ABSTRACT

RANDOLPH, HENRY ANTHONY. Evaluation of Shoreline Plantings for Wetland Mitigation at Coddle Creek Reservoir in Piedmont North Carolina. (Under the direction of E. Carlyle Franklin and Douglas J. Frederick.)

Wetland mitigation provides a method of compensating for loss of vital wetland functions while allowing unavoidable wetland degradation. Coddle Creek Reservoir, located in northwest Cabarrus County, North Carolina, is in its final stages of development as a drinking water supply for nearby municipalities experiencing dramatic population increases. Approximately 356 acres of shoreline plantings were installed to mitigate wetland losses associated with development of the reservoir. Recently, considerable controversy has developed over mitigation projects and their effectiveness in replacing wetland functions. The objective of this study was to evaluate the mitigation plantings at Coddle Creek Reservoir by comparing them to naturally developed shoreline vegetation at a nearby reservoir. Results will be used for long-range management of vegetation at Coddle Creek as well as future reservoir construction projects.

Vegetation, soil, and hydrologic data were collected at Mountain Island Lake to determine natural community development along reservoir shorelines. Natural succession has created distinct community types progressing from the Mountain Island Lake shoreline upslope along an elevational (moisture) gradient. Project design at Coddle Creek Reservoir delineated three specific planting zones to mimic natural community development along a moisture gradient. Results of this study suggest that design and initial establishment of vegetation zones at Coddle Creek Reservoir closely resemble the natural zonation of vegetation adjacent to Mountain Island Lake. A narrow fringe of wetland vegetation occurs along the reservoir shoreline that progresses upslope into a zone of transitional vegetation that blends into the upland zone that dominated prior to reservoir construction. This wetland zone is most limited by the amount of wetland soils

present adjacent to the reservoir. The extent of wetland soil conversion is strongly correlated to the slope of the site.

EVALUATION OF SHORELINE PLANTINGS FOR WETLAND MITIGATION AT CODDLE CREEK RESERVOIR IN PIEDMONT NORTH CAROLINA

by

HENRY ANTHONY RANDOLPH

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APPROVED BY:

E. Carlyle Franklin
Co-Chair of Advisory Committee

Douglas J. Frederick
Co-Chair of Advisory Committee

Charles B. Davey

PERSONAL BIOGRAPHY

Henry Anthony Randolph graduated from North Carolina State University in Raleigh in 1992 with a Bachelor of Science Degree in Forestry and a minor in Environmental Science. While working on his undergraduate degree, Henry was active in the Forestry Club, Society of American Foresters, and participated in the Cooperative Education Program. Upon completion of his undergraduate degree, Henry enrolled in the Graduate School at NCSU to pursue a Master of Science Degree from the College of Forest Resources. Henry's research was through the Woodlot Forestry R&D Program under the direction of Dr. Carlyle Franklin and was funded by the Coddle Creek Wetland Mitigation Project.

In 1995 Henry founded Randolph Forest Management, a professional forestry consulting firm in Lillington, NC. Randolph Forest Management provides a variety of forest management services to private landowners in central and eastern North Carolina. Henry resides near Lillington with his wife, Glenda Holder Randolph, and their three year old daughter, Meredith Renee Randolph.

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1. INTRODUCTION

1.1 Background

Rapidly expanding urban areas and population growth are creating a large demand for clean water in areas lacking sufficient water resources. Traditionally, reservoir construction has been the primary solution for this type of problem. Reservoirs provide a reliable source of water while also creating a variety of recreational opportunities, flood control, and wildlife habitat. Reservoir construction, however, may result in severe ecological impacts on the local environment as well as the entire watershed. In order for projects affecting wetlands to be permitted by the Corps of Engineers under Section 404 of the Clean Water Act, the project ". . . must be clearly water dependent, meet a demonstrated public need, and represent the least damaging reasonable alternative available " (Brown 1989). Of primary importance is the reduction of impacts to valuable wetland habitats present on project sites. Wetlands are those areas defined by the U.S. Army Corps of Engineers Wetlands Delineation Manual as follows:

> "Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas" (U.S. Army Corps of Engineers 1987).

While wetlands are vital systems that provide many key functions, their primary values are often associated with the following: 1) cleansing both surface and groundwater; 2) reducing the effects of flooding by storing stormwater; and 3) serving as critical feeding grounds and nurseries for a variety of fish, waterfowl, and other wildlife (Clewell and Lea 1990; Dennison and Berry 1993). Many of the beneficial ecological functions provided by wetlands are due to the characteristics of the vegetation present which is inherently determined by the hydrology of the wetland (Lowe 1986). Recognizing these and other values of wetlands, federal law (Fish and Wildlife Coordination Act, 16 U.S.C.

661-667[e]) requires that any wetland loss incurred during a permitted project be mitigated through an accepted method (Brown 1989). Mitigation alternatives are outlined in the Council on Environmental Quality's National Environmental Policy Act (40 CFR Part 1508.20 [a-e]) and most wetland mitigation projects fall under section C, which states: " . . . rectifying the impact by repairing, rehabilitating, or restoring the affected environment" (Brown 1989). Restoration and creation of wetland habitats on site as mitigation for wetlands lost during project construction are desired methods (Dennison and Berry 1993). This method also prolongs the functional life of the reservoir through sedimentation control and reduces future water treatment costs through reduction of pollutants entering the reservoir. Less desirable alternatives include off-site mitigation and mitigation banking. Mitigation banking is now more strongly endorsed through a recent regulatory guidance document (USACE, 1995)

Identification and delineation of wetlands are essential if these areas are to be protected. Wetland determination relies on the presence of indicators of three parameters: 1) hydrophytic vegetation, 2) wetland hydrology, and 3) hydric soils (U.S. Army Corps of Engineers, 1987; Dennison and Berry, 1993). However, in the case of created wetlands, such as wetlands along reservoir shorelines, the presence of hydric soils is generally not required for wetland determination. This is because hydric soils develop only after long periods of inundation and most created wetlands have not been in existence long enough to develop hydric soils (U.S. Army Corps of Engineers, 1987). It has been estimated that the time required to form Fe depletions around root channels could vary from one year to more than 100 years (Vepraskas and Geurtal, 1992). This period would be dependent on how long reducing conditions occurred and how much iron was present in solution each day (Vepraskas, 1992). It is generally agreed that if wetland hydrology and hydrophytic vegetation are present, the soils are developing toward a hydric status.

1.2 Coddle Creek Mitigation Project

An impoundment has been completed on Coddle Creek, in northwest Cabarrus County, North Carolina (Figure 1.1). This area is experiencing rapid population growth as the urban sprawl in Mecklenburg County and nearby Charlotte spreads into neighboring areas. In anticipation of this growth and water demand, Cabarrus County officials developed this reservoir as a drinking water supply for the future. The construction of Coddle Creek Reservoir impacted approximately 1900 acres (770 ha) of woodlands, crop land, and pastures. Two specific types of wetlands were present at the Coddle Creek reservoir site prior to construction. Bottomland hardwoods along the shoreline of Coddle Creek and an unique emergent marsh in an area of lowlands adjacent to Coddle Creek. The U.S. Army Corps of Engineers' policy of in-kind mitigation requires that restored or created wetland closely mimics the type of impacted by the project. Required mitigation consisted of creating 186 acres (75.3 ha) of bottomland hardwood habitat and restoration of 170 acres (68.8 ha) of upland forested habitat through shoreline plantings. Included in the bottomland hardwood acreage is a "creation site" designed to replace the emergent marsh habitat that was present on site. Bates et al. (1978) recommend shoreline plantings as an option for shoreline management for the following reasons: potential shoreline stabilization, increased wildlife habitat, replacement of wetlands lost in reservoir construction, and an aesthetically pleasing diversification of shoreline habitat. Project design delineated three planting zones around the reservoir shoreline based on a projected mean pool level of 650 feet above sea level. The three planting zones were delineated along contour lines as 1) Low-wet zone (648 to 650 feet); 2) High-wet zone (650 to 652 feet); and 3) Upland zone (Above 652 feet). Approximately 600 canopy trees per acre (1482 /ha) and 126 shrubs per acre (311 /ha) were planted on open cropland and pastures adjacent to the reservoir. Each of the three planting zones received a unique mix of tree and shrub species based on the projected frequency of inundation.

This project was designed to facilitate research in several areas of restoration ecology, including vegetation and soil changes over time, hydrological changes, impacts to wildlife, and other biological changes. Additional research included examining various site preparation techniques, a seed bank study, and the use of a Global Positioning System (GPS) as an effective mapping alternative.

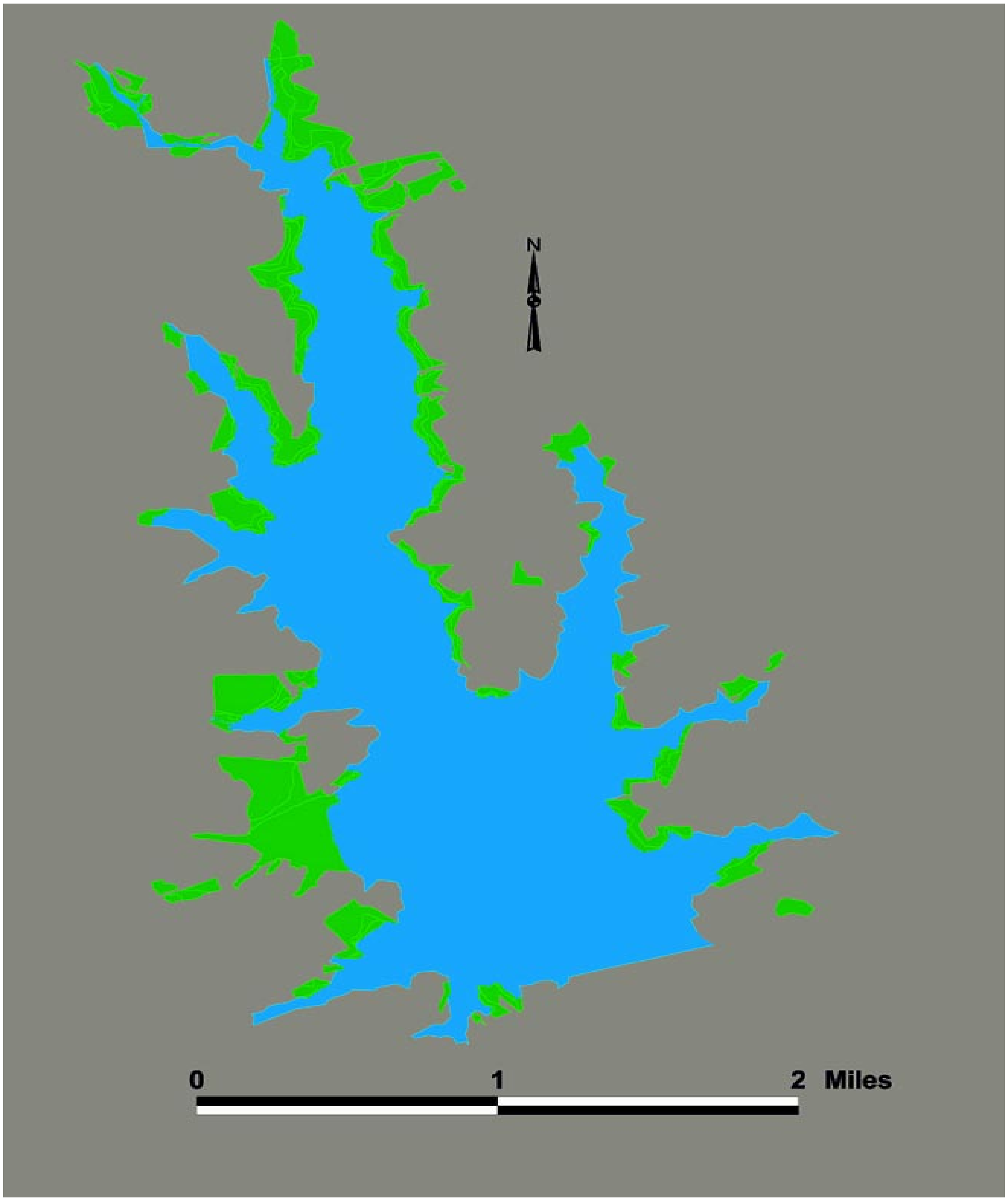

Figure 1.1. Wetland mitigation planting sites (green) along shoreline at Coddle Creek Reservoir (Blue).

1.3 Mountain Island Lake Reservoir

Mountain Island Lake Reservoir, a 2792.3 acre (1130 ha) impoundment was developed in 1923 for steam generation by Duke Power and currently supplies drinking water for the City of Charlotte and Mecklenburg County. Located along the Catawba River south of Cowan's Ford Dam at Lake Norman, Mountain Island Lake is bounded by Gaston, Iredell, and Mecklenburg counties (Figure 1.1). Most of the property adjacent to the reservoir is owned by Duke Energy Company and managed by Crescent Resources. Management of lands has primarily been for forest products and lakeside real estate development. Property adjacent to the reservoir is also utilized for recreation and wildlife habitat. Cowan's Ford Wildlife Refuge is located on a peninsula that projects into the reservoir and supports many species of migratory waterfowl as well an high population of white-tailed deer.

At the time of construction of Mountain Island Lake Reservoir, there were no laws concerning wetlands, therefore, mitigation was not necessary. However, since its construction, wetlands have developed along the fringe of the reservoir and at the terminus of many of the small feeder streams that empty into the reservoir. Reservoir construction substantially altered the plant communities that were present prior to flooding. This type of site is of special importance to current and future reservoir projects such as Coddle Creek. Mountain Island Lake provides a unique opportunity to compare a naturally developed reservoir coenocline to mitigation plantings at newly created reservoirs. Ideally, mitigation plantings that occur on similar projects would progress into mature, functioning wetlands such as those present at Mountain Island Lake.

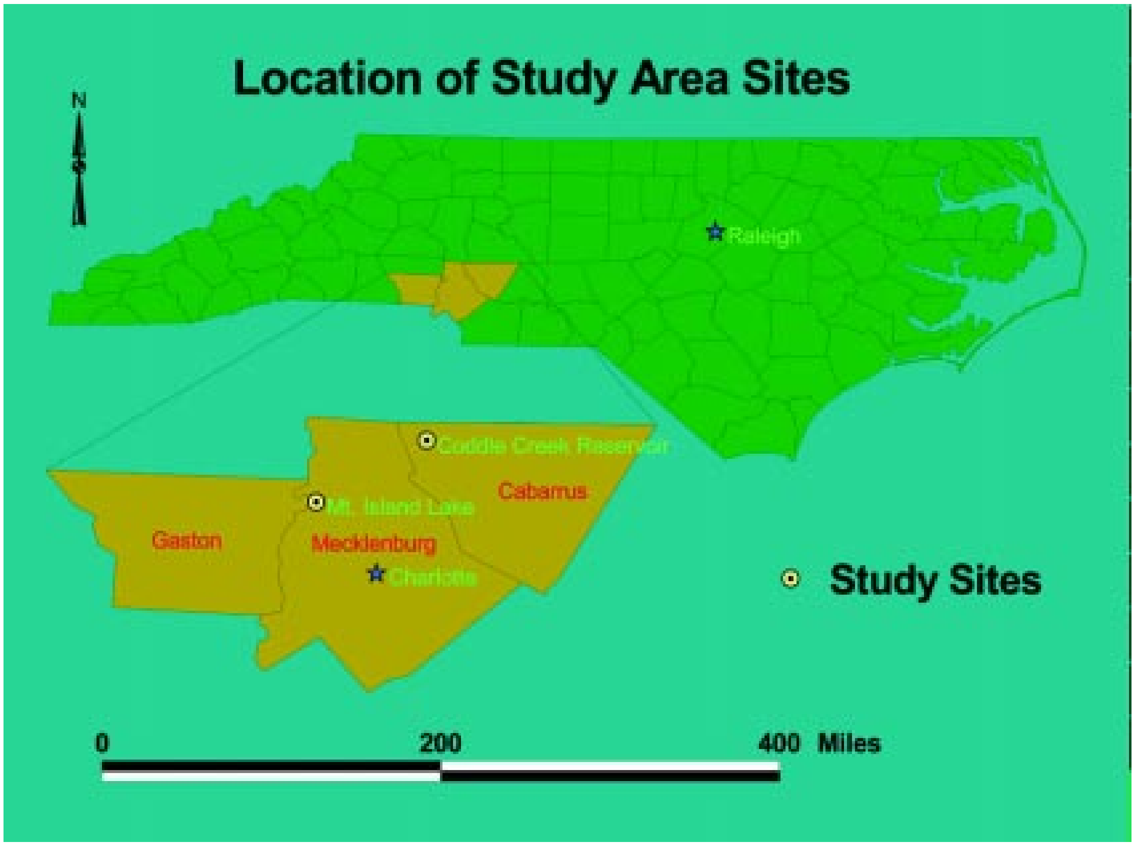

Figure 1.2. Location of Coddle Creek Reservoir and Mountain Island Lake in the North Carolina Piedmont.

1.4 Objectives

The objective of this study was to evaluate the delineation of planting zones at the Coddle Creek Mitigation Project based on vegetation and soil data collected at Mountain Island Lake. The hypothesis was that planting zone design at Coddle Creek Reservoir is similar to vegetation distribution adjacent to Mountain Island Lake that has developed in distinct zones progressing from the reservoir shoreline upslope along an elevational gradient over the past 76 years. It was proposed that elevation and soil moisture along this coenocline determine the boundaries of natural plant communities. Results of this study will indicate if artificially restored wetland habitats along the fringe of Coddle Creek Reservoir will develop through time to resemble habitat that has developed naturally at Mountain Island Lake.

This study will serve as a reference point for periodic comparison in the long-range management of Coddle Creek Reservoir vegetation. Also, the study data may play an important role in the development of future Piedmont reservoirs such as the proposed Randleman Reservoir in Randolph County, North Carolina, and wetland mitigation issues associated with this reservoir project. Also of interest, is the determination of any suitable variables that can be used as a predictor for success of mitigation projects such as soil type or hydrologic regime.

2. Methods

2.1 Study Sites

Although the objective of this study was to evaluate the wetland mitigation conducted at Coddle Creek Reservoir, the bulk of the field work was conducted along the shoreline of Mountain Island Lake. Sampling sites were mixed hardwood forests located along the reservoir shoreline. Site selection was influenced by several variables. Factors that played a role in site selection follow in order of importance:

1) Natural bottomland hardwood community present
2) No major disturbance since creation of reservoir (timber harvesting and development are primary sources of disturbance around the reservoir)
3) Moderate elevational gradient (i.e. slopes < 15%)
4) Soil types (Similar soil order as found at Coddle Creek)
5) Aspect
6) Access

Potential sites were selected from aerial photographs, county soil survey maps, oral communication with Duke Energy and Crescent Resource, Inc. land managers, USGS topographic maps, and many field visits. The task of locating suitable sites was challenging due to substantial forest management and development activities adjacent to the reservoir. Ultimately three sites were deemed acceptable: 1) Riverbend Steam Station Boating Access (6 transects); 2) Neck Road Boating Access (2 transects); and 3) Cowan's Ford Wildlife Refuge (2 transects) for a total of 10 suitable sampling transects (Figure 2.1).

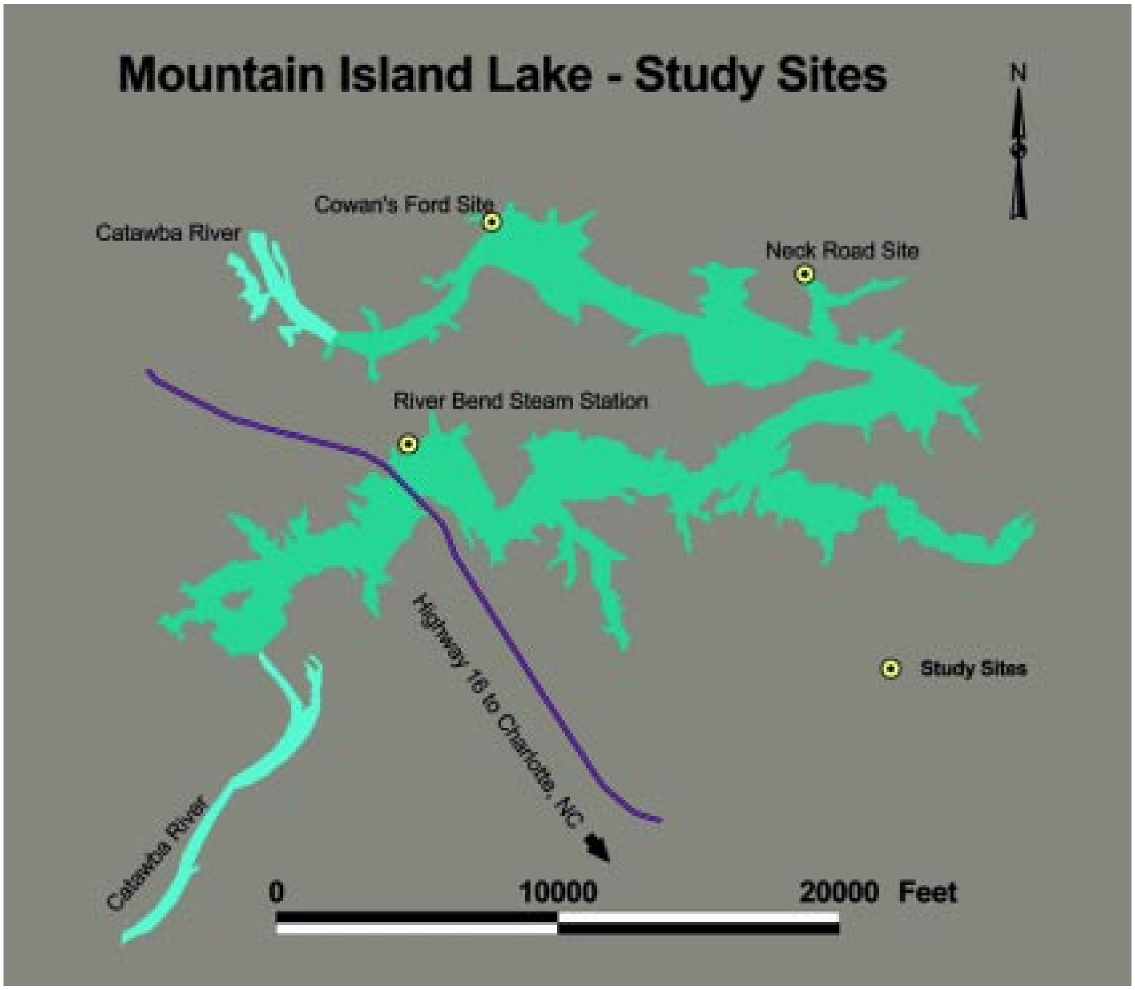

Figure 2.1. Location of Study Sites Aound Mountain Island Lake. 1) Riverbend Steam Station Boating Access (6 Transects), 2) Neck Road Boating Access (2 Transects), 3) Cowan's Ford Wildlife Refuge (2 Transects).

2.2 Vegetation Sampling

Vegetation was sampled using a variation of the method designed by Peet *et al*. (1990) for use with the North Carolina Vegetation Survey. This methodology allows for significant variation in plot size and shape and data collected. Transects were selected as the method to be used for data collection. Transects were 50 meters in length , 10 meters in width and each consisted of 50, 1 m x 10 m sampling belts. A spacing of 15 meters between transects was maintained at all sites. Transects were oriented perpendicular to the reservoir shoreline and began when woody species were first encountered nearest the water's edge. In most cases, transects began in the water where emergent woody vegetation began.

Although herbaceous species are frequently used as wetland indicators, the Coddle Creek mitigation plantings involved woody species only, and I chose to limit my study to woody plants only. This limitation is acceptable because the age of Mountain Island Lake has allowed sufficient time for woody species development. All woody vegetation present within the transects was sampled between August 1993 and May 1994. Diameters (nearest .1 inch) and heights (nearest 5 foot increment) were recorded for all woody stems greater than 1 meter in height. Sample species less than 2.54 cm dbh were grouped separately as understory saplings.

2.3 Soils

Although the primary objective of this study was to investigate vegetation development, an additional objective was to determine the extent of jurisdictional wetland acreage around Mountain Island Lake. For this reason, jurisdictional wetland boundaries were delineated on each of the transects using soil characteristics and hydrology based on criteria from the 1987 U.S. Army Corps of Engineers' Wetland Delineation Manual. This would indicate how closely soil features corresponded to hydrologic regime at Mountain Island Lake. Using a bucket auger and a Munsell Color

Chart, presence, color, and depth to mottles and concretions were determined in each transect. Sampling began at the first 1-meter belt adjacent to the shoreline and proceeded upslope until all indicators of reducing conditions were absent or encountered at a depth greater than 1 meter.

These results provided a baseline for projections of wetland area that will develop around Coddle Creek Reservoir. Typical redoximorphic features (mottling and concretions) distinctly delineated the wetland zone adjacent to Mountain Island Lake. It is predicted that these properties also will develop through time in soils at Coddle Creek Reservoir after prolonged inundation.

2.4 Hydrology

Hydrology of a site is the most important causal factor with respect to its existing vegetation. Daily lake level readings were obtained for Mountain Island Lake since May 1971 with only minimal gaps in the data. By observing the annual fluctuations in lake levels, a correlation was developed between lake levels and vegetation zones. To do this, three aspects of the hydrologic data were evaluated: 1) average levels, 2) variation (extreme levels), and 3) duration. Hydrologic data were also analyzed to determine statistically significant year-round, growing season, and dormant season conditions.

Since the hydrology at Coddle Creek reservoir will be maintained via anthropocentric means, the success of the mitigation plantings can be directly controlled by manipulating lake levels. For this reason, developing correlations between lake levels and vegetation zones at Mountain Island Lake was essential.

Hydrology and reduced soil conditions share a cause and effect relationship and it may seem redundant to determine hydrologic patterns along the transects after locating redoximorphic features in the soil. However it was desired to determine how closely these features followed the actual hydrology that could be observed through basic field methods. In addition to sampling soils for redoximorphic features, depth to free water along each sampling belt was also measured.

2.5 Data Analysis

The first step in analyzing vegetation data was classifying it into groups based on similarities. A cluster analyses program entitled CLUSTR from the PC-ORD software system was utilized for this purpose. Groups of data were initially separated based on .15 meter (6 inch) steps along the elevational gradient beginning at the shoreline and progressing upslope. These data were then input into the CLUSTR program for analysis. The purpose was to break this series of data sets into closely related subgroups. The CLUSTR program is heirarchical, agglomerative, and polythetic (McCune, 1991). This simply means that the resulting large clusters are made up of smaller clusters (heirarchical), that the clusters are formed by combining smaller groups (agglomerative) rather than dividing larger ones, and that many attributes are utilized in determining how to optimally combine clusters (polythethic). This analysis allowed separation of all distinct subgroups of vegetation that had developed across this environmental gradient. After this initial data analysis, further examination of the resulting subgroups was conducted with another PC-ORD program. With the interpretation of ecological data, community ecologists often run into data sets that do not meet the assumptional requirements of traditional statistical tests. Basic assumptions of multivariate normal distribution and homogenous variances are required for t-tests and one-way analysis of variance F-tests. An alternative statistical analysis method called multi-response permutation procedures (MRPP) allows testing for differences among groups (similar to t and F tests) and depends only on the internal variability of the existing data (Zimmerman *et al*., 1985). The MRPP calculates a test statistic that describes the degree of separation between groups. Thus, the MRPP allows comparisons of vegetation groups to ascertain if there are significant amount of differences in species composition. The objective was to determine the degree of separation (difference in species composition) between wetland community vegetation and upland vegetation along each transect, thus statistically defining the extent of wetland vegetation present.

Data were tested initially based on the assumption that there were only two vegetational communities present -- wetland and upland. For the first analysis, the data were divided into two groups. Group 1 (wetland) consisted of the vegetation present in the first .3048 meter (1.0 foot) elevational increment along the reservoir shoreline. Group 2 (upland) represented all vegetation within the transect that occurred above the first .3048 meter elevational increment. The MRPP then calculated a test statistic to determine if the groups were statistically different. The upland and wetland data sets were then adjusted by taking one .15 meter (6 inch) increment from the upland and placing it with the wetland for each subsequent test. This was an attempt to find the line of separation between wetland and upland communities. This line would represent a highly significant separation of the entire vegetation data set into two subgroups.

After completing this analysis, the data were tested based on the breakdown that was utilized at Coddle Creek which designated the first .6096 meter (2.0 feet) elevational increment as wetland, followed by .6096 meter of transition vegetation, and all vegetation above 1.2192 meter (4.0 feet) as upland. The initial test was for the presence of a .6096 meter wetland zone along the fringe of the reservoir with the remainder of the transect as upland. The next test projected a 1.2192 meter wetland zone vs the remainder of the transect as upland. The final test was for a .6096 meter wetland zone, a .6096 meter transition zone, and the remainder of the transect as upland which correlates with the planting design at Coddle Creek Reservoir.

Once these tests were completed, it was important to see the statistical separation between the following vegetation zones: 1) wetland and transition zones; 2) wetland and upland zones; and 3) the transition and upland zones. I ran MRPP on each of these groupings to determine how well the vegetation fit into subgroups and how distinctly these subgroups were separated from one another by species composition.

Next, measured soil, hydrologic, and vegetative indicators (essentially delineating the jurisdictional wetland) were used to separate the data into groups. The objective was to determine if statistical separation based on vegetative composition resulted in subgroups comparable to field delineation.

3.0 Results

3.1 Vegetation

Vegetation sampling provided a clear picture of which species were present along the shoreline of Mountain Island Lake and where they occurred along the elevational gradient (Table 3.1). The species planted at Coddle Creek Reservoir also can be found in Table 3.1 along with their wetland indicator status. This table presents the data regarding which species were present at Mountain Island Lake, those species planted at Coddle Creek, and those species that fall into both categories. Twenty-one of the twenty-four (88%) species planted at Coddle Creek occurred naturally at Mountain Island Lake.

It was important to determine the location of species along the elevational gradient adjacent to the reservoir at Mountain Island Lake. Species composition varies significantly between the three zones that progress upslope from the shoreline. Zone 1 which begins at the shoreline and extends upslope to two feet above the shoreline is dominated by wetland vegetation. Over 86 percent of the stems present is this zone are *Alnus serrulata* and *Cornus ammomum* (Table 3.1a). The transition zone (2-4 feet) contains only 43 % wetland indicator species. This zone has a greater number of species present than the wetland zone and is comprised primarily of *Ulmus alata*, *Quercus nigra*, and *Liquidambar styraciflua* (Table 3.1b). The upland zone (greater than 4 feet) was the most diverse zone and contained only 15 % wetland indicator species. *Ulmus alata* and *Cornus florida* comprised 20% and 18% of stems present respectively (Table 3.1c).

Table 3.1a. Species composition of the zone 0-.6096 meter above mean pool (29.261m – 29.871 m guage height) at Mountain Island Lake Reservoir.

Species	**# of Stems Sampled**	**Wetland Indicator**	**Percent of Total Stems**
Alnus serrulata	486	FACW+	63.78%
Cornus ammomum	175	FACW+	22.97%
Liquidambar styraciflua	29	FAC-	3.81%
Fraxinus pennsylvanica	25	FACW	3.28%
Betula Nigra	22	FACW	2.89%
Platanus occidentalis	17	FACW	2.23%
Acer rubrum		FACW	0.00%
Ulmus alata	4	FACU+	0.52%
Diospyros virginiana	2	FAC	0.26%
Juniperus virginiana	2	FACU-	0.26%
Total Stems Sampled	**762**		

Percentage of FAC, FAC+, FACW-, FACW, and FACW+ 95.50%

Table 3.1b. Species composition of the zone .6096 m – 1.2192 meters above mean pool (29.871 m – 30.48 meters guage height) at Mountain Island Lake Reservoir.

Species	**# of Stems Sampled**	**Wetland Indicator**	**Percent of Total Stems**
Ulmus alataa	50	FACU+	26.74%
Quercus nigra	46	FAC	24.60%
Liquidambar styraciflua	38	FAC-	20.32%
Fraxinus pennsylvanica	10	FACW	5.35%
Betula Nigra	9	FACW	4.81%
Platanus occidentalis	5	FACW-	2.67%
Juniperus virginiana	5	FACU-	2.67%
Quercus phellos	4	FACW-	2.14%
Prunus serotina	4	FACU	2.14%
Pinus echinata	4	UP	2.14%
Liriodendron tulipifera	3	FAC	1.60%
Cornus florida	3	FACU	1.60%
Celtis laevigata	2	FACW	1.07%
Diospyros virginiana	2	FAC	1.07%
Quercus falcata	2	FACU-	1.07%
Total Stems Sampled	**187**		

Percentage of FAC, FAC+, FACW-, FACW, and FACW+ 43.32%

Table 3.1c. Species composition of the zone above 1.2192 meters over mean pool (30.48 meters +) at Mountain Island Lake Reservoir.

Species	**# of Stems Sampled**	**Wetland Indicator**	**Percent of Total Stems**
Ulmus alataa	131	FACU+	19.79%
Cornus florida	121	FACU	18.28%
Acer barbatum	62	FACU-	9.37%
Quercus nigra	53	FAC	8.01%
Liquidambar styraciflua	52	FAC-	7.85%
Prunus serotina	40	FACU	6.04%
Juniperus virginiana	37	FACU-	5.59%
Fraxinus americana	32	FACU	4.83%
Quercus stellata	22	FACU	3.32%
Carya tomentosa	17	UP	2.57%
Morus rubra	15	FAC	2.27%
Ulmus americana	12	FACW	1.81%
Cercis canadensis	10	FACU	1.51%
Quercus falcata	9	FACU-	1.36%
Pinus echinata	8	UP	1.21%
Nyssa sylvatica	7	FAC	1.06%
Viburnum prunifolium	7	FACU	1.06%
Liriodendron tulipifera	6	FAC	0.91%
Quercus alba	5	FACU	0.76%
Acer negundo	4	FACW	0.60%
Carya glabra	3	FACU	0.45%
Juglans nigra	3	FACU	0.45%
Quercus coccinea	2	UP	0.30%
Celtis laevigata	2	FACW	0.30%
Diospyros virginiana	2	FAC	0.30%
Total Stems Sampled	**662**		

Percentage of FAC, FAC+, FACW-, FACW, and FACW+ 15.26%

3.2 Soils

There are two soil orders present at the Coddle Creek site--ultisols and alfisols. These orders were present at Mountain Island Lake in addition to inceptisols (Table 3.2). The inceptisol present at Mountain Island is in the Monocan series which consists of soils formed from recent alluvium in floodplains. Similar soils are likely to form from alluvial deposits adjacent to the Coddle Creek Reservoir. These soils should resemble the Monocan series found at Mountain Island Lake and support similar vegetation.

Table 3.2 Soils Present at Mountain Island Lake and Coddle Creek

Mountain Island Lake	
Riverbend Steam Station — Gaston County	
1) Cecil Urban Land Complex, 8-15% slopes	Ultisol
2) Cecil Urban Land Complex, 2-8% slopes	Ultisol
Neck Road Boating Access — Mecklenburg County	
1) Enon Sandy Loam, 2-8% slopes	Alfisol
2) Iredell fine sandy loam, 0-1% slopes	Alfisol
Wildlife Refuge Site — Mecklenburg County	
1) Monocan Loam	Inceptisol
2) Pacolet Sandy Loam	Ultisol
Coddle Creek Reservoir Site — Cabarrus County	
1) Altavista Sandy Loam, 2-6 % slopes	Ultisol
2) Iredell Loam, 2-6 % slopes	Alfisol
3) Cecil Sandy Clay Loam, 2-8 % slopes	Ultisol
4) Enon Sandy Loam, 8-15 % slopes	Alfisol
5) Poindexter Loam, 8-15 % slopes	Alfisol
6) Sedgefield Sandy Loam, 2-8 % slopes	Alfisol

Soils surrounding Mountain Island Lake which are periodically inundated have developed features quite different from the typical upland soils existing at Coddle Creek. For instance, the Cecil Urban Land Complex found at the Riverbend Steam Station Site exhibited distinct gleying and mottling in the upper one meter of the profile for several meters upslope from the reservoir shoreline. Similar changes in the upland soils adjacent to Coddle Creek following inundation can be expected.

Table 3.2a Results of Wetland Delineation by Indicator Presence at Mountain Island Lake

*data expressed in feet above mean pool level in .5 foot increments

Transect	Soils	Moisture	Vegetation	All Parameters
1	1.5	1.0	2.5	1.5
2	2.0	2.0	3.5	2.0
3	2.5	2.5	2.5	2.5
4	2.0	2.0	2.5	2.0
5	2.0	2.0	3.0	2.0
6	1.5	1.0	2.0	1.5
7	2.5	2.5	7.5	2.5
8	4.5	4.5	8.5	4.5
9	2.5	2.5	3.5	2.5
10	1.0	1.0	2.0	1.0
Mean	2.2	2.1	3.75	**2.2**

Riverbend Steam Station Site – Transects 1-6
Neck Road Boating Access Site – Transects 7-8
Cowan's Ford Wildlife Refuge Site – Transects 9-10

**Graphical representation of the the wetland area delineated at each transect as shown in Table 3.2a can be found in Appendix 2.

3.3 Hydrology

Hydrology at Coddle Creek reservoir is regulated primarily in response to required water demand from nearby municipalities. Optimally, lake level will be maintained near mean pool height (198.12 meters above sea level) to minimize fluctuation and guarantee a constant water supply. This hydrologic regime is very similar to the regime maintained at Mountain Island Lake from 1971 to 1994. There, constant pool is maintained at 196.14 meters above mean sea level (29.26 meters guage level) and fluctuated only minimally around this level. Growing-season lake levels are important to wetland creation around the Mountain Island Lake Reservoir (Table 3.3). During the growing season, constant pool or 29.26 meters was flooded 57 % of the time over the last 23 years. This is sufficient to classify this area as a wetland. However the upper end of the wetland zone, 29.87 meters, is inundated only 3.4 % of the time. Perhaps this zone should be narrowed down to .3048 meter rather than .6096 meter to correlate more closely with the hydrologic regime that has been demonstrated over the recent history of the reservoir. The upper end of the transition zone is also fairly vague and perhaps should be cut off at 30.17 meters where the contour is inundated approximately 1 % of the time during the growing season. These data demonstrate that variation in growing-season lake levels suggests a less extensive wetland and transition zone than was predicted based solely on vegetation zones around Mountain Island Lake Reservoir.

Year	94.5	95	95.5	96	96.5	97	97.5	98	98.5	99	99.5	100	100.5	101	101.5	102	102.5	103	103.5
1971	172	172	167	40	21	14	10	10	10	6	3	2	0	0	0	0	0	0	0
1972	184	184	182	42	25	17	12	7	7	4	4	4	1	0	0	0	0	0	0
1973	184	184	178	59	41	29	21	13	7	5	3	1	1	1	1	0	0	0	0
1974	184	183	165	43	27	19	13	9	7	2	1	0	0	0	0	0	0	0	0
1975	184	184	164	66	36	21	8	4	1	0	0	0	0	0	0	0	0	0	0
1976	184	184	124	20	8	5	1	0		0	0	0	0	0	0	0	0	0	0
1977	184	184	174	20	6	3	1	0	0	0	0	0	0	0	0	0	0	0	0
1978	184	184	182	50	14	5	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	184	184	183	67	31	16	9	3	2	1	0	0	0	0	0	0	0	0	0
1980	184	184	183	105	29	13	8	3	1	1	1	1	1	0	0	0	0	0	0
1981	184	184	184	107	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	184	184	183	139	43	13	7	4	0	0	0	0	0	0	0	0	0	0	0
1983	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1984	184	184	184	159	76	46	21	13	7	2	0	0	0	0	0	0	0	0	0
1985	184	184	183	141	51	25	10	2	1	0	0	0	0	0	0	0	0	0	0
1986	184	184	184	93	20	5	2	1	0	0	0	0	0	0	0	0	0	0	0
1987	184	184	184	150	71	39	20	11	3	1	0	0	0	0	0	0	0	0	0
1988	184	184	184	140	42	6	3	1	0	0	0	0	0	0	0	0	0	0	0
1989	184	184	184	174	83	42	23	15	10	5	4	3	3	3	3	1	1	1	0
1990	184	184	184	159	84	34	21	9	3	1	0	0	0	0	0	0	0	0	0
1991	184	183	177	159	83	33	10	0	0	0	0	0	0	0	0	0	0	0	0
1992	142	142	142	130	66	42	24	12	8	2	0	0	0	0	0	0	0	0	0
1993	153	153	153	146	101	56	26	12	0	0	0	0	0	0	0	0	0	0	0
1994	183	183	183	172	66	30	16	12	6	4	4	4	4	4	1	0	0	0	0
Total	4146	4144	4011	2381	1034	514	266	141	73	34	20	15	10	8	5	1	1	1	0
%	100	99.95	96.74	57.43	24.94	12.4	6.42	3.4	1.76	0.82	0.48	0.36	0.24	0.19	0.12	0.02	0.02	0.02	0

Table 3.3 Number of days during the growing season (April 19-October 19) that each contour line is flooded at Mountain Island Lake. NA - Data not available.

3.4 Data Analysis

Results of the CLUSTR analysis demonstrated two distinct subgroups formed within the lowest elevational data sets. The first four .15 meter increments (005, 010, 015, 020) fell into place along the gradient exactly as they were sampled. These four plots formed a distinct subgroup that was classified as wetland vegetation. The next distinct subgroup consisted of plots 025, 030, 035, 045, 060, and 085. This cluster was not quite as distinct as the first subgroup but it matched up with the vegetation classified as transitional. The remainder of the sample plots did not cluster into distinct subgroups and were classified as upland vegetation.

Results of the MRPP provided the basis for separation between upland and wetland vegetation based on the assumption that these are the only types of vegetation present and that this test was appropriate for the data set (Tables 3.4 and 3.5). Wetland groupings of .762 meter and greater are highly significant but differences are too small to distinguish.

Table 3.4 Results of Multi-Response Permutation Procedures

Testing for differences in vegetation composition between wetland zone (Group 1) and upland zone (Group 2) detected a significant delineation at 2 feet above mean pool.

Group 1	Group 2	Probability of a Smaller Delta
1	21.5	0.1216
1.5	21	0.0599
2	20.5	0.0050*
2.5	20	> .001
3	19.5	> .001
3.5	19	> .001
4	18.5	> .001
4.5	18	> .001
5	17.5	> .001
5.5	17	> .001

The MRPP testing for delineation of vegetation zones assuming the presence of wetland, transition, and upland community types (Table 3.5) provides the most statistically significant separation when no transition zone is present. The second most significant result delineates two feet of wetland, two feet of transition, and the remainder as upland vegetation. This suggests the zonation utilized at the Coddle Creek planting sites is similar to naturally developed vegetation zones around Mountain Island Lake. Tests 3-6 which checked for the degree of separation between the three groups provided some additional insight into these results.

Table 3.5 Results of Multi-Response Permutation Procedures (MRPP)
Testing for vegetation zones with transition zone included indicates most significant result delineating two feet of wetland zone and two feet of transition zone and the remainder of the vegetation upland.

Test	Wetland	Transition	Upland	Probability of Smaller Delta
1	2	0	20.5	0.0050
2	4	0	18.5	> .001
3	2	2	18.5	> .001
4	2	2		0.0635*
5	2		18.5	> .001
6		2	18.5	> .001

4.0 Discussion

When evaluating success of restored or created wetlands species composition at the project site shuold be compared with a "generalized forest ecosystem" that occurs in the same locality (Clewell and Lea 1990). Clewell and Lea (1990) suggested that comparing projects to specific reference wetlands was inadequate due to the variation that occurs between stands of the same community. As discussed previously, Whittaker (1978) supports the creation of composite transects when studying community ecology. He proposed that composite transects "average out the irregularities affecting individual samples, and produce a clearer, more easily interpreted picture of species distribution... ." The composite transect of vegetation data collected at Mountain Island Lake provided the necessary list of native species occurring at a similar location for comparison to plantings at Coddle Creek. Of the 24 species included in plantings at Coddle Creek, only 3 of these species were not present at Mountain Island Lake. Bald cypress and water tupelo were two exotic species included in the plantings. These species were included in the planting zones that will be frequently inundated because they have high flood tolerance. Chickasaw plum was the only other species not found in the Mountain Island study sites that was planted at Coddle Creek. This is most likely due to the early successional nature of Chickasaw plum and the late successional nature of the woodlands studied at Mountain Island Lake. By including only three species in the Coddle Creek plantings that were not present in the Mountain Island Lake composite transect, it appears that planting design matched species to site properly.

The CLUSTR analysis provided the initial separation of vegetation data into subgroups based on similarities. Two distinct subgroups distinguishable at the lower end of the elevational gradient were tentatively classified as wetland and transition zones, with the remaining data falling into the broad classification as uplands. Results from cluster analysis also provided an indication of what to expect from additional analysis using MRPP. The first MRPP tests resulted in a highly significant break between 1.372 meters of wetland vegetation and 5.486 meters of upland vegetation. This however, did not match the planting design at Coddle Creek that included a transition zone. Analysis of the Coddle Creek planting design provided a highly significant separation into three vegetation zones: .6096 meter of wetland, .6096 meter of transition, and 5.639 meters of upland vegetation. I then attempted to explain which result more aptly described natural zonation of vegetation by analyzing the differences between wetland and transition zones, wetland and upland zones, and transition and upland zones. The MRPP tests 4-6 were inconclusive regarding the separation between these zones. Test 4 indicated a minimal degree of separation ($p = 0.06$) between wetland and transition zones which should be expected because many species could occur in both of these zones. Test 5 presented a statistically significant ($p < 0.001$) separation between wetland and upland zones which is to be expected based on the greater difference in species occurring on these two sites. The MRPP test 6 also resulted in a highly significant ($p <0.001$) separation between transition and upland vegetation. These tests determined that vegetative composition of the transition zone was more similar to wetland species composition than upland species composition. On the upper end of the transition zone there is some overlapping of species into the upland zone. There is also overlapping of species between the lower end of the transition zone and the upper end of the wetland zone. This overlapping is much greater than that between upland and transition zones based on the greater similarity in species compostion between the transition and wetland zones.

Based on these statistical analyses of vegetation zones along the elevational gradient adjacent to Mountain Island Lake, the planting design at Coddle Creek Reservoir has closely mimicked that natural system. This study, however significant the results may appear, compares only the design and initial establishment of vegetation zones at Coddle Creek Reservoir to a mature community that has developed since 1923 at Mountain Island Lake. It is therefore essential to consider the problems that may arise at Coddle Creek resulting in some system far removed from the functioning wetlands present at Mountain Island Lake.

Planting design does not allow for control of natural seeding of species into the planting zones. It is possible that competition from natural regeneration may change the species composition of the planting zones significantly. If this occurs, it is most likely to result in a less diverse mixture of species, particularly in the wetland and transition zones prior to soil saturation. Due to variation in growing season inundation, it is difficult to predict soil changes over time and how this will affect the species composition of planting zones. The wetland planting zone stands to encounter the most significant effects of soil saturation. Of special consideration is how hardpans present in the agricultural fields and pastures will affect soil saturation around the fringe of the reservoir. These hardpans could result in perched water tables that significantly alter the vegetation along the shoreline.

Hydrology is the most important factor regarding vegetation patterns adjacent to the reservoir but this variable is difficult to control. If human population growth exceeds current projections, increased water demand could reduce the mean pool level and result in fewer wetland acres. Perhaps the most important question regarding this planting design is "Will the wetland function?" If this design is successful the vegetation will progress into functioning wetland communities that will truly offset the wetlands that were destroyed during construction of Coddle Creek Reservoir.

5. List of References

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6.0 APPENDICES

6.1 Master Species List

#	Species	Common Name	Indicator Status	MIL	CC
1	*Acer barbatum* Michaux	Southern Sugar Maple	FACU-	*	
2	*Acer negundo* L.	Box Elder	FACW	*	
3	*Acer rubrum* L.	Red Maple	FAC	*	P
4	*Alnus serrulata* Willd.	Hazel Alder	FACW+	*	P
5	*Anisostichus capreolata* (L.)	Cross Vine	FAC	*	
6	*Betula nigra* L.	River Birch	FACW	*	
7	*Carpinus caroliniana* Walter	Ironwood	FAC	*	
8	*Carya glabra* Miller	Pignut Hickory	FACU	*	
9	*Carya tomentosa* (Poiret)	Mockernut Hickory	UPL	*	
10	*Celtis laevigata* Willd.	Sugarberry	FACW	*	P
11	*Cephalanthus occidentalis* L.	Button Bush	OBL	*	P
12	*Cercis canadensis* L.	Redbud	FACU	*	P
13	*Cornus amomum* Miller	Silky Dogwood	FACW+	*	
14	*Cornus florida* L.	Flowering Dogwood	FACU	*	P
15	*Crataegus* sp. L.	Hawthorn	FAC	*	P
16	*Diospyros virginiana* L.	Persimmon	FAC	*	P
17	*Elaeagnus umbellata* Thunberg	Silverberry		*	
18	*Fagus grandifolia* Ehrhart.	American Beech	UPL	*	
19	*Fraxinus americana* L.	White Ash	FACU	*	P
20	*Fraxinus pennsylvanica* Marshall	Green Ash	FACW	*	P
21	*Gleditsia triacanthos* L.	Honey Locust	FAC-	*	
22	*Ilex opaca* Aiton	American Holly	FAC-	*	P
23	*Juglans nigra* L.	Black Walnut	FACU	*	P
24	*Juniperus virginiana* L.	Red Cedar	FACU-	*	
25	*Ligustrum sinense* Lour.	Privet	FAC	*	
26	*Liquidambar styraciflua* L.	Sweetgum	FAC-	*	P
27	*Liriodendron tulipifera* L.	Tulip Tree	FAC	*	P
28	*Lonicera japonica* Thunberg	Japanese Honeysuckle	FAC-	*	
29	*Lyonia ligustrina*	Male-berry	FACW	*	
30	*Morus rubra* L.	Red Mulberry	FAC	*	P
31	*Nyssa aquatica* L.	Water Tupelo	OBL		P
32	*Nyssa sylvatica* Marshall	Black Gum	FAC	*	
33	*Pinus echinata* Miller	Shortleaf Pine	UPL	*	
34	*Pinus virginiana* Miller	Virginia Pine	UPL	*	P
35	*Platanus occidentalis* L.	Sycamore	FACW-	*	P
36	*Populus deltoides* Marshall	Cottonwood	FAC+	*	
37	*Prunus angustifolia* Marshall	Chickasaw Plum			P
38	*Prunus serotina* Ehrhart	Black Cherry	FACU	*	
39	*Quercus alba* L.	White Oak	FACU	*	P

Master Species List Continued

#	Species	Common Name	Indicator Status	MIL	CC
40	*Quercus coccinea* Muenchh.	Scarlet Oak	UPL	*	
41	*Quercus falcata* Michaux	Southern Red Oak	FACU-	*	P
42	*Quercus nigra* L.	Water Oak	FAC	*	P
43	*Quercus phellos* L.	Willow Oak	FACW-	*	P
44	*Quercus stellata* Wang.	Post Oak	FACU	*	
45	*Quercus velutina* Lam.	Black Oak	UPL	*	
46	*Rhus radicans* L.	Poison Ivy	FAC	*	
47	*Rosa palustris* Marshall	Swamp Rose	OBL	*	
48	*Sambucus canadensis* L.	Elderberry	FACW-	*	
49	*Staphylea trifolia* L.	Bladdernut	FAC	*	
50	*Taxodium distichum* (L.) Richard	Bald Cypress	OBL		P
51	*Ulmus americana* L.	American Elm	FACW	*	
52	*Ulmus alata* Michaux	Winged Elm	FACU+	*	
53	*Viburnum prunifolium* L.	Black Haw	FACU	*	
54	*Vitis* spp.	Grape Vine		*	

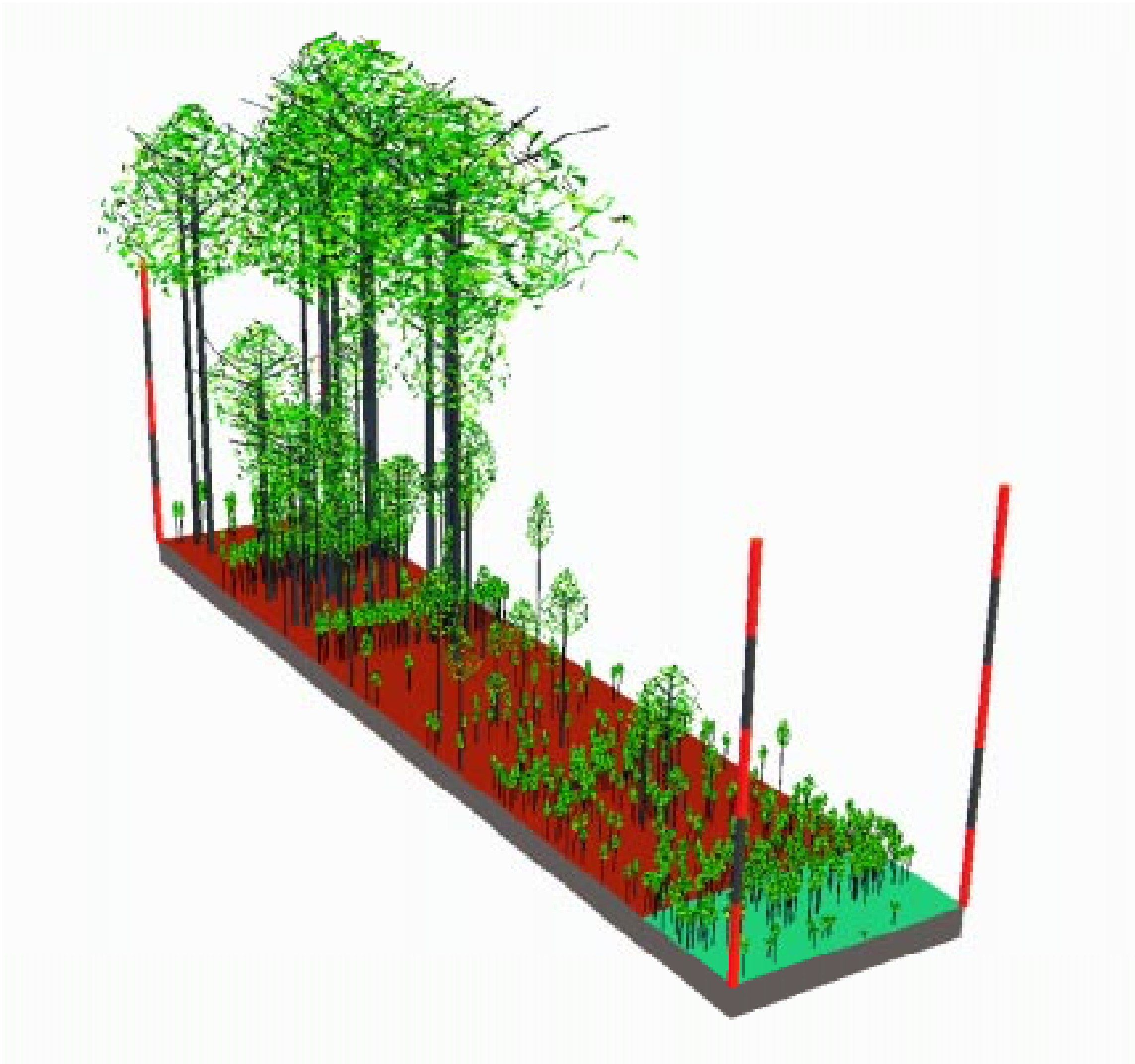
INDICATOR STATUS
OBL (Obligate)- frequency of occurrence in wetlands exceeds 99%
FACW (Facultative Wetland) - frequency of occurrence in wetlands ranges from 67-99%
FAC (Facultative) - frequency of occurrence in wetlands ranges from 34-66%
FACU (Facultative Upland)- frequency of occurrence in wetlands ranges from 1-33%
UPL (Obligate Upland) - frequency of occurrence in wetlands is less than 1 %

Classification based upon Radford, Ahles, and Bell, 1968.

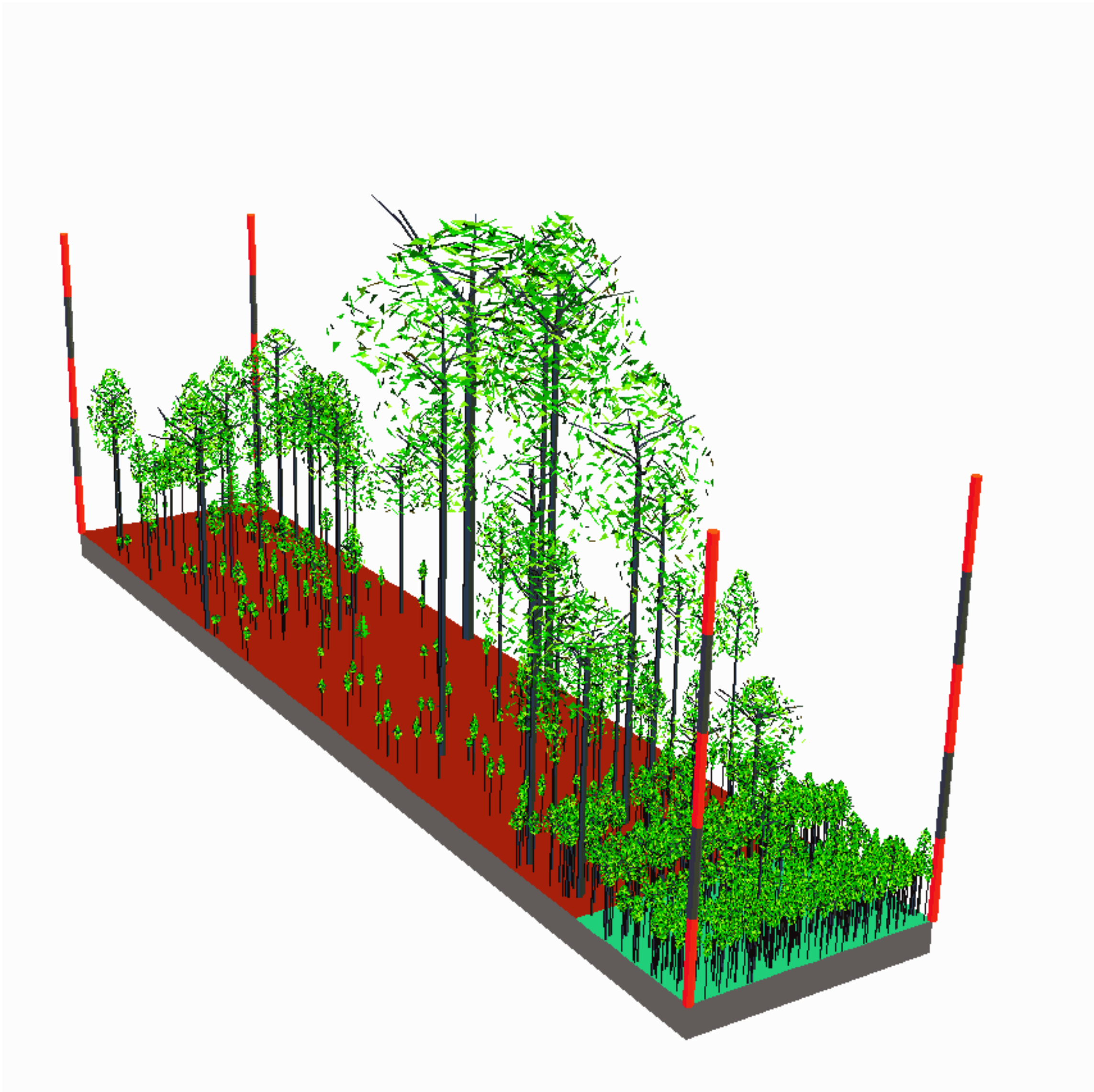
* = indicates species was present in vegetation sample at Mountain Island Lake (MIL)
P = indicates species was planted at Coddle Creek Reservoir (CC)

6.2 Sampling Transects at Mountain Island Lake

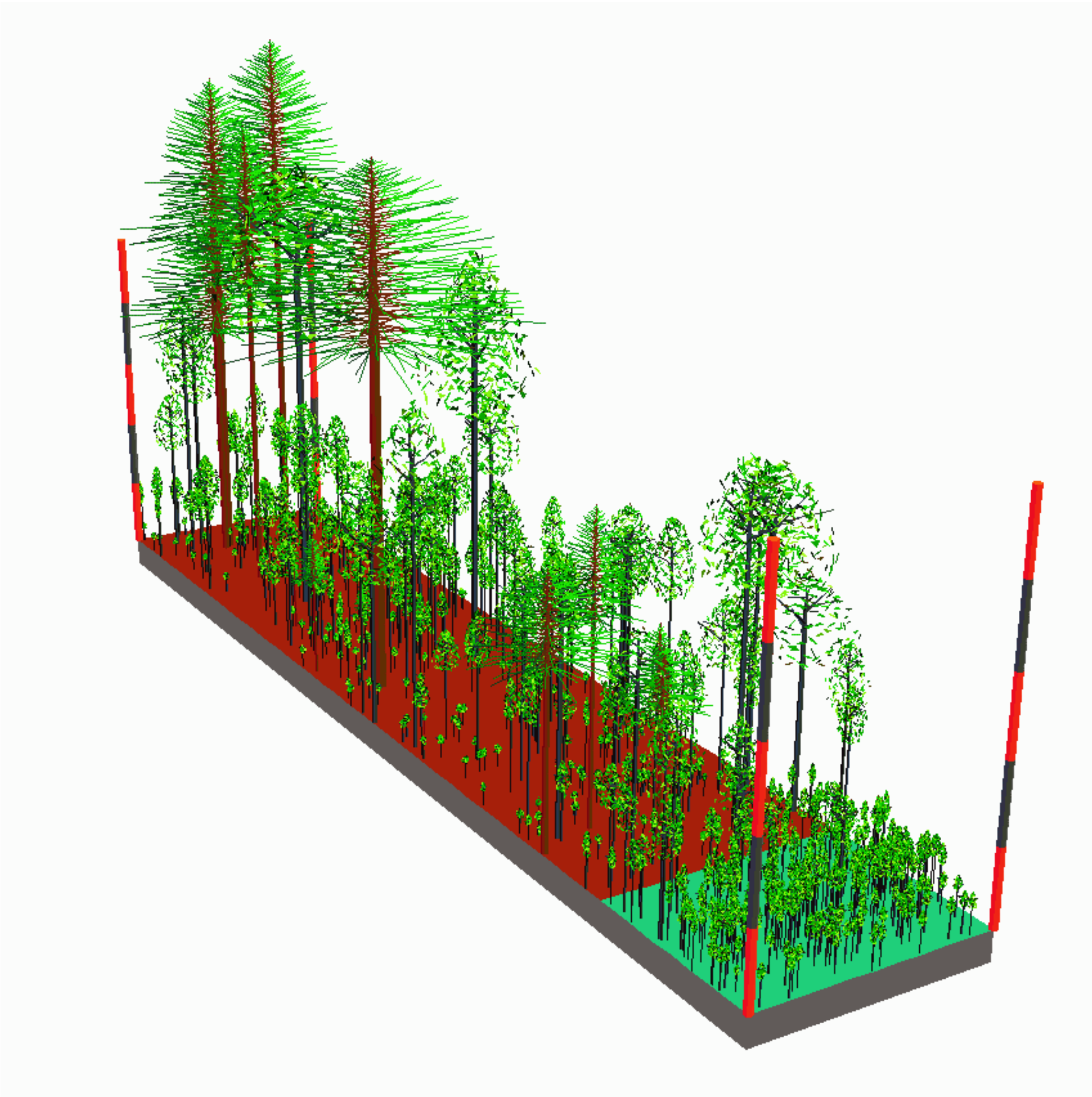
A visual representation of the vegetation data collected in each sampling transect at Mountain Island Lake Reservoir was created with the "Stand Visualization System." The Stand Visualization System (SVS) was developed by Robert J. McGaughey, a Research Forester with the USDA Forest Service at the Pacific Northwest Research Station. This software allows the user to utilize specific stand information collected in the field to create a graphic representation of stand conditions. In this study, species, diameter, height and location within the sampling transects were the variables used to generate the graphic images found in this Appendix.



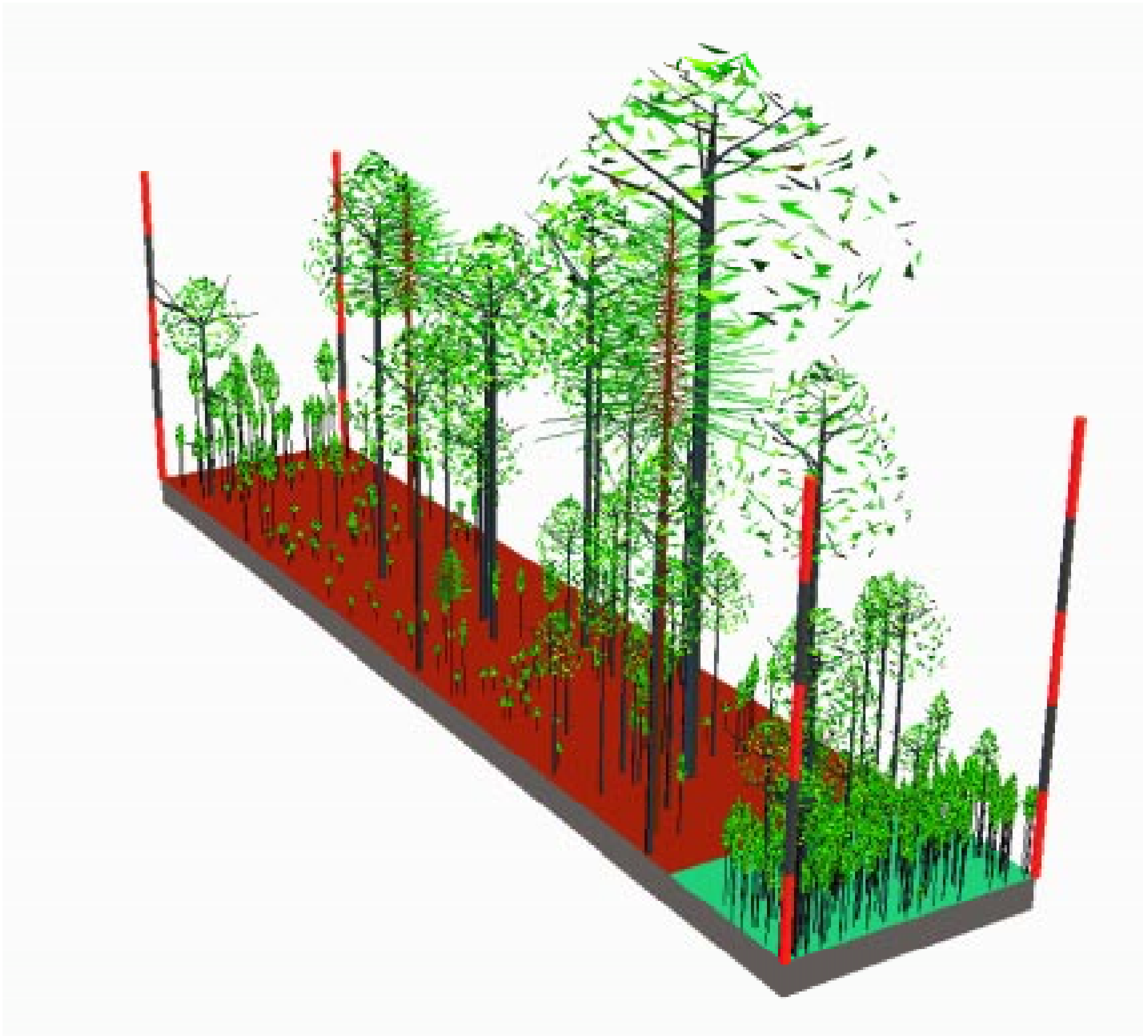
6.21 Transect 1. Located at Riverbend Steam Station Site. Wetland vegetation (Blue background) extends 1.5 meters above mean pool level. Upland vegetation is represented with a brown background.



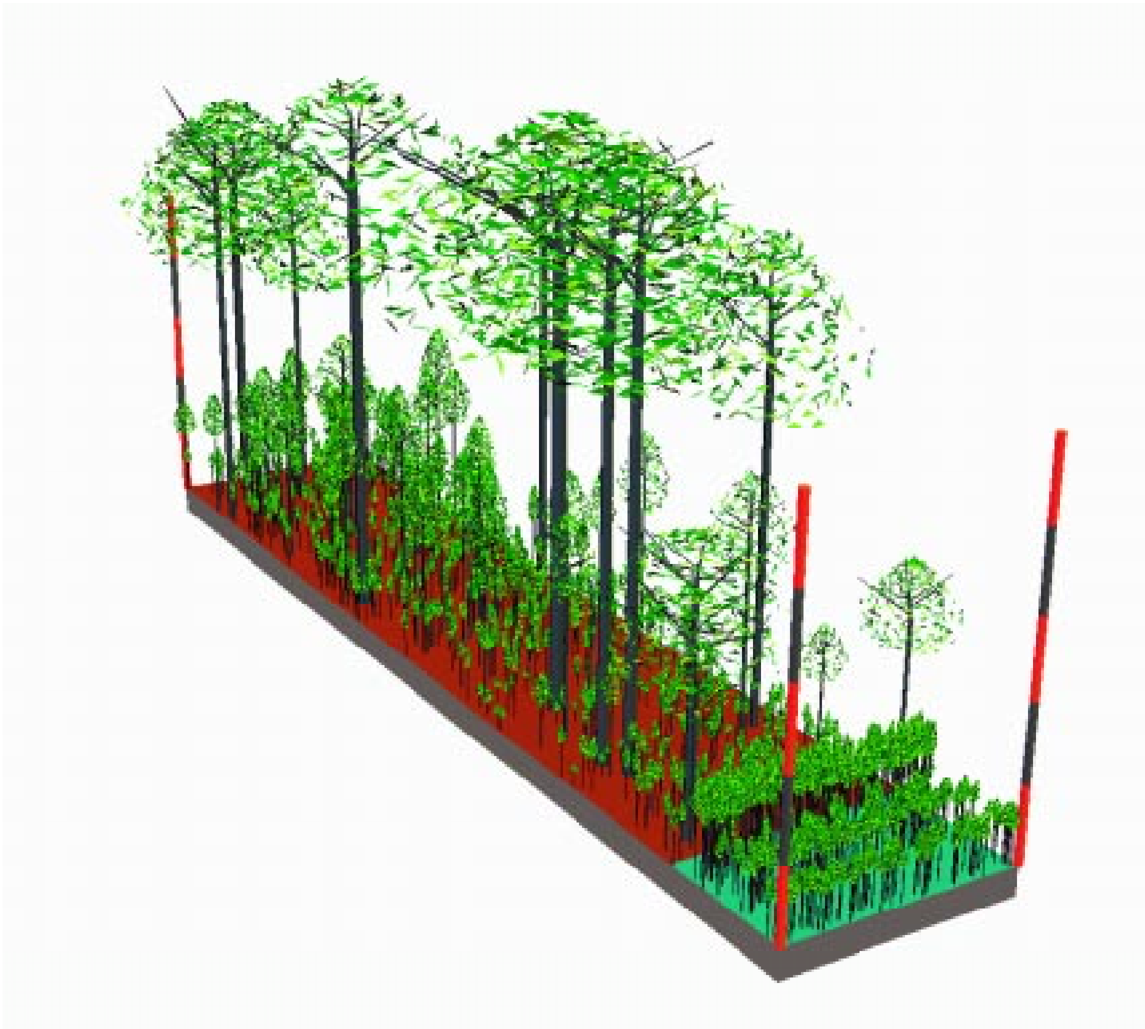
6.22 Transect 2. Located at Riverbend Steam Station Site. Wetland vegetation (Blue background) extends 2.0 meters above mean pool level. Upland vegetation is represented with a brown background.



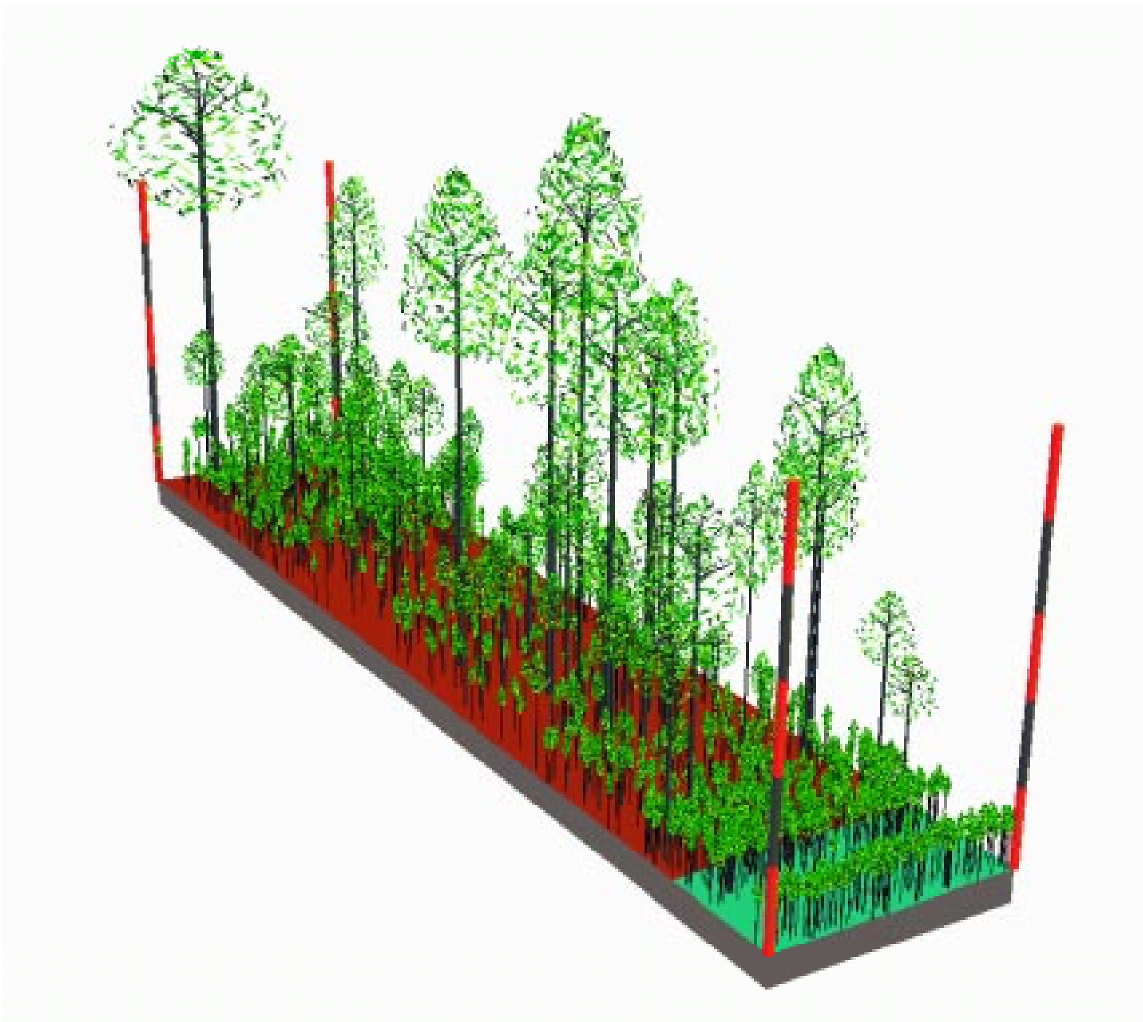
6.23 Transect 3. Located at Riverbend Steam Station Site. Wetland vegetation (Blue background) extends 2.5 meters above mean pool level. Upland vegetation is represented with a brown background.



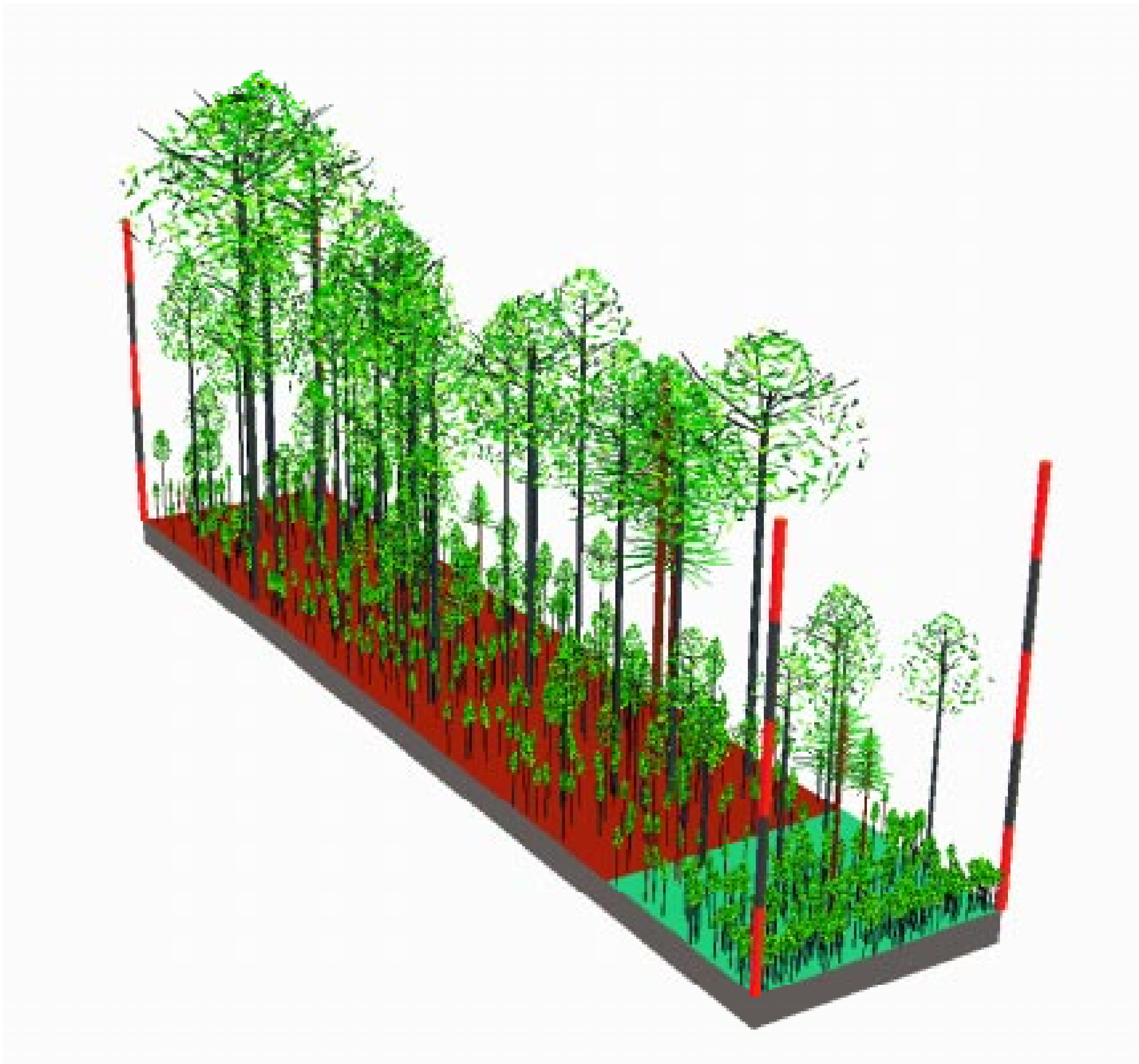
6.24 Transect 4. Located at Riverbend Steam Station Site. Wetland vegetation (Blue background) extends 2.0 meters above mean pool level. Upland vegetation is represented with a brown background.



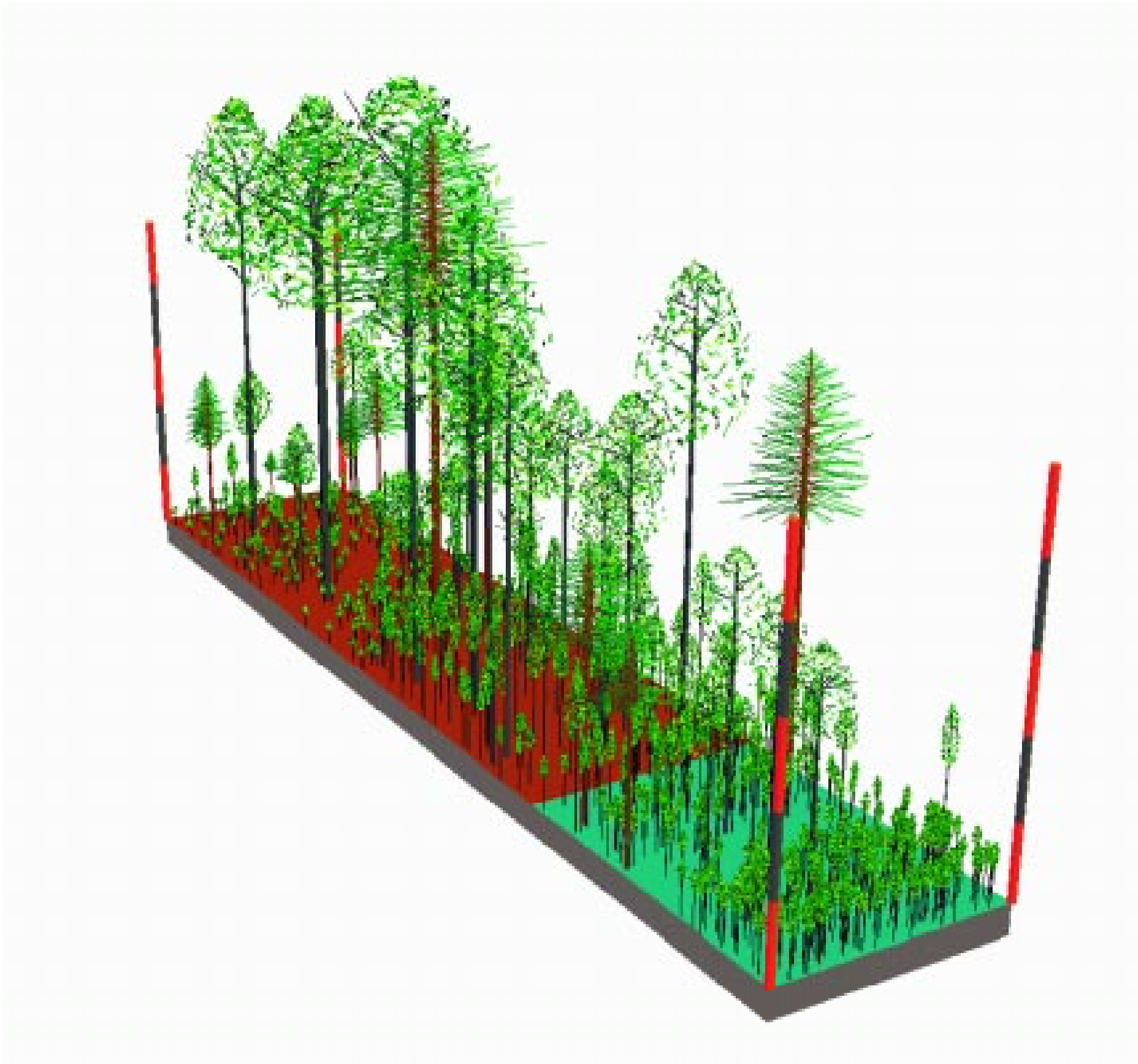
6.25 Transect 5. Located at Riverbend Steam Station Site. Wetland vegetation (Blue background) extends 2.0 meters above mean pool level. Upland vegetation is represented with a brown background.



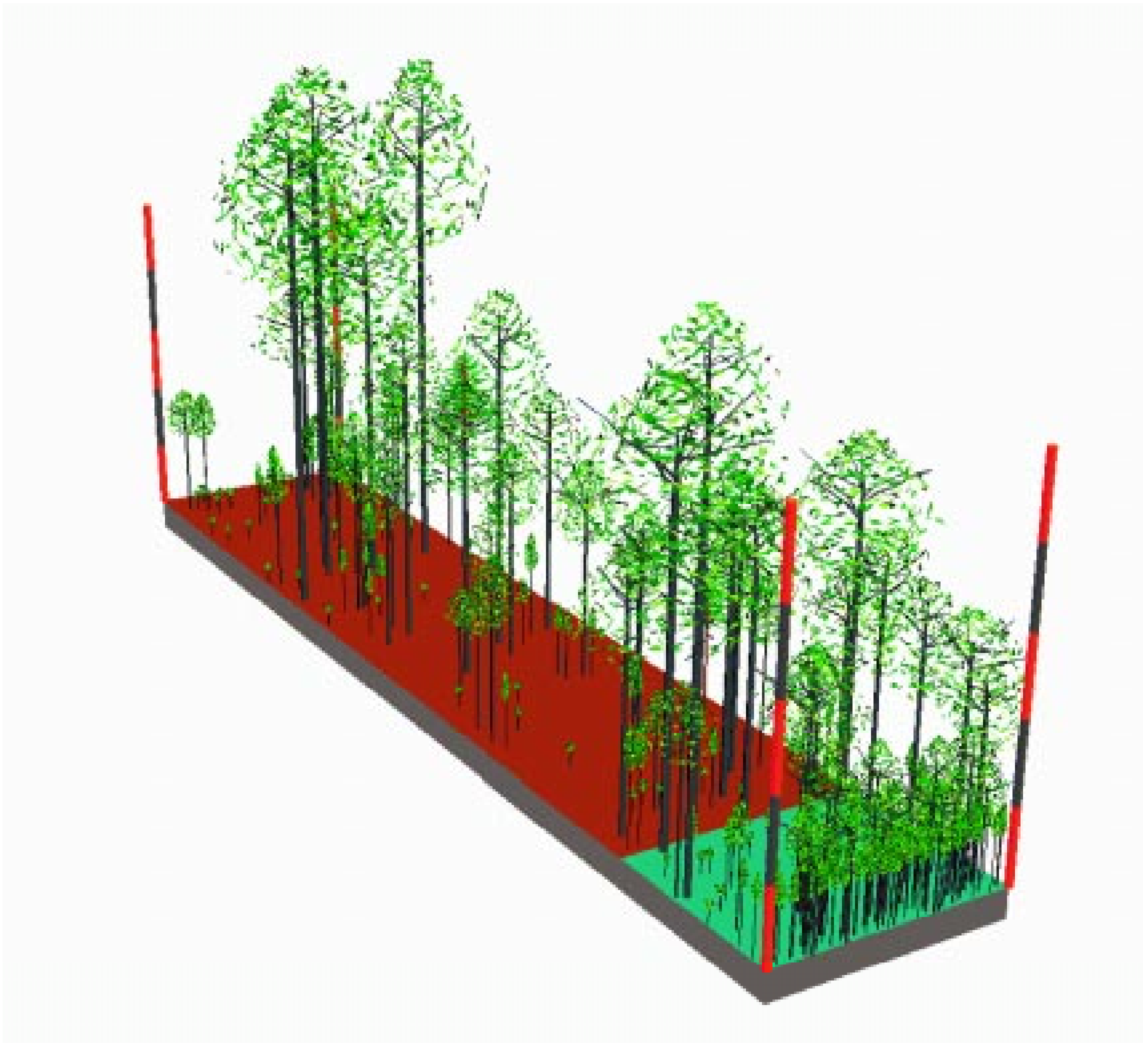
6.26 Transect 6. Located at Riverbend Steam Station Site. Wetland vegetation (Blue background) extends 1.5 meters above mean pool level. Upland vegetation is represented with a brown background.



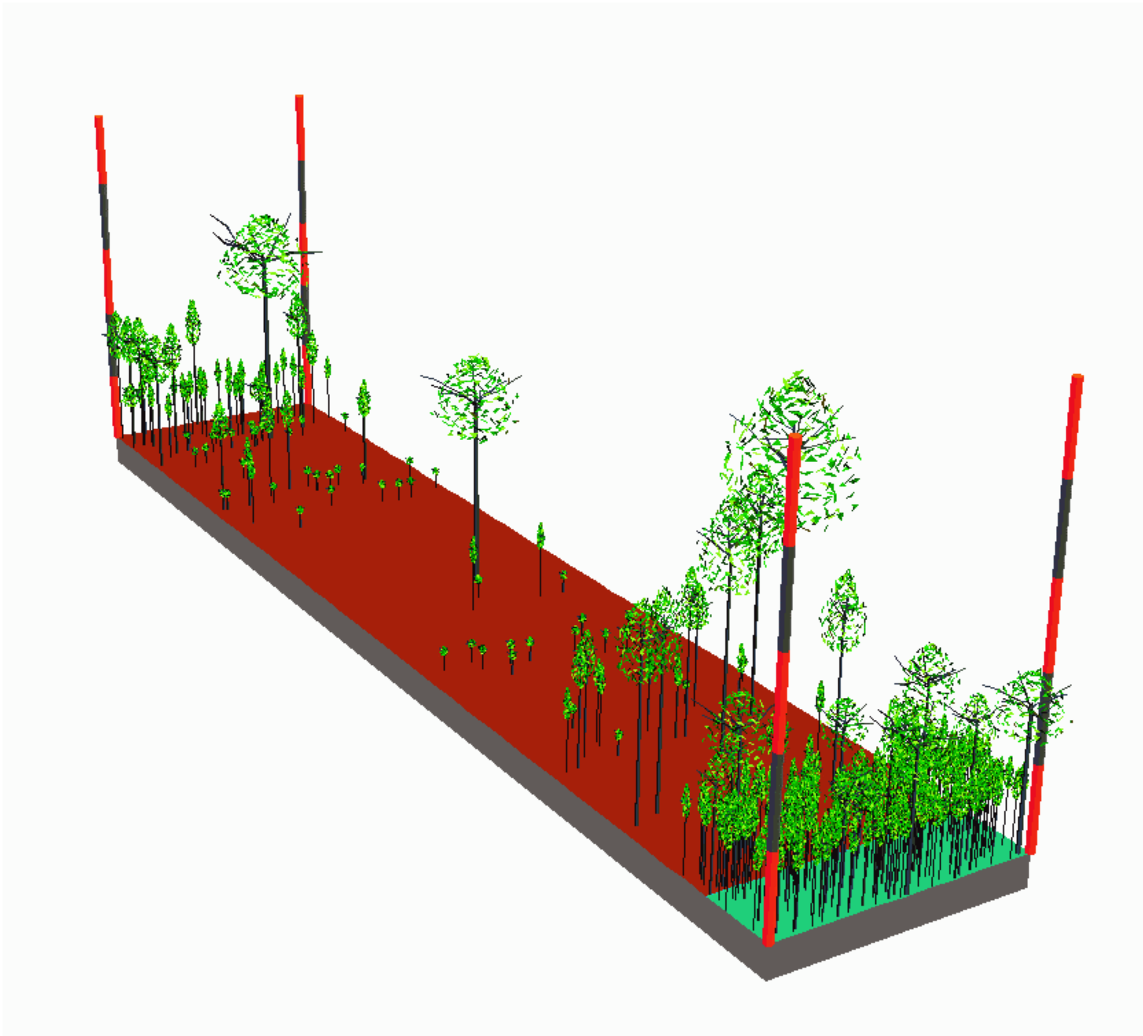
6.27 Transect 7. Located at Neck Road Boating Access Site. Wetland vegetation (Blue background) extends 2.5 meters above mean pool level. Upland vegetation is represented with a brown background.



6.28 Transect 8. Located at Neck Road Boating Access Site. Wetland vegetation (Blue background) extends 4.5 meters above mean pool level. Upland vegetation is represented with a brown background.



6.29 Transect 9. Located at Cowan's Ford Wildlife Refuge Site. Wetland vegetation (Blue background) extends 2.5 meters above mean pool level. Upland vegetation is represented with a brown background.



6.210 Transect 10. Located at Cowan's Ford Wildlife Refuge Site. Wetland vegetation (Blue background) extends 1.0 meters above mean pool level. Upland vegetation is represented with a brown background.