawrence	0.75	Restore - 0.75 Enhance - ?	Restore - 0.75 Enhance - ?	N/A	0.25	-0.25
21	95.402 Marion	0.62	Create - 0.62	Create - 0.62	N/A	N/A	0
22	95.402 Marion	0.60	Create - 0.60	Create - 0.39	N/A	0.21	-0.21
23	91.066 Putnam	1.50	Create - 1.50 Enhance - ?	Create - 0.30 Enhance - ?	N/A	1.20	-1.20
24	93.280 Putnam	2.50	Create - 2.50 Enhance - ?	Create - 2.50 Enhance - ?	N/A	N/A	0
25	93.280 Putnam	***	Create - 2.50 Enhance - ?	Create - 1.50 Enhance - ?	0.20	0.80	-1.0
26	95.790/ 95.541 Putnam	1.04	Pres. - 10.50	Pres. - 10.50	N/A	N/A	-1.04
27	95.209 Roane	0.25	Create - 0.50	Create - 0.40	N/A	0.10	+0.15
28	94.413 Roane	0.10	Restore - 0.50	Restore - 0.50	N/A	0.10	+0.40
29	94.045 Rutherford	0.90	Create - 0.90 Enhance - ?	Create - 0.40 Enhance - ?	N/A	0.50	-0.50
30	87.014 Rutherford	3.80	Create - 3.80	Create - 1.10	N/A	2.70	-2.70
31	95.445 Sequatchie	0.07	Create - 0.15	Create - 0.03	N/A	0.04	-0.04
32	94.422 Shelby	0.90	Restore - 0.90	Restore - 0.90	N/A	N/A	0
33	94.422 Shelby	***	Pres. - 5.20	Pres. - 5.20	N/A	N/A	0
34	95.370 Shelby	0.25	Create - 0.62	Create - 0	N/A	0.63	-0.25
35	93.843 Shelby	1.60	Create - 3.50	Create - 3.30	N/A	0.20	+1.70

Appendix A (cont'd)

Site Number	Permit # and County	Acres Filled	Wetland Acres Proposed	Wetland Acres Present	Vegetated Shallow Acres Present	Upland Acres Present	Net Gain/ Loss (ac)*
36	93.843 Shelby	***	Pres. - 1.0	Pres. - 1.0	N/A	N/A	0
37	94.806 Shelby	0.1	Create - 0.1	Create - 0	N/A	N/A	-0.1
38	96.045 Shelby	0.04	Pres. - 0.42	Pres.- 0.42	N/A	N/A	-0.04
39	95.215 Shelby	1.00	Create - 2.00	Create - 2.00	N/A	N/A	+1.00
40	95.139 Shelby	0.20	Create - 0.20	Create - 0.11	N/A	0.09	- 0.09
41	93.453 Shelby	2.00	Restore - 2.00	Restore - 1.60	N/A	0.40	-0.40
42	92.131 Shelby	7.0	Create - 14	Create - 4.9	2.20	6.90	-2.10
43	LR/BC-25 Shelby	10.60	Create - 8.00 Enh. - 10.00 Pres. - 8.00	Create - 4.19 Enh. - 10.00 Pres. - 6.82	3.81	1.18	-5.81
44	93.014 Sumner	4.70	Restore - 9.40 Enhance - ?	Restore - 2.50 Enhance - ?	N/A	6.90	-2.20
45	92.026 Sumner	4.40	Enh. - 4.40 Restore - ?	Enh. - 3.0 Restore - ?	N/A	1.40	-4.40
46	92.026 Sumner	***	Enh. - 8.85 Restore - ?	Enh. - 8.50 Restore - ?	N/A	0.03	****
47	93.310 Washington	0.85	Enh. - 2.35	Enh. - 2.35	N/A	N/A	-0.85
48	93.310 Washington	***	Pres. - 1.14	Pres. - 1.14	N/A	N/A	****
49	93.260 Weakley	12.17	Restore - 26.0	Restore - 21.0	4.59	0.41	+8.83
50	93.064 White	1.2	Create - 2.4 Restore - ? Enhance - ?	Create - 2.4 Restore - ? Enhance - ?	N/A	N/A	+1.00

* Calculation does not include preservation or enhancement.
** Area was flooded as a result of beaver activity. Wetland present was fringe surrounding permanently flooded area.
*** Indicates fill was included in the previous record.
**** Indicates net gain or loss was included in previous record.
? Indicates mitigation type listed was not apparent and in question

APPENDIX B. Tree survival estimates for wetland mitigation sites during 1998-1999.

PERMIT #	SITE #	COUNTY	PLANTED	%SURVIVAL
93.849	1	Benton	Yes	75%
93.059	2	Blount	Yes	78%
94.631	3	Campbell	Yes	15%
93.402	4	Cheatham	Yes	50%
91.001	5	Davidson	Yes	85%
92.086	6	Dekalb	Yes	90%
MFFDR-17	7	Gibson	Yes	70%
92.142	8	Grainger	Yes	70%
95.495	9	Greene	Yes	70%
92.046	10	Hamilton	Yes	90%
93.304	11	Hamilton	Yes	50%
96.165	12	Hardin	Yes	5%
90.121	13	Henry	Yes	75%
92.153	14	Hickman/ Williamson	Yes	60%
95.450	15	Houston	Yes	19%
92.049	16	Humphreys	Yes	53%
51.575	17	Jackson	Yes	25%
94.253	18	Knox	Yes	95%
94.800	19	Lauderdale	Yes	80%
92.114	20	Lawrence	Yes	50 %
95.402	21	Marion	Yes	18%
95.402	22	Marion	Yes	75%
91.066	23	Putnam	Yes	27%
93.280	24	Putnam	Yes	50%

APPENDIX B. (cont'd)

PERMIT #	APPLICANT	COUNTY	PLANTED	% SURVIVAL
93.280	25	Putnam	Yes	50%
95.790/95541	26	Putnam	No	NA
95.209	**27**	Roane	Yes	90 %
94.413	28	Roane	Yes	45 %
94.045	29	Rutherford	Yes	50 %
87.014	30	Rutherford	Yes	45 %
95.445	31	Sequatchie	Yes	60 %
94.422	32	Shelby	Yes	80 %
94.422	33	Shelby	No	N/A
95.370	34	Shelby	Yes	0 %*
93.843/95.759	35	Shelby	Yes	5 %
93.843	36	Shelby	No	N/A
94.806	37	Shelby	Unknown	Unknown
96.045	38	Shelby	No	N/A
95.215	39	Shelby	Yes	65 %
95.139	40	Shelby	Yes	40 %
93.453	41	Shelby	Yes	50 %
92.131	42	Shelby	Yes	40 %
LR/BC-25	43	Shelby	Yes	60 %
93.014	44	Sumner	Yes	30 %
92.026	45	Sumner	Yes	75 %
92.026	46	Sumner	Yes	75 %
93.310	47	Washington	Yes	50 %
93.310	48	Washington	No	N/A
93.260	49	Weakley	Yes	90 %

APPENDIX B. (cont'd)

PERMIT #	**SITE #**	**COUNTY**	**PLANTED**	**% SURVIVAL**
93.064	50	White	Yes	65 %

*Site was not completed by the expiration date of the permit and had not been planted.

Appendix C. Plant species documented at wetland mitigation sites in Tennessee during 1998-1999.

Species	Common Name
Acer rubrum	Red maple
Acer saccharinum	Silver maple
Agrostis alba	Redtop
Alisima subcordatum	Subcordate water-plantain
Alnus serrulata	Alder
Amaranthus sp.	Amaranth
Ambrosia artemisifolia	Common ragweed
Ambrosia trifida	Giant ragweed
Ammania coccinia	Purple ammania
Andropogon virginicus	Broom-sedge
Apios americana	American potato-bean
Aster paternus	Aster sp.
Aster simplex	Panicled aster
Aster vimineus	Small white aster
Bidens frondosa	Devil's beggar-tick
Boehmaria cylindrica	Small-spike false nettle
Brunnichia cirrhosa	Redvine
Campsis radicans	Trumpet-creeper
Cardamine bulbosa	Bulbous bitter-cress
Carex bromoides	Brome-like sedge
Carex complanata	Hirsute sedge
Carex crinita	Fringed sedge
Carex gigantea	Large sedge
Carex lupulina	Hop sedge
Carex lurida	Shallow sedge
Carex stipata	Sedge
Carex stricta	Uptight sedge
Carex vulpinoidea	Fox sedge
Cassia fasiculata	Partridge pea
Cephalanthus occidentalis	Common buttonbush
Chasmanthium sessiflorum	Long-leaf spikegrass
Cichorium intybus	Chickory
Cicuta maculata	Water hemlock
Commelina caroliniana	Creeping dayflower
Coreopsis rosea	Pink tickseed
Cornus amomum	Silky dogwood
Cornus florida	Flowering dogwood
Cyperus globulosus	Baldwin flatsedge
Cyperus irea	Irea flatsedge
Cyperus odoratus	Rusty flatsedge

Appendix C. (cont'd).

Species	Common Name
Cyperus pseudovegetus	Marsh flatsedge
Cyperus strigosus	Straw-colored flatsedge
Dactylis glomerata	Orchard grass
Daucus carota	Queen Anne's lace
Desmodium canadense	Showy tick-trefoil
Dicanthelium clandestinum	Deer-tongue witchgrass
Digitaria sp.	Crabgrass
Diodea teres	Rough buttonweed
Diodea virginiana	Virginia buttonweed
Echinochloa crusgalli	Barnyard grass
Eleocharis obtusa	Blunt spikerush
Erigeron philadelphicus	Philadelphia fleabane
Euonymus americanus	American strawberry bush
Eupatorium perfoliatum	Common boneset
Eupatorium purpureum	Joe-pye-weed
Fraxinus pennsylvanica	Green ash
Festuca arundinacea	Kentucky fescue
Gallium sp.	Bedstraw
Gratiola neglecta	Clammy hedgehyssop
Hibiscus moschotos	Swamp hibiscus
Hypericum adepressum	Creeping St. John's-wort
Impatiens capensis	Spotted touch-me-not
Ipomoea sp.	Morning-glory
Juncus acuminatus	Taper-tip rush
Juncus canadensis	Canada rush
Juncus coriaceus	Leathery rush
Juncus effusus	Soft rush
Juncus interior	Inland rush
Juncus marginatus	Grass-leaf rush
Juncus tenuis	Slender rush
Juniperus virginiana	Eastern red cedar
Leersia oryzoides	Rice cutgrass
Lemna sp.	Duckweed
Lespedeza cuneatum	Lespedeza .
Liquidambar styraciflua	Sweetgum
Lolium sp.	Rye grass
Lonicera japonica	Japanese honeysuckle
Ludwigia alternifolia	Bushy seedbox
Ludwigia linearis	Narrow-leaf seedbox
Ludwigia peploides	Floating seedbox
Lycopus americanus	American bugleweed

Appendix C. (cont'd).

Species	Common Name
Mentha spicta	Spearmint
Mimulus alatus	Sharp-wing monkey-flower
Mimulus ringens	Alleghany monkey-flower
Nelumbo lutea	American lotus
Panicum rigidulum	Red-top panic grass
Panicum scoparium	Panic grass
Parthenocissus quinquefolia	Virginia creeper
Paspalum dilatatum	Dallisgrass
Peltandra virginica	Arrow arum
Penthorum sedoides	Ditch stonecrop
Phleum pratense	Timothy
Pinus taeda	Loblolly pine
Plantago lanceolata	English plantain
Platanus occidentalis	Sycamore
Polygonum hirsutum	Hairy smartweed
Polygonum hydropiper	Marshpepper smartweed
Polygonum hydropiperoides	Swamp smartweed
Polygonum pensylvanicum	Pennsylvania smartweed
Polygonum perscaria	Lady's thumb
Populus deltoides	Eastern cottonwood
Potomogeton sp.	Pondweed
Prunus serotina	Black cherry
Ptilimniun sp.	Bishop-weed
Quercus phellos	Willow oak
Rhexia lutea	Yellow meadow-beauty
Rhyncospora corniculata	Short-bristle beakrush
Rosa sp.	Rose
Rubus alleghaniensis	Blackberry
Rubus argutus	Serrate-leaf blackberry
Rubus sp.	Blackberry
Rubus trivialis	Southern dewberry
Rumex crispus	Curly dock
Salix nigra	Black willow
Saururus cernuus	Lizard's tail
Scirpus americanus	Hard-stem bulrush
Scirpus atrovirens	Green bulrush
Scirpus cyperinus	Wool-grass
Scirpus pendulus	Drooping bulrush
Smilax bona-nox	Saw greenbriar
Smilax rotundifolia	Common greenbriar
Solidago leavenworthii	Leavenworth's goldenrod

Appendix C. (cont').

Species	Common Name
Solidago sp.	Goldenrod
Sorgham halepense	Johnsongrass
Sisyrinchium angustifolia	Blue-eyed grass
Trifolium pratense	Red clover
Trifolium repens	White clover
Typha angustifolia	Narrow-leaf cattail
Typha latifolia	Common cattail
Ulmus alatus	Winged elm
Urtica dioica	Stinging nettle
Vicia cracca	Vetch
Xanthium strumarium	Rough cocklebur

Appendix D. Avian species documented at wetland mitigation sites in Tennessee during 1998-1999.

Species	Common Name
Actitis macularia	Spotted sandpiper
Agelaius phoeniceus	Red-winged blackbird
Aix sponsa	Wood duck
Anas discors	Blue-winged teal
A. platyrhynchos	Mallard
Archilochus colubris	Ruby-throated hummingbird
Ardea herodias	Great blue heron
Botaurus lentiginosus	American bittern
Branta canadensis	Canada goose
Buteo linearis	Red-shouldered hawk
Butorides striatus	Green-backed heron
Calidris sp.	Unknown sandpiper
Cardinalis cardinalis	Northern cardinal
Carduelis tristis	American goldfinch
Casmerodius albus	Great egret
Ceryle alcyon	Belted kingfisher
Charadrius vociferus	Killdeer
Coccyzus americanus	Yellow-billed cuckoo
Colaptes auratus	Northern flicker
Colinus virginianus	Northern bobwhite
Columba livea	Rock dove
Contopus virens	Eastern wood pewee
Corvus brachyrhynchos	American crow
Cyanocitta cristata	Blue jay
Dendroica petechia	Yellow warbler
Drycopus pileatus	Pileated woodpecker
Gallinago gallinago	Common snipe
Geothlypis trichas	Common yellowthroat
Hirundo rustica	Barn swallow
Icteria virens	Yellow-breasted chat
Ictinia mississippiensis	Mississippi kite
Melanerpes carilinus	Red-bellied woodpecker
M. erythrocephalus	Red-headed woodpecker
Meleagris gallopavo	Wild turkey
Melospiza georgiana	Swamp sparrow
M. melodia	Song sparrow
Mimus polyglottos	Northern mockingbird
Molothrus ater	Brown-headed cowbird
Myiarchus crinitus	Great-crested flycatcher

Appendix D. (cont'd).

Species	Common Name
Parus bicolor	Tufted titmouse
P. carolinensis	Carolina chickadee
Passer domesticus	House sparrow
Passerina cyanea	Indigo bunting
Picoides pubescens	Downy woodpecker
Pipilo erythropthalmus	Eastern towhee
Polioptila caerulea	Blue-gray gnatcatcher
Protonotaria citrea	Prothonotary warbler
Quiscalus quiscula	Common grackle
Rallus elegans	King rail
Regulus sp.	Unknown kinglet
Sayornis phoebe	Eastern phoebe
Scolopax minor	American woodcock
Sialia sialis	Eastern bluebird
Sitta carolinensis	White-breasted nuthatch
Spizella pusilla	Field sparrow
Strix varia	Barred owl
Sturnella magna	Eastern meadowlark
Sturnus vulgaris	European starling
Tachycineta bicolor	Tree swallow
Toxostoma rufum	Brown thrasher
Turdus migratorius	American robin
Tringa solitaria	Solitary sandpiper
Troglodytes aedon	House wren
Tyrannus tyrannus	Eastern kingbird
Vireo griseus	White-eyed vireo
Zenaida macroura	Mourning dove

Appendix E. Frog species documented at wetland mitigation sites in Tennessee from 1998-1999.

Species	Common Name
Acris crepitans	Northern cricket frog
Gastrophryne carolinensis	Eastern narrowmouth toad
Hyla chrysoscelis	Cope’s gray treefrog
Hyla gratiosa	Barking treefrog
Pseudacris crucifer	Spring peeper
Pseudacris triseriata	Western chorus frog
Rana catebeiana	Bullfrog
Rana clamitans	Green frog
Rana utricularia	Southern leopard frog
Woodhousii fowleri	Fowler’s toad

Appendix F. Mammalian species documented at wetland mitigation sites in Tennessee during 1998-1999.

Species	Common Name
Canis latrans	Coyote
Castor canadensis	Beaver
Didelphis virginianus	Opossum
Mephitis mephitis	Striped skunk
Odocoileus virginianus	Whitetail deer
Odontra zibethicus	Muskrat
Procyon lotor	Raccoon
Sciurus carolinensis	Eastern gray squirrel
Sylvilagus floridanus	Eastern cottontail rabbit