ATTACHMENT 1 TO APPENDIX 1

WETLAND MONITORING REPORTS

Results of 2006 Monitoring/Functional Assessment of Selected USACE Reforested Bottomland Hardwood Sites in the Yazoo Basin

by

Jeff Lin

Environmental Laboratory

Department of the Army
Corps of Engineers Research and Development Center
Waterways Experiment Station
3909 Halls Ferry Rd, Vicksburg, MS 39180-6199

Date

12/1/2006

Prepared for:

US Army Engineer District, Vicksburg
Vicksburg, MS 39180-5191

INTRODUCTION

Since 1990, the USACE, Vicksburg District has reforested over 25,000 acres of bottomland hardwood forest on former agricultural land within the Yazoo Basin, MS. Monitoring of these sites using the Hydrogeomorphic (HGM) functional assessment method began in 2001 in order to measure functional recovery at these sites, and to determine whether or not recovery is occurring along expected trajectories.

In 2001, all sites existing at the time were sampled. Subsequently, a rotational sampling schedule was created so that a select number of existing sites (as well as any new plantings) would be assessed and reported on annually. The schedule is designed so that sites will then be re-assessed every five years. The first round of rotational sampling began in 2002. An initial report detailing and analyzing the results of the 2001 and 2002 sampling (Humphrey et al., 2004) has been previously published as a technical note. A report of the 2003 sampling of the Big Twist, Sky Lake, and Stock restoration sites, the 2004 sampling of the Lake George restoration site, and the 2005 sampling of the Po Lutken and Darlove restoration sites have also previously been provided to the Vicksburg District.

In 2006, sampling occurred at four new restoration sites which had been planted in 2004 or later. These sites are Alligator, Island Lake, Pushmahata Plantation, and Washington (Figure 1).

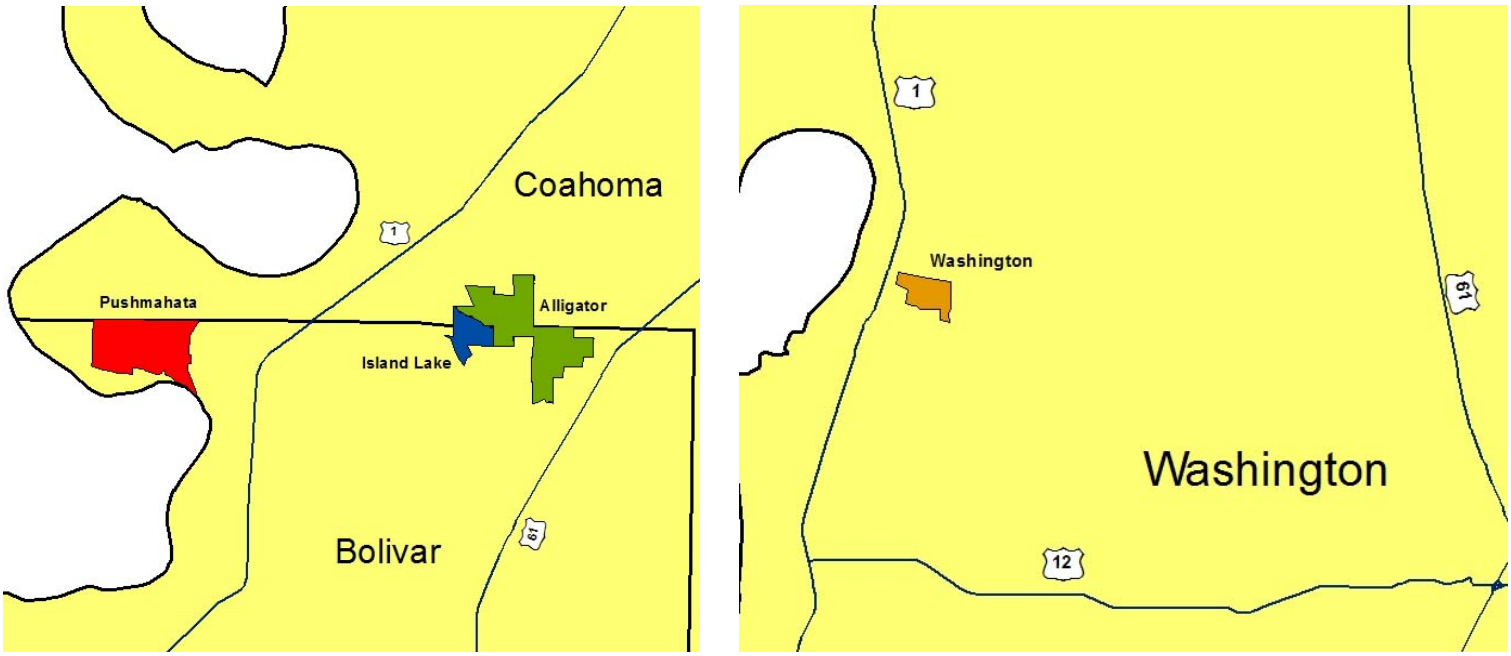


Figure 1. Maps depicting locations of Alligator, Island Lake, Pushmahata Plantation, and Washington restoration sites.

METHODS

Because of the early age of these sites, HGM assessments were not performed. Previous experience sampling has shown that for very early age sites (< 5 years,

approximately), the functional scores obtained by using the HGM approach may not be very informative, as it is already known that the "Provide Fish & Wildlife Habitat" score will be 0.0 (due to there not being any trees, which are stems > 4 in. dbh). Also, because of the seasonal variability of ground cover, and the relative lack of soil organic matter, woody debris, snags, and shrubs, the remaining functional scores at these very early aged sites are driven primarily by flood frequency, sapling composition, microdepressions, and soil integrity, which are variables that are unlikely to have changed since the initial planting. At these very early aged sites, more information is likely gained by looking at seedling survival and the presence of volunteer species at the site.

Sites were sample during the period of 10/23/06 – 11/8/06. Multiple 0.04 ha plots were established at each site. All seedlings within each plot were counted and their species recorded. The heights of a random selection of seedlings within the plot were also measured, a photograph was taken, and any notable features were recorded. These plots are meant to be "permanent" in that the same plot will be used for HGM assessment sampling in the future. Therefore, the center was marked with a metal stake, and the GPS coordinate was taken.

RESULTS

General Notes for All Sites

In recording species, all oaks, with the exception of Willow Oak (*Quercus phellos*) and Water Oak (*Quercus nigra*) were recorded as Quercus spp., since it was difficult to quickly distinguish between other species of oak (primarily *Quercus nuttallii* and *Quercus shumardii*) at this early stage. The species abbreviations used in the tables are as follows:

CI - *Carya illinoinensis*
FP - *Fraxinus pennsylvanica*
PD - *Populus deltoides*
PO - *Platanus occidentalis*
QN - *Quercus nigra*
QP - *Quercus phellos*
QS - *Quercus spp*

In terms of HGM classification, all the restoration sites fall within the Riverine Backwater regional subclass.

Alligator

The Alligator restoration site is approximately 2,500 acres and is located along the Coahoma and Bolivar County line, between Highway 1 and Highway 61 and near the town of Alligator, MS. Approximately 1,300 acres were planted in 2004 with 315,800 bareroot seedlings, primarily (91%) various oak species (*Quercus sp.*), along with some Bald Cypress (*Taxodium distichum*), Green Ash (*Fraxinus pennsylvanica*), Pecan (*Carya illinoinensis*), and Persimmon (*Diospyros virginiana*). The remaining 1,200 acres were planted in 2005 with 383,200 bareroot seedlings, which again were primarily various oak species (84%), along with Bald Cypress, Green, Pecan, and Persimmon.

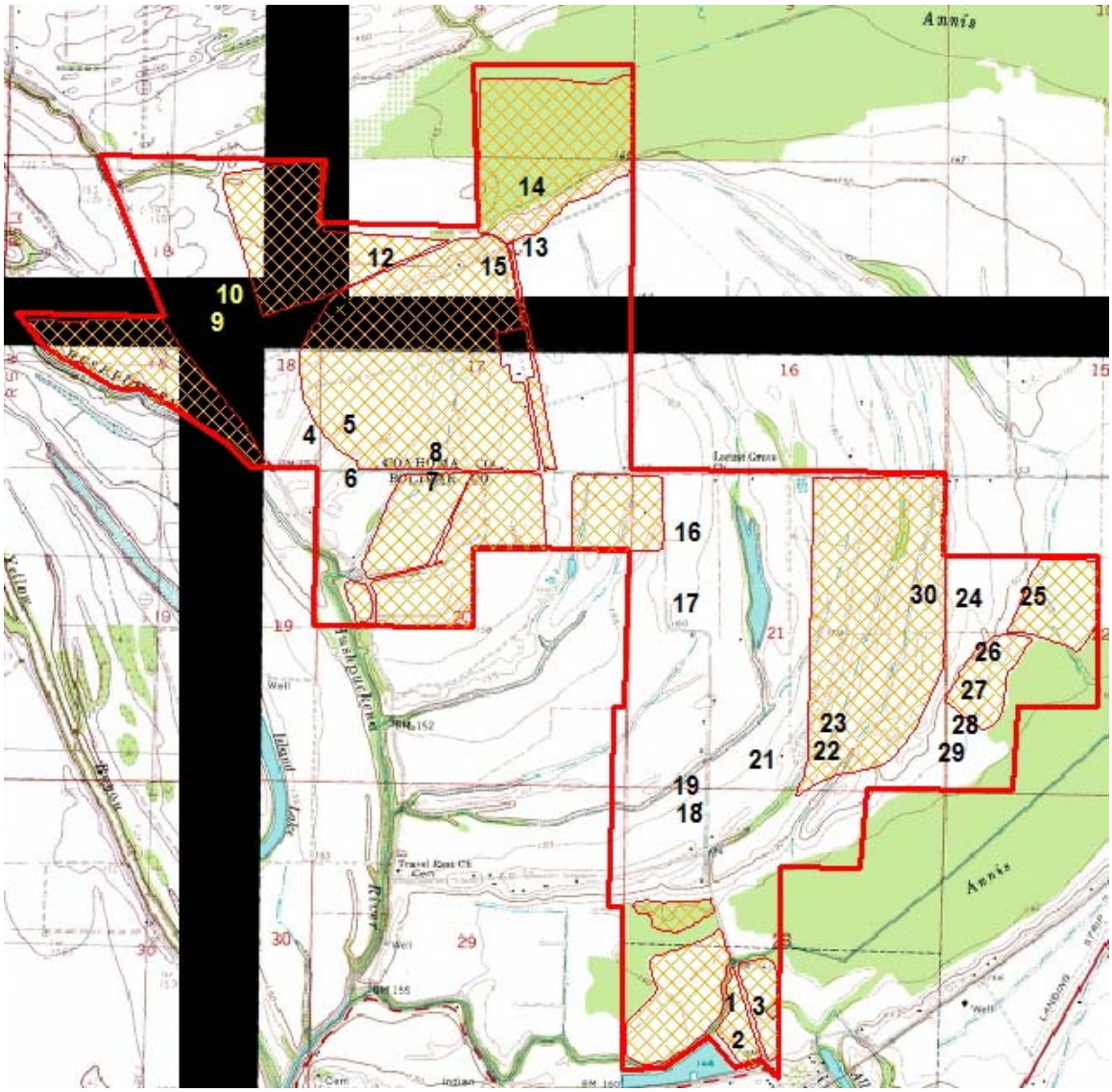


Figure 2. Location of monitoring plots at Alligator restoration site. Cross-hatched areas were planted in 2005, all other areas were planted in 2004.

The site was sampled on 10/23/06 and 10/24/06. Figure 2 shows the locations of the sampling plots. Table 1 and 2 show the number of trees by species that were counted at each plot in the 2004 planting areas and 2005 planting areas, respectively. Table 3 is a summary of the tree counts at both planting areas, and Table 4 shows the average heights of various tree species that were measured.

2004 Planting

	Number of Trees by Species								
Plot	**QN**	**QP**	**QS**	**FP**	**PD**	**TD**	**PO**	**CI**	**Total**
4			21						21
6									29
9			10						10
10		2		7	4	3			16
13		2	18						20
16									0[1]
17		1							1[2]
18			26						26
19			31						31
20	1	7	3		1		2	1	15
21	1	1	18					3	23
24		3	13	4					20
28		10	5					1	16
29		7	8						15

[1] All trees in this plot were dead

[2] 25 dead trees were counted in this plot

Table 1. Count of trees by species at the 2004 planting of Alligator restoration site.

2005 Planting

	Number of Trees by Species							
Plot	**QN**	**QP**	**QS**	**FP**	**PD**	**TD**	**CI**	**Total**
1	3	1	4					8
2								NoData[1]
3	2	2	1	10				15
5			13					13
7		1	8	3				12
8			10					10
11			16					16
12		4	14					18
14			1					1[2]
15		3	6					9
22		3	7				1	11
23		4	4					8
25								NoData[3]
26		7	5					12
27		1	3			1		5
30		2	10	6				18

[1] Data sheet for this plot was lost

[2] Dense aster growth at this plot made it likely that there was an undercount of the number of trees at this plot.

[3] Data was not collected at this plot. Aster growth was so thick at the plot that locating seedlings was nearly impossible.

Table 2. Count of trees by species at the 2005 planting of Alligator restoration site.

	Planting Date	
	2004	*2005*
Avg Trees per Plot	20.2	11.1
Standard Deviation	6.2	5
Avg Trees/Ha	505	278
Avg +/- 1SD	350 - 660	153 - 402
Planted Trees/Ha	600	790

Table 3. Summary of tree counts for 2004 and 2005 plantings at Alligator restoration site. The values from 2004 do not include the data from plots 16 and 17, where nearly all the trees were dead.

	Planting Date			
	2004		*2005*	
Species	Avg Height (in)	# measured	Avg Height (in)	# measured
QP	22	5	17	9
QS	31	10	20	9
FP	22	2	25	3
PD	105	2	-	-
TD	23	1	-	-
CI	33	2	-	-

Table 4. Average height of trees (in inches) by species at the 2004 and 2005 plantings at Alligator restoration site.

On the whole, the 2004 planting areas appear to be doing well. The exception was in the area of plots 16 and 17, where almost all seedlings appeared to be dead. Since this area is near an active agricultural field, a likely explanation for the seedling mortality is that the area was over-sprayed with pesticide. Excluding these two plots, the average survival for 2004 planting areas was 82%, and the actual planted tree density was within the range of the average counted tree density +/- 1 standard deviation. The tree species counted that were not on the original planting list were Eastern Cottonwood (*Populus deltoides*) and Sycamore (*Platanus occidentalis*), although both these species combined accounted for < 3% of the total trees counted. The large majority of the trees counted were *Quercus sp.*, similar to what was originally planted.

The 2005 planting areas do not appear to be doing as well as the 2004 planting areas. Average survival was 35%, and the range of the average counted tree density +/- 1 standard deviation was well below that of the actual planted tree density. No volunteer species were counted in the 2005 planting areas.

Island Lake

The Island Lake Restoration site is approximately 537 acres and is located along the Coahoma and Bolivar County line, between Highway 1 and Highway 61, adjacent to the Alligator restoration site. The site was planted in 2005 with 132,600 bareroot seedlings, primarily (86%) various oak species (*Quercus sp.*), along with some Green Ash (*Fraxinus pennsylvanica*), Pecan (*Carya illinoinensis*), and Persimmon (*Diospyros virginiana*)

The site was sampled on 10/24/06 and 10/30/06. Figure 3 shows the locations of the sampling plots. Table 5 shows the number of trees by species that were counted at each plot, Table 6 is a summary of the tree counts at the site, and Table 7 shows the average heights of various tree species that were measured.

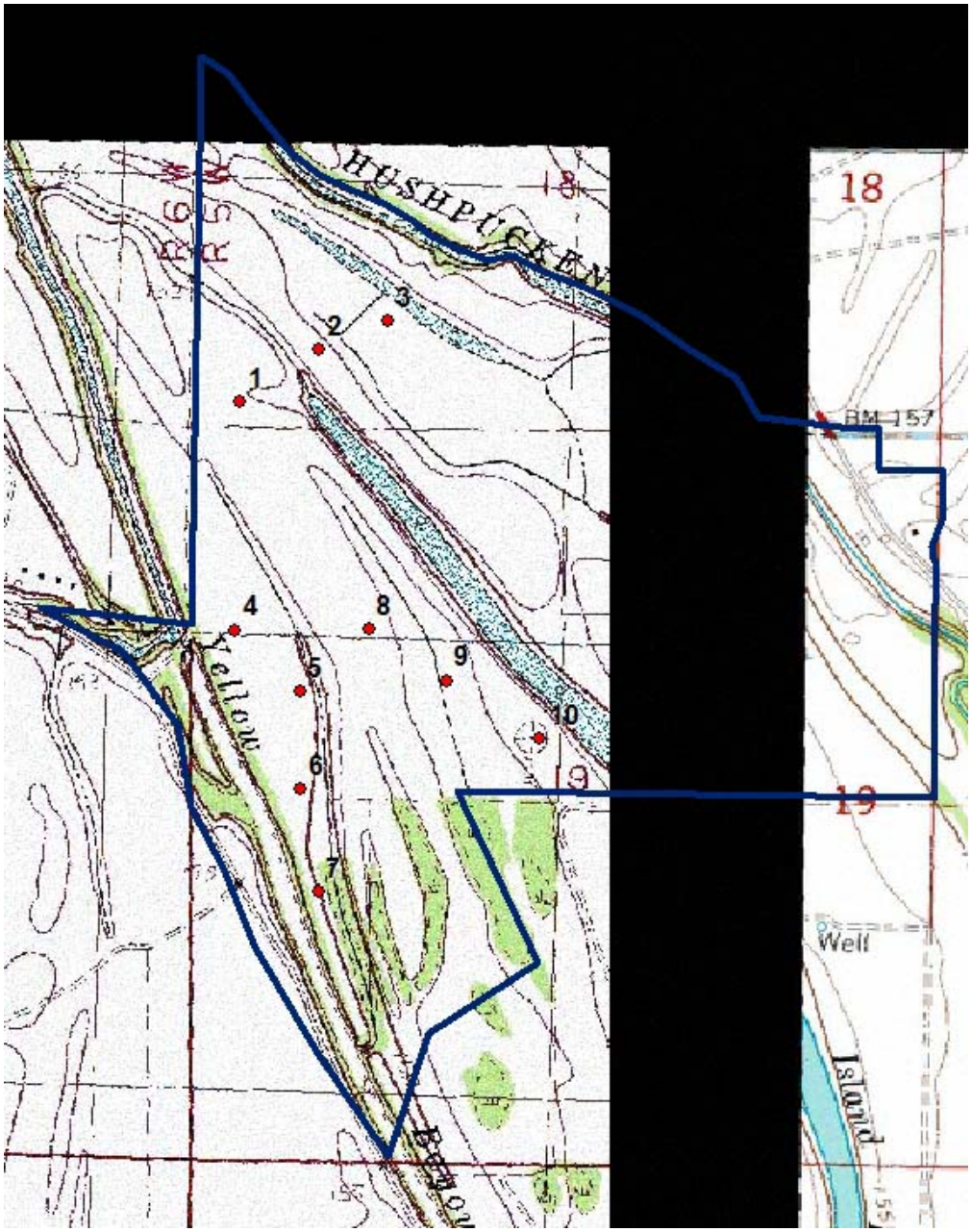


Figure 3. Location of monitoring plots at Island Lake restoration site.

	Number of Trees by Species					
Plot	**QN**	**QP**	**QS**	**FP**	**PD**	**Total**
1		2	11			13[1]
2		2	9			11
3		2	13			15[2]
4		3	4	5		12
5		10	5			15
6		1	7	1		9
7		1	7			8
8			10			10
9	1	1	15		1	18
10			20			20

[1] Dense aster growth at this plot made it likely that there was an undercount of the number of trees at this plot.

[2] One dead oak counted at this plot

Table 5. Count of trees by species at the Island Lake restoration site.

Avg Trees per Plot	13.1
Standard Deviation	3.9
Avg Trees/Ha	328
Avg +/- 1SD	230-425
Planted Trees/Ha	610

Table 6. Summary of tree counts at Island Lake restoration site.

Species	Avg Height (in)	# measured
QP	19	4
QS	18	9
FP	26	2

Table 7. Average height of trees (in inches) by species at the Island Lake restoration site.

In terms of seedling establishment and survival, the Island Lake site appears to be doing better than the portion of the Alligator site that was planted in the same year (2005), with a survival rate of 54% vs. 35%. Since the calculation of average trees per plot included two plots where seedlings were possibly undercounted (due to dense aster growth), the survival rate may be slightly higher than what is reported in Table 6. One *Populus deltoides* tree was counted, which was the only volunteer species counted at the site.

Pushmahata Plantation

The Pushmahata Plantation restoration site is 2,157 acres and is located in Bolivar County, immediately south of the Coahoma/Bolivar county line and between the Mississippi river and the levee. The site was planted in 2006 with 525,000 bareroot seedlings, primarily (89%) various oak species (*Quercus sp.*), along with some Green Ash (*Fraxinus pennsylvanica*), Pecan (*Carya illinoinensis*), Bald Cypress (*Taxodium distichum*) and Persimmon (*Diospyros virginiana*).

The site was sampled on 11/8/06. Figure 4 shows the locations of the sampling plots. Table 6 shows the number of trees by species that were counted at each plot, Table 7 is a summary of the tree counts at the site, and Table 8 shows the average heights of various tree species that were measured.

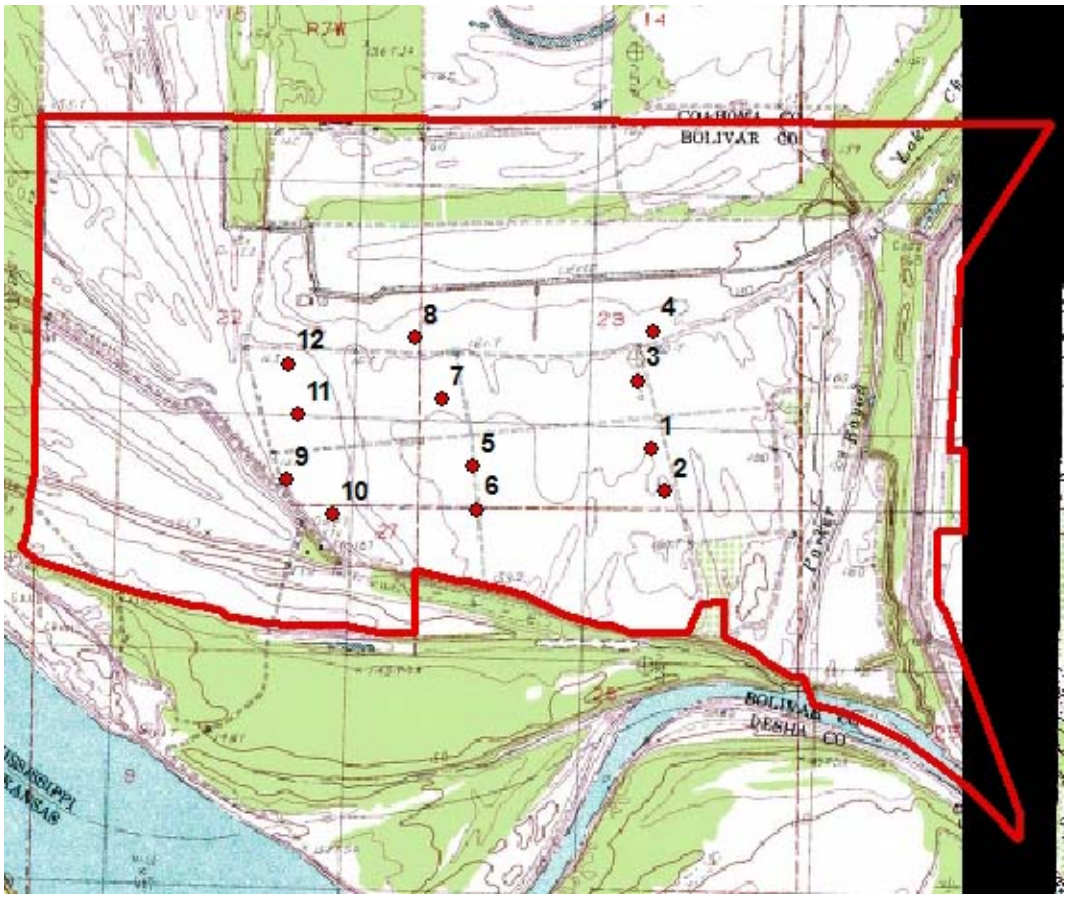


Figure 4. Location of monitoring plots at Pushmahata Plantation restoration site.

Plot	Number of Trees by Species			
	QP	QS	FP	Total
1		7		7
2		1	1	2
3		1		1
4		1		1
5		0		0
6		1		1
7		2		2
8		1		1
9		0		0
10		9		9
11	1	8		9
12		6		6

Table 6. Count of trees by species at Pushmahata Plantation restoration site.

Avg Trees per Plot	3.3
Standard Deviation	3.5
Avg Trees/Ha	83
Avg +/- 1SD	0-170
Planted Trees/Ha	601

Table 7. Summary of tree counts at Pushmahata Plantation restoration site

Species	Avg Height (in)	# measured
QP	18	1
QS	15	6

Table 8. Average height of trees (in inches) by species at the Pushmahata Plantation restoration site.

The initial establishment of seedlings at Pushmahata restoration site appears to be going poorly, with only an average of about 3 trees per plot being counted (~ 14% survival). No volunteer species were counted, and of the original species planted only various Oaks (*Quercus sp.*) and Green Ash (*Fraxinus pennsylvanica*) were counted.

Since no dead seedlings were found, one possible explanation for the low count is herbivory, where the entire seedling has been eaten or uprooted. Several seedlings that were counted showed evidence of being grazed upon (figure 5) and several animal tracks were also seen throughout the site (figure 6). Since survival at this site is much lower than at other sites where survival was previously measured in the first year of planting (Sky Lake site, 2003 addition – 24.5% survival, Stock – 40.7% survival- see 2003 monitoring report for details), it is suggested that the Pushmahata Plantation site be visited again next year to see if any seedlings have regenerated. If survival still remains low, then re-planting may be necessary at the site.

Figure 5. Seedling showing evidence of grazing at Pushmahata Plantation restoration site.

Figure 6. Animal tracks at Pushmahata Plantation restoration site.

Washington

The Washington restoration site is 347 acres, located in Washington County, east of Highway 1 and northwest of highway 12. The site was planted in 2004 with 108,000 bareroot seedlings, primarily (93%) various oak species (*Quercus sp.*), along with some Green Ash (*Fraxinus pennsylvanica*), and Pecan (*Carya illinoinensis*).

The site was sampled on 10/25/06. Figure 7 shows the locations of the sampling plots. Table 9 shows the number of trees by species that were counted at each plot, Table 10 is a summary of the tree counts at the site, and Table 11 shows the average heights of various tree species that were measured.

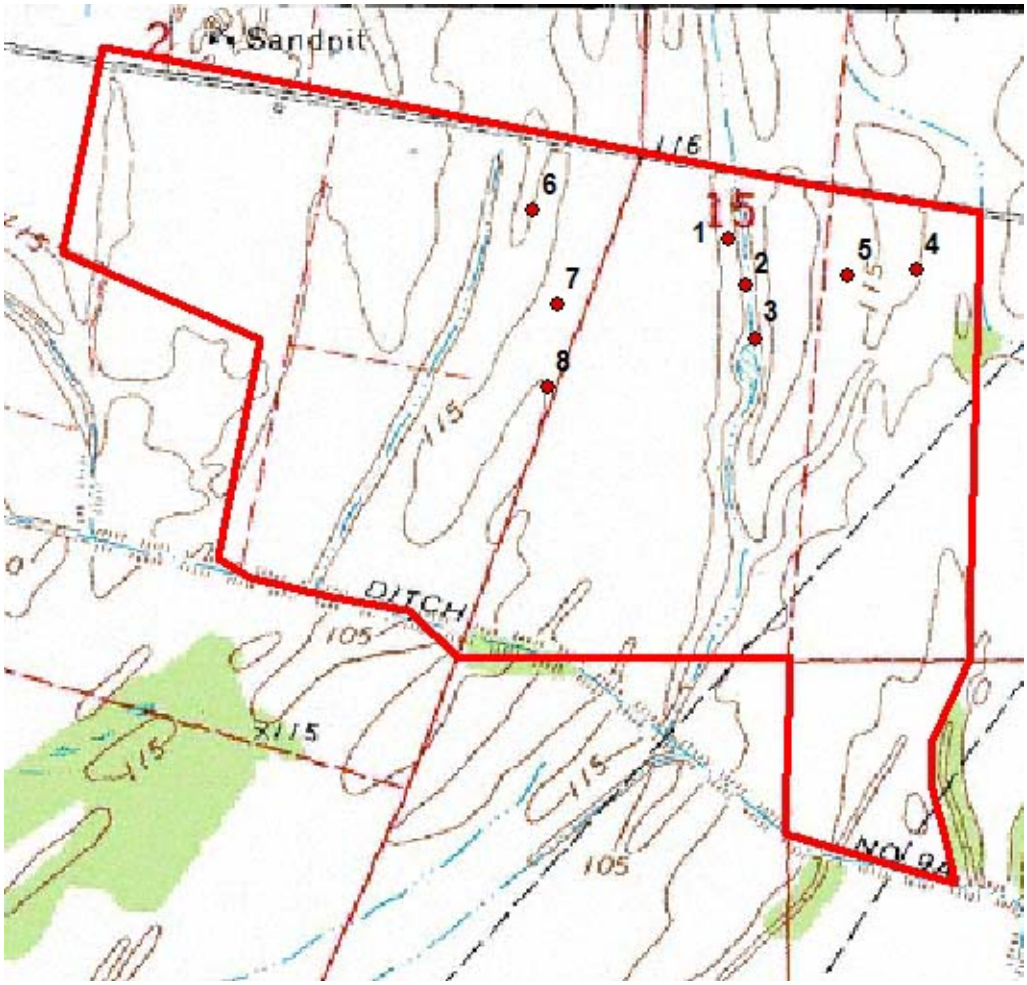


Figure 7. Location of monitoring plots at Washington restoration site.

	Number of Trees by Species			
Plot	**QS**	**FP**	**CI**	**Total**
1	12			12[1]
2	13			13[1]
3	8	1		9[1]
4	19			19
5	19			19[1]
6	19		1	20
7	8			8[2]
8	10			10

[1] There was a very dense amount of tall goldenrod at the plot, making an accurate count difficult.
[2] 4 dead oaks were counted at this plot
Table 9. Count of trees by species at the Washington restoration site.

Avg Trees per Plot	13.8
Standard Deviation	4.9
Avg Trees/Ha	345
Avg +/- 1SD	222-468
Planted Trees/Ha	770

Table 10. Summary of tree counts at the Washington restoration site.

Species	Avg Height (in)	# measured
FP	40	1
QS	36	8

Table 11. Average height of trees (in inches) by species at the Washingtonrestoration site.

The Washington restoration site was difficult to assess because at the time of sampling, most of the site was covered with a very dense growth of tall (> 6ft) goldenrod (*Solidago* sp.), making it difficult to find (and therefore accurately count) seedlings in the majority of plots. The tree counts reported in table 9 (especially plots 1,2,3,5, and 7) should therefore be considered as the *minimum* number of seedlings that were in that plot. As such, the average number of trees per plot (13.8) reported in table 10 is probably low. However, the site is still probably not doing as well in terms of survival as the portion of the Alligator site that was planted in the same year (2004).

All species (*Quercus sp,. Fraxinus pennsylvanica, Carya illinoinensis*) that were originally planted were found at the site, however, no volunteer species were found.

SUMMARY

Of the sites sampled in 2006, the 2004 Alligator planting appears to be doing the best in terms of survival. With the exception of an area adjacent to an agricultural field where it appears most of the planted seedlings have died, average seedling survival at the site was 82%. Survival rates at the 2005 Alligator planting, Island Lake, and Washington ranged from about 35% to 55%. Survival at the Pushmahata site was the lowest, at 14%. The low survival rate at Pushmahata might be due to extensive herbivory at the site.

According to the Yazoo Basin Regional HGM Guidebook (Smith and Klimas 2002), a desirable tree density range (that which would scale to a 1.0 for the variable) for a Riverine Backwater site is between 250-600 stems/ha. The only site where the current

average measured tree density did not fall into that range is the Pushmahata site, which only had 83 trees/ha. When factoring in the standard deviation of measured tree density, however, all other sites (with the exception of 2004 Alligator), fall below 250 stems/ha at the lower end of the measured density range, but this could be due to a possible undercount of trees at several of the plots. Therefore, the only restoration site that should be of some concern at this stage is the Pushmahata site. It is recommended that the site be revisited next year. If survival still remains low at that point, a replanting of the site should be considered.

REFERENCES

Humphrey, M.N., Lin, J.P., Kleiss, B.A., and Evans, D.E. (2004). "Monitoring Wetland Functional Recovery of Reforested Bottomland Hardwood Sites in the Yazoo Basin, MS." *WRAP Technical Notes Collection* (ERDC/EL TN-04-01). U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Smith, R.D., and Klimas, C.V. (2002). "A regional guidebook for applying the hydrogeomorphic approach to assessing wetland functions of selected regional wetland subclasses, Yazoo Basin, Lower Mississippi River Alluvial Valley," ERDC/EL TR-02-4, U.S. Army Engineer Research and Development Center, Vicksburg, MS

Results of 2005 Monitoring/Functional Assessment of Selected USACE Reforested Bottomland Hardwood Sites in the Yazoo Basin

by

Jeff Lin

Environmental Laboratory

Department of the Army
Corps of Engineers Research and Development Center
Waterways Experiment Station
3909 Halls Ferry Rd, Vicksburg, MS 39180-6199

Date

Prepared for:

US Army Engineer District, Vicksburg
Vicksburg, MS 39180-5191

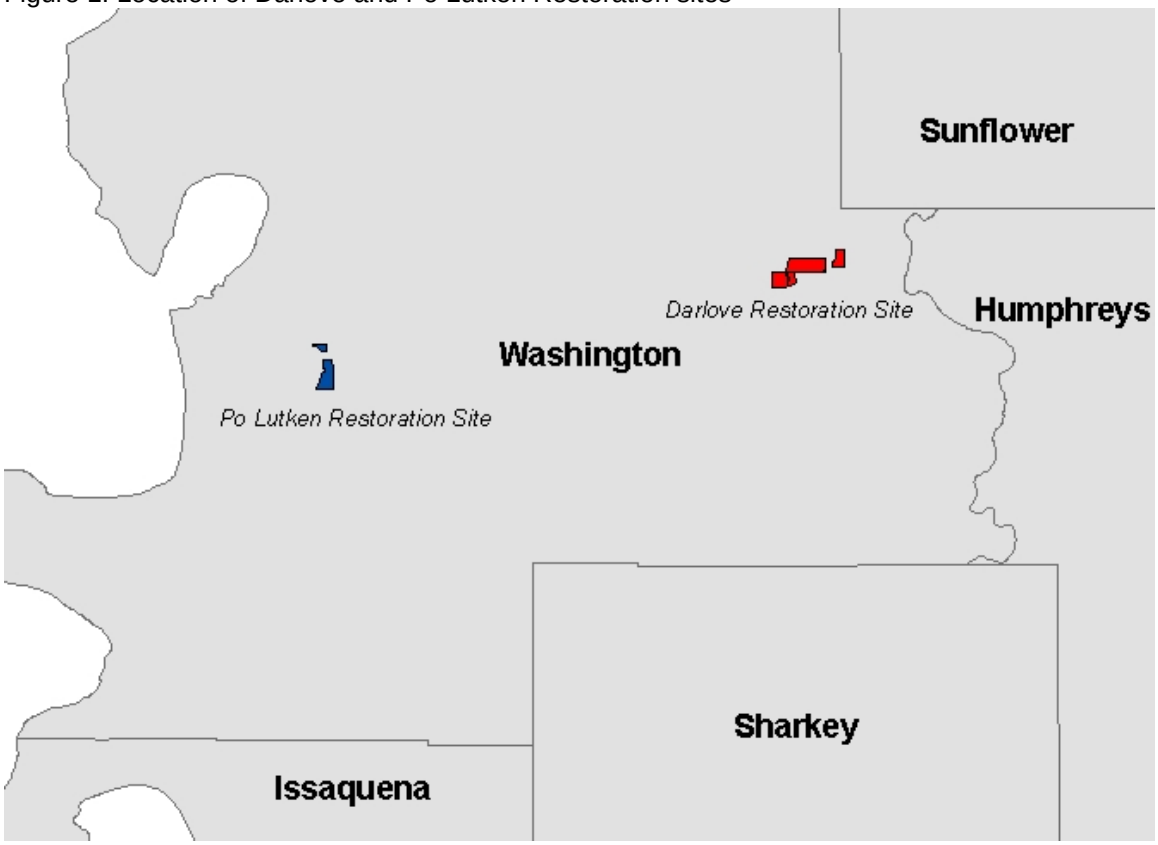
INTRODUCTION

Since 1990, the USACE, Vicksburg District has reforested over 20,000 acres of bottomland hardwood forest on former agricultural land within the Yazoo Basin, MS. Monitoring of these sites using the Hydrogeomorphic (HGM) functional assessment method began in 2001 in order to measure functional recovery at these sites, and to determine whether or not recovery is occurring along expected trajectories.

In 2001, all existing sites were sampled. Subsequently, a rotational sampling schedule was created so that a select number of existing sites (as well as any new plantings) would be assessed and reported on annually. The schedule is designed so that sites will then be re-assessed every five years. The first round of rotational sampling began in 2002. An initial report detailing and analyzing the results of the 2001 and 2002 sampling (Humphrey et al., 2004) has been published. A report of the 2003 sampling of the Big Twist, Sky Lake, and Stock restoration sites and the 2004 sampling of the Lake George restoration site have also previously been provided to the Vicksburg District.

In 2005, sampling occurred at the Po Lutken and Darlove restoration sites (Figure 1).

Figure 1: Location of Darlove and Po Lutken Restoration sites



STUDY AREA

Darlove Restoration Area

Darlove, a 518-acre tract, is located in Washington County and is bordered by the Bogue Phalia. The tract was planted in 1998-1999 planting season with a total of 490 acres of both 1-0 bareroot and container grown seedlings. Species planted at the site include red oaks, bald cypress, and green ash. Most of the site is classified in the Flats HGM subclass.

Po Lutken Restoration Area

The Polutken mitigation site is also located in Washington County. It is 333 acres in total size with 296 acres hand planted with container seedlings in 1997-1998. Planted species include various red oaks and bald cypress. The site is located in an abandoned channel and classified in the Isolated Depression HGM subclass.

METHODS

HGM functional assessments were performed at each of the restoration sites using methodology outlined in the Yazoo Regional HGM Guidebook (Smith and Klimas, 2002). Both sites were sample in late October, 2005.

For the HGM assessment, data on the following variables were collected in the field, using 0.04 ha plots, and various sized subplots and transects within the larger plot:

1. 'A' Horizon thickness (average of 4 soil cores taken in plot)
2. 'O' Horizon thickness (average of 4 soil cores taken in plot)
3. Composition of tallest woody vegetation strata (0.04 ha plot)
4. Tree composition (0.04 ha plot)
5. Tree density (0.04 ha plot)
6. Tree basal area (0.04 ha plot)
7. Log volume (2, 50-ft transects)
8. Woody debris volume (2 50-ft transects)
9. Snag density (0.04 ha plot)
10. Percent ground vegetation cover (average of 4, 1-m^2 plots)
11. Shrub/sapling density (average of 2, 0.004 ha plots)
12. Microdepressional ponding (0.04 ha plot)

Two more HGM variables are based on the presence of altered soils in the assessment area:

13. Change in soil cation exchange capacity
14. Percent area of altered soils

However, since it was assumed that soils in the assessment area were unaltered, both of these variables were automatically scored 1.0 for their subindex scores.

Additional HGM variables were calculated using a GIS. These variables were:

15. Area of wetland tract
16. Percent of wetland perimeter that is connected to suitable habitat
17. Percent of wetland tract that is core area
18. Frequency of flooding

A total of 12 plots were sampled at the Darlove site, and 11 at the Po Lutken site.

Calculation of site FCI scores

In the Humphrey et al. report (2004), site FCI scores were determined by calculating FCIs for individual plots (based on the metrics measured at that plot), then averaging the FCIs from these plots in order to obtain scores for the entire site. This method was used in order to make statistical comparisons of FCI scores between sampling years.

In this present report, FCI scores were not calculated for individual plots. Instead, the site FCI scores were determined by averaging metrics from the individual sample plots, then using these values to obtain one FCI score for the entire site.

Because the two methods of calculation can yield slightly different FCI scores, the method used in this report will be the one used in any future reports.

RESULTS

Darlove Restoration Area

General Observations

The Darlove restoration area consists of three separate blocks (Figure 2). The block east of Sixmile Bayou and the block west of Jones Bayou were inaccessible by foot, and therefore were not sampled. The condition of the center block, which was sampled, was fairly consistent across the sampling points (figure 3). Dominant tree species were Green Ash (*Fraxinus pennsylvanica*), Willow Oak (*Quercus phellos*), and Nuttall Oak (*Quercus nuttallii*). None of the saplings found at the sampling points were large enough (≥ 4 in. dbh) to be considered “trees” for purposes of the FCI calculations.

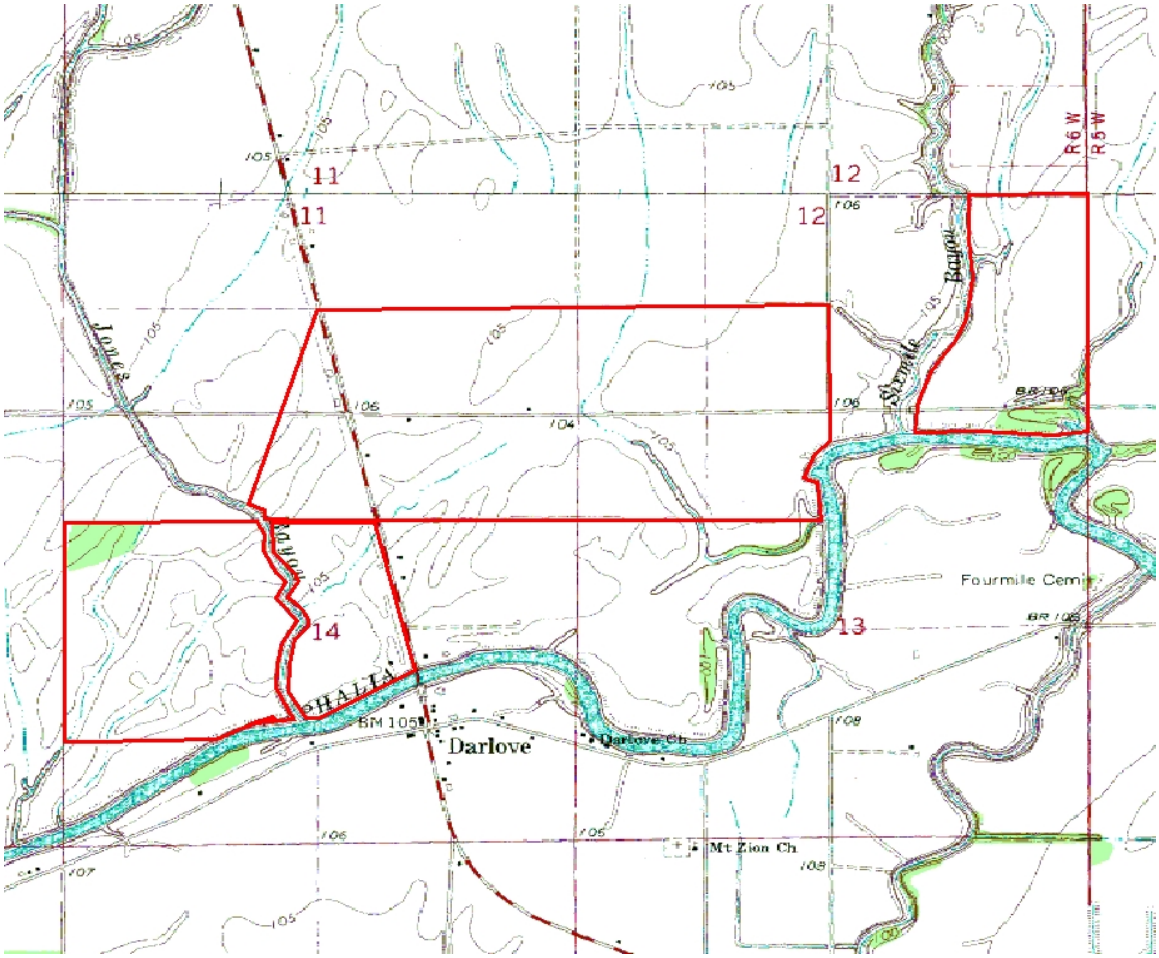


Figure 2. Darlove restoration area. The sampling blocks are primarily in the Flats HGM subclass. The area west of Jones Bayou and the area east of Sixmile Bayou were inaccessible by foot and therefore not sampled.

Figure 3. Photos of typical sampling plots at Darlove restoration area. Dominant tree species were typically Green Ash (*Fraxinus pennsylvanica*), Willow Oak (*Quercus phellos*), and Nuttall Oak (*Quercus nuttallii*). No trees within sampling plots were yet > 4 in. DBH. Shrub-sapling density averaged 480 stems/ha.

FCI Scores

The Darlove Restoration area is primarily of the Flats HGM subclass. Flats perform four functions- detain precipitation, cycle nutrients, maintain plant communities, and provide fish and wildlife habitat. Since Flats are located outside of the 5-year floodplain, they do not perform the Detain Floodwater or Export Organic Carbon functions. Table 1 compares the FCI scores calculated from the 2005 sampling with those calculated from the 2001 sampling.

Function	FCI (2005)	FCI (2001)
Detain Precipitation	0.6	0.5
Cycle Nutrients	0.4	0.4
Maintain Plant Communites	0.4	0.4
Provide Fish and Wildlife Habitat	0.0	0.0

Table 1. Comparison of FCI scores at Darlove Restoration site from 2001 to 2005.

FCI scores remain relatively unchanged from 2001 to 2005 except for a small increase in the Detain Precipitation function. The Provide Fish and Wildlife Habitat function still scores a 0.0, as that function is dependent on the presence of trees greater than 4 inches dbh, of which there were none.

Po Lutken Restoration Area

General Observations

The Po Lutken restoration area consists of two separate blocks, both in the Isolated Depression subclass (figure 4). The southern block (figure 5) was fairly consistent across sampling plots, which consisted primarily of Green Ash (*Fraxinus pennsylvanica*), Willow Oak (*Quercus phellos*), and Nuttall Oak (*Quercus nuttallii*), although average shrub sapling density was somewhat lower here than in the similarly aged Darlove site. Samples in the smaller, northern block were taken in a large natural ditch area, and these plots were substantially different in appearance than what was found in the southern block (figure 6). These plots were very dense with saplings and shrubs, mostly Black cherry (*Prunus serotina*) and Sugarberry (*Celtis laevigata*) which appear to have naturally regenerated and were far outnumbering the planted Green Ash, Willow Oak, and Nuttall oak. The plots were also covered with large amounts of poison ivy (*Toxicodendron radicans*)

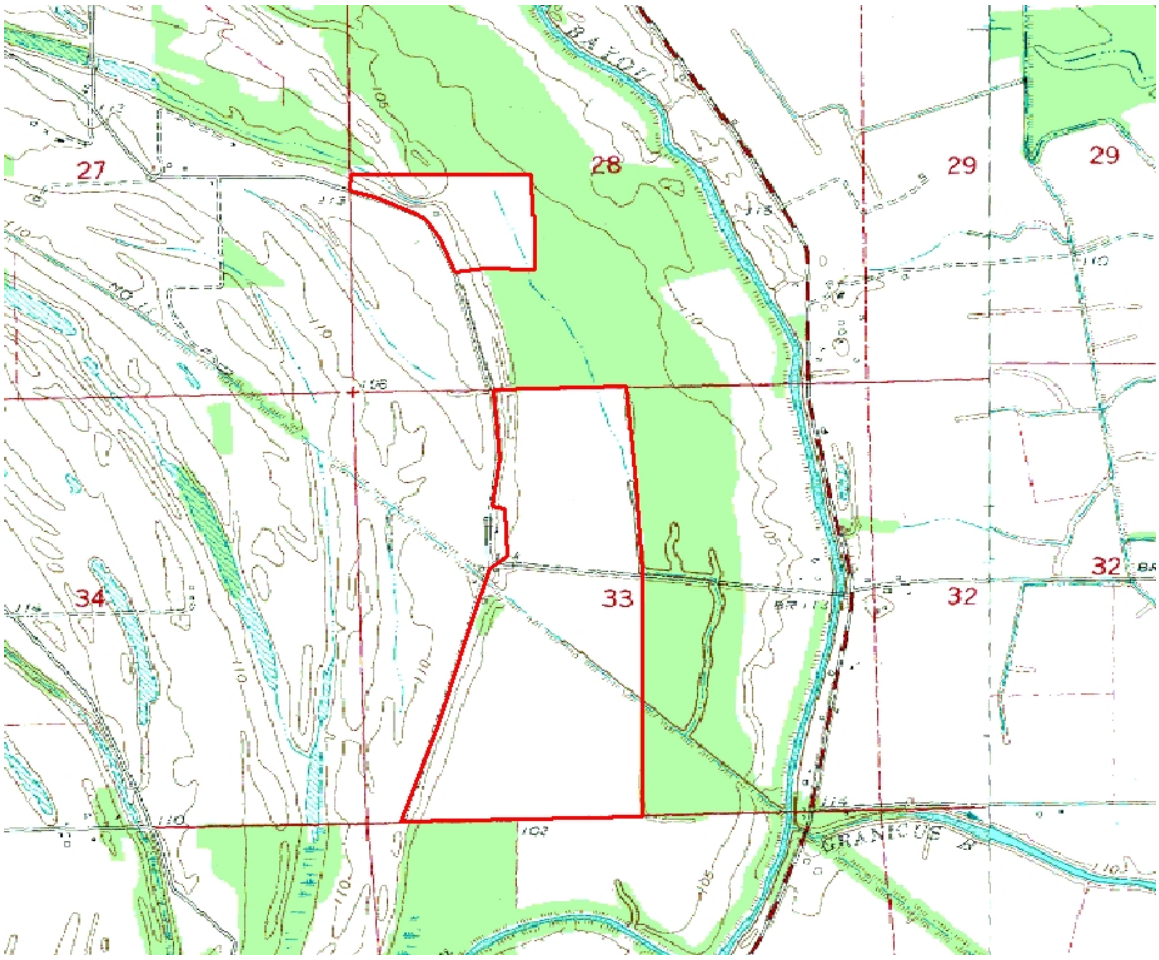


Figure 4. Po Lutken restoration area. The two blocks are in the Isolated Depression HGM subclass.

Figure 5. Photo of typical sampling plot in the larger southern block of the Po Lutken restoration area. Dominant tree species were typically Green Ash (*Fraxinus pennsylvanica*), Willow Oak (*Quercus phellos*), and Nuttall Oak (*Quercus nuttallii*). No trees within sampling plots were yet > 4 in. DBH. Shrub-sapling density averaged 265 stems/ha.

Figure 6. Photo of sampling plot located in depressional area in the northern block of the Po Lutken restoration area. Dominant tree species were Black cherry (*Prunus serotina*) and Sugarberry (*Celtis laevigata*), which appear to have naturally regenerated in the area. Planted Green Ash (*Fraxinus pennsylvanica*), Willow Oak (*Quercus phellos*), and Nuttall Oak (*Quercus nuttallii*) were also present. No trees within sampling plots were yet > 4 in. DBH. Shrub-sapling density averaged 12,500 stems/ha.

FCI Scores

Table 2 contains the FCI scores calculated in north and south blocks of the Po Lutken restoration site, along with the FCI scores from 2001, when the two blocks were not distinguished from each other. Isolated Depressions only perform 3 functions. Both blocks scored 0.0 for the Provide Fish and Wildlife Habitat function, as neither block contained observed trees greater than 4 in. dbh. The Cycle Nutrients functional score is higher in the north block because of the much higher shrub sapling density, while the Maintain Plant Communities function is lower because of the prevalence of less desirable, naturally regenerating tree species. However, the Maintain Plant Communities function is markedly higher in both blocks then it was when measured in 2001.

Function	FCI (North Block))	FCI (South Block)	FCI (2001)
Cycle Nutrients	0.2	0.1	0.1
Maintain Plant Communites	0.6	0.7	0.2
Provide Fish and Wildlife Habitat	0.0	0.0	0.0

Table 2. Comparison of FCI scores at the north and south blocks of the Po Lutken restoration site, and FCI scores measured in 2001 (where the two blocks were not distinguished from each other).

SUMMARY

Both the Po Lutken and Darlove restoration sites show some improvement in function from when they were last measured in 2001, and appear to be maintaining successful recovery trajectories.

REFERENCES

Humphrey, M.N., Lin, J.P., Kleiss, B.A., and Evans, D.E. (2004). "Monitoring Wetland Functional Recovery of Reforested Bottomland Hardwood Sites in the Yazoo Basin, MS." *WRAP Technical Notes Collection* (ERDC/EL TN-04-01). U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Smith, R.D., and Klimas, C.V. (2002). "A regional guidebook for applying the hydrogeomorphic approach to assessing wetland functions of selected regional wetland subclasses, Yazoo Basin, Lower Mississippi River Alluvial Valley," ERDC/EL TR-02-4, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Results of 2004 Monitoring/Functional Assessment of Selected USACE Reforested Bottomland Hardwood Sites in the Yazoo Basin

by

Jeff Lin

Environmental Laboratory

Department of the Army
Corps of Engineers Research and Development Center
Waterways Experiment Station
3909 Halls Ferry Rd, Vicksburg, MS 39180-6199

Date
11/2004

Prepared for:

US Army Engineer District, Vicksburg
Vicksburg, MS 39180-5191

INTRODUCTION

Since 1990, the USACE, Vicksburg District has reforested over 20,000 acres of bottomland hardwood forest on former agricultural land within the Yazoo Basin, MS. Monitoring of these sites using the Hydrogeomorphic (HGM) functional assessment method began in 2001 in order to measure functional recovery at these sites, and to determine whether or not recovery is occurring along expected trajectories.

In 2001, all existing sites were sampled. Subsequently, a rotational sampling schedule was created so that a select number of existing sites (as well as any new plantings) would be assessed and reported on annually. The schedule is designed so that sites will then be re-assessed every five years. The first round of rotational sampling began in 2002. An initial report detailing and analyzing the results of the 2001 and 2002 sampling (Humphrey et al., 2004) has been published. A report of the 2003 sampling of the Big Twist, Sky Lake, and Stock restoration sites has also been provided to the Vicksburg District.

In 2004, sampling occurred at the Lake George restoration site (Figure 1), and a new site that is concurrently being used by the USGS (henceforth referred to in this report as the USGS site) to test for water quality benefits derived from reforestation.

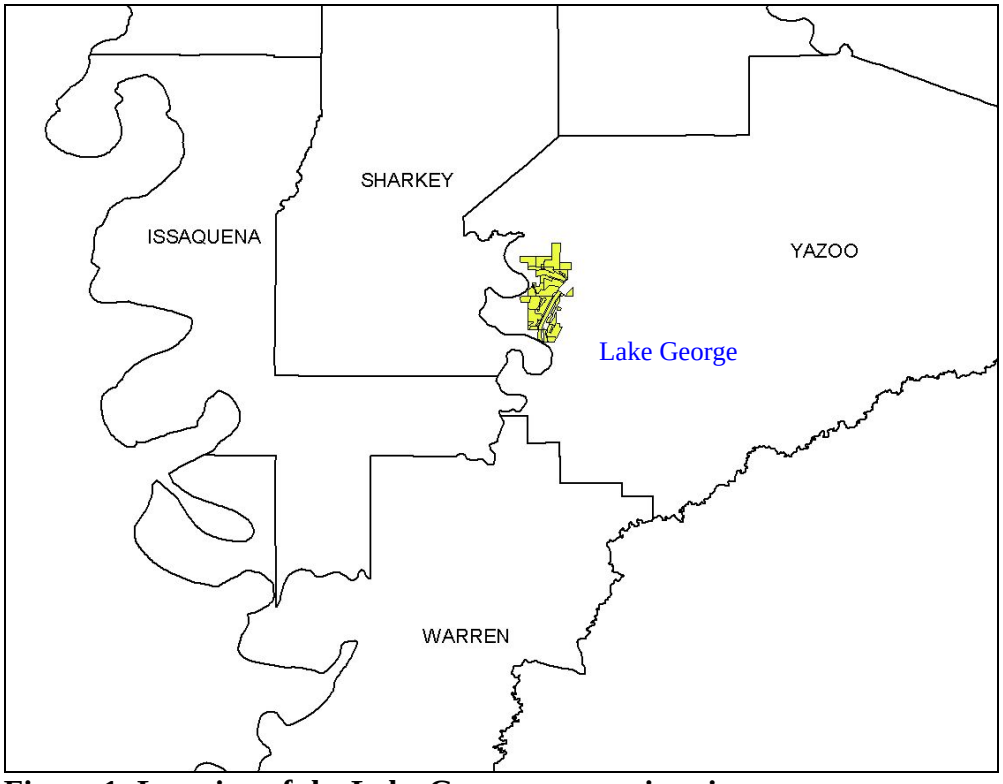


Figure 1: Location of the Lake George restoration site

SAMPLING SITES

Lake George

The Lake George site, located in western Yazoo County, encompasses approximately 8,400 acres. Initial planting at Lake George began in 1990-1991, with additional planting occurring annually, concluding in 1996-1997 (figure 2). Therefore, as of 2004 the site contains areas ranging anywhere from 8 to 14 years of age. The Lake George site is classified as belonging to the Riverine Backwater HGM class, and most of the site is contained within the 2-year floodplain.

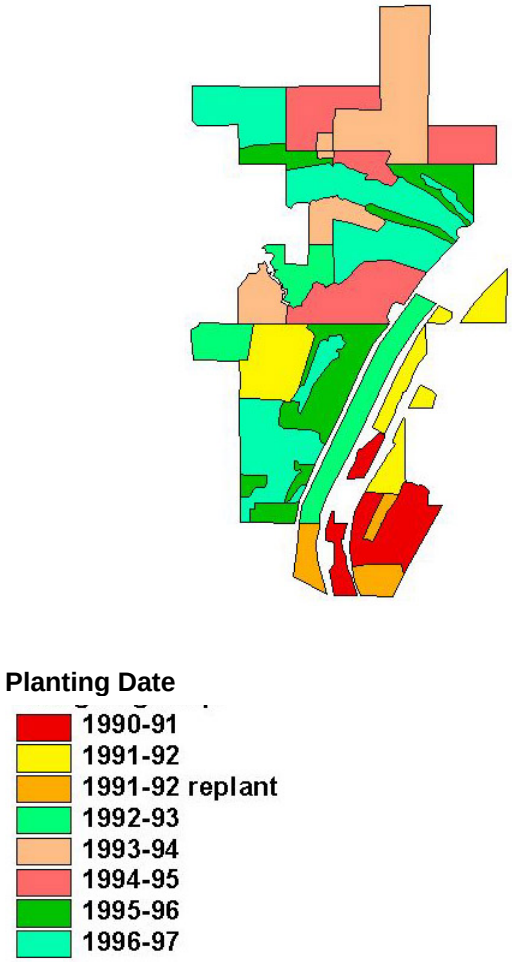


Figure 2: Location of areas of various planting dates at the Lake George restoration site.

Photos of Lake George at the various planting ages are included in the appendix section of this report.

USGS Site

The USGS sites are located in Sharkey County, near the Sharkey/Humphreys county line and just south of Highway 14. Exact boundaries or acreages for the sites were not available, but figure 3 shows their general location.

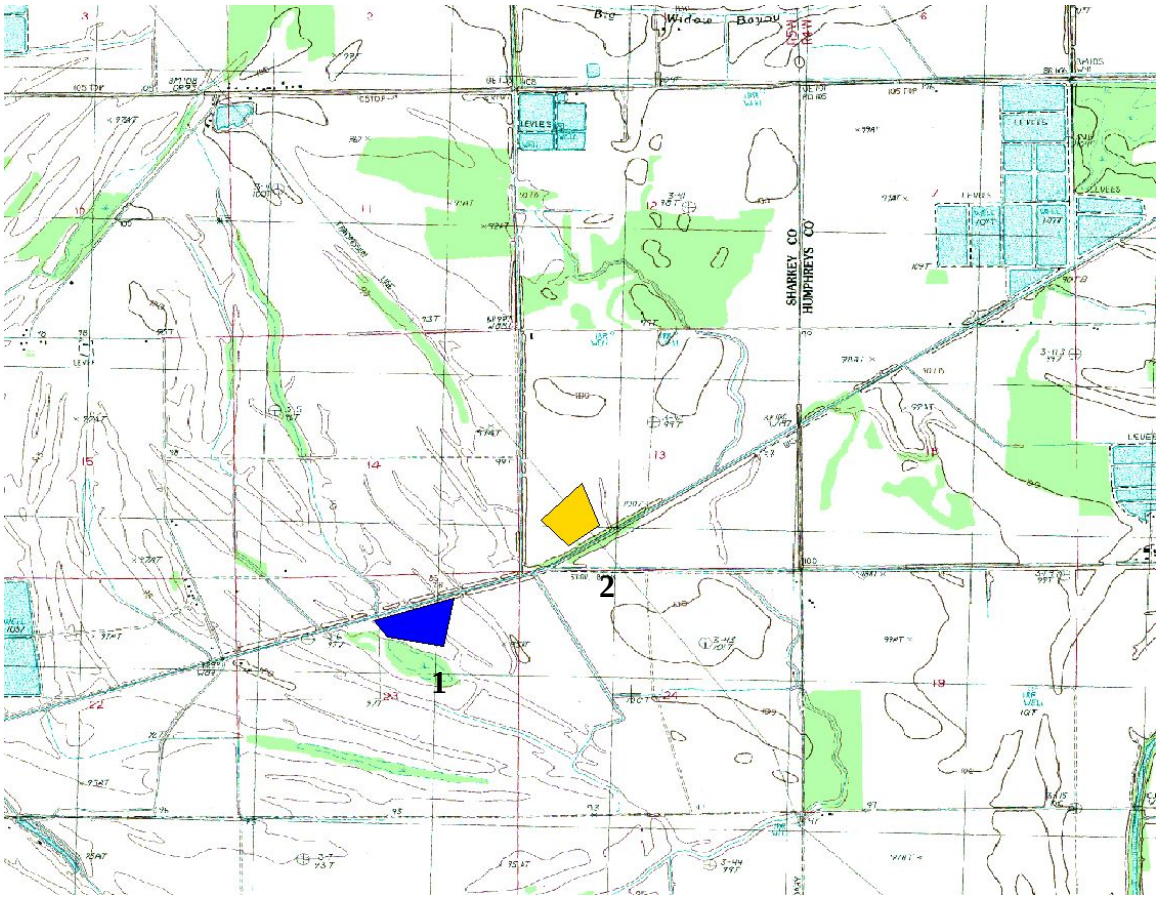


Figure 3. General location of the USGS sites. Polygons are not accurate in terms of boundaries or size.

The two sites are both in the Riverine Backwater HGM subclass, but are being assessed separately because Site 1 (blue) is primarily in the <2 year floodplain, while Site 2 (yellow) is in the 3-5 year floodplain. The sites are supposedly ≤ two years old, and were planted entirely with Eastern Cottonwood (*Populus deltoides*). Photos of the USGS site are included at the appendix at the end of this report.

METHODS

HGM functional assessments were performed at each of the restoration sites using methodology outlined in the Yazoo Regional HGM Guidebook (Smith and Klimas, 2002). All sampling occurred during mid to late October, 2004.

For the HGM assessment, data on the following variables were collected in the field, using 0.04 ha plots, and various sized subplots and transects within the larger plot:

1. 'A' Horizon thickness (average of 4 soil cores taken in plot)
2. 'O' Horizon thickness (average of 4 soil cores taken in plot)
3. Composition of tallest woody vegetation strata (0.04 ha plot)
4. Tree composition (0.04 ha plot)
5. Tree density (0.04 ha plot)
6. Tree basal area (0.04 ha plot)
7. Log volume (2, 50-ft transects)
8. Woody debris volume (2 50-ft transects)
9. Snag density (0.04 ha plot)
10. Percent ground vegetation cover (average of 4, 1-m^2 plots)
11. Shrub/sapling density (average of 2, 0.004 ha plots)
12. Microdepressional ponding (0.04 ha plot)

Two more HGM variables are based on the presence of altered soils in the assessment area:

13. Change in soil cation exchange capacity
14. Percent area of altered soils

However, since it was assumed that soils in the assessment area were unaltered, both of these variables were automatically scored 1.0 for their subindex scores.

Additional HGM variables were calculated using a GIS. These variables were:

15. Area of wetland tract
16. Percent of wetland perimeter that is connected to suitable habitat
17. Percent of wetland tract that is core area
18. Frequency of flooding

In addition, some data on tree height was collected using a clinometer for select trees (with a diameter at breast height (dbh) ≥ 4) that were within the 0.04 ha HGM plots. If a plot had only one tree present, that tree's height was measured. If a plot had two or more trees present, height was usually measured for two trees. Trees selected for measurement were generally ones that had an unobstructed line of sight from the clinometer at a distance of 8-10 meters. Tree height is not used in the HGM assessment, but was collected at the request of Vicksburg District personnel. These height data provide additional information that can be used for comparisons within and between various restoration sites in the future.

In 2004, 64 plots were sampled at Lake George. 24 of these plots were ones used in the 2001 and 2002 samplings (Humphrey et al. 2004), and the remaining 40 were newly established plots. It is expected that these 64 plots will be the same ones used in for sampling in subsequent years.

Because the USGS site was relatively small and homogeneous, only seven plots were sampled there- four at Site 1, and three at Site 2.

Calculation of site FCI scores

In the Humphrey et al. report (2004), site FCI scores were determined by calculating FCIs for individual plots (based on the metrics measured at that plot), then averaging the FCIs from these plots in order to obtain scores for the entire site. This method was used in order to make statistical comparisons of FCI scores between sampling years.

In this present report, FCI scores were not calculated for individual plots. Instead, the site FCI scores were determined by averaging metrics from the individual sample plots, then using these values to obtain one FCI score for the entire site.

Because the two methods of calculation can yield slightly different FCI scores, the method used in this report will be the one used in any future reports.

At the Lake George site, flood frequency maps were not available for areas east of the backwater levee. However, most of the Lake George site where flood frequency is available is mapped within the 2-year floodplain, although small portions of it fall within the 3-5 year floodplain. Rather than attempting to weight the FCI scores based on the coverage area of the two different floodplains, all FCI scores were calculated assuming a 2-year flood. Because the areas solely in the 3-5 year floodplain are relatively small, the affect of this assumption of FCI scores is minimal.

USGS Site 2 is mapped in the 3-5 year floodplain. Therefore, for the purposes of calculating the FCI scores, a flood frequency of 4 years will be used for Site 2. Scores for Site 1 were calculated using a 2 year flood frequency.

Finally, for the USGS site, the "Provide Fish and Wildlife Habitat" score was calculated assuming a <150 ha tract size, a 20% core area, and a 20% perimeter connection to other suitable habitat. These values are estimates, since exact site boundaries and acreages were unavailable at the time this report was written.

RESULTS

Lake George

General Site Observations

Based simply on visual observation of various planting areas, there was a wide range in tree and understory growth throughout the entire restoration area, even among areas of identical planting dates (see various photos in the appendix). In general, most areas seemed to be adequately progressing in terms tree/sapling density and individual tree growth, although there were smaller individual areas where tree/sapling density was sparse and individual tree growth was less than might be expected.

HGM Results

Table 1 displays the FCI scores calculated for 2004, as well as those calculated in 2002. The scores obtained in 2004 show an increase in nearly every function for every planting date. The largest increases are seen in the "Provide Fish and Wildlife Habitat" function- in 2002, most planting dates scored a "0.0" for this function, but in 2004, scores ranged from 0.3 to 0.5.

The increases in FCI scores are largely attributable to the increased presence of trees (individuals ≥ 4.0 inches dbh) in 2004. The presence of trees is required for the "Provide Fish and Wildlife Habitat" function to have a score greater than 0.0, and also affects the scores for the "Detain Floodwater", "Cycle Nutrients", "Export Organic Carbon" and "Maintain Plant Community" functions.

As might be expected, the highest scores across all functions are found in the oldest planting dates (90-91 and 91-92), with the highest overall functional scores in the 91-92 planting date areas. The lowest overall FCI scores are for the 92-93 planting date areas. However, because the results among the various planting years are fairly similar to one another (the largest difference between FCIs for a single function between any two planting years is 0.2), the Lake George site can probably begin to be assessed as a whole unit, rather than separately by planting date. The bottom of table 1 also includes the FCI scores calculated using metrics averaged from the entire site.

Table 1: FCI Scores for various planting years, as calculated in 2004 and 2002. 2004 scores are in bold. FCI scores for 2002 are rounded from those reported in Humphrey et al. (2004). The table also includes 2004 scores for the site assessed as a whole.

	FUNCTION/FCI Scores						
Planting Year	**Detain Floodwater**	**Detain Precipitation**	**Cycle Nutrients**	**Export Organic Carbon**	**Remove Elements & Compounds**	**Maintain Plant Communities**	**Provide Fish and Wildlife Habitat**
90-91(2004)	**0.5**	**0.6**	**0.5**	**0.4**	**0.9**	**0.6**	**0.5**
90-91(2002)	0.3	0.4	0.4	0.3	0.9	0.5	0.1
91-92 (2004)	**0.5**	**0.6**	**0.5**	**0.4**	**0.9**	**0.7**	**0.5**
91-92(2002)	0.3	0.4	0.4	0.3	0.9	0.5	0.1
92-93 (2004)	**0.3**	**0.6**	**0.4**	**0.3**	**0.9**	**0.6**	**0.3**
92-93(2002)	0.3	0.5	0.4	0.3	0.8	0.6	0
93-94(2004)	**0.4**	**0.6**	**0.4**	**0.3**	**0.9**	**0.7**	**0.5**
93-94(2002)	0.3	0.5	0.4	0.3	0.8	0.5	0
94-95(2004)	**0.3**	**0.6**	**0.4**	**0.3**	**0.9**	**0.6**	**0.4**
94-95(2002)	0.3	0.4	0.4	0.3	0.8	0.5	0
95-96(2004)	**0.5**	**0.6**	**0.5**	**0.4**	**0.9**	**0.6**	**0.4**
95-96(2002)	0.4	0.6	0.5	0.4	0.9	0.6	0
96-97(2004)	**0.5**	**0.6**	**0.5**	**0.4**	**0.9**	**0.6**	**0.3**
96-97(2002)	0.3	0.5	0.4	0.3	0.9	0.5	0
Entire Site (2004)	**0.5**	**0.6**	**0.5**	**0.4**	**0.9**	**0.6**	**0.4**

Figure 4 shows projected functional recovery rates for a properly reforested Riverine Backwater system over a 60-year period. This chart was generated using data published in Smith and Klimas (2004). Table 2 compares the projected scores for a 10-year-old site against the actual scores for the 94-95 planting date (10 years old), and the scores for the site as a whole (average age of 11 years).

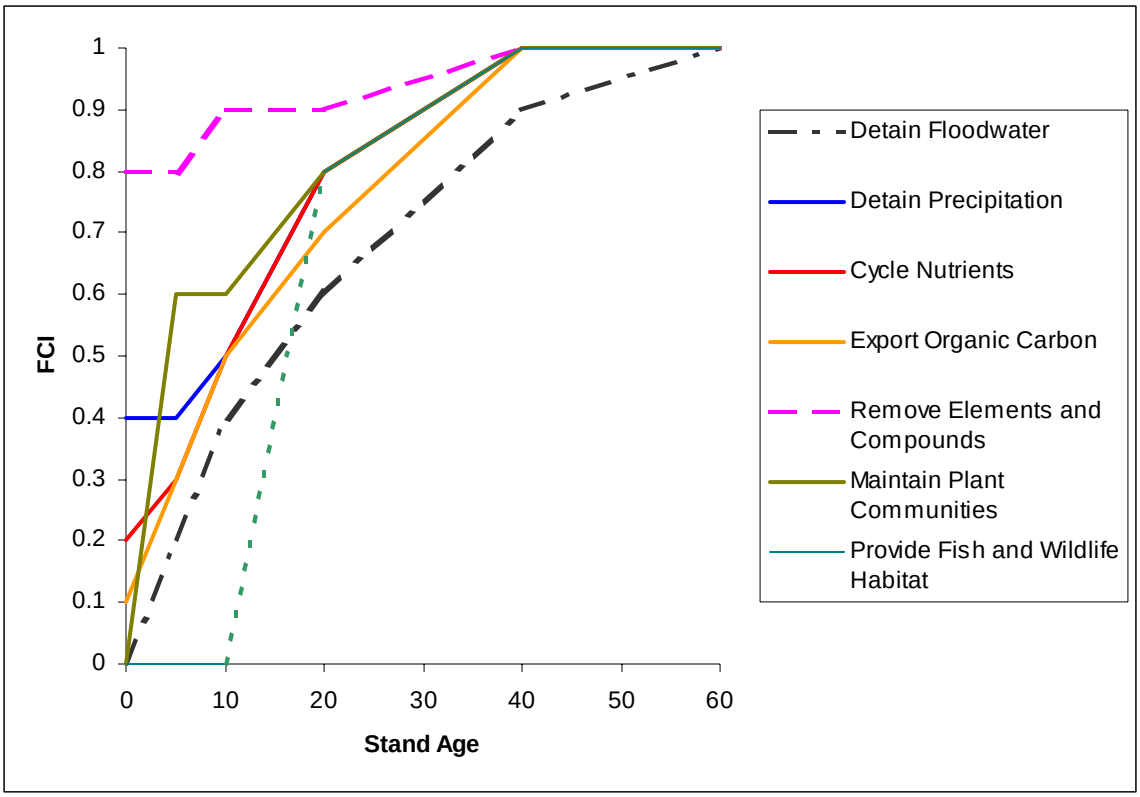


Figure 4. Projected functional recovery of a Riverine Backwater site over 60 years.

Table 2. Comparison of 2004 FCI scores for the 1994-95 planting area, the entire Lake George site, and projected FCI scores for a 10-yr old site.

	FUNCTION/FCI Scores						
Planting Year	Detain Floodwater	Detain Precipitation	Cycle Nutrients	Export Organic Carbon	Remove Elements & Compounds	Maintain Plant Communities	Provide Fish and Wildlife Habitat
1994-95	0.3	0.6	0.4	0.3	0.9	0.6	0.4
Entire Site	0.5	0.6	0.5	0.4	0.9	0.6	0.4
Projected 10 Year	0.4	0.6	0.5	0.5	0.9	0.6	0.0

The largest difference between the projected and actual FCI scores is in the "Provide Fish and Wildlife Habitat" function, with the actual scores being higher than the projected scores. However, as seen in figure 4, the projected FCI for this function increases rapidly after 10 years. For the remaining functions, the projected and actual scores are fairly similar to each other.

Height Data

Height was measured on 38 individual trees with ≥ 4.0 inches dbh throughout the Lake George site. Trees measured included 1 Red Cedar (*Juniperus virginiana*), 1 Sweetgum (*Liquidambar styraciflua*), 1 Overcup Oak (*Quercus lyrata*), 2 Bald Cypress (*Taxodium*

distichum), 3 Water Oak (*Quercus nigra*), 2 Willow Oak (*Quercus phellos*), and 28 Nuttall Oak (*Quercus nutallii*). The results are displayed in figure 5.

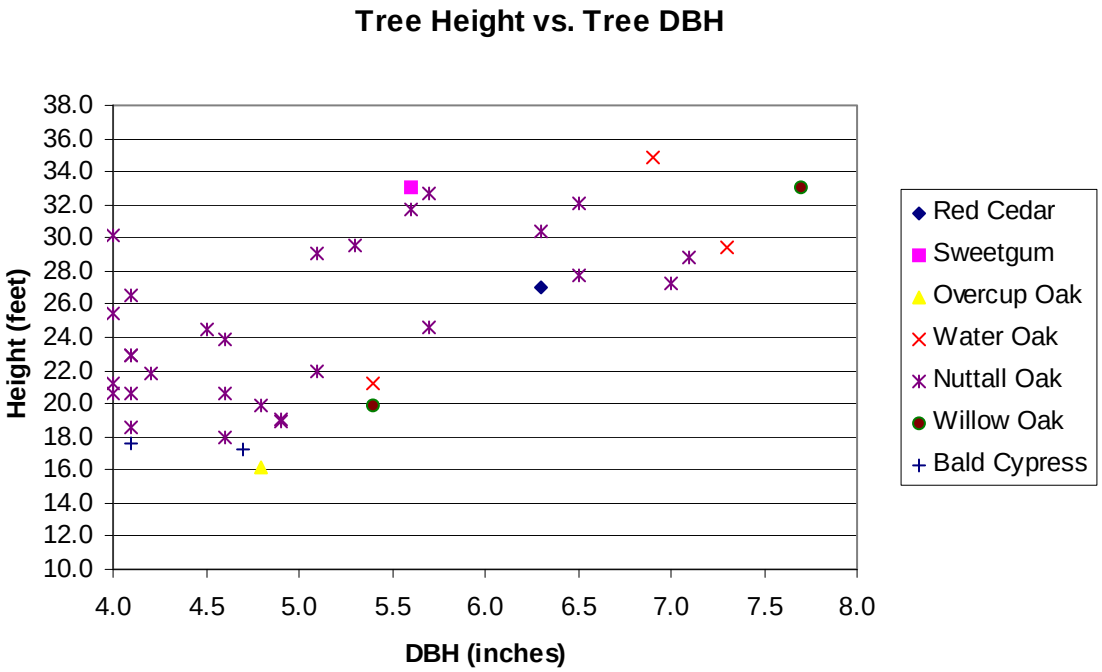


Figure 5. Tree height as a function of tree dbh for various species measured at the Lake George restoration site.

USGS Site

General Site Observations

The sites were planted entirely with Eastern Cottonwood (*Populus deltoides*), but some oaks (*Quercus sp.*) have begun to grow there as well. Both sites contain adjacent areas that are scheduled to be planted in 2005. Site 1 appears to have larger trees than Site 2, otherwise both sites are relatively homogenous in appearance.

HGM Data

The FCI scores for the USGS site are shown in table 3. The scores are lower in Site 2 because that area did not have any trees (≥ 4 in. dbh), plus the site was assessed as being in a 4-year, rather than 2-year floodplain.

Table 3. FCI scores for the USGS site.

	FUNCTION/FCI Scores						
Site	**Detain Floodwater**	**Detain Precipitation**	**Cycle Nutrients**	**Export Organic Carbon**	**Remove Elements & Compounds**	**Maintain Plant Communities**	**Provide Fish and Wildlife Habitat**
Site 1	0.4	0.5	0.5	0.4	0.8	0.6	0.3
Site 2	0.3	0.5	0.5	0.2	0.6	0.6	0.0

Height Data

Heights were collected for 2 *Populus deltoides* tress located at Site 1. The heights for those trees are 31.1 ft (5.2 inches dbh), and 34.7 ft (5.3 inches dbh).

SUMMARY

Based on the data collected this year, the Lake George site appears to functioning as or better than expected, especially when the site is taken as a whole. The USGS site also seems to be functioning adequately at this early stage. More information on site boundaries and acreage of the USGS site will be needed in the future in order to accurately assess the "Provide Fish and Wildlife Habitat" function for that site.

REFERENCES

Humphrey, M.N., Lin, J.P., Kleiss, B.A., and Evans, D.E. (2004). "Monitoring Wetland Functional Recovery of Reforested Bottomland Hardwood Sites in the Yazoo Basin, MS." *WRAP Technical Notes Collection* (ERDC/EL TN-04-01). U.S. Army Engineer Research and Development Center, Vicksburg, MS.

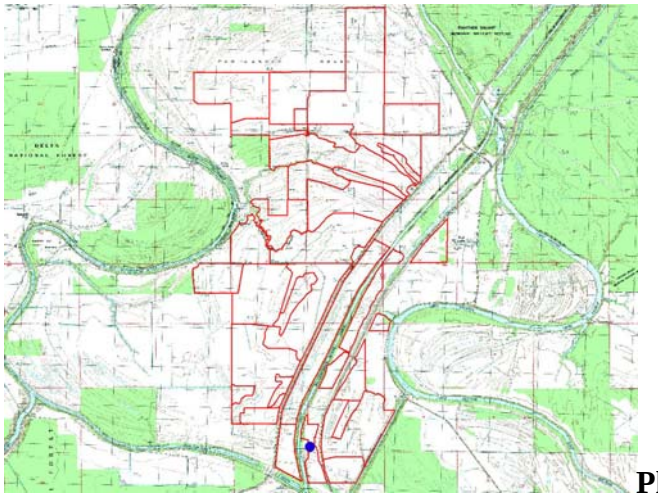
Smith, R.D., and Klimas, C.V. (2002). "A regional guidebook for applying the hydrogeomorphic approach to assessing wetland functions of selected regional wetland subclasses, Yazoo Basin, Lower Mississippi River Alluvial Valley," ERDC/EL TR-02-4, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

APPENDIX

This Appendix provides annotated photos of representative sampling plots from the Lake George and USGS sites, as well as each plot's location on the USGS topographic map and their actual decimal degree coordinates. All photos were taken in mid to late October, 2004.

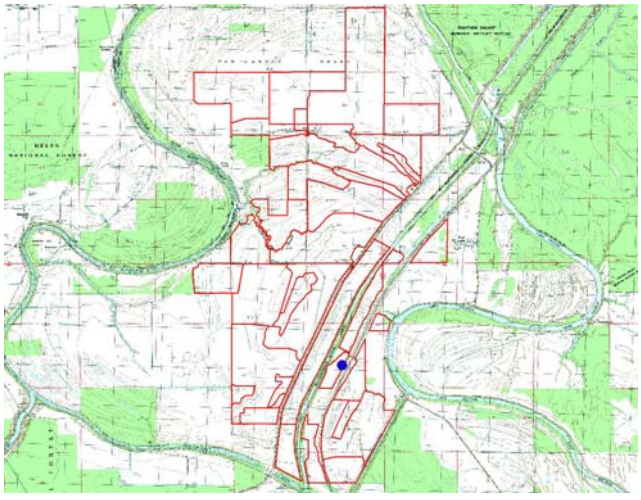
LAKE GEORGE

1990-1991 Planting. Plot #59. ***Plot has relatively dense woody understory, dominated by Box Elder, with some Pecan and Green Ash also present. The plot also contains a few Nuttall Oak trees > 4 in. dbh. Ground vegetation cover is sparse (~20%).***



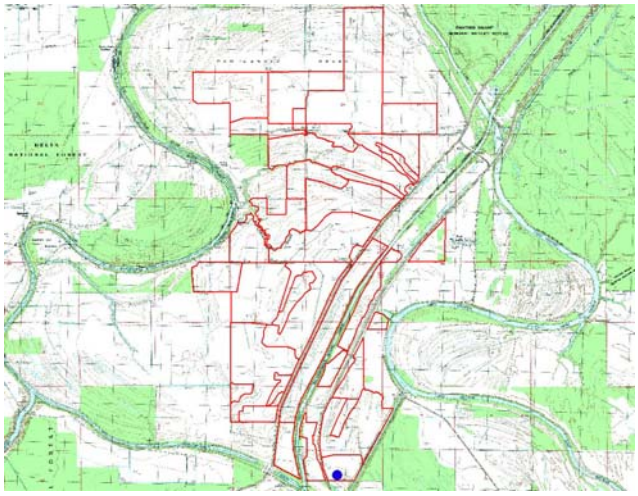
Plot #59. X:-90.67212, Y: 32.70737

19901-1991 Planting. Plot #56. ***Plot does not have any trees greater than 4 in. dbh, and appears less dense than adjacent areas seen in background of photo. Pecan and Bald Cypress are the dominant trees, with some Green Ash and Holly also present.***



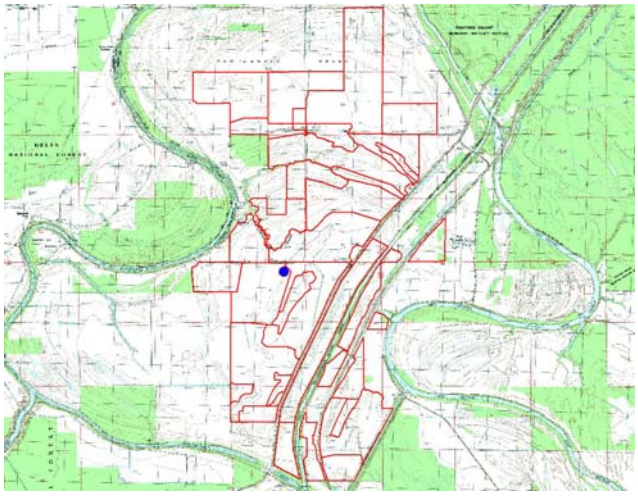
Plot #56. X: -90.66490, Y: 32.72590

1991-92 Planting. Plot #53. ***Plot has a closed canopy. There are several relatively tall trees with > 4 in. dbh, which are a mix of Bald Cypress, Nuttall Oak, and Sweetgum. Blackberry vines are ubiquitous in the understory.***



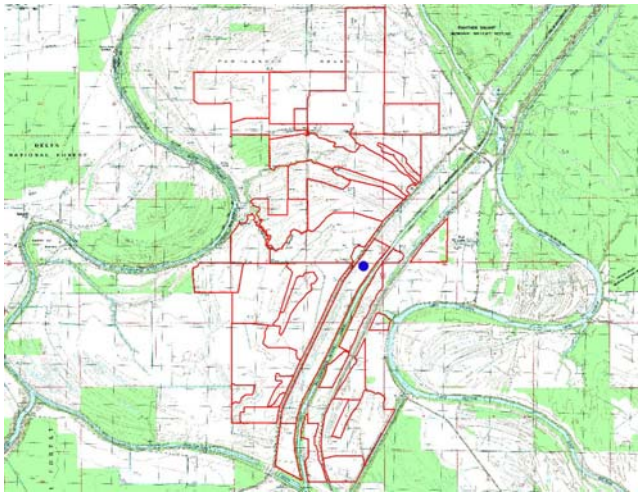
Plot #53. X: -90.66569, Y: 32.70043

1991-92 Planting. Plot #54. ***Plot is mostly Willow Oak and Nuttall Oak saplings, with some Baccharus shrubs. Overall, plot is very different than plot #53, which has the same planting date but is in a different area.***



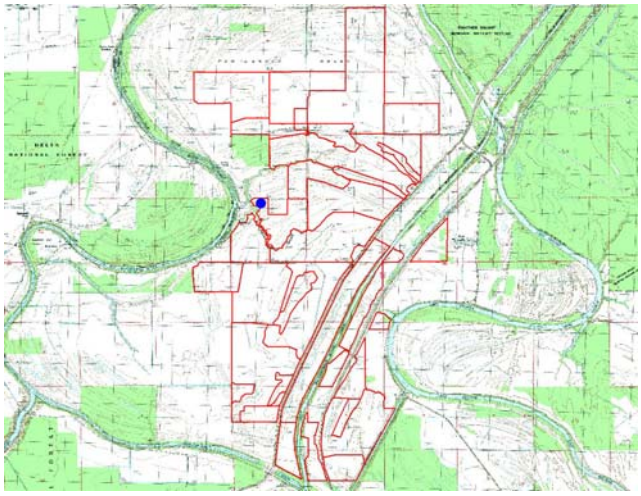
Plot #54. X: -90.67775, Y: 32.74692

1992-1993 Planting. Plot # 36. ***Plot is relatively open, woody vegetation is a scattered mix of short Green Ash and Bald Cypress saplings, and Buttonbush shrubs.***



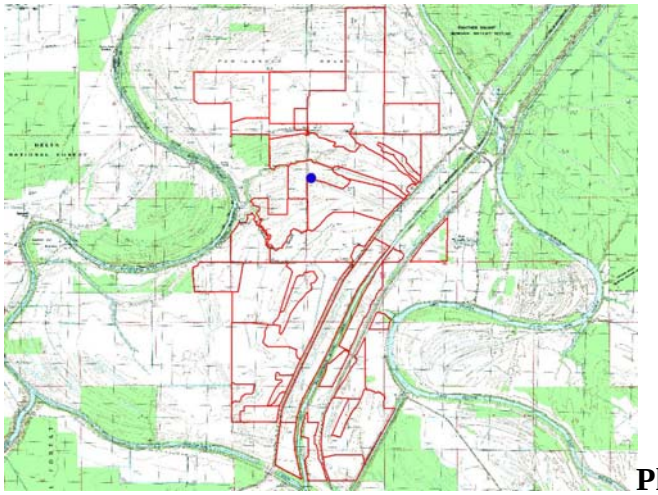
Plot # 36. X: -90.66005, Y: 32.74825

1992-1993 Planting. Plot # 40. ***Plot has much denser vegetation compared to plot #36. Blackberry is common throughout the plot. Trees are mostly Nuttall Oak saplings, with some Green Ash saplings present as well.***



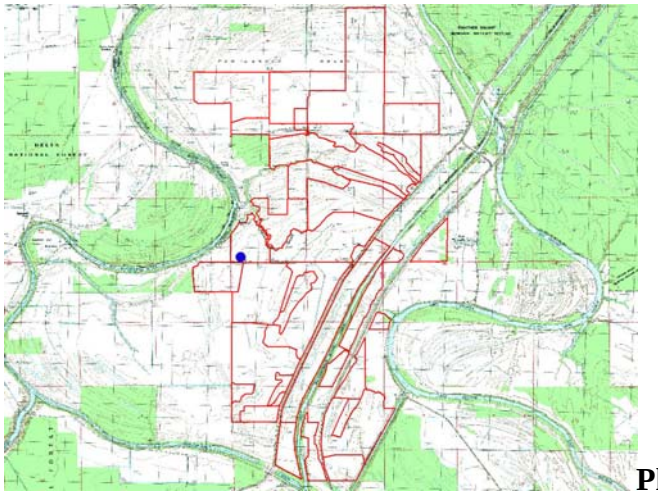
Plot # 40. X: -90.68327, Y: 32.76245

1993-1994 Planting. Plot #29. ***Plot has several Nuttall Oak trees with > 4 in. dbh.***



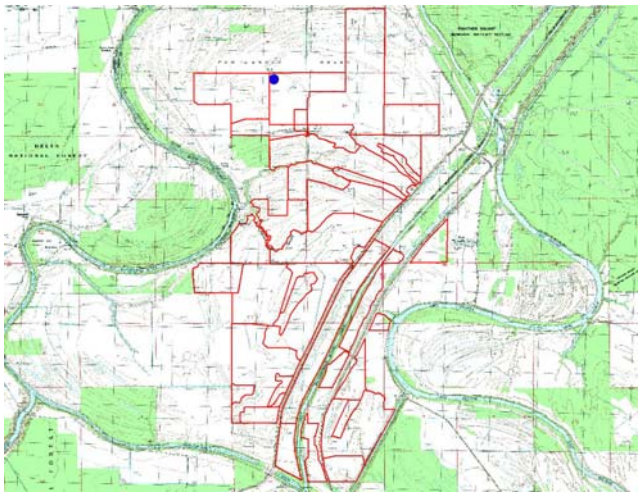
Plot #29. X: -90.67195 Y: 32.76820

1993-1994 Planting. Plot #34. ***Plot has one Nuttall Oak tree > 4 in. dbh. Other trees are mostly Nuttall Oak saplings, along with several thin Sweetgums.***



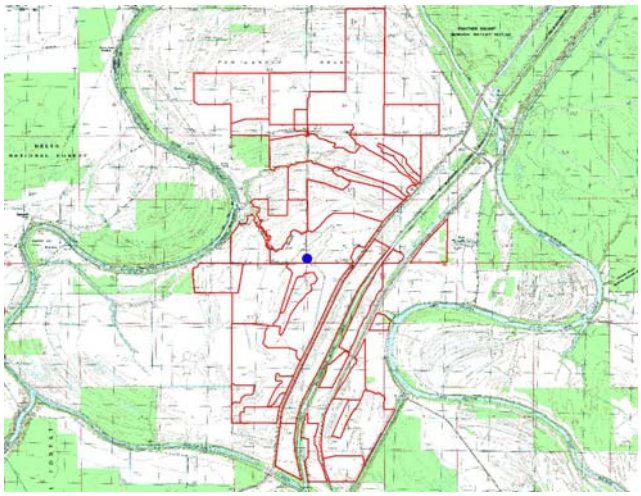
Plot #34. X: -90.68785, Y: 32.75022

1994-1995 Planting. Plot #21. ***Plot has relatively high ground vegetation cover (~75%). Trees are a mix of Willow Oaks and Nuttall Oaks, with two > 4 in. dbh. Several Buttonbush shrubs are also within the plot.***



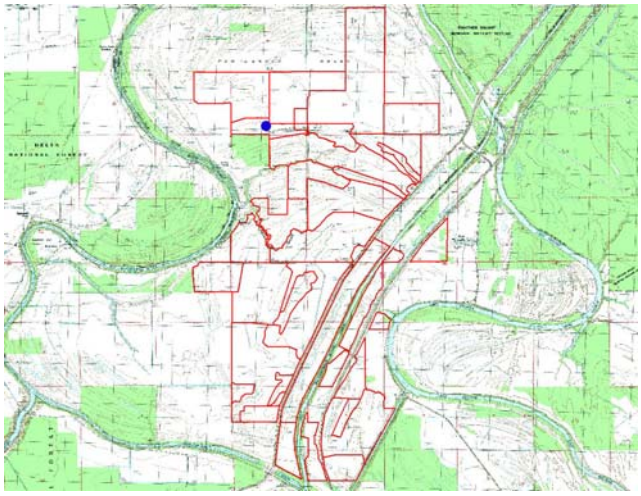
Plot #21. X: -90.68029, Y: 32.79088

1994-1995 Planting. Plot #23. ***Plot has only a few small Nuttall Oak saplings, and about 90% ground vegetation cover.***



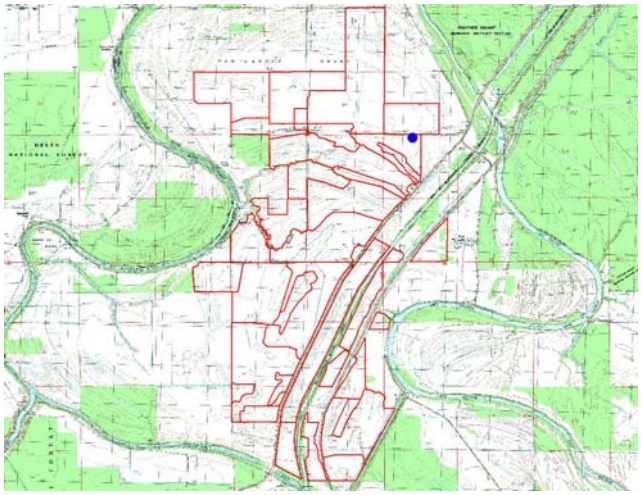
Plot #23. X: -90.67278, Y: 32.75004

1995-1996 Planting. Plot #14. ***Dominant saplings are Pecan and Nuttall Oak, with some Persimmon saplings and Buttonbush shrubs present as well. There were no trees > than 4 in. dbh in the plot.***



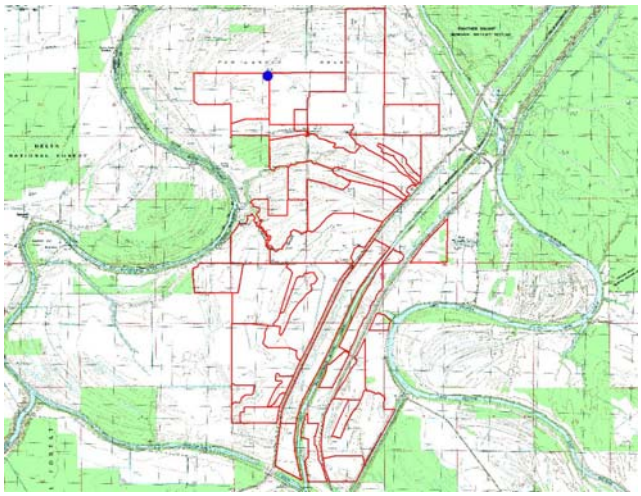
Plot #14. X: -90.68210, Y: 32.78002

1995-1996 Planting. Plot #20. ***Trees in plot are all Nuttall Oaks, with one > 4 in. dbh.***



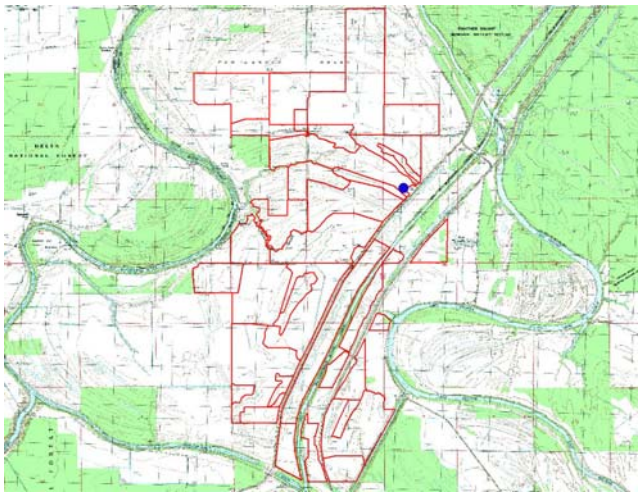
Plot #20. X: -90.64981, Y: 32.77739

1996-1997 Planting. Plot #1. ***Woody vegetation in the plot is an even mix of Nuttall Oaks, Buttonbush shrubs, and Green Ash. The trees are generally short and thin.***



Plot #1. X: -90.68177, Y: 32.79163

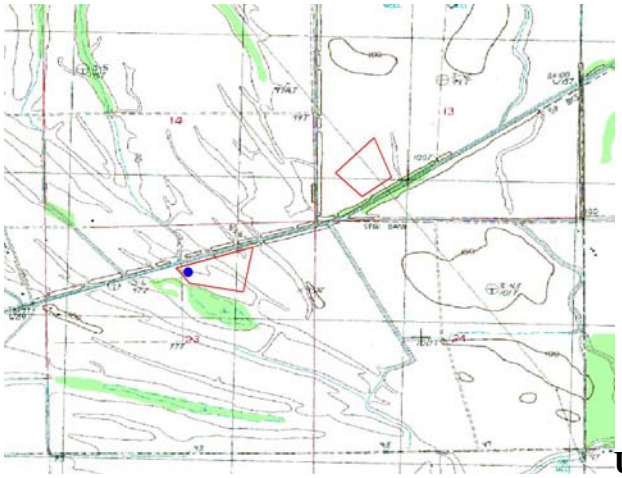
1996-1997 Planting. Plot #11. ***Baccharus shrubs are growing very densely in the plot. Several Water Oaks and Willow Oaks are also present.***



Plot #11. X: -90.65089, Y: 32.76617

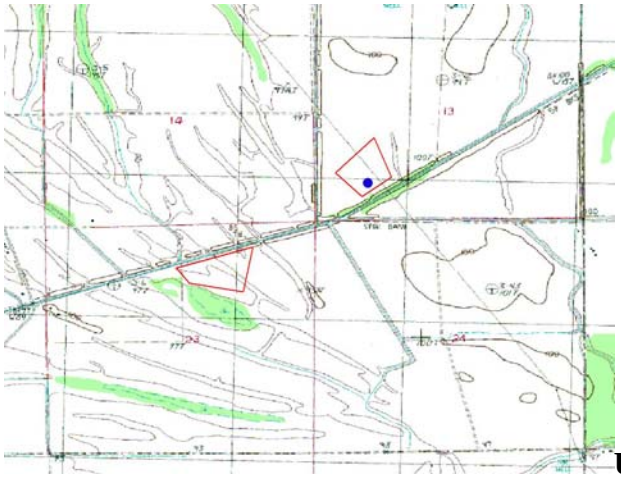
USGS

USGS Site 1, Plot #1. ***Plot contains Cottonwood trees growing in discernible rows. Many of the trees are > 4 in. dbh. Ground vegetation cover is ~25%.***



USGS Plot 1. X: -90.68142, Y: 32.96256

USGS Site 2, Plot #6. ***Plot contains Cottonwood trees growing in discernible rows, at a typical density of 1000 trees/ha. None of the trees are yet > 4 in. dbh.***



USGS Plot 6. X: -90.67003, Y: 32.96822

Results of 2003 Monitoring/Functional Assessment of Selected USACE Reforested Bottomland Hardwood Sites in the Yazoo Basin

by

Jeff Lin

Environmental Laboratory

Department of the Army
Corps of Engineers Research and Development Center
Waterways Experiment Station
3909 Halls Ferry Rd, Vicksburg, MS 39180-6199

Date
10/30/2003

Prepared for:

US Army Engineer District, Vicksburg
Vicksburg, MS 39180-5191

INTRODUCTION

Since 1990, the USACE, Vicksburg District has reforested over 20,000 acres of bottomland hardwood forest on former agricultural land within the Yazoo Basin, MS. Monitoring of these sites using the HGM functional assessment method began in 2001 in order to measure functional recovery at these sites, and to determine whether or not recovery is occurring along expected trajectories.

In 2001, all existing sites were sampled. Subsequently, a rotational sampling schedule was created so that a select number of existing sites (as well as any new plantings) would be assessed and reported on annually. The schedule is designed so that sites will then be re-assessed every five years. The first round of rotational sampling began in 2002. A report detailing and analyzing the results of the 2001 and 2002 sampling (Humphrey et al., in review) was provided to the Vicksburg District in 2003.

In 2003, additional sampling occurred at three locations- Big Twist, Sky Lake (both existing and newly planted areas) and Stock (a new restoration area planted in 2003). The location of these sites in relation to the Yazoo backwater area is shown in figure 1. This report presents and discusses the results from the 2003 sampling effort at these sites.

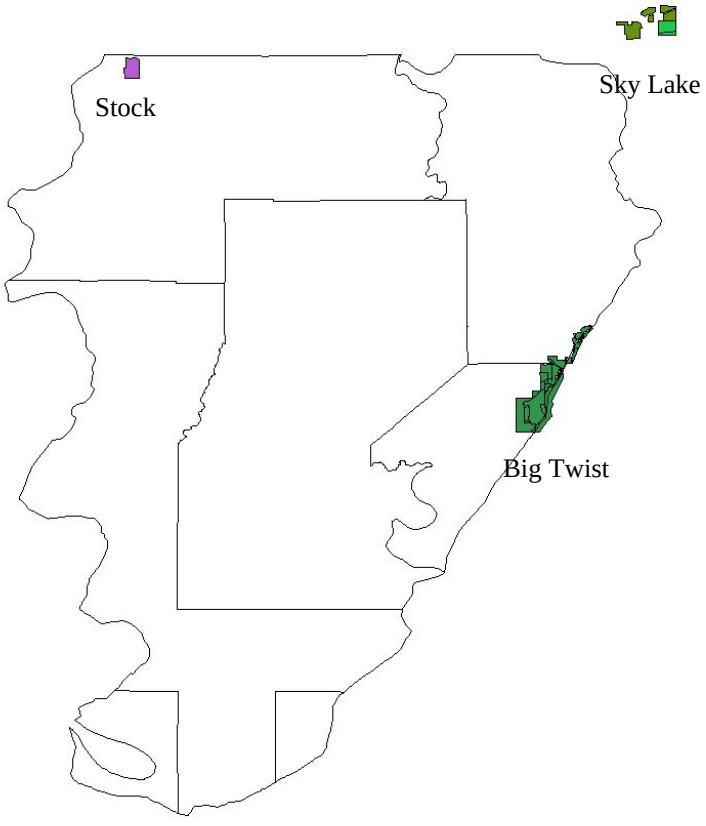


Figure 1: Big Twist, Stock, and Sky Lake restoration sites in relation to Yazoo backwater area.

SAMPLING SITES

Stock

The Stock site, which was planted in 2003, is located in Washington county, east of the town of Avon. It is approximately 815 acres. Based on field observations it was assumed that the site was in the 5-year floodplain and belonged to the Riverine Backwater HGM subclass (maps showing flood return intervals were not provided for this site).

Photo of Stock sampling plot, planted in 2003.

Sky Lake

The Sky Lake site is located in Humphrey and Leflore counties, near the town of Belzoni. It is approximately 3,130 acres, with 710 of those acres planted in 2003, and the remainder in 1999 and 2001. Based on field observations it was assumed that the site was in the 5-year floodplain and belonged to the Riverine Backwater HGM subclass (maps showing flood return intervals were not provided for this site). This classification of the Sky Lake site differs from that used in the Humphrey et al. report provided to the Vicksburg District, where the Sky Lake site was divided into flats, riverine backwater, and connected depressions subclasses.

Photo of Sky Lake sampling plot, 2003 planting

Photo of Sky Lake sampling plot, 1999 planting.

Big Twist

The Big Twist site consists of approximately 6,648 acres along Panther Creek and the Will M. Whittington Auxiliary Channel, north of Panther Swamp national wildlife refuge. The site has been planted in 1995, 1996, and 1997. The Big Twist site consists of wetlands in both the Flats and Riverine Backwater HGM subclasses.

Photo of Big Twist sampling plot, 1995 planting.

METHODS

HGM functional assessments were performed at each of the restoration sites using methodology outlined in the Yazoo Regional HGM Guidebook (Smith and Klimas, 2002). In addition, all trees within a sampling plot were counted and identified, regardless of size. Details of the protocol used in 2003 are similar to those outlined in the previous report provided to the Vicksburg District (Humphrey et al., in review). However, for the old sites (Big Twist and parts of Sky Lake), the number and location of some plots being sampled differed from the 2001 and 2002 samplings. It is expected that the plots established in 2003 will now be the ones resampled in subsequent years.

Sites were sampled between May and October, 2003. Because the Stock and portions of Sky Lake are new plantings, seedling survival was also determined at these sites.

Calculation of site FCI scores

In the Humphrey et al. (in review) report, site FCI scores were determined by calculating FCIs for individual plots (based on the metrics measured at that plot), then averaging the FCIs from these plots in order to obtain scores for the entire site. This method was used in order to make statistical comparisons of FCI scores between sampling years.

In this present report, FCI scores were not calculated for individual plots. Instead, the site FCI scores were determined by averaging metrics from the individual sample plots, then using these values to obtain one FCI score for the entire site.

Because the two methods of calculation can yield slightly different FCI scores, the method used in this report will be the one used in any future reports.

RESULTS

Standing seedling stems without leaves were observed in several of the sample plots at both the Stock and the 2003 Sky Lake sites. In some instances, these stems constituted the majority or even all of the trees in the plot. Although it is possible that these stems will still survive, they were not considered to be "live" trees at the time of sampling and thus were not included in the tree count when calculating seedling survival or tree composition at the site.

Stock

HGM results

The Stock site was sampled a few months after its initial planting in 2003. Functional Capacity Index (FCI) scores calculated for the Stock site are shown in table 1.

Function	FCI
Detain Floodwater	**0.1**
Detain Precipitation	**0.5**
Cycle Nutrients	**0.3**
Export Organic Carbon	**0.1**
Remove Elements & Compounds	**0.4**
Maintain Plant Communities	**0.5**
Provide Fish & Wildlife Habitat	**0**

Table 1. 2003 FCI scores for Stock restoration site, riverine backwater subclass.

Tree composition, density, and seedling survival

The Stock site was planted at a density of ~302 stems/acre. Mean density at the time of sampling was measured as 123 stems/acre (SD = 77 stems/acre), yielding a seedling survival rate of 40.7%. Of the trees counted, ~85% were various red oak species (*Quercus sp*.) and ~15% were green ashes (*Fraxinus pennsylvanica*).

Sky Lake

HGM results

The Sky Lake restoration site has been planted 3 times- in 1999, 2001, and 2003. The entire site was sampled a few months after its 2003 planting. FCI scores calculated for the 1999 and 2003 plantings are shown in tables 2 and 3, respectively. FCI scores for the 2001 planting were not calculated. For logistical reasons, only two plots in the 2001 planting area were sampled. In general, a minimum of 3 plots should be sampled in order to obtain a more accurate assessment.

Function	FCI
Detain Floodwater	**0.1**
Detain Precipitation	**0.5**
Cycle Nutrients	**0.3**
Export Organic Carbon	**0.1**
Remove Elements & Compounds	**0.4**
Maintain Plant Communities	**0.6**
Provide Fish & Wildlife Habitat	**0**

Table 2. 2003 FCI scores for Sky Lake restoration site, riverine backwater subclass, 1999 planting.

Function	FCI
Detain Floodwater	**0.1**
Detain Precipitation	**0.5**
Cycle Nutrients	**0.4**
Export Organic Carbon	**0.1**
Remove Elements & Compounds	**0.4**
Maintain Plant Communities	**0.6**
Provide Fish & Wildlife Habitat	**0**

Table 3. 2003 FCI scores for Sky Lake restoration site, riverine backwater subclass, 2003 planting.

Tree composition, density, and seedling survival

2003 planting

The 2003 Sky Lake addition was planted at a density of ~302 stems/acre. Mean density at the time of sampling was measured as 74 stems/acre (SD = 41 stems/acre), yielding a seedling survival rate of 24.5%. Of the trees counted, ~28% were various red oak species, ~47% were green ashes, and ~25% were bald cypresses (*Taxodium distichum*).

1999 planting

Mean density at the time of sampling was measured as 127 stems/acre (SD = 74 stems/acre). Because this is already an established planting, seedling survival was not calculated. Of the trees counted, ~68% were various red oak species (*Quercus sp*.), and ~25% were green ashes. Bald cypress, pecan (*Carya illinoisensis*) and water locust (*Gleditsia aquatica*) comprise the remaining 7%.

Big Twist

HGM results

The Big Twist site was planted in 1995, 1996, and 1997. FCI scores for each of these years (separated into riverine backwater and flats subclasses) are shown in tables 4, 5, and 6 respectively.

	FCI	
Function	*Riverine Backwater*	*Flats*
Detain Floodwater	**0.3**	
Detain Precipitation	**0.5**	**0.4**
Cycle Nutrients	**0.5**	**0.4**
Export Organic Carbon	**0.3**	
Remove Elements & Compounds	**0.7**	
Maintain Plant Communities	**0.5**	**0.3**
Provide Fish & Wildlife Habitat	**0**	**0**

Table 4. 2003 FCI scores for Big Twist restoration site (riverine backwater and flats subclasses), 1995 planting.

	FCI	
Function	*Riverine Backwater*	*Flats*
Detain Floodwater	**0.2**	
Detain Precipitation	**0.5**	**0.5**
Cycle Nutrients	**0.4**	**0.5**
Export Organic Carbon	**0.2**	
Remove Elements & Compounds	**0.7**	
Maintain Plant Communities	**0.5**	**0.3**
Provide Fish & Wildlife Habitat	**0**	**0**

Table 5. 2003 FCI scores for Big Twist restoration site (riverine backwater and flats subclasses), 1996 planting.

	FCI	
Function	*Riverine Backwater*	*Flats*
Detain Floodwater	**0.2**	
Detain Precipitation	**0.4**	**0.5**
Cycle Nutrients	**0.5**	**0.4**
Export Organic Carbon	**0.2**	
Remove Elements & Compounds	**0.5**	
Maintain Plant Communities	**0.5**	**0.4**
Provide Fish & Wildlife Habitat	**0**	**0**

Table 6. 2003 FCI scores for Big Twist restoration site (riverine backwater and flats subclasses), 1997 planting.

Tree composition and density

Because Big Twist is already an established site, survival was not calculated for any of the planting dates.

1995 planting

Flats

Mean density at the time of sampling was measured as 163 stems/acre (SD = 36 stems/acre). Of the trees counted there were ~42% various red oak species, ~27% green ashes, and ~12% bald cypresses. The remaining 19% consisted of pecan, persimmon (*Diospyros virginiana*), American elm (*Ulmus americana*), sycamore (*Platanus occidentalis*), sugarberry (*Celtis laevigata*), box elder (*Acer negundo*), buttonbush (*Cephalanthus occidentalis*), and eastern cottonwood (*Populus deltoides*), with none of these species comprising more than 5% of the total number of trees.

Riverine Backwater

Mean density at the time of sampling was measured as 259 stems/acre (SD = 162 stems/acre). Of the trees counted there were ~13% various red oak species, ~59% green ashes, ~12% bald cypresses, and ~10% persimmon. The remaining 6% consisted of American elm, sycamore, buttonbush, possum-haw (*Ilex decidua*) and sweetgum (*Liquidambar styraciflua*), with none of these species comprising more than 5% of the total number of trees.

1996 planting

Flats

Mean density at the time of sampling was measured as 283 stems/acre (SD = 98 stems/acre). Of the trees counted there were ~53% various red oak species, ~21% green ashes, ~12% buttonbush, ~9% American elm, 5% pecan, and < 1% water locust.

Riverine Backwater

Mean density at the time of sampling was measured as 182 stems/acre (SD = 130 stems/acre). Of the trees counted there were ~39% various red oak species and ~56% were green ashes. The remaining 5% consisted of bald cypress and red maple (*Acer rubrum*).

1997 planting

Flats

Mean density at the time of sampling was measured as 200 stems/acre (SD = 83 stems/acre). Of the trees counted there were ~86% various red oak species and ~10%. The remaining 4% consisted of buttonbush, sweetgum, and hackberry (*Celtis occidentalis*).

Riverine Backwater

Mean density at the time of sampling was measured as 287 stems/acre (SD = 35 stems/acre). Of the trees counted there were ~89% various red oak species and ~7% were green ashes. The remaining 4% consisted of bald cypress and persimmon.

DISCUSSION

Stock

HGM functional assessment

The initial HGM functional assessment results are in line with what would be expected for a reforested riverine backwater agricultural site with a 5-yr flood return interval within the first year post planting (Table 7). The "Maintain Plant Communities" function is slightly lower than expected because one of the sample plots contained no live seedlings.

Function	FCI
Detain Floodwater	**0.1**
Detain Precipitation	**0.5**
Cycle Nutrients	**0.3**
Export Organic Carbon	**0.1**
Remove Elements & Compounds	**0.4**
Maintain Plant Communities	**0.6**
Provide Fish & Wildlife Habitat	**0**

Table 7. Expected FCI scores for a reforested riverine backwater site in the first year following planting, using the following assumptions- a 5-yr flood return interval, 20% microtopography, and oak species as the dominant planted species.

Survival

Measured seedling density at the Stock site was approximately 41% of the 302 stem/acre planting density. Survival was particularly low in two plots located in the northwest corner of the site (with one of these plots having no standing live stems at all). As mentioned earlier in this report, stems with no leaves were not considered to be live trees and thus were not included in the count. However, it is still possible that these stems will exhibit new growth in the second year, thus resulting in a higher survival rate. Depending on what the District's acceptable or desired seedling survival rate is, it may be necessary to re-check or re-plant certain areas of the site in the near future.

Sky Lake

HGM functional assessment

FCI scores calculated for the 2003 Sky Lake site are identical to the expected scores listed in table 7. Scores for the 1999 planting are similar to the 2003 numbers, except for the "Remove Elements and Compounds" function, which is 0.1 lower in 1999. This is attributable a lower ground vegetation cover subindex score in 1999.

Survival

Measured seedling density at the 2003 stock site was approximately 25% of the 302 stem/acre planting density. Survival did not appear to be particularly higher or lower in any one area of the site. Current tree density at the 2003 site is only about 60% of that measured at the 1999 planted site. A 25% survival rate seems to be a less than desirable result, and the site may need to be rechecked/replanted in the near future.

Big Twist

HGM functional assessment

Based on both visual observations in the field and the calculated FCI scores, functional recovery at all planting dates of the Big Twist site appears to be progressing fairly well, although there was a fair amount of variety among plots in terms of tree and shrub density (as evidenced by the large standard deviations in tree density seen in some areas) and thickness/growth of the underlying herbaceous layer. At this stage, the "Provide Fish and Wildlife Habitat" function still has a score of "0" since there were no observed stems > 4 in. dbh (necessary to obtain a score > 0 for this function), although a few trees were observed to be nearing this size.

FCI scores among the three years are similar for both riverine backwater and flats classes, although the oldest (1995) site has the highest overall scores in the riverine backwater subclass, but the lowest overall scores in the flats subclass. The higher 1995 FCI scores in the riverine backwater subclass are due largely to greater sections of that planting area being located in the 2-yr floodplain than the 1996 and 1997 planting areas, which directly influences the "Detain Floodwater", "Export Organic Carbon", and "Remove Elements and Compounds" functions. The lower FCI scores for the 1995 flats subclass are a result of lower subindex scores for the shrub/sapling density and 'O' horizon variables, although the ultimate cause affecting these numbers is unknown.

REFERENCES

Humphrey, M.N., Lin, J.P., Kleiss, B.A., and Evans, D.E. (In review). "Monitoring Wetland Functional Recovery of Reforested Bottomland Hardwood Sites in the Yazoo Basin, MS."

Smith, R.D., and Klimas, C.V. (2002). "A regional guidebook for applying the hydrogeomorphic approach to assessing wetland functions of selected regional wetland subclasses, Yazoo Basin, Lower Mississippi River Alluvial Valley," ERDC/EL TR-02-4, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

ERDC/EL TN-04-01
March 2004

US Army Corps of Engineers®

Monitoring Wetland Functional Recovery of Bottomland Hardwood Sites in the Yazoo Basin, MS

by Monica N. Humphrey, Jeff P. Lin, Barbara A. Kleiss, and Darrell E. Evans

PURPOSE: The U.S. Army Corps of Engineers (USACE) Vicksburg District has the task of mitigating functions of bottomland hardwood (BLH) wetland forests in Mississippi lost as a result of the construction of various water resource projects. To date, the Vicksburg District has reforested almost 20,000 acres of BLH forest. This technical note reports on early functional recovery and monitoring at several of these sites, utilizing methodology based on "The Regional Guidebook for Conducting Functional Assessments Based on Hydrogeomorphic (HGM) Classification and Reference Wetlands for Selected Wetland Subclasses in the Yazoo Basin, Lower Mississippi River Alluvial Valley, USA" (Smith and Klimas 2002).

BACKGROUND: Since 1991, the Vicksburg District has replanted about 18,000 acres of bottomland hardwood (BLH) forest at five sites within the Yazoo Basin. This mitigation entailed planting mast-producing species such as oaks and hickories on frequently flooded former agricultural land. Because of flood frequency, these areas possess the hydric soils and sufficient hydrology necessary for the development of a functional BLH forest.

Assessing wetland functions as they develop in newly reforested areas is essential in order to determine if current methods of mitigation are accomplishing the goal of full wetland functional recovery. When measuring functions, it is desirable to have a standard methodology that is not too time-consuming or expensive to implement, but is also sensitive enough to detect a change in wetland functions over time. Generally, the most cost-effective, time-efficient and replicable option is the use of indirect indicators. These indicators convey information about the performance of a given function based on an indirect measure of that function. Indicators are most often used instead of direct measures, which are usually too time-consuming and expensive to carry out for monitoring purposes. One such methodology that uses indirect indicators is the hydrogeomorphic (HGM) functional assessment approach.

The purpose of this study was to perform a preliminary functional assessment of the Vicksburg District BLH mitigation sites. This assessment was carried out utilizing models and methods from a regional HGM guidebook developed for the Yazoo Basin (Yazoo Regional Guidebook) by Smith and Klimas (2002).

STUDY AREA: Monitoring was carried out at five mitigation sites (Figure 1) of various sizes and ages, located within the Yazoo Basin, Mississippi, and described as follows:

Lake George. Located in Yazoo County between the Delta National Forest and Panther Swamp National Wildlife Refuge, this is the largest of the planted tracts at a total of 8,383 acres. The site has had eight planting dates from 1991 to 1998, covering 7,668 acres. Initial plantings at this site

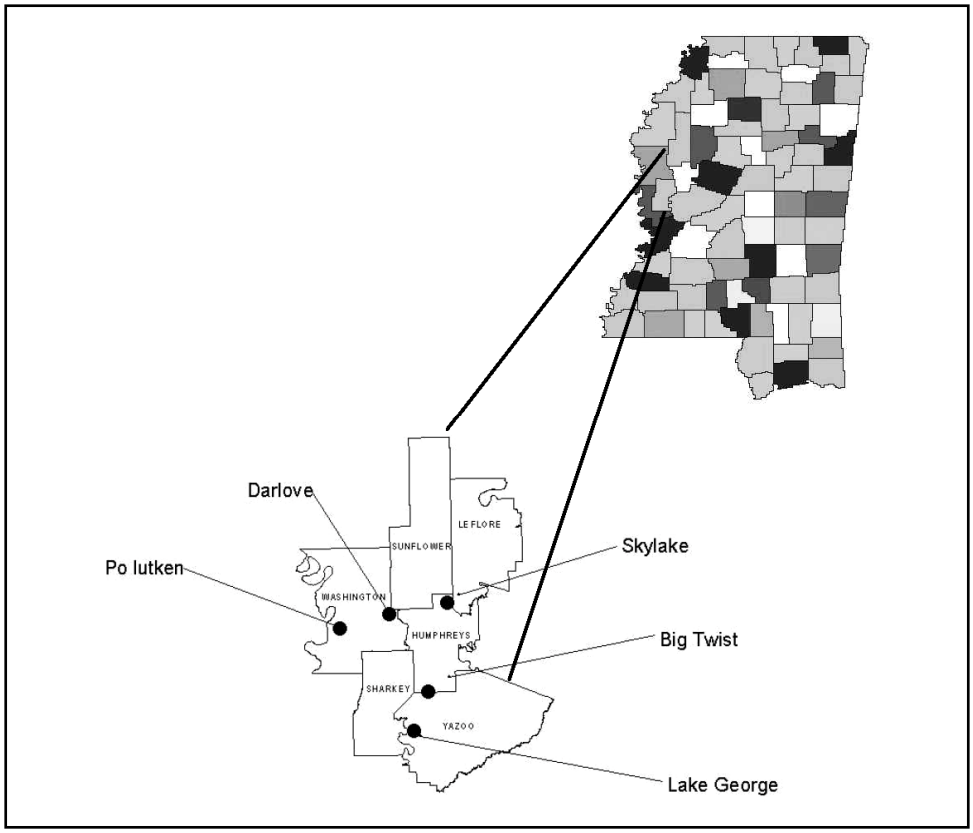


Figure 1. Location of mitigation sites in the Yazoo Basin, Mississippi

consisted of a combination of 1-0 bareroot, direct seeding and container-grown planting stock. The later plantings beginning in 1993 consisted of 1-0 bareroot and container stock only. Species planted include red oaks (*Quercus* spp.), bald cypress (*Taxodium distichum*), green ash (*Fraxinus pennsylvanica*), pecan (*Carya illinoensis*), sycamore (*Platanus occidentalis*), and water tupelo (*Nyssa aquatica*).

Big Twist. This is the second-largest tract and is located in Yazoo and Humphreys Counties. It is 6,648 acres in size and is partially bordered by Panther Swamp National Wildlife Refuge and The Will M. Whittington Canal. Seedlings planted at this site consisted only of 1-0 bareroot and container-grown seedlings, with planting beginning in 1995 and ending in 1998. A total of 5,610 acres have been planted with red oaks, bald cypress, pecan, and sycamore.

Darlove Mitigation Site. This is a 518-acre tract located in Washington County, bordered by the Bogue Phalia. The tract was planted in the 1998-1999 planting season, with a total of 490 acres of both 1-0 bareroot and container-grown seedlings. Species planted at the site include red oaks, bald cypress, and green ash.

Polutken Mitigation Site. This site is also located in Washington County. It is 333 acres in total size, with 296 acres hand planted with container seedlings in 1997. Planted species include various red oaks and bald cypress.

Skylake Mitigation Site. This site is located in Humphreys County. It consists of 2,420 acres planted with bare root seedlings in 1999. Species planted include red oaks and bald cypress.

SITE CLASSIFICATION: Since HGM functional assessment models are specific to a particular wetland subclass, it is necessary to classify sites before the model can be applied. The HGM methodology classifies wetlands based on geomorphic setting, water source, and hydrodynamics (Brinson 1993). The Yazoo Regional Guidebook identifies and describes seven regional HGM subclasses in the Yazoo Basin. Of these seven, four are found in the Vicksburg District mitigation sites: Riverine Backwater, Isolated Depressions, Connected Depressions, and Flats. Brief descriptions of each of the four subclasses follow:

Riverine Backwater. This wetland subclass is subjected to backwater flooding occurring at a frequency of five years or less. Backwater flooding is defined as inundation resulting from impeded drainage due to high water in downstream systems. Distinctive characteristics of the subclass include:

- Direct connection to a channel system with a flood frequency of at least 5 years.
- On-site flooding is a result of backwater, as opposed to overbank, flow.
- Floodwater drains back into the channel, rather than being retained on site in depressions.

This subclass supports a variety of community types and can occur on various substrates. Typical species include green ash and Nuttall oak (*Quercus nuttallii*).

Isolated Depressions. Depressions tend to occur on abandoned channels and courses and large point bar swales. Isolated depressions are not directly connected to a stream system, but receive and detain water from precipitation and surface and subsurface flows. Because of their size and depth, they are able to hold this water for extended periods of time, and dry very slowly. This wetland subclass usually exhibits two or more of the following attributes:

- Loamy gleyed matrix or hydrogen sulfide aroma hydric soil indicators.
- Topographic depression with the Dowling or Tunica soils.
- Significant vegetative component of one or more of the following: bald cypress, swamp tupelo (*Nyssa aquatica*), swamp privet (*Foresteria accuminata*), water elm (*Planera aquatica*), or buttonbush (*Cephalanthus occidentalis*).

Connected Depressions. This wetland subclass has the same characteristics as the isolated depressions subclass; however, these depressions are connected to a stream system, giving them an additional source of water.

Flats. Flats are primarily precipitation-driven systems. They can occur on a variety of depositional surfaces, but are most characteristic of point bar deposits. They tend to be the driest of the subclasses, with shagbark hickory (*Carya ovatica*) and water oak (*Quercus nigra*) as characteristic species.

WETLAND FUNCTIONS: Smith and Klimas (2002) identify seven functions that are performed by wetlands in the Yazoo Basin:

- Detain floodwater.
- Detain precipitation.
- Cycle nutrients.
- Export organic carbon.
- Remove elements and compounds.
- Maintain plant communities.
- Provide fish and wildlife habitat.

However, not all functions are assessed for, or performed by each subclass (Table 1). A brief description of each of the functions follows:

Detain Floodwater. This function is the capacity of a wetland to store, convey, and reduce the velocity of floodwater. It is assessed by estimating "roughness" within the wetland, as well as flood frequency.

Detain Precipitation. This function is the ability of a wetland to prevent or slow runoff of rainfall to streams. The function is assessed by estimating micro-depressions storage and organic surface layer available to improve absorption and infiltration.

Cycle Nutrients. This function is the ability of a wetland to convert nutrients from inorganic to organic forms and back. It is assessed by measuring components of living and dead organic material in the wetland.

Table 1
Functions Assessed for Each of the Wetland Subclasses Found at the Yazoo BLH Mitigation Sites

Function	Wetland Subclass			
	Riverine Backwater	Connected Depression	Isolated Depressions	Flats
Detain floodwater	X	X		
Detain precipitation	X			X
Cycle nutrients	X	X	X	X
Export organic carbon	X	X		
Remove elements and compounds	X	X		
Maintain characteristic plant community	X	X	X	X
Provide fish and wildlife habitat	X	X	X	X

Export Organic Carbon. This function is the ability of the wetland to export dissolved and particulate organic carbon. It is assessed by measuring the presence of movable organic material and flood frequency.

Remove Elements and Compounds. This function is the ability of a wetland to permanently remove or temporarily immobilize elements and compounds such as macronutrient or heavy metals that are imported into the wetland. It is assessed using indicators of the clay and organic components of the soil, and flood frequency.

Maintain Plant Communities. This function is the ability of the wetland to provide an environment necessary to develop and maintain a plant community characteristic of the system. It is assessed using various indicators of soil, hydrologic, and vegetative characteristics of the site.

Provide Fish and Wildlife Habitat. This function is the ability of a wetland to support fish and wildlife species that utilize wetlands during some part of their life cycle. It is assessed using indicators of habitat availability and landscape integrity.

METHODS: Sampling at the mitigation sites occurred during 2000-2002.

Sampling Year 2000. The initial phase of the project involved establishing permanent monitoring plots at each mitigation site. Five rectangular 0.04-ha plots were established within each planting date at each site. A GPS reading was taken at the center of each plot for documentation and mapping purposes. Various baseline vegetation data were collected, although these data are not used in the HGM analysis.

Sampling Year 2001. The second phase of the project began with the completion in February 2001 of documentation needed to measure the indicator metrics used in the HGM functional assessment models. In the spring of 2001, a two-member sampling team visited the mitigation sites and began collecting metrics following the systematic procedure listed below:

- Identification of wetland subclass. Identifying the wetland subclass(es) in the project areas involved using a dichotomous key from the Yazoo Regional Guidebook and information from Saucier (1994). The GPS points collected from the permanent plots established in 2000 were incorporated into an ArcView GIS database and used to create a map that displayed the location of sampling plots in reference to flood frequency, soil series, and land use and land cover. Information from this map was used for initial classification of the mitigation sites.
- Define the assessment areas. The wetland assessment area (WAA) is an area of wetland within a project area that belongs to a single regional wetland subclass and is relatively homogeneous with respect to the criteria used to assess wetland functions (i.e., hydrologic regime, vegetation structure, topography, soils, successional stage). In many areas, there will be just one WAA. However, as the size and heterogeneity of the site increase, it is more likely that it will be necessary to define and assess multiple WAAs within a project area.
- Collect field data. Variables and metrics used to assess the wetland functions are collected at several different spatial scales. Data Form 1 (Figure 2) is organized so as to facilitate data collection at each of these spatial scales. For example, the first group of variables, which includes VTRACT, contains information about landscape-scale characteristics collected using aerial photographs, maps, and field reconnaissance of the area surrounding the WAA. Information on the second group of variables, which includes VPOND, is collected during a walking reconnaissance of the WAA. Data collected for these two groups of variables are entered directly into the data form. Information on the next group of variables is collected in sample plots and along transects placed in representative locations throughout the WAA.

  In collecting the metrics, two 0.04-ha circular plots were established. One subplot was located in the center of the permanent plot and the other 100 m outside the permanent plot. In some instances because of the heterogeneity of the site, additional WAAs were established. GPS readings were taken at the center of each plot for map production and verification of subclass classification.

Data Form 1: Functional Assessment in the Yazoo Basin		
Assessment Team:	**Regional Subclass:**	
Project Name / Location:	**Date:**	
Sample the following variables using field reconnaissance, aerial photos, topographic maps, or GIS		
V_{TRACT}	Size of forested wetland that is contiguous with the assessment area	ha
V_{CORE}	Size of wetland tract that is core area	ha
$V_{CONNECT}$	Percent of wetland tract that is connected to "suitable habitat"	%
V_{FREQ}	Overbank flood recurrence interval	years
Sample the following variables based on a walking field reconnaissance of the assessment area		
V_{POND}	Percent of the assessment area with topographic microdepressions that pond water	%
V_{SOIL}	Percent of the assessment area with native and culturally unaltered soils	%
V_{CEC}	Percent difference in CEC in assessment area (from Data Form 2)	%
Transfer plot values for the following variables to this sheet from the Data Forms 3-6		
V_{TBA}	Average tree basal area plot values below (Data Form 3) and record at right Plot 1 ____ m^3/ha Plot 2 ____ m^3/ha Plot 3 ____ m^3/ha	m^2/ha
V_{TDEN}	Average tree density plot values below (Data Form 3) and record at right Plot 1 __ stems/ha Plot 2 __ stems/ha Plot 3 __ stems/ha	stems/ha
V_{SNAG}	Average snag density plot values below (from Data Form 3) and record at right Plot 1 __ stems/ha Plot 2 __ stems/ha Plot 3 __ stems/ha	stems/ha
V_{TCOMP}	Average percent concurrence with dominant trees plot values below (Data Form 4), and record at right Plot 1 ___ % Plot 2 ___ % Plot 3 ___ %	%
V_{COMP}	Average percent concurrence with dominant species in tallest woody stratum plot values below (Data Form 4), and record at right Plot 1 ___ % Plot 2 ___ % Plot 3 ___ %	%
V_{WD}	Average volume of woody debris plot values below (Data Form 5), and record at right Plot 1 ____ m^3/ha Plot 2 ____ m^3/ha Plot 3 ____ m^3/ha	m^3/ha
V_{LOG}	Average volume of log plot values below (Data Form 5), and record at right Plot 1 ____ m^3/ha Plot 2 ____ m^3/ha Plot 3 ____ m^3/ha	m^3/ha
V_{SSD}	Average density of shrub-sapling strata plot values below (Data Form 6), and record at right Plot 1 __ stems/ha Plot 2 __ stems/ha Plot 3 __ stems/ha	stems/ha
V_{GVC}	Average ground vegetation cover plot values below (Data Form 6), and record at right Plot 1 ___ % Plot 2 ___ % Plot 3 ___ %	%
V_{OHOR}	Average thickness of "O" horizon cover plot values below (Data Form 6), and record at right Plot 1 ___ cm Plot 2 ___ cm Plot 3 ___ cm	cm
V_{AHOR}	Average thickness of "A" horizon cover plot values below (Data Form 6), and record at right Plot 1 ___ cm Plot 2 ___ cm Plot 3 ___ cm	cm

Figure 2. Data sheet showing metrics collected at each site (Smith and Klimas 2001)

The sites sampled were all less than 15 years old; therefore several of the variables were not measured. Identification of highest strata present within the plot was the initial step following plot layout. Species were identified and dbh was measured on saplings. Herbaceous vegetation cover was estimated using a 1-m^2 plot at two locations within each sub-plot. The "O" horizon was measured within each of these plots and the "A" horizon was measured at one of the selected subplots. Woody debris was measured along a 15-m transect that began in subplot center. Shrub-sapling density was measured within each subplot on trees with dbh <10 cm and greater than 1.2 m in height. On average, it would take a two-person crew about half an hour to an hour to collect all of the necessary data at each plot.

- Analysis of field data. The raw metrics data were converted into scaled variable scores ranging from 0.0-1.0. These variable scores were then inserted into various Functional Capacity Index (FCI) equations, yielding an FCI score for each function. The FCI score is a value from 0.0-1.0 and is a relative indicator of the capacity of a wetland to perform the given function as compared to other wetlands in an identical regional subclass. The graphs used to scale individual variables and the equations used to calculate FCIs are published in the Yazoo Regional Guidebook.

Sampling Year 2002. As part of a rotational sampling schedule, the Lake George (all planting dates) and Big Twist (1995 planting date) sites were resampled during the summer of 2002. The sampling occurred in the same 0.04-ha plots established in 2001, although a few plots were not resampled for logistical reasons. The only changes in the 2002 sampling protocol were that dbh was only measured for saplings ≥4 in. dbh, and the "A" horizon was not measured, as this value is assumed to have remained constant from the previous year.

RESULTS AND DISCUSSION:

2001 Sampling, Lake George. The Lake George mitigation area contains sites consisting of seven different planting dates in the riverine backwater. Table 2 summarizes the Lake George FCI scores by planting date. In this and subsequent tables and text, the following abbreviations are used for each function:

FCI_{FLOOD} = Detain Floodwater
FCI_{RAIN} = Detain Precipitation
FCI_{NUTR} = Cycle Nutrients
FCI_{ORG} = Export Organic Carbon
FCI_{ELEM} = Remove Elements and Compounds
FCI_{PLANT} = Maintain Characteristic Plant Community
FCI_{FISH} = Provide Fish and Wildlife Habitat

Planting dates were compared statistically using a one-way ANOVA (differences considered significant if $p < 0.05$). There are some significant differences in function among the 1992 to1995 planting dates, but for the most part, functional scores did not vary significantly among the various planting dates.

Table 2
Summary of FCI Scores for Various Planting Dates/Wetland Subclasses at the Lake George Mitigation Site[1]

Function	Planting Date						
	1991	1992	1993	1994	1995	1996	1997
FCI_{FLOOD}	$0.26^{a,b}$	$0.26^{a,b}$	0.38^{a}	0.20^{b}	$0.22^{a,b}$	$0.26^{a,b}$	$0.29^{a,b}$
FCI_{RAIN}	0.40^{a}	0.44^{a}	0.52^{a}	0.48^{a}	0.50^{a}	0.50^{a}	0.42^{a}
FCI_{NUTR}	$0.38^{a,b}$	$0.39^{a,b}$	0.45^{a}	$0.35^{a,b}$	0.32^{b}	$0.38^{a,b}$	$0.39^{a,b}$
FCI_{ORG}	0.28^{a}	0.29^{a}	0.35^{a}	0.25^{a}	0.22^{a}	0.28^{a}	0.29^{a}
FCI_{ELEM}	0.84^{a}	0.88^{a}	0.87^{a}	0.88^{a}	0.80^{a}	0.84^{a}	0.83^{a}
FCI_{PLANT}	$0.52^{a,b}$	0.49^{a}	$0.55^{a,b}$	$0.57^{a,b}$	0.62^{b}	$0.56^{a,b}$	$0.53^{a,b}$
FCI_{FISH}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}

[1] Values in the same row followed by the same letter(s) are statistically similar ($p > 0.05$).

2001 Sampling, Big Twist. The Big Twist mitigation site contains sites consisting of three different planting dates and two wetland subclasses (riverine backwater and flats). Table 3 summarizes the Big Twist FCI scores by planting date for both the flats subclass and the riverine backwater subclass. Statistical comparisons were again made using a one-way ANOVA. Overall, the 1995 planting appears to have the highest level of functioning. This is attributable to large portions of the 1995 planting being located in the 1- and 2-year floodplains, which resulted in a significant functional lift in the FCI_{FLOOD}, FCI_{ORG}, and FCI_{ELEM} functions over the 1996 and 1997 planting dates, which were located primarily in the 3- to 5-yr floodplain. Functions among the flats, however, were statistically similar across the three planting dates.

Table 3
FCI Scores for Various Planting Dates/Wetland Subclasses at the Big Twist Mitigation Site[1]

Function	1995	1996	1997
Riverine Backwater Subclass			
FCI_{FLOOD}	0.28^{a}	0.10^{b}	0.12^{b}
FCI_{RAIN}	0.58^{a}	0.26^{b}	0.60^{a}
FCI_{NUTR}	0.46^{a}	0.42^{a}	0.44^{a}
FCI_{ORG}	0.30^{a}	0.10^{b}	0.12^{b}
FCI_{ELEM}	0.74^{a}	0.19^{b}	0.33^{b}
FCI_{PLANT}	0.48^{a}	0.53^{b}	0.61^{b}
FCI_{FISH}	0.00^{a}	0.00^{a}	0.00^{a}
Flats Subclass			
FCI_{RAIN}	0.60^{a}	0.56^{a}	0.56^{a}
FCI_{NUTR}	0.40^{a}	0.41^{a}	0.46^{a}
FCI_{PLANT}	0.30^{a}	0.43^{a}	0.42^{a}
FCI_{FISH}	0.00^{a}	0.00^{a}	0.00^{a}

[1] Values in the same row followed by the same letter(s) are statistically similar ($p > 0.05$).

2001 Sampling, Darlove, Skylake, Polutken. The Darlove, Skylake, and Polutken mitigation areas are all single planting date sites. Table 4 summarizes the FCI scores for each of these sites by wetland subclass.

2002 Sampling. Tables 5 and 6 are comparisons of FCI scores between the 2001 and 2002 planting dates at the Lake George and Big Twist mitigation sites. Statistical comparisons were made using a two sample T- test (differences significant if a two-tailed $p < 0.05$).

Although some planting dates at both sites showed significant increases in specific functions, for the most part functional index scores were similar between the 2001 and 2002 samplings.

Table 4
FCI Scores for Various Planting Dates/Wetland Subclasses at the Darlove, Polutken, and Skylake Mitigation Sites

Darlove, 1998		
	Wetland Subclass	
Function	Flats	Connected Depressions
FCI_{FLOOD}		0.01
FCI_{RAIN}	0.48	
FCI_{NUTR}	0.35	0.03
FCI_{ORG}		0.01
FCI_{ELEM}		0.50
FCI_{PLANT}	0.36	0.71
FCI_{FISH}	0.00	0.00

Polutken, 1998		
	Wetland Subclass	
Function	Flats	Isolated Depressions
FCI_{FLOOD}		
FCI_{RAIN}	0.67	
FCI_{NUTR}	0.30	0.10
FCI_{ORG}		
FCI_{ELEM}		
FCI_{PLANT}	0.27	0.20
FCI_{FISH}	0.00	0.00

Skylake, 1999			
	Wetland Subclass		
Function	Flats	Connected Depressions	Riverine Backwater
FCI_{FLOOD}		0.16	0.26
FCI_{RAIN}	0.48		0.42
FCI_{NUTR}	0.32	0.13	0.33
FCI_{ORG}		0.11	0.24
FCI_{ELEM}		0.83	0.56
FCI_{PLANT}	0.40	0.71	0.50
FCI_{FISH}	0.00	0.00	0.00

Wetland Functional Recovery. Tables 1-4 report functional capacity of the sites as of 2001. However, in order to determine *changes* in functioning, these values need to be compared to functional capacity of the sites prior to restoration. Because no baseline HGM data were collected at the sites before they were restored, certain assumptions need to be made about the condition of sites prior to planting. Prior to restoration, it is assumed that values for shrub-sapling density, ground vegetation cover, small woody debris volume, and organic horizon depth are all zero. In the early years following restoration, changes in these metrics should be the primary force driving increases in function. Any metric relating to trees (trees defined as individuals >4 in. dbh) is also assumed to have a value of zero prior to restoration. For the most part, as of 2001 these values remain at zero since sites are still not old enough to have trees >4 in. dbh. Finally, because no hydrologic or topographic modifications were made at any of the sites, it is assumed that metrics such as soil integrity, microdepressional ponding, and flood frequency were the same prior to planting as they

Table 5
Comparison of FCI Scores Between Sampling Years for the 1995 Planting Date at the Big Twist Mitigation Site[1]

	Wetland Subclass			
	Flats		Riverine Backwater	
	Sampling Date			
Function	2001	2002	2001	2002
FCI_{FLOOD}			0.28	0.30
FCI_{RAIN}	0.60	0.60	0.58	0.58
FCI_{NUTR}	0.40	0.50	0.46	0.52
FCI_{ORG}			0.30	0.34
FCI_{ELEM}			0.74	0.74
FCI_{PLANT}	0.30	0.33	0.48	0.48
FCI_{FISH}	0.00	0.00	0.00	0.00

[1] For each subclass, values in the same row in bold type are statistically different ($p < 0.05$).

Table 6
Comparison of FCI Scores Between Sampling Years at the Lake George Mitigation Site[1]

	Planting Date													
	1991		1992		1993		1994		1995		1996		1997	
	Sampling Year													
Function	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
FCI_{FLOOD}	0.26	0.25	0.26	0.34	0.22	0.26	0.26	0.26	0.29	0.33	0.38	0.42	0.20	0.30
FCI_{RAIN}	0.40	0.38	0.44	0.44	0.50	0.50	0.50	0.50	0.42	0.42	0.52	0.56	0.48	0.50
FCI_{NUTR}	0.38	0.35	0.39	0.43	0.32	0.42	0.38	0.38	0.39	0.42	0.45	0.46	0.35	0.40
FCI_{ORG}	0.28	0.28	0.29	0.33	0.22	0.34	0.28	0.28	0.29	0.33	0.35	0.36	0.25	0.30
FCI_{ELEM}	0.84	0.85	0.88	0.88	0.80	0.80	0.84	0.84	0.83	0.82	0.87	0.88	0.88	0.88
FCI_{PLANT}	0.52	0.50	0.49	0.50	0.62	0.58	0.56	0.52	0.53	0.52	0.55	0.56	0.57	0.54
FCI_{FISH}	0.00	0.05	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02

[1] For each planting date, values in bold type in the same row are statistically different ($p < 0.05$).

are today. Based on these assumptions, it is possible to calculate FCI scores for the sites prior to replanting. Table 7 shows the differences between these scores and those calculated for 2001 (for Lake George and Big Twist, the average scores across planting dates were used) for each site, by subclass. Because they are largely dependent on vegetation-related metrics (which are the variables more likely to change early on) the largest increases are seen in the FCI_{PLANT}, followed by the FCI_{NUTR} and FCI_{FLOOD} functions.

Larger increases in the FCI_{NUTR}, FCI_{ORG}, FCI_{FISH}, and FCI_{PLANT} functions can be expected once sites are old enough to contain trees (>4 in. dbh). In particular, the FCI_{FISH} function requires either trees or snags in order to have any value >0.0. Smaller increases are expected in the FCI_{FLOOD}, FCI_{RAIN}, and FCI_{ELEM} functions, since measurement of these functions involves variables (such as flood frequency) that are less likely to change over time. However, in some cases (FCI_{ELEM} in the Sky Lake connected depressions, for instance) these functions are already being performed at a relatively high level.

Table 7
Differences in FCI Between 2001 and Pre-planting at Each Mitigation Site ((FCI 2001) – (FCI pre-planting))[1]

	Mitigation Site									
	Lake George	Big Twist		Darlove		Polutken		Skylake		
	Wetland Subclasses									
Function	Riverine Backwater	Flats	Riverine Backwater	Flats	Connected Depressions	Flats	Isolated Depressions	Flats	Riverine Backwater	Connected Depressions
FCI_{FLOOD}	0.3		0.2		0				0.3	0.2
FCI_{RAIN}	0.1	0.2	0.1	0		0		0	0	
FCI_{NUTR}	0.2	0.2	0.2	0.2	0	0.1	0.1	0.2	0.2	0.1
FCI_{ORG}	0.1		0.2		0				0.1	0.1
FCI_{ELEM}	0.1		0		0				0	0
FCI_{PLANT}	0.6	0.4	0.5	0.4	0.7	0.3	0.2	0.4	0.6	0.7
FCI_{FISH}	0	0	0	0	0	0	0	0	0	0

[1] Values have been rounded to the nearest first decimal point.

Figure 3 shows the projected functional recovery over a period of 60 years for a hypothetical restored riverine backwater site. These curves are based on recovery trajectories for tree basal area, tree, shrub-sapling, and snag density, ground vegetation cover, log and woody debris volume, and 'O' horizon depth, published in the Yazoo Regional Guidebook, and are derived from data collected at actual sites. The curves are also based on the assumption that the site is at least 3000 ha with a minimum of 40 percent core area and 40 percent connectivity to other wildlife habitat. It is also assumed that the composition of tree species does not alter significantly from what was originally planted, and that the site is within the 2-year floodplain.

Table 8 compares the FCI scores of the 5- and 10-year-old (as of 2002) Lake George plantings with the projected 5- and 10-year FCI scores depicted in Figure 3. At the 5-year-old site, the actual FCI values generally exceed the projected values, with the exception of the FCI_{PLANT} function (due to the planted tree composition at the actual site, as well as the introduction of some volunteer species). However, scores at the 10-year-old planting tended to be slightly lower than the projected values, which is due primarily to a lower-than-projected shrub-sapling density.

CONCLUSIONS: Monitoring of restoration projects is critical for determining whether or not recovery of desirable wetland functions is occurring at a given site. The HGM method as presented in this technical note allows for functional assessment to occur in an effective and cost-efficient manner. The method is also sensitive enough that it can detect functional changes in a single year (Table 6).

Results from preliminary monitoring efforts indicate that functional recovery is occurring at the Vicksburg District wetland mitigation sites (Table 7), although some functions are recovering more rapidly than others. Based on Figure 3, it is expected that sites will continue to show a sharp and rapid increase in function between 10 and 20 years of age, and by age 40 will achieve near full functional recovery (FCI = 1.0) of the cycle nutrients, detain precipitation, maintain plant community, and provide fish and wildlife habitat functions. The other functions may or may not

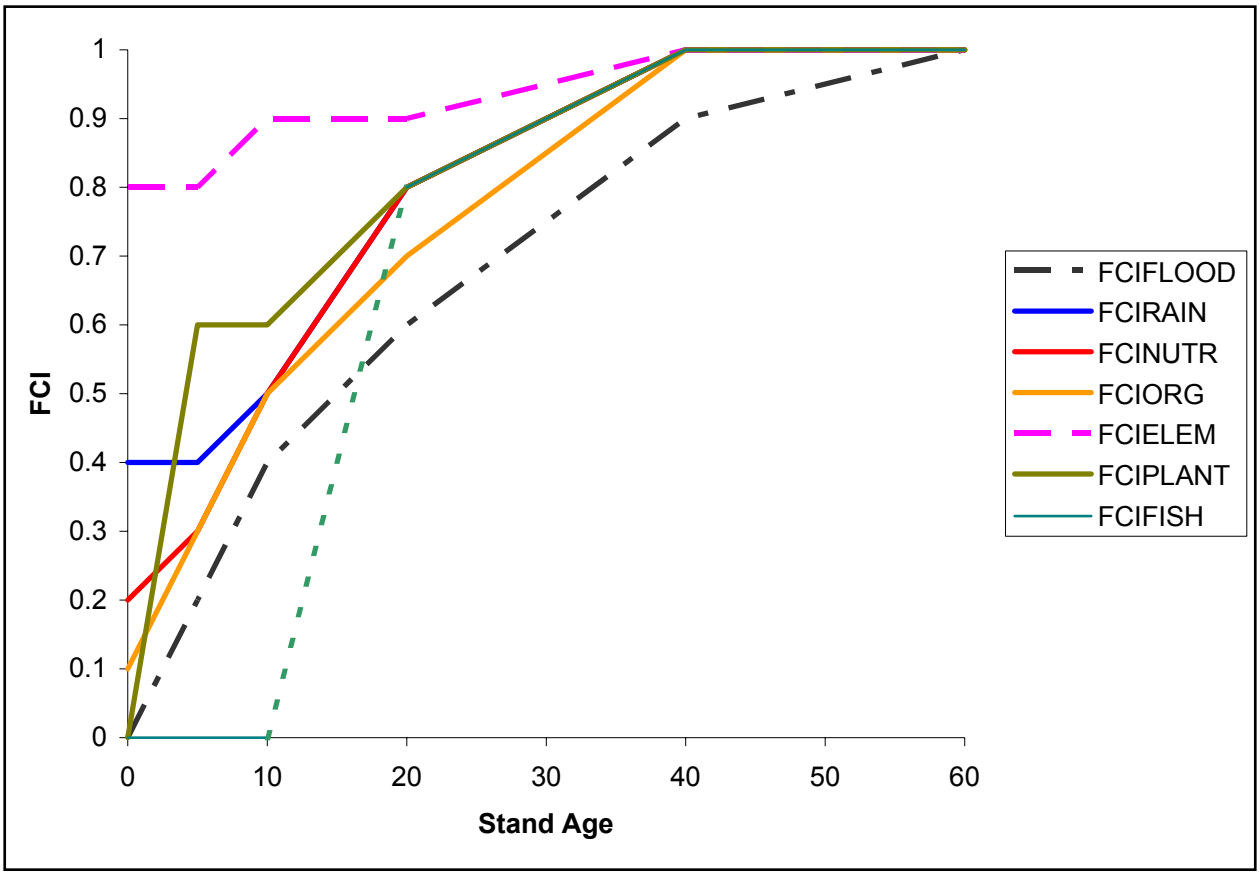


Figure 3. Functional recovery trajectories of a hypothetical riverine backwater restoration site

Table 8
Comparison of FCI Scores From Lake George and a Hypothetical Riverine Backwater Restoration Site at 5 and 10 Years After Planting

Function	5 Years Old		10 Years Old	
	Actual	Projected	Actual	Projected
FCI_{FLOOD}	0.33	0.2	0.34	0.4
FCI_{RAIN}	0.42	0.4	0.44	0.5
FCI_{NUTR}	0.42	0.3	0.43	0.5
FCI_{ORG}	0.33	0.3	0.33	0.5
FCI_{ELEM}	0.82	0.8	0.88	0.9
FCI_{PLANT}	0.52	0.6	0.5	0.6
FCI_{FISH}	0	0	0.06	0

reach full recovery (or may not be performed at all in he case of Flats and Isolated Depression subclasses), depending on the flood frequency at each site. However, since these sites are still relatively young, continued monitoring is necessary in order to ensure that functional recovery is still occurring as expected.

POINTS OF CONTACT: This technical note was written by Ms. Monica N. Humphrey at the USACE, Vicksburg District, and Mr. Jeff P. Lin, Dr. Barbara A. Kleiss, and Mr. Darrell E. Evans at the Engineer Research and Development Center, Vicksburg, MS. For additional information, contact Mr. Lin (601-634-2068, Jeff.P.Lin@erdc.usace.army.mil). This technical note should be cited as follows:

> Humphrey, M. N., Lin, J. P., Kleiss, B. A. and Evans, D. E. (2004). "Monitoring Wetland Functional Recovery of Bottomland Hardwood Sites in the Yazoo Basin, MS," *WRAP Technical Notes Collection* (ERDC/EL TN-04-01). U.S. Army Engineer Research and Development Center, Vicksburg, MS.

REFERENCES

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

Saucier, R.T. (1994). "Geomorphology and quaternary geologic history of the Lower Mississippi Valley," Vol I (report), Vol II (map folio), U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Smith, R.D., and Klimas, C.V. (2002). "A regional guidebook for applying the hydrogeomorphic approach to assessing wetland functions of selected regional wetland subclasses, Yazoo Basin, Lower Mississippi River Alluvial Valley," ERDC/EL TR-02-4, U.S. Army Engineer Research and Development Center, Vicksburg, MS.