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Early Secondary Succession in the Bottomland Hardwood Forests of Southeastern Virginia

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EARLY SECONDARY SUCCESSION IN THE BOTTOMLAND HARDWOOD FORESTS OF
SOUTHEASTERN VIRGINIA

A Thesis

Presented to

The Faculty of the School of Marine Science

The College of William and Mary in Virginia

In Partial Fulfillment

Of the Requirements for the Degree of

Master of Science

by

David R. Spencer

1998

APPROVAL SHEET

This thesis is submitted in partial fulfillment of
the requirements for the degree of

Master of Science

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Abstract

With losses of bottomland hardwood forests in the southeast continuing to be problematic, efforts to minimize the net loss of ecological and societal functions remain focused on the creation or restoration of similar habitats. In order to provide a manageable protocol for monitoring the success of bottomland hardwood mitigation sites, emphasis is now being directed towards establishing “reference” sites that are representative of regional and local conditions. However, the time period over which created or restored bottomland hardwoods begin to resemble natural systems is more on the order of decades rather than years, much longer than the average permit applicant could be expected to monitor a mitigation site. This project examines the early successional properties of a chronosequence of seventeen forested wetlands that have been clearcut and allowed to naturally revegetate. Density and either cover or basal area of vegetation were measured in each of three strata. Relative hydrology was established through the installation of monitoring wells and soil was analyzed for pH, organic matter content, and cation exchange capacity. Ordinations performed on the data using CANOCO software indicated three general types of communities - one dominated by bald cypress (*Taxodium distichum*) and water tupelo (*Nyssa aquatica*), one dominated by black willow (*Salix nigra*), and one with a species composition similar to that of a mature stand of bottomland hardwoods. These divisions were correlated with the percentage of stems originating as coppice on stumps leftover from the clearcut. In particular, the bottomland hardwood stands were regenerating predominantly as coppice, while the cypress/tupelo and black willow stands were regenerating primarily as seedlings. As indicated by the earlier development of overstory basal area, coppice sites were also regenerating much faster. The hydrology of a site also exhibited a strong impact on the rate of regeneration, with the semi-permanently to permanently flooded portions of sites often exhibiting little or no regeneration. The results indicate that, because of the overwhelming reliance on coppice sprouts as the main source of stems and the concomitant enhanced rates of regeneration, certain vegetative parameters of clearcut bottomland hardwood stands would not be effective benchmarks by which to judge the relative success of creation and restoration efforts. Exceptions might include bottomland hardwood mitigation sites that have been colonized by black willow, as well as created or restored cypress swamps where the substrate contains a viable seed source and a natural physical regime is present.

Keywords: bottomland hardwood forest, wetland, clearcut, reference, restoration, monitoring, succession, mitigation, vegetation

**EARLY SECONDARY SUCCESSION IN THE BOTTOMLAND HARDWOOD FORESTS OF
SOUTHEASTERN VIRGINIA**

1. Introduction

Bottomland hardwood forests, often referred to elsewhere as palustrine forested wetlands (Cowardin et al. 1979) or southern floodplain forests (Kuchler 1964), are a dominant landscape feature across the southeastern United States. Among the various types of wetlands found in the United States, these ecosystems have historically suffered disproportionately large losses, primarily through agricultural conversion, with draining and clearing of forested wetlands beginning in earnest around the mid-1800's and accounting for average annual losses of approximately 165,000 acres per year between 1940 and 1975. Although the push towards agricultural conversion has slowed somewhat in recent years, the losses associated with development pressures have since increased dramatically and the net loss of bottomland hardwoods continues to be problematic (Harris and Gosselink 1986, Gosselink and Lee 1987, Tiner et al. 1994).

While federal, state, and local governments have attempted to stem the tide of wetland loss through an assortment of direct and indirect legislative efforts, Section 404 of the Clean Water Act remains the cornerstone of protection for threatened bottomland hardwood systems in the United States (Muir et al. 1990). While not expressly written as a wetlands protection law, this powerful legislation mandates that anyone seeking a U.S. Army Corps of Engineers permit to fill wetlands provide compensatory mitigation for any unavoidable impacts. Compensatory mitigation is defined in 40 CFR 1508.20(e) as "compensating for the impact by replacing or providing substitute resources or environments," and is considered by the Corps of Engineers to include preservation, enhancement, restoration, or creation of wetlands.

Although the standards dictated by the Clean Water continue to remain controversial, the creation and restoration of wetlands has nevertheless been a growth industry in recent years as permit applicants seek to avoid the project constraints associated with avoidance and

minimization of wetland impacts. Based on the premise that wetlands perform critical ecological and societal functions, these efforts are undertaken with the intention of minimizing the net loss of these functions within the impacted ecosystem (Mitsch and Gosselink 1993).

Currently, however, the science upon which compensatory mitigation projects are based is still in its relative infancy and there remain serious questions concerning the potential for successful recreation of bottomland hardwood systems. In an effort to ensure the effectiveness of creation and restoration efforts, regulators often require monitoring of mitigation sites as a condition of project authorization. In the case of freshwater and saltwater marshes, colonization and succession of plant communities is fairly rapid and the degree of success attained can generally be ascertained within a few years (Landin and Webb 1986). On the other hand, the time frame over which created or restored bottomland hardwoods begin to resemble natural systems is more on the order of decades rather than years (Kusler 1986, Mitsch and Gosselink 1993), much longer than the average permit applicant could reasonably be expected to monitor a mitigation site and, for that matter, much longer than the institutional memory of the regulatory agencies charged with seeing that mitigation requirements are met (Clewail and Lea 1990).

Thus, in order to provide a manageable protocol for monitoring of bottomland hardwood mitigation sites, emphasis is now being directed towards the establishment of "reference wetlands" that are representative of regional and local conditions (Mitsch and Gosselink 1993, Clewail and Lea 1990, Erwin 1990, Brooks and Hughes 1986). The concept of reference wetlands has become increasingly familiar to wetland professionals during recent years with the ongoing development of the hydrogeomorphic functional assessment method (HGM) (Brinson 1993, Brinson and Rheinhardt 1996, Rheinhardt, Brinson, and Farley 1997). In the HGM methodology, reference wetlands are selected to represent a range of ecological conditions, from pristine (assumed to represent the highest level of functioning) to disturbance-mediated, within a

defined wetland class and geomorphic setting. Field parameters from these sites are used to determine reference standards which, in turn, allow development of a model of the wetland functions performed by that particular class of wetlands. The model quantifies the loss of functions associated with wetland impacts, as well as the recovery of functions when wetlands are created or restored, providing a defensible method of determining a ratio between acres impacted and acres compensated that is consistent with the goal of no net loss of wetland functions (Brinson and Rheinhardt 1996).

While the process of developing reference wetlands pursuant to HGM methodology accounts for many of the spatial, temporal, and environmental gradients that influence the functions performed by bottomland hardwood systems, it must be realized that this procedure does not provide a means of estimating the developmental trajectory of forested wetland systems during the earliest stages of succession. These first few years, however, represent the time period during which most creation and restoration projects are monitored for success. Thus, there is an need for data on these early successional processes (Allen 1997) that can be used as a benchmark to indicate whether these compensatory wetlands are indeed proceeding towards a mature system that will adequately replace the functions previously performed by the impacted wetland.

The purpose of this project was to examine a suite of naturally revegetated forested wetlands and to quantify early secondary succession in the bottomland hardwood forests of southeastern Virginia. This was carried out by conducting vegetation analyses on a chronosequence of seventeen sites that were clearcut over the last two to twenty years and allowed to naturally revegetate. In order to more closely approximate the natural successional changes following timber harvest, sites were selected based on the presence of an unimpacted hydrologic regime and the lack of artificial treatments, such as seeding, burning, or use of chemicals. Species composition was not a determining factor in the site selection process, as this

was expected to be one of the factors influencing successional trajectory and would have thus biased the results of the study.

During the site selection phase of this study, it was evident that the most readily discernible and dramatic differences between early successional sites would be related to their structural characteristics (i.e. the amount of herbaceous vegetation, overstory development, etc.). The challenge, then, would be to identify any edaphic, biotic, or hydrologic factors that maintain an overriding influence on the rate of change of structural composition. Although there is relatively little information available regarding the initial pulse of regeneration following timber harvest, both documented and anecdotal accounts indicate the importance of coppice sprouts to the rapid development of an overstory (B. Heeren, pers. comm.). Also noted as influencing the productivity of forested wetlands is the hydrologic regime and the associated flow of nutrients through a site, with primary productivity peaking where there is a pulsing hydroperiod (Taylor et al. 1990). Thus, it was hypothesized that the data would indicate successive dominance of structural components, from herbaceous to woody understory to forest vegetation as time progresses. Dominance of particular species and structural components at a given age was expected to be correlated with hydrologic regime and the availability of stumps for coppice sprouting, and to a lesser extent soil characteristics and other environmental variables. In particular, the presence of extensive coppice regeneration was expected to accelerate the early development of an understory, while regeneration was expected to be stunted in those sites characterized by a stagnant hydrology with continuous or nearly continuous inundation. The data gathered in this study is intended to provide the foundations of a database that will assist regulators in the establishment of achievable goals for the creation and restoration of bottomland hardwoods in southeastern Virginia, as well as an objective means of evaluating the relative success or failure of these efforts.

2. Literature Review

2.1 Succession in General

Warming (1909), Moss (1910), Braun, and Furrer (Braun and Furrer 1913) represent just a few of the many early plant ecologists concerned with the processes of formation and association in plant communities; among these, however, F.E. Clements has consistently proven to be among the most influential (van der Valk 1982). Clements (1916) summarized succession research dating back to 1685 and then proceeded to develop a model of the dynamics of natural vegetation. This model sought to describe succession as a function of six basic processes: nudation, migration, ecesis, competition, reaction, and stabilization. Nudation, or the creation of bare patches of soil, is traditionally considered the beginning of succession and is followed by colonization of the area by migrating propagules or propagules already contained in the soil. Environmental conditions initially control the successful establishment of plant species, or ecesis, after which competition for limited resources eliminates some species and favors others. As plants grow and die, changing environmental conditions affect the availability of resources and is thus reflected by the reactions of plant communities to these changes. Stabilization, the final stage of Clementsian succession which rarely occurs, is manifested in the domination of a site by very long-lived and self-reproducing species.

While the above listed processes are still extremely relevant to any discussion of successional theory, it is Clements' further assertion that all succession moves towards a stable, self-reproducing terrestrial community in equilibrium with the regional climate that continues to draw criticism from plant ecologists. This approach has often been interpreted as a gross simplification in which all wetland vegetation exists as a series of relatively short-lived stages,

eventually leading to a terrestrial climax community (van der Valk 1982). Clements merely described the situation in which development of a climax community is halted indefinitely as a sericlimax and pointed specifically to the cypress-gum swamps as an example (Weaver and Clements 1938).

The first major theoretical departure from Clements' concept of succession was developed by Gleason (1917, 1927). Gleason's theory, known as the individualistic concept of plant association, argues against the existence of a climax community *per se*, and instead emphasizes the importance of migration and environmental selection to the propagation of individual species in a given area. Basically, he is implying that disseminules migrate everywhere, growing where favorable environmental conditions exist until these conditions no longer occur, and rendering the survival of any given species subject to the limitations of the environmental gradients it is able to endure. Thus, vegetative "communities" are actually nothing more than a conglomeration of species able to survive under similar environmental conditions. As conditions change, either spatially or temporally, some species can no longer endure while new ones are able to propagate, making it impossible to rigidly define the scope or extent of a plant association. Lacking this definition, plant associations can not be logically grouped into larger classifications representative of the successional series suggested by Clements (Gleason 1927).

Despite frequent criticism of the assumptions made by Clements, the underlying principles of his theory have remained pervasive in discussions of ecological succession throughout most of this century. Odum (1969), for example, based his holistic theory of ecosystem development on three parameters that closely parallel Clements' ideas: (1) succession is an orderly process of community change that is reasonably directional and therefore predictable; (2) it is community controlled in that it results from modification of the physical

environment by the community; and (3) it eventually culminates in a stabilized ecosystem. Odum differs somewhat in that he relates his conclusions more in terms of the biomass of the system, rather than the particular species present.

Over the past two decades, however, a substantial number of articles have been explicitly critical of the Clementsian theory of succession (McCormick 1968, Drury and Nisbet 1971, Horn 1974, 1975). Connell and Slayter (1977) provides a review of the theory and the evidence supporting it, and go on to propose two alternative models. Facilitation, the Clementsian model, is said to lack supporting evidence and to have been deduced from the concept that the mature community is in steady state and maintained by internal feedback control mechanisms, although it is conceded that the mechanisms determining community development may apply to heterotrophic successions and certain primary successions. The tolerance model describes succession as a process by which the combination of species that most efficiently exploits the different kinds or proportions of resources eventually dominates the community. Several examples are given to support the assertion that, in dense light-limited forests, the species able to grow on the lowest level of resources will dominate the community at equilibrium; however, in the examples the forests are apparently replacing themselves by vegetative reproduction (root sprouts) rather than by independant offspring (seedlings). The final model, inhibition, occurs where there exists no competitively superior species, so whichever colonizes the site first maintains their position against all comers save those that bring along or create their own resources. This leaves damage and death as the only means by which replacement occurs, which results in a gradual shift in species composition towards those that live longer and removes the directional mechanisms present in the first two models in deference to basic life-history characteristics.

2.2 Succession in Wetlands

Early studies of wetland succession dealt primarily with the zonation of vegetation around lakes in England and the United States and were predominantly influenced by Clementsian theories of successional communities (Pearsall 1920, Gates 1926, Wilson 1935). Wilson (1935) describes the progressive development of seepage lakes in Wisconsin as occurring in a series of steps by which the lake is isolated from a drainage system, the bays are isolated from the main body of water smoothing the outline of the lake, and organic sediments accumulate to the point that the plant community begins to change from one type to another. Gates (1926) takes this one step further by asserting that zonation of vegetation around lakes directly represents the successional processes underway at a given time and that lakes will eventually fill and resemble the surrounding upland community. Other historical studies of succession in wetlands have dealt primarily with vegetation changes occurring after drawdowns of impoundments in the interest of managing the impoundments for optimum waterfowl conditions (Harris and Marshall 1963, Meeks 1969).

More recently, van der Valk (1981, 1982) has introduced the concept of a Gleasonian approach to succession in wetlands. He constructs a model of succession in temperate North American wetlands in which vegetation changes are a function of environmental conditions and life history characteristics of species present. The wetland environment is said to act as a sieve, regulating the establishment of species through changing water levels. Recognizing the paucity of information available on the majority of wetland species, van der Valk has limited his model to allogenic succession, rather than general succession, based on three key life-history features: life-span, propagule longevity, and propagule establishment requirements. Species are classified as being either annuals, perennials, or vegetatively reproducing perennials with an indefinite life

span; as dispersal-dependent species with short-lived propagules or seed bank species with long-lived propagules; and, as drawdown species that can become established only in the absence of standing water or standing-water species that can get established when there is standing water, respectively. The result is a qualitative model that predicts only which species will be present, with no information provided as to their relative abundance, and that fails to include the effects of interactions among plants which are potentially significant in determining presence or absence.

2.3 Succession in Bottomland Hardwood Forests

Very little research has been specifically directed at quantifying the early successional vegetation dynamics of forested wetlands. In one of the more recent attempts, Johnson et al. (1985) examined vegetation succession on newly formed islands in the Atchafalaya River delta. They conclude that the environmental factors varying most consistently with plant associations are the physical factors dependent on hydrologic regime, namely percent variation in water level, organic carbon, and percentage sand, while little correlation was observed between plant associations and soil mineral content. It should be noted, however, that this study examines primary succession as opposed to secondary succession. According to Tilman (1988), primary succession generally begins as a bare mineral substrate, perhaps following sand dune formation, glacial recession, volcanic eruption, or major erosion; whereas secondary succession occurs on substrates where organic soil and the propagules of various plant species are present at the outset, as is the case after abandonment of farming or clearcutting.

Bowling and Kellison (1983) examined secondary succession in the twenty-two years following clearcutting of a bottomland hardwood forest in Mississippi. Their results challenge

the traditional notion among hardwood silviculturalists that the oak component of a regenerated stand will not be present if advance oak reproduction was not present in the preceding stand. While early regeneration in the study site was dominated by ironwood (*Carpinus caroliniana*) and sweetgum (*Liquidambar styraciflua*), with oak comprising a relatively minor constituency, by age 19 oak had outcompeted the shade-tolerant ironwood to become the dominant species along with sweetgum. Bowling and Kellison results support their contention that a desirable species composition is attained when a stand is clearcut and allowed to naturally regenerate. Mentioned but not addressed directly was the proliferation of coppice sprouts on the project sites and their role in the early successional structure of bottomland hardwood forests. Coppice, which refers to stems originating from the cut stumps or following harvest, was identified more recently in a study by Messina et al. (1997) as accounting for 83% of the stems in a Texas bottomland hardwood forest in the years immediately following a clearcut.

Clearcutting, in fact, is considered by most experts to be the best method for harvesting bottomland hardwood forests in terms of providing for successful regeneration (Stubbs 1973, McKnight and Johnson 1975, Heeren 1983). In a study of woody plant regeneration following timber harvest by helicopter and by rubber-tired skidder, Mader (1990) quantified changes in plant community structure, noting in particular total standing biomass, habitat suitability, and species richness. Within two years plant productivity had reached approximately seventy percent of that in an undisturbed reference forest, propelled mostly by rapidly growing herbaceous vegetation and stump sprouts. The rapid recovery of plant productivity and other wetland functions, such as nutrient retention, prompted the conclusion that clearcutting forested wetlands is an acceptable and, indeed, preferable forestry management practice. Conner (1994) pointed out that the primary causes of species composition changes in timbered wetlands have been the selective cutting of bald cypress (*Taxodium distichum*), often leading to dominance by water

tupelo (*Nyssa aquatica*), and modification of the natural hydrologic regime. Contrary to Mader (1990), Gresham (1985) argued that species composition and spatial distribution three years after a clearcutting of a forested wetland in the coastal plain of South Carolina is unacceptable and recommends the postharvest planting of seeds or seedlings.

In a study of woody plant regeneration in four closed-canopied floodplain forests, Jones et al. (1995) noted the following: (1) smaller-seeded species comprised a dominant proportion of seeds and germinants; (2) survival rates were greater for species germinating early in the growing season; (3) survival rates for seedlings increases during the first several growing seasons; (4) seedlings growing near conspecific adults experienced reduced survival rates; and, (5) dense understory seedling pools were established as a result of slow growth of seedlings.

2.4 Wetland Functions

Taylor et al. (1990) outlined four interdependent classes of functions typically present in bottomland hardwood systems. The first includes those functions related to community dynamics: (a) primary production, which is estimated to range from 700 to nearly 1800 g C/m²/yr depending in part on hydrology and vegetation (Brinson et al. 1981), (b) the decomposition of litterfall through leaching of soluble materials, mechanical fragmentation, and biological decay, (c) the export of organic detritus to support aquatic food chains, and (d) the provision of habitat for a diverse array of aquatic and terrestrial organisms. Second, physiochemical processes, which are mediated largely by the velocity and volume of water in the wetland and the amount of sediment it carries, include the deposition of sediments as streamwater flows across the floodplain, the bioassimilation of nutrients and pollutants contained in surface runoff, and a myriad of biochemical transformations. Third, surface water storage refers to the capacity of

wetlands to retain pulses of water associated with spring runoff and storm events. Finally, the ability of some floodplain wetlands to recharge both surficial and deep aquifers through percolation of surface water, and of others to discharge groundwater during low-flow periods, comprises the groundwater storage class of functions.

When these functions are considered in light of their ability to meet current human needs, their economic value to society becomes readily apparent. This has in turn led various researchers to attempt quantification of particular values, such as flood mitigation and control, biomass production, and even visual-cultural qualities (Johnson and Linder 1986, Farber and Costanza 1987, Costanza et al. 1989). For example, it has been estimated that loss of the 3,400 hectares of wetlands in the Charles River Basin, Massachusetts, would increase annual flood damages by approximately \$17 million (U.S. Army Corps of Engineers 1972 in Mitsch and Gosselink 1993).

2.5 Analytic Methods - Community Structure

Although there are no standardized methods for analyzing the community structure of bottomland hardwood forests, most studies are similar in that they examine the density and dominance of species according to specific vegetative classes based on height, stem diameter, and other physiognomic characteristics. These classes can include, but are not limited to, overstory, understory, trees, saplings, seedlings, shrubs, vines, and herbaceous plants. The divisions between the respective classes are often rather arbitrary, varying significantly with the vegetative composition of the study site as well as the objectives of a particular study. Frequently in studies of swamp community structure, overstory has included those trees greater than 2.5 cm diameter

breast height (dbh) (Day 1984, Fowler 1987, Silberhorn 1992), although this cutoff is by no means consistent throughout all studies of the forested wetlands of the mid-Atlantic region (Doumlele et al. 1985, Pavel 1993, Rheinhardt 1991).

Analyses of forest vegetation frequently employ quadrat methods, in which the investigator determines densities and basal areas of plants rooted within a circular or rectangular plot (Meuller-Dombois and Ellenberg 1974), as well as a variety of somewhat more efficient plotless techniques which, generally speaking, determine the same parameters through the use of variable radius circular plots (Bitterlich 1948, Grosenbaugh 1952, Meuller-Dombois and Ellenberg 1974) or by calculating distances between plants (Cottam and Curtis 1956, Meuller-Dombois and Ellenbergh 1974). One particular distance method, the point-centered quarter technique (Cottam and Curtis 1956) has proven to be particularly effective in studies of swamp community structure (Fowler 1987, Doumlele et al. 1985). This technique, however, suffers the same limitation as other distance techniques in that it assumes a random distribution of plants (Meuller-Dombois and Ellenberg 1974) which, given the preponderance of coppice regrowth and aggregations of seedlings in timbered wetlands, is not a valid assumption for young ecosystems of this type. Therefore, studies of forested wetland regeneration have tended to utilize the variety of quadrat methods available (Huenneke and Sharitz 1986, Mader 1990, Pavel 1992).

Evaluation of the herbaceous communities of forested wetlands involves the use of similar, albeit smaller, quadrats. Rather than measuring basal area to determine dominance, cover, or the vertical projection of the crown or shoot area of a species onto the ground, is estimated as a fraction or percent of the quadrat area (Meuller-Dombois and Ellenberg 1974). This can be accomplished directly through point-intercept methods, although these are often time-consuming and difficult to implement properly (Meuller-Dombois and Ellenberg 1974). More frequently, percent cover is visually estimated for each species in each quadrat, then ranked

and averaged according to a cover class scale comprised of a series of ranges of percentages (Meuller-Dombois and Ellenberg 1974). Although the differences between available cover class scales are minimal (Meuller-Dombois and Ellenberg 1974), several recent studies have employed a modified Daubenmire technique (Daubenmire 1959, 1966, 1968) to assess terrestrial and wetland plant communities of the mid-Atlantic coastal plain (Levy 1976, Levy et al. 1984, Perry 1991, Rheinhardt 1991).

2.6 Statistical Methods

Data gathered during field studies of plant community structure tends to be bulky and rather complex, complicating efforts to identify any correlations or relationships that may exist. Multivariate statistical methods, which allow examination of numerous variables simultaneously, provide useful techniques for summarizing the data and elucidating any structure that may exist (Gauch 1982). Austin (1977) suggests that multivariate methods can be particularly effective for describing the temporal changes in vegetation associated with succession and for demonstrating interactions between spatial patterns of environment and vegetation over time.

Among the many multivariate statistical analyses available, ordination techniques are widely used to summarize plant community data. They do so by reducing large data matrices (usually consisting of species and stands) into a low-dimensional space with proximity of data points corresponding to similarity (Gauch et al. 1977, Causton 1988). The primary methods of ordination include Bray-Curtis (Bray and Curtis 1957), principal components analysis (Goodall 1954, Orloci 1966), reciprocal averaging (Hill 1973), and detrended correspondence analysis (Hill and Gauch 1980). Principal components analysis was one of the earliest ordination techniques, yet one still commonly used to examine a variety of types of data. It is a non-polar

ordination method that establishes axes by considering maximum variation of the stand set as a whole, rather than basing them on pairs of very dissimilar stands as in polar ordination (Causton 1988). It has the advantages of accommodating many types of data and of being an especially objective ordination technique in that it requires no weighting of data or selection of endpoints (Gauch 1977). However, principal components analysis is problematic in that the mathematic model on which it is based requires the investigator to make unrealistic assumptions about the normality of ecological data, which then produces an arch effect when plotted in two dimensions that is typically not a reflection of any ecological attribute of the data (Causton 1988).

The effectiveness and accuracy of principal components analysis has been questioned by several authors who performed a variety of prominent ordination techniques on identical data sets, both actual and simulated (Gauch and Whitaker 1972, Beals 1973, Kessell and Whitaker 1976, Gauch et al. 1977). Gauch et al. (1977) compared principal components analysis to reciprocal averaging and Bray-Curtis ordination. Reciprocal averaging is a weighted averaging technique, the main advantages of which are simultaneous ordering of sites and species, rapid computation, and robustness despite nonlinear and unimodal relationships to environmental gradients, which has been a problem for principal components analysis (Palmer 1993). While reciprocal averaging was generally found to be superior to principal components analysis, it is still subject to a pronounced arch effect in the second axis and accuracy deteriorates when outlier samples are included in the analysis. Also, reciprocal averaging has a tendency to obscure discontinuities in the data set by compressing data onto the first axis (Beals 1984). Interestingly, Gauch et al. (1977) found that the most robust of the techniques was the Bray-Curtis ordination, which is not subject to an arch effect or distorted by clusters of samples and outliers.

The polar ordination method was devised by Bray and Curtis in the 1950's for the purpose of understanding the complex interactions of environmental and vegetative factors over

gradients, as opposed to the non-polar ordination methods which were not designed specifically for ecological data (Gauch 1977). It requires the computation of percent dissimilarity between stands and, based on this, the selection of the two most dissimilar stands as endpoints, or poles, of the ordination axis. Gauch and Whitaker (1972) and Beals (1984) recommend Sørensen's coefficient of community rather than the Czekanowski (percentage similarity) variant first used by Bray and Curtis. Provided that an outlier is not selected as one of the endpoints, this method of ordination consistently provides results as good as or superior to those provided by the mathematically more rigorous methods mentioned above (Gauch and Whitaker 1972, Beals 1973, Kessell and Whitaker 1976, Gauch et al. 1977).

Habeck (1968) used Bray-Curtis ordination to examine secondary succession in the cedar-hemlock forests of Glacier National Park. A total of 78 quantitative characteristics, including importance values of trees, saplings, and seedlings, as well as quadrat frequencies for common understory species, were included in the ordination of 33 stands ranging in age from approximately 50 to 400 years old. Due to the environmental homogeneity of the study area, a single axis was sufficient to describe compositional change with time, whereas a more variable environment would have required that a multidimensional ordination be performed. The results firmly supported earlier qualitative analyses of the same area and corresponded to recorded changes in structural properties, such as reduced densities of trees over time.

A later modification of reciprocal averaging known as detrended correspondence analysis (DCA) (Hill and Gauch 1980) was designed to correct the relationship between the first and second axes that produces the arch effect. One of the most widely used ordination techniques, DCA is an indirect gradient analysis, meaning that environmental gradients are inferred from species data, rather than studied directly. While the detrending step successfully accomplishes the objective of eliminating the arch effect, Palmer (1993) points out that the

improved method fails to account for the information lost when data is compressed onto the first axis and that, like its predecessor, it is significantly affected by rare species or outlier samples.

More recently, another variation of reciprocal averaging, canonical correspondence analysis (CCA), has gained considerable prominence. Based largely on the work of Ter Braak (1985, 1986, 1988), CCA differs from DCA in that it is a direct gradient analysis, directly and immediately relating species composition to measured environmental variables (Palmer 1993). In a comparison between CCA and DCA using simulated data, Palmer (1993) described CCA as “having all of the advantages and none of the disadvantages of CCA..” Specifically, the arch effect appeared only when there existed a true arch in the data and results did not appear to exhibit the compression of data points that produces the “tongue effect” in other reciprocal averaging techniques. CCA is also capable of performing a technique known as partial ordination, in which covariables representing site-to site environmental variation are factored out of the ordination. The procedure thus minimizes the effect of covariables on the outcome of the ordination, and does so with no major distortion of the grid (Palmer 1993).

3. Methods

3.1 Study site

The field work for this research took place in the watersheds of the Blackwater, Nottoway, and Meherrin rivers, which together form a considerable portion of the Chowan River Basin in southeastern Virginia and northeastern North Carolina. Sites were located in the upper coastal plain, an area that has an average frost-free period of approximately 200 days (Plunkett and Hall 1995) and receives approximately 48 inches of rain per year, mostly between April and September. Predominant land uses in the region include silviculture and agriculture, with corn, cotton, peanuts, and soybeans representing the main crops.

Seventeen sites, as shown in Figure 1, were selected for inclusion in this study, all of which are owned either by Union Camp Corporation or by private citizens who manage their land in coordination with the Virginia Department of Forestry. Each has been clearcut at some point within the last twenty years and their respective "ages" are determined by the number of years since the area was logged. Sites are identified in this report according to their age and an identifying letter (i.e. 20a and 20b represent the two twenty year old sites evaluated). Every effort was made to ensure that each of the project sites had been allowed to revegetate naturally without the influence of chemical treatment, planting, or burning. Maps and descriptions of each site are located in Appendix *.

3.2 Field data collection

Prior to the initiation of sampling, it was decided that vegetation should be divided into

Figure 1. Locations of project sites.

three sampling components: herbaceous (or ground plane), understory, and overstory. The herbaceous component included all herbaceous species, all vines, and woody plants (trees and shrubs) less than 50 cm tall. The understory consisted of saplings and shrubs equal to or greater than 50 cm tall but less than 2.5 cm dbh (diameter at 1.5 m above ground). The overstory included all woody vegetation equal to or greater than 2.5 cm dbh (Mader 1990, Rheinhardt 1992).

Sampling points for understory and overstory components were located using a random walk technique, ensuring that wetlands were sampled evenly yet randomly while avoiding any overlap of plots (Tilman 1988). The number of sampling points per site ranged between four and ten, depending in large part on the density of understory at a particular site.

Because of the relative lack of overstory in early successional forested wetlands and the necessity of avoiding upland/wetland ecotones in some of the more narrow project sites, 2.81 m radius (25 m²) circular plots were selected as efficient, yet reasonably thorough, means of sampling both understory and overstory vegetation. Despite the benefits of reduced variance, the larger plots more typically found in studies of swamp community structure (Doumlele et al. 1985, Rheinhardt 1992) were considered too cumbersome in the dense understory of many project sites, while the various plotless methods available would have provided little information in younger stands and not adequately accounted for the coppice regrowth on stumps remaining from the clearcut. Within each circular plot, stems were tabulated by species, sampling component, and origin (i.e., seedling or sprout). The dbh of overstory stems was measured to the nearest half centimeter, while understory vegetation was measured at 40 cm above the base for trees and at 3 cm above the base for shrubs, also to the nearest half centimeter (Mader 1990). Each stem was classified as either a seedling or sprout, being considered sprouts if they originated below 40 cm on residual stumps and were counted separately if they forked within three centimeters of the

base (Mader 1990).

The herbaceous component was sampled using quadrats of dimensions 1 m x 0.5 m (0.5 m²) that were positioned in a stratified random manner based on the centerpoints of the radial plots. Density for each species was measured by counting only those plants actually rooted within the quadrat. Total herbaceous cover and coverage of each species present within the quadrat, regardless of root location, was determined by a modified Daubenmire (1968) technique, involving ocular estimation of cover and assignment into one of seven coverage classifications: trace, 1-5%, 5-25%, 25-50%, 50-75%, 75-95%, or 95-100% (Rheinhardt 1992).

At each study site, two soil samples were taken from each of two locations consistent, where possible, with the one or two elevations most representative of vegetation sampling points. A standard chemical analysis, including measurements of pH, organic matter content, and cation exchange capacity, was performed on each sample by the Department of Crop and Soil Environmental Sciences at Virginia Polytechnic Institute and State University.

Hydrologic characteristics of study sites were evaluated through installation and monitoring of PVC groundwater wells. Wells were constructed of screened 4-inch PVC pipe positioned from approximately 1-2 m below ground to within 15 cm of the surface and attached to solid 4-inch PVC pipe that extended about 1 m above the ground surface. Because of the unavailability of remote dataloggers and the resulting time considerations involved in checking the wells manually, only one well was installed at most sites. At three project sites, two monitoring wells were established to indicate any possible differences in microsite hydroperiod. Water levels were recorded biweekly for one year, although occasional datapoints are missing where high water levels rendered sites inaccessible.

3.3 Data analysis

Information obtained during field sampling was used to calculate estimates for population densities and dominance according to the following formulas:

$$X_{den} = X_{tot} / ((A_{plot}) (N_{plot}))$$

where: X_{den} = absolute density of species X (in # / m²),

A_{plot} = area of individual plots (0.5 m² or 25 m²), and

N_{plot} = total number of plots on a given site;

$$X_{dom} = (X_{ba}) (X_{den})$$

where: X_{dom} = absolute dominance of species X, and

X_{ba} = mean basal area (cover estimation for herbaceous species) of individuals of species X (in m²).

The relative values according to species and sampling component was then determined for each of these measures using the following formulas:

$$RX_{den} = X_{den} / Tot_{den}$$

where: RX_{den} = relative density of species X, and

Tot_{den} = sum of density values for all species;

$$RX_{dom} = X_{dom} / Tot_{dom}$$

where: RX_{dom} = relative dominance of species X, and

Tot_{dom} = sum of dominance values for all species;

Species importance values were then formulated for each sampling component by taking one-half of the sum of relative density and relative dominance (Mueller-Dombois and Ellenberg 1974).

Community dynamics were then analyzed using a variety of ordination techniques available as part of the CANOCO software package developed by Ter Braak (1988). Results of the canonical correspondence analysis are presented here using species-site biplots that detail the first two ordination axes. The role of measured environmental variables, such hydrology and soil chemistry, was evaluated by examining their correlation with each other and with the first two ordination axes. The changes in community characteristics associated with age were minimized by using that factor as a covariable.

4. Results

The results for each site, without respect to the particular species present, are contained in Table 1. Densities and basal areas have been standardized to hectares to facilitate comparison with other studies. Overstory densities range from 0 stems/hectare at Site 3a to 5920 stems/hectare at 14a. Site 3a, which was whole-tree chipped at harvest leaving few visible stumps, also had the lowest proportion of stems originating as coppice in both the overstory and understory. Site 14a, on the other hand, exhibited the prevalence of coppice sprouts that was characteristic of a number of project sites and that generally corresponded with enhanced stem densities. Likewise, Site 15a, which had the second highest percentage of overstory stems originating as coppice, was the most productive site in terms of total basal area, more so than even the seventeen and twenty year old sites. In comparing the overstories of sites of the same age, a notable discrepancy exists between the two 20-year-old sites. Despite having roughly similar densities, Site 20b exhibited almost twice the basal area as Site 20a. Not accounted for in the data, though, was a considerable mortality among the canopy trees at Site 20a, limited almost entirely to *Salix nigra* and, to a lesser extent, *Populus heterophylla*. Understory densities displayed considerable variability throughout the seventeen project sites, ranging from just over 1500 stems/hectare to greater than 30,000 stems/hectare. Some notable aberrations would appear to be Sites 8a, 8b, and 17a. At the latter two, beaver activity resulted in numerous stumps that produced a prodigious number of new sprouts, while at site 8a, suckering at the base of *S. nigra* saplings substantially augmented understory stem densities. This explains the notably higher understory basal area at Site 8a, since it was not subjected to the post-establishment reduction in basal area associated with beaver activity.

Table 1
Structural vegetation data from project sites. Site number indicates years since harvest when sampled. Percent sprouts indicates the percentage of stems originating as coppice.

Site #	Overstory			Understory			Herbaceous
	density stems/hect	basal area m ² /hect	stem origin % sprouts	density stems/hect	basal area m ² /hect	stem origin % sprouts	
2a	320	0.18	38	14720	2.00	38	80.5
2b	320	0.21	75	9600	1.01	87	85.5
3a	0	0	0	10293	0.65	2	75.3
3b	1280	1.03	44	16320	4.21	11	56.5
5a	686	1.19	33	6686	1.07	54	94.2
5b	2080	2.40	46	10880	2.40	28	47.5
7a	933	1.09	64	8267	2.27	43	53.8
8a	743	0.57	23	28114	5.25	11	25
8b	2600	9.53	73	30500	3.72	17	58.8
9a	2800	10.46	83	17520	2.06	82	38
10a	3040	20.40	87	10160	0.96	79	43
14a	5920	21.64	75	11440	1.77	47	9.5
15a	4533	36.39	85	4200	0.87	79	22.5
15b	8300	31.42	46	7400	1.70	11	3.7
17a	3133	20.36	60	15000	2.72	52	42.1
20a	3943	18.81	36	1543	0.49	48	3.3
20b	4400	35.28	66	1600	0.14	75	1.9
Mean	2648.88	12.41	54.9	12014.29	1.96	44.9	43.6
Median	2600	9.53	60	10293	1.77	47	43

Tables 2 and 3 list importance values of the dominant and co-dominant species within the overstory and understory components, respectively, for all of the project sites combined. Although a total of twenty-seven species were sampled in the overstories of project sites, only nine were dominant or co-dominant on at least one project site. Dominance and co-dominance were determined by the species or group of species, respectively, as ranked by importance values, necessary to accumulate a combined importance value greater than 50 within a particular site. It should be noted that, because of difficulty in identifying the particular species of such young specimens from the genus *Fraxinus*, all occurrences were classified as *Fraxinus* spp. Several species and subspecies are, in fact, known to occur within this geographical region, including *F. caroliniana*, *F. profunda*, and, primarily, *F. pennsylvanica* (Rheinhardt 1992, Glascock and Ware 1979). As indicated by the total importance value for all sites combined, *A. rubrum* and *S. nigra* were the dominant species throughout the study. However, the fact that *S. nigra* was the only species occurring in the overstory of site 2b enhances its relative importance with respect to this measure. Three species - *Platanus occidentalis*, *Ulmus americanus*, and one unidentified species referred to as "T2b10" - occurred in the overstories of no more than two project sites. In the case of *P. occidentalis* and T2b10, they were generally found to occur on the edges of or on hummocks within the sampled wetlands, while limited *U. americanus* populations possibly reflect the lingering impact of Dutch Elm, which tends to reduce seed production in mature trees (G. Silberhorn, pers. comm., S. Ware, pers. comm.).

When understory importance values are summed for all stands, *A. rubrum* and *S. nigra* are joined by *Fraxinus* spp. and *T. distichum* as the dominant species among all seventeen project sites, as indicated by total importance values greater than 200. The presence of *S. nigra*, dominant in the understories of several project sites, greatly diminishes between the seventh and tenth growing seasons, correlating with the early stages of canopy development. Between years

Table 2.

Importance values of overstory species. Species listed include those classified as dominant or co-dominant, as defined in the text, on at least one project site. Site number indicates years since harvest at time of sampling. Total importance value = (sum of importance values for all sites) / 1700 * 100.

Site #	2a	2b	3a	3b	5a	5b	7a	8a	8b	9a	10a	14a	15a	14b	17a	20a	20b	Total I.V.
<i>A. rubrum</i>					23	55		44.4	61.6	50		27.6	6.2	25.6	15.7	17.9	49.5	22.1
<i>S. nigra</i>	100			38.4	13.1	2.7	66.3	48.1		13.4				22.7	5.6	22.3	7.2	21.2
<i>Fraxinus spp.</i>				36.6		28.8		7.4	21.7			11.9	53.7	22.7	9.4	8.2	28	13.4
<i>L. styraciflua</i>											50.3	46.6		4.3		11.9	11.3	7.3
<i>N. aquatica</i>									7.1	16.2	14	32.6			40.7			6.5
<i>P. occidentalis</i>		76.1													14.5			5.3
<i>T. distichum</i>					8.9		23.3		2.3	20.3	21.6				6.3			4.9
<i>U. americanus</i>					37.1											8.2		2.7
T2b10 (unident. spec.)		23.9																1.4
Other species	0	0	0	5	17.9	13.5	10.4	0.1	7.3	0.1	14.1	13.9	7.5	24.7	7.8	31.5	4	15.2

Table 3.

Importance values of understorey species. Species listed include those classified as dominant or co-dominant, as defined in the text, on at least one project site. Site number indicates years since harvest at time of sampling. Total importance value = (sum of importance values for all sites) / 1700 * 100.

Site #	2a	2b	3a	3b	5a	5b	7a	8a	8b	9a	10a	14a	14b	15a	17a	20a	20b	Total I.V.
<i>A. rubrum</i>	7.7	0.7	0.9		11.4	35.5	3.4	0.6	57.6	25.5	2.4	17.6	48	7.8	9.4	47.1	62.9	19.9
<i>Fraxinus spp.</i>	9.9	29.5		17		19.5	0.5	3.4	29.4		18.9	16.4	17.8	78	2.7	18.9	31	17.2
<i>S. nigra</i>	59.8	14.4	5.9	14.9	38.7	1.2	12.3	85.9	29.2	2.5					1.4			15.7
<i>T. distichum</i>		10	59.6		16.8		57.2	0.8	0.2	14.8	8			5.2	47.9			13
<i>L. styraciflua</i>	1.8	13.7	13.7	1.6	18.9				0.5	10.1	13.8	3.1		3.8	2.5			4.9
<i>C. occidentalis</i>				61.5	0.9	3.4	2.4		1.4	16.9	1.9	1.1						4.3
<i>N. aquatica</i>							19		3.4		31.9				0.6			4.2
<i>Q. lyrata</i>									1.2				21.6			23.4		2.7
<i>P. occidentalis</i>	3	24.3	0.1	4.1	1.1							0.7	0.8		2.9			2.2
<i>M. virginica</i>	0.4	6.8										18.2		4.3				1.7
<i>L. racemosa</i>					5.1	18.4					1.1	0.9			2.6			1.6
<i>I. opaca</i>												15	0.7					1
Other species	17.4	0.6	19.8	0.9	7.1	22	5.2	9.3	6.3	3.5	19.5	27	11.1	0.9	30	10.6	6.1	11.6

ten and twenty, the increasing presence of an understory of shade-tolerant sub-canopy and canopy species is indicated by the presence of *Ilex opaca* and *Quercus lyrata*, respectively.

Data obtained from monitoring groundwater wells is shown in Table 4. Fluctuation, indicated by the range of measured water levels at a given site, was greatest at the two 20 year old sites, where measured highs and lows were over a meter apart. Flooding regimes at these two sites were somewhat different, though, with site 20a exhibiting flooding at the surface for approximately 68 % of the year compared to 28 % of the year for site 20b. At the other end of the hydrologic spectrum, sites 8a and 2a had water levels ranging less than 20 centimeters. Again, this was not necessarily indicative of an overwhelming similarity between the hydrologic regimes of the two sites. Water levels never dropped below 30 cm at site 8a, while at site 2a surface flooding was never observed (although there were secondary indicators of its presence). At two sites, 7a and 8a, measurements do not accurately reflect the high end of water level ranges with respect to the other sites because on several occasions the logging roads by which they were accessed were impassable due to high water levels.

Table 5 represents soil data for the entire suite of measured variables. In general, there were few apparent trends associated with site age. Soil pH levels ranged from 4.2 to 5.7 and organic carbon content ranged from 0.34 percent to 8.36 percent at a depth of 10 cm. Although there did appear to be a general decrease in soil pH over time at a depth of 10 cm, the lack of multiple samples from project sites and the considerable within-site variability, particularly at sites with a high degree of microtopographic variability, precluded analysis of the significance of apparent trends in soil data. Site 2a was notable in that it exhibited among the highest values for each of the variables indicated in Table 5.

The initial CCA of the 17 sampled stands (Figure 2) revealed a fairly even distribution of stands along the vertical (y, second) axis. However, site 2b was so vegetatively different from

Table 4.
Hydrologic data. Duration of inundation, as indicated by the percentage of well checks for which water was present at the levels (cm) shown, relative to ground surface. Site numbers indicate years since harvest at time of sampling.

Site #	2a	2b	3a	3b	5a	5b	7a	8a	8b	9a	10a	14a	15a	15b	17a	20a	20b
80							0										
70							7		0							0	
60				0			15		7	0				0		5	
50				20			31	0	7	56				0		5	
40			0	40		0	46	68	7	33			0	5		5	0
30			5	63		14	54	100	7	78		0	5	5	0	5	6
20			10	60	0	86	77		7	89	0	6	11	5	0	5	6
10		0	30	67	5	100	100		29	94	6	6	21	26	27	47	6
ground level	0	6	60	73	26				64	94	38	41	26	89	67	68	28
-10	82	22	70	80	68				86	100	81	71	63	89	100	74	39
-20	94	67	90	80	100				93		100	88	79			84	61
-30	100	83	90	87					93			94	95			95	67
-40		100	95	100					100			100	95			95	79
-50			95										95			95	83
-60			95										95			100	89
-70			100										95				94
-80													100				100
range (cm)	18.00	39.49	98.52	92.42	28.37	19.21	54.60	10.06	32.33	53.38	36.30	56.12	112.24	61.00	22.88	113.16	100.98

Table 5.
Soil chemistry at depth of approximately 10 cm.

Site #	pH	Org C %	Ca (meq/100 g)	Mg (meq/100 g)	K (meq/100 g)	CEC (meq/100 g)
2a	5.7	8.36	15.1	2.3	0.54	33.74
2b	5.5	3.07	8.28	0.64	0.12	21.04
3a	4.5	2.72	1.62	0.43	0.14	16.79
3b	4.7	3.39	4.45	1.31	0.45	23.81
5a	5.3	4.15	8.02	2.18	0.55	28.55
5b	4.7	2.59	4.24	2.19	0	23.63
7a	4.5	1.33	5.53	2.49	0.14	21.16
8a	4.4	3.03	1.37	0.43	0.1	18.70
8b	5.1	0.37	5.73	0.94	0.09	12.76
9a	4.7	1.41	2.85	0.52	0.09	13.46
10a	4.7	4.6	3.53	0.93	0.24	29.70
14a	4.2	1.07	0.1	0.1	0.1	19.70
15a	4.8	3.17	3.12	0.74	0.22	16.33
15b	4.6	1.71	4.26	1.57	0.1	22.08
17a	4.7	0.34	0.22	0.08	0.04	15.74
20a	4.4	3.02	5.82	0.88	0.14	23.24
20b	4.5	2.29	3.29	1.07	0.18	19.14

the other sixteen sites that, along the horizontal (x, second) axis, it proved to be obviously disjunct from the other sites, which themselves exhibited little variation along that particular axis. The most obvious reason for this difference is the dominance of *P. occidentalis* in the overstory and its co-dominance in the understory, with I.V.'s of 76 and 24, respectively. With regard to morphology of the site, 2b is more adequately characterized as a braided stream complex, separated by the hummocks on which *P. occidentalis* is regenerating predominantly as coppice. Also, the site was the only one at which no surface flooding was recorded during well checks, being observed only once during the entire monitoring period in the course of other research on the site. Instead, water was generally confined to the well-defined channels, a trait not shared by any of the other project sites. Of note also in this ordination was the inverse relationship between the presence of organic carbon in the soil and the percentage of overstory stems originating as coppice.

Because of these differences, site 2b was removed from subsequent ordinations. With the disjunct stand removed, a considerably more distinct grouping of the sites was revealed (Figure 3). By delineating the understory importance values of *T. distichum* and *S. nigra* as indicated in the biplot, the presence of three types of sites is indicated - Cypress, Willow, and Mixed Hardwood. The environmental parameter most highly correlated with the first ordination axis is the percentage of overstory stems originating as coppice, which clearly separates the Mixed Hardwood sites from the Cypress and Willow sites. Potassium is most highly correlated with the second axis, although the significance of this is not readily apparent.

In the final ordination (Figure 4), age was inserted as a covariable, effectively minimizing its influence on the outcome. Three of the Willow sites now fell into the larger cluster with the Mixed Hardwood stands, indicating that, as these sites age, they are most likely succeeding into communities more representative of those regenerating as coppice after the

Canonical Correspondence Analysis

All Sites, No Covariables

Figure 2. Canonical correspondence analysis of all project sites with no covariables. Vegetation data includes understory and overstory importance values for each species recorded in those strata (i.e. two values may exist for each species). Environmental variables included information related to hydrologic regime, soil chemistry, and stem origin. Only those environmental variables exhibiting the highest correlation with ordination results are depicted by arrows in the figure. Org C = organic carbon; Flood = duration of flooding as a percentage of the calendar year; O-Cop = percentage of overstory stems originating as coppice. The dashed line encloses the only site in which *Platanus occidentalis* exhibited an overstory importance value greater than 75.

Canonical Correspondence Analysis

Site 2b Removed

Figure 3. Canonical correspondence analysis with Site 2b removed and no covariables; other covariables identical to Figure 2. U-Cop = percentage of understory stems originating as coppice. The upper dashed line encloses those sites in which *Salix nigra* exhibited an overstory importance value greater than 50. The lower dashed line encloses those sites in which *Taxodium distichum* exhibits an understory importance value greater than 30.

Canonical Correspondence Analysis

Site 2b Removed, Age Covariable

Figure 4. Canonical correspondence analysis with Site 2b removed from the ordination and age inserted as a covariable. The dashed line to the right encloses those sites in which *Taxodium distichum* exhibits an understory importance value greater than 45. The dashed line to the left encloses those sites in which *Taxodium distichum* exhibits an understory importance value less than 6.

clearcut. The three sites most dominated by *T. distichum* still fell out distinctly as Cypress stands; however, three other sites - 5a, 9a, and 10a - fell out between the Mixed Hardwood stands and the Cypress stands on the first axis. On the second axis, these sites were distinguished from the Cypress stands by the generally higher prevalence of coppice. As observed in the field, these sites tended to have a substantial degree of microtopographic variability. Thus, they exhibited a wider range of environmental conditions, resulting in species compositions similar to Mixed Hardwood stands in some areas and Cypress stands in others. Calcium was the variable exhibiting the greatest correlation with the horizontal axis, a result also noted by a decrease in average values for the clusters moving from left to right on the biplot.

5. Discussion

5.1 *Species composition of project sites*

Excluding Site 2a, where the significant areal extent of drier hummocks may have resulted in a plant community composition considerably different than that of the other 16 sites, the ordination results indicated the presence of two general community types. The first, referred to as Cypress, is characterized by an understory of *T. distichum* and is represented primarily by three sites and by portions of three others. The differences between the three principal sites, however, give an indication of confounding interaction of factors that lead to development of this community type. For example, the three-year-old Cypress site exhibited a 1 m range of water levels comparable to that of several 15-20 year old sites, while the seventeen-year-old Cypress site only fluctuated over approximately 25 cm throughout the course of the study. Furthermore, while the seven-year-old Cypress site was continuously flooded at the surface, the three-year-old and seventeen-year-old Cypress sites were flooded at the surface only 60 and 66 percent of the time, respectively. Human impacts may account for some of the different environmental characteristics of these three sites. At the seventeen-year-old Cypress site, a cypress tupelo swamp upstream has been artificially impounded, which may have implications for the hydrologic conditions of the site during portions of the year. The characteristic common to all three of the Cypress stands is a low percentage of stems originating as coppice, in spite of the fact that *T. distichum* displayed the capability to sprout from stumps on these and other sites. The "whole tree chipping" of one Cypress site likely left few viable stumps on which coppicing could take place and the dense seedlings on the site did not appear to be originating as root sprouts. At another, the stumps remaining from the clearcut are massive in comparison to those seen

producing viable sprouts elsewhere, supporting the assertion that increased stump size, in terms of both diameter and height, serves to minimize the likelihood of viable sprout production (B. Heeren, pers. comm.). From the perspective of landscape geomorphology, Sites 3a and 17a can both be considered small stream bottoms, while Site 7a is a major floodplain of the Nottoway River and, as such, is hydrologically impacted more by overbank flooding than by the groundwater levels predominantly influencing the other two sites. In retrospect, it is believed that a logging road may in fact be augmenting the effect of overbank flows by impounding flood waters and substantially increasing the duration and depth of flooding on the site. Given the lack of continuous or even prolonged flooding, it is unclear why the three-year-old Cypress site still exhibits such pronounced dominance by *T. distichum*, except that it is surrounded by an expansive complex of early successional pine uplands and agricultural fields, with no mature wetland species, save a few remnant mature specimens of *T. distichum*, in close enough proximity to provide an effective seed source (Clewall and Lea 1990). In fact the only portion of the swamp being colonized is a narrow strip on either side of a short road crossing. (Considering that *S. nigra* utilizes wind as its primary seed dispersal mechanism and that the species appeared to excel under a wide variety of hydrologic conditions at various project sites, it is unclear why its presence at this particular site would be limited to the road crossing.) Therefore, because of anthropogenic modification of adjacent areas, the developing Cypress community at the three-year-old site is perceived to be acting as an artifact of past site conditions, irrespective of current environmental characteristics that would seem to render the site more suitable for the establishment of other wetland species.

As indicated in Figure 3, those sites not classified as Cypress can be subdivided into two separate groups - the Mixed Hardwood sites and the Willow sites. During early stages of succession, a significant portion of early regeneration can be attributed to coppice sprouts, which

were also noted recently by Messina et al. (1997) as accounting for 83 percent of stems one year following clearcutting of a Texas floodplain forest. The overwhelming prevalence of this type of regeneration potentially limits the capacity of the system to respond to small-scale environmental changes that would normally produce incremental changes in species composition over time. The Mixed Hardwood Sites also tend to exhibit greater fluctuations in water levels, which is believed to reflect the ability of established root networks enhance evapotranspiration rates relative to sites regenerating predominantly from seed. As sites of this classification increase in age, so do the measured fluctuations in water levels. The exception to this is Site 5b, which is similar to the seven-year-old Cypress site in that it is located in the floodplain of a major coastal plain river rather than a small stream bottom.

The Willow sites, as represented by Sites 2a and 8a, are characterized by a dominant overstory of *S. nigra* and water level fluctuations of less than 20 cm. Although multiple stems are exhibited by *S. nigra* specimens at both sites, actual coppicing is rare, a condition not unexpected given the fact that the species was not a likely constituent of the canopy prior to clearcutting. The third Willow site identified by the ordinations is important in that it offers an insight into the time frame over which this community is succeeding into a more typical Mixed Hardwood stand. *Salix nigra*, overwhelmingly dominant during the first ten to fifteen years of regeneration as indicated by remaining live specimens and substantial amounts of both standing and fallen deadwood, has within twenty years begun to reach the end of its life span and is not reproducing, either vegetatively or by seed, under the limiting conditions of a closed canopy. Also of importance is the presence of ecologically desirable mast-producing species in the understory of twenty-year-old Willow site. It is thought that the success of this component, so often sought after in creation and restoration efforts and generally uncommon in the secondary growth characterizing many of the bottomland hardwood forests remaining in southeastern

Virginia, is directly related to the stabilization of site hydrology and the sporadic canopy openings associated with the mortality of *S. nigra*. Under these conditions, species best adapted to specific microsites are more likely to succeed because they are insulated from the dramatic changes in site conditions during the years immediately following timber harvest.

A review of the available literature indicates a high degree of correlation between the Cypress sites in this study and those identified by past researcher in the region. Plunkett and Hall (1995) identified *T. distichum* and *N. aquatica* as the important dominants in flooded open swamps, partially flooded swamps, and stream bottoms. No quantitative analysis of hydrology is offered, however, except to mention that the flooded open swamps remain deeply flooded throughout the year and the partially flooded swamps and stream bottoms exhibit prolonged, but not continuous, flooding. One notable difference between these results and those of Plunkett and Hall (1995) is the role of *N. aquatica* in partially flooded swamps and stream bottoms. While it was identified as an important species at several of the current project sites, its presence was more attributable to coppicing than to seedling establishment. The increased dominance in the mature canopies of Plunkett and Hall (1995) is likely due to past selective cutting of *T. distichum* throughout the Southeast, which has often been cited as leading to domination by *N. aquatica* of wetlands historically characterized as Cypress swamps (Wharton et al. 1982). As recent research has indicated (Stubbs 1973, McKnight and Johnson 1975, Conner 1994, Pavel 1993), clearcutting of cypress stands will result in a more effective recovery of natural species distributions, which is consistent with the dominance of *T. distichum* on the understories of Cypress sites in this study.

Glascoek and Ware (1979) noted that, aside from a few geographically limited species, there was a remarkable similarity in the composition and structure of stream bottoms from New Jersey all the way down to Florida. This study generally corresponds with their findings

regarding the dominant species associations. The most notable difference would be the reduced significance of *Carpinus caroliniana* among sites in the current study, whereas Glascock and Ware (1979) and Plunkett and Hall (1995) consistently found it to be a prevalent constituent of the overstories of bottomland hardwood forests in southeastern Virginia. Characterized as a small understory tree by Godfrey and Wooten (1981), its presence in the overstories of mature sites is, again, probably the result of past selective harvests throughout the region, which allowed economically undesirable understory species like *C. caroliniana* to take advantage of the increased resource availability and become important components of the overstory. Given the lack of old growth bottomland hardwood forests in the region, one can only speculate as to the role of the species under natural circumstances; however, it is apparent that the species is quickly outcompeted during the earlier stages of post-clearcut regeneration.

5.2 *Quantitative aspects of project data*

Generally speaking, the limited amount of past research on the early successional development of bottomland hardwood forests and the inconsistent data collection protocols make comparison with the quantitative data of other studies problematic. However, the results of these other studies can provide a context by which to gauge the successional rates of projects examined as part of this study. Within the same region, Doumlele et al. (1985) recorded a total basal area of 91.35 m²/hectare and overstory densities of nearly 2750 stems/hectare in a mature tidal freshwater swamp. This was substantially more productive than the four Savannah River floodplain forests examined by Jones et al. (1994), where overstory basal areas ranged between 29 and 38 m²/hectare, and the seventeen sites examined by Megonigal et al. (1997), where basal areas ranged from 13.6 to 54.5 m²/hectare and densities of live stems ranged from 330 to 930

stems/hectare. Given natural variation of this magnitude and the lack of pre-clearcut quantitative data on project sites, the difficulty of estimating the rate at which they are proceeding towards a mature canopy becomes evident. In a similar study, Bowling and Kellison (1983) noted bottomland hardwood overstories developing at rates remarkably similar to those noted for Mixed Hardwood stands in this study. In fact, the slight differences that did occur can likely be accounted for by the fact that overstory stems in the former study were limited to those over 10 cm. Like the present study, much of the regeneration was attributed to coppice sprouts; however, data from the Cypress and Willow stands, where coppice sprouts were few and regeneration much slower, suggest that physical and/or biological characteristics may be influencing the successional trajectory of project sites.

One of these characteristics that has not been previously addressed is the presence of wetland soils. Given the consistent presence of established wetland soils at project sites, it is difficult to estimate their relationship to early successional trajectory following clearcut. However, a chronosequence of early successional old field sites in the coastal plain of New Jersey indicates no tree layer whatsoever until 25 years after abandonment (Hanks 1971), and Noon (1996) noted the presence of no trees in the first eleven years following wetland creation on the mineral soils of reclaimed mine lands.

5.3 *Successional processes*

Noon (1996) developed a model of wetland primary succession on reclaimed mine sites using a chronosequence similar to this study. As in van der Valk's (1981, 1982) Gleasonian model of succession, two distinct phases in early wetland succession were identified - the Arrival and Establishment Phase, followed after 3 years by the Autogenic Dominance Phase. The

development of species composition during the Arrival and Establishment is the result of a combination of factors, particularly the availability of resources and species' life history traits. Then, during the Autogenic Dominance Phase, established species compete for dominance through biomass production.

Although used to describe primary succession by Noon (1996), this concept would seem to have applications useful in describing secondary succession of forested wetlands as well. It would seem that the naturally regenerating sites represent an accelerated version of Noon's model of succession, with the rate of acceleration being determined by such factors as coppice sprouting, hydrology, and soil characteristics. This acceleration is in fact accomplishing a goal inherent in many creation and restoration projects of quickly replacing the functions performed by lost wetlands. Specifically, the results of this study are consistent with the presence of an Arrival and Establishment Phase, albeit one that is by no means linked inextricably to the time frame of roughly 3 years described by Noon (1996). The presence of wetland soils alleviates much of the competition for resources evident during primary succession and allows near total cover often by the end of the first growing season. At this point, the site has already begun entering the Autogenic Dominance Phase, the dynamics of which are determined by the species ability to produce biomass, as well as the stress related to the physical regime of the location.

Both of the above factors seem to contribute to dominance by one or several species as the site moves farther into this second successional phase. In the Mixed Hardwood stands, the proliferation of coppice sprouts and subsequent development of a canopy once again creates a resource limitation, except the availability of light is the limiting factor rather than soil nutrients or water. In those sites characterized by the harsh physical regime associated with continuous flooding or high sedimentation rates, an overwhelming dominance is displayed by the few species capable of surviving in those conditions. This idea is consistent with Odum's (1969) assertion of

an inverse relationship between environmental stress and diversity and was also evident in the results of Johnson et al. (1985), who attributed the success of *S. nigra* on early successional islands in the Atchafalaya River Delta, LA, to the species ability to withstand high sedimentation rates and quickly develop large fibrous root systems. Specific examples in this study were Sites 8a, 7a, and 3b. Site 8a, which is densely populated by *S. nigra* except for a few higher points where *Acer rubrum* has sprouted, is bordered by steeply sloping, early successional pine uplands, providing the high energy, high sedimentation environment that largely prevents successful seedling establishment by competing wetland species. In a similar manner, *Celtis occidentalis* and *Polygonum* spp. were able to outcompete other species over a significant portion of Site 3b, located in the first bottom of the alluvial Meherrin River and, thus, subject to a physical environment largely reflective of climatic events across the much larger piedmont watershed. Finally, at Site 7a, where the intense flooding of the adjacent Meherrin River is possibly exacerbated by logging road-induced impoundment, much of the site is covered by dense, monospecific stands of herbaceous perennials. However, towards the edges of the site, where drawdowns are more prevalent and flooding less intense, a more diverse assemblage of both woody and herbaceous species is found.

Two events appear capable of interrupting this cycle of dominance during the Autogenic Dominance Phase. First, as dominant species begin to reach the end of their life span, species growing beneath them are given access to previously limiting resources. This is believed to have occurred at Site 20a, where a significant dieback of *S. nigra* and *P. heterophyllus* is underway and the overstory is in transition from one composed almost entirely of early colonizers to that of a more traditional mixed hardwood stand. The second means of breaking this cycle of dominance is a dramatic alteration in the physical regime of the site, such as the prolonged drawdown of water levels necessary for the germination of *T. distichum*. It is hypothesized that

the lack of a drawdown has effectively stalled the regeneration of Site 7a and allowed domination of the site by a few species of herbaceous perennials. Both of these situations appear consistent with the “inhibition” model of succession introduced by Connell and Slayter (1977), which states that initial colonists will inhibit the establishment of later colonists until such time as the former are damaged or die.

These processes are represented conceptually in Figure 5. Following clearing of the site, vegetation development is driven largely by hydrologic regime, which is modified on a site-specific basis soil characteristics and landscape factors, such as positioning of the site in the broader geomorphologic setting and microtopographic variation within a site. The herbaceous community then proceeds towards one of two communities - Mixed Hardwood or Cypress. Development of the Cypress community is mediated largely by the hydrology regime, especially interannual changes related to climatic factors, although factors not specifically examined as part of this study, such as viability of the seed bank, are likely to play a role as well. Development of the Mixed Hardwood community is more directly related to the extent of coppice regeneration on the site, which is driven by such factors as hydrology, harvest regime, and species composition prior to timber harvest. A time scale is deliberately excluded from this model, as this is perhaps the most difficult factor to scale when predicting early successional changes in community structure, point in case being the length of time that a site is “dominated” by herbaceous cover, which in this study ranged from less than two to at least seven years.

5.4 Relevance of clearcut swamps to monitoring created and restored wetlands

Given the overriding economic considerations and the often conflicting objectives of development and environmental interests, the establishment of success criteria for compensation

Figure 5. Conceptual model of early secondary succession in the forested wetlands of southeastern Virginia

wetlands is and will surely remain a contentious issue. In fact, it is clear from this research that the complex interaction of factors influencing successional trajectories - including the extent of vegetative reproduction, hydrologic regime, seed source, and soil characteristics, to name a few - result in a natural variability that makes efforts to develop vegetative success criteria, and still maintain the short time frames now typical of most monitoring programs, prohibitively speculative and not scientifically justifiable.

Despite the variability of this data set, it has nevertheless illustrated successional processes that are germane to any attempt to create or restore forested wetlands in the region. Principally, the role of the Willow community, as a precursor to the subsequent development of a Mixed Hardwood stand, speaks to the need for allocation of more resources to engineering of creation and restoration projects prior to initiation and long-term monitoring that recognizes the early successional processes of bottomland hardwood forests, as opposed to intensive, short-term vegetation monitoring in the absence of scientifically justifiable criteria. Basically, except in cases of extreme drought or intensive ponding, regeneration *will occur*; the question becomes one of whether the site will be performing the desired functions as it matures. Planners must take into consideration such factors as the quantity and source of water available to the proposed project, the relationship between hydrology and geomorphology of the site, and how this will influence the natural colonization of the site. For example, if the goal of a project is to replace or restore a cypress swamp, considered for inclusion in the project should be deposition of topsoil from a cypress swamp being impacted elsewhere and an open hydrologic regime, accepting that the germination of cypress seedlings is subject to a certain amount of climatic stochasticity. The emphasis here is on ensuring that conditions are favorable to the development of a mature cypress swamp, while reducing the need for costly, and often unsuccessful, plantings and avoiding the imposition of monitoring requirements, such as seedling survival rates, that are not

consistent with the natural development of the system. In another case, where the re-establishment of mast-producing species is a priority and mature specimens of the desired species may not be in close enough proximity to serve as an adequate seed source, the physical regime of sites should be allowed to stabilize through natural colonization. This would allow the natural variation in hydrologic regime related to evapotranspiration to reach an equilibrium and encourage the natural establishment of species optimally suited to microtopographic environmental gradients, increasing the efficiency of the project as well as the potential for desired species composition in the long run. As the early successional colonizers begin to reach the end of their natural life span, fifteen to twenty years for *S. nigra*, then the progress of the site can be reevaluated and supplemental plantings can be pinpointed where they will enjoy the greatest chance of survival. Basically, these observations support the assertions by Mitsch and Wilson (1996) that mitigation projects must be allowed a greater amount of time before judgment of success or failure is attempted and that projects should be allowed a greater element of self-design.

6. Conclusion

This study examined a chronosequence of recently clearcut forested wetlands for the purposes of determining whether these sites could serve as suitable reference wetlands for monitoring the success of created and restored wetlands. Several factors were found to significantly alter successional trajectories at the project sites and, in doing so, to greatly complicate any future attempts to use vegetative characteristics from clearcut forested wetlands to establish success criteria. First and foremost, the overwhelming presence of coppice regeneration on mixed hardwood sites results in an enhanced rate of vegetation community development that bears little resemblance to what could reasonably be expected at a created or restored site, even one where wetland soils were already present and appropriate species were planted. Even at the Willow and Cypress sites, where vegetation development following clearcut could be expected to more closely approximate that of a created or restored site, physical factors mitigate the usefulness of vegetative criteria. For example, at the seven-year-old Cypress site, it is clearly evident that the nearly continuous flooding has almost completely suppressed regeneration of woody species over the majority of the cleared area. It would be more appropriate, perhaps, to undertake monitoring of sites like the three-year-old-Cypress site and eight-year-old Willow site over longer time scales and only then try to elucidate the relationship between environmental characteristics and successional trajectory, rather than attempting to establish the relationship by coalescing data from substantially different sites representing a broad spectrum of ages.

This research also points to the need for research into the relationship between soils and early successional trajectory. While certain chemical characteristics were analyzed as part of this study, this aspect was extremely limited in scope and not comprehensive enough to support justifiable conclusions. More information is needed on how these characteristics change over

time, as well as on the role of seed banks and organic soils in advancing regeneration. This, too, could be more effectively achieved through long-term monitoring of selected sites, as could a greater understanding of changes in hydrologic regime during the early stages of site development.

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Appendix

Figure 1. Locations of project sites.

Figure 2. Canonical correspondence analysis of all project sites with no covariables. Vegetation data includes understory and overstory importance values for each species recorded in those strata (i.e. two values may exist for each species). Environmental variables included information related to hydrologic regime, soil chemistry, and stem origin. Only those environmental variables exhibiting the highest correlation with ordination results are depicted by arrows in the figure. Org C = organic carbon; Flood = duration of flooding as a percentage of the calendar year; O-Cop = percentage of overstory stems originating as coppice. The dashed line encloses the only site in which *Platanus occidentalis* exhibited an overstory importance value greater than 75.

Figure 3. Canonical correspondence analysis with Site 2b removed and no covariables; other covariables identical to Figure 2. U-Cop = percentage of understory stems originating as coppice. The upper dashed line encloses those sites in which *Salix nigra* exhibited an overstory importance value greater than 50. The lower dashed line encloses those sites in which *Taxodium distichum* exhibits an understory importance value greater than 30.

Figure 4. Canonical correspondence analysis with Site 2b removed from the ordination and age inserted as a covariable. The dashed line to the right encloses those sites in which *Taxodium distichum* exhibits an understory importance value greater than 45. The dashed line to the left encloses those sites in which *Taxodium distichum* exhibits an understory importance value less than 6.

Site # - 2a

Location (Coordinates) - 36o43'00 76o49'15"

Owner and Contact - J.D. & Sarah Wright

Nearest Stream - Beaver Dam swamp

River Basin - Blackwater

NWI Classification - PF01A

Approximate Size of Site - 49 acres

Age of Site - 2

Site 2a herbaceous	Mean Cover	Relative Dom	Density/ 0.5 m^2	Relative Density	Importanc Values
Total	115.66	1	308.2	1	1
Juncus effusus	24.52	0.212001	153.6	0.498378	0.355189
Leersia virginica	23	0.198859	89.8	0.291369	0.245114
Murdania keisak	18.5	0.159952	33.2	0.107722	0.133837
Lonicera spp	7	0.060522	4	0.012979	0.03675
Zizaniopsis milacea	7.5	0.064845	1.8	0.00584	0.035343
Typha spp	6.02	0.052049	2.2	0.007138	0.029594
Acer rubrum	4	0.034584	2.8	0.009085	0.021835
Toxicodendron radicans	3.02	0.026111	2.2	0.007138	0.016625
***	3	0.025938	2	0.006489	0.016214
Boehmeria cylindrica	3.5	0.030261	0.6	0.001947	0.016104
***	3	0.025938	1	0.003245	0.014591
***	3.02	0.026111	0.8	0.002596	0.014353
Mikania scandens	3	0.025938	0.6	0.001947	0.013942
Arundinaria gigantea	3	0.025938	0.4	0.001298	0.013618
Eleocharis obtusa	0.02	0.000173	7	0.022713	0.011443
***	0.5	0.004323	1.8	0.00584	0.005082
Platanus occidentalis	1	0.008646	0.4	0.001298	0.004972
***	0.5	0.004323	1.4	0.004543	0.004433
Carex lurida	0.5	0.004323	0.6	0.001947	0.003135
***	0.5	0.004323	0.4	0.001298	0.00281
***	0.5	0.004323	0.2	0.000649	0.002486
***	0.02	0.000173	1	0.003245	0.001709
Alnus rugosa	0.02	0.000173	0.2	0.000649	0.000411
***	0.02	0.000173	0.2	0.000649	0.000411

*** - unidentified species

Site 2a understory	Meter^2/ Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	1.995697	1	14720	1	0.380435	1
Salix nigra	1.573938	0.788666	6000	0.407609	0.653333	0.598137
***	0.164541	0.082448	2240	0.152174	0	0.117311
Fraxinus spp	0.124093	0.06218	2000	0.13587	0.76	0.099025
Acer rubrum	0.023562	0.011806	2080	0.141304	0	0.076555
Alnus rugosa	0.044768	0.022432	560	0.038043	0.285714	0.030238
Platanus occidentalis	0.011781	0.005903	800	0.054348	0	0.030126
Liquidambar styraciflua	0.017279	0.008658	400	0.027174	0	0.017916
Liriodendron tulipifera	0.002356	0.001181	240	0.016304	0	0.008742
Rubus spp	0.006676	0.003345	160	0.01087	0	0.007107
Nyssa sylvatica	0.014137	0.007084	80	0.005435	0	0.006259
Magnolia virginiana	0.006283	0.003148	80	0.005435	0	0.004292
Pinus taeda	0.006283	0.003148	80	0.005435	0	0.004292

Site 2A overstory	Meter^2/ Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	0.182605	1	320	1	0	1
Salix nigra	0.182605	1	320	1	0	1

*** - unidentified species

Site # - 2b

Location (Coordinates) -36o52'40" 76o51'00"

Owner and Contact - Matney Timber

Nearest Stream - Tucker Swamp

River Basin - Blackwater River

NWI Classification -

Approximate Size of Site - 10 acres

Age of Site - 2

Site 2b herbaceous	Mean Cover	Relative Dom	Density/ 0.5 m^2	Relative Density	Importanc Values
Total	111.62	1	259	1	1
***	7.5	0.067192	200	0.772201	0.419697
Salix nigra	24.52	0.219674	0.4	0.001544	0.110609
***	23	0.206056	0.6	0.002317	0.104186
Scirpus cyperinus	18.5	0.165741	0.4	0.001544	0.083643
Juncus effusus	0.5	0.004479	27	0.104247	0.054363
Saururus cernuus	7	0.062713	1.2	0.004633	0.033673
Typha angustifolia	6.02	0.053933	1.6	0.006178	0.030055
Scirpus americanus	3	0.026877	5.8	0.022394	0.024635
Boehmeria cylindrica	4	0.035836	3.4	0.013127	0.024482
***	0.5	0.004479	11.2	0.043243	0.023861
Impatiens capensis	3.5	0.031356	1	0.003861	0.017609
Toxicodendron radicans	3.02	0.027056	1	0.003861	0.015459
***	3	0.026877	0.6	0.002317	0.014597
Fraxinus spp	3	0.026877	0.4	0.001544	0.014211
***	3.02	0.027056	0.2	0.000772	0.013914
Lonicera spp	0.02	0.000179	2.8	0.010811	0.005495
Taxodium distichum	1	0.008959	0.2	0.000772	0.004866
Campsis radicans	0.5	0.004479	1	0.003861	0.00417
Eupatorium spp.	0.02	0.000179	0.2	0.000772	0.000476

*** - unidentified species

Site 2b understory	Meter^2/ Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	1.006488	1	9600	1	0.291667	1
Fraxinus spp	0.283921	0.282091	2960	0.308333	0.864865	0.295212
Platanus occidentalis	0.312588	0.310574	1680	0.175	0.619048	0.242787
Salix nigra	0.097782	0.097152	1840	0.191667	0	0.144409
Liquidambar styraciflua	0.140586	0.13968	1280	0.133333	0	0.136507
Taxodium distichum	0.100924	0.100273	960	0.1	1	0.100137
Magnolia virginiana	0.060868	0.060476	720	0.075	0	0.067738
Acer rubrum	0.006283	0.006243	80	0.008333	0	0.007288
***	0.003534	0.003512	80	0.008333	0	0.005922

Site 2b overstory	Meter^2/ Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total		1		1	0.75	1
Platanus occidentalis	0.160614	0.771698	240	0.75	1	0.760849
***	0.047517	0.228302	80	0.25	0	0.239151

*** - unidentified species

Site # -3a

Location (Coordinates) - 36o41'44" 77o02'30"

Owner and Contact -Jimmy Willis - Curtis Johnson

Nearest Stream -Nottaway Swamp

River Basin - Nottaway River

NWI Classification - PF01A

Approximate Size of Site - 38 acres

Age of Site - 3

Site 3a herbaceous	Mean Cover	Relative Dom	Density/ 0.5 m^2	Relative Density	Importanc Values
Total	61.16667	0.997283	0.033243	1.006749	1.002016
Eleocharis spp	1.333333	0.021739	0.000725	0.241282	0.131511
Juncus effusus	2.333333	0.038043	0.001268	0.149606	0.093825
Ludwigia decurrens	7.5	0.122283	0.004076	0.040495	0.081389
Carex lurida	6.5	0.105978	0.003533	0.047807	0.076892
Hydrocotyle umbellata	2.666667	0.043478	0.001449	0.084364	0.063921
Ludwigia palustris	3.5	0.057065	0.001902	0.055681	0.056373
Murdania keisak	3.5	0.057065	0.001902	0.054556	0.05581
Arundinaria gigantea	4.5	0.07337	0.002446	0.029809	0.051589
Scirpus americanus	4.666667	0.076087	0.002536	0.01631	0.046199
Erechtites hieraciifolia	3.5	0.057065	0.001902	0.025872	0.041469
Ptilimnium capillaceum	1.166667	0.019022	0.000634	0.061305	0.040163
***	2.5	0.040761	0.001359	0.026434	0.033598
***	1	0.016304	0.000543	0.032058	0.024181
Polygonum spp	1.666667	0.027174	0.000906	0.012936	0.020055
***	1.166667	0.019022	0.000634	0.01856	0.018791
Hypericum virginicum	2	0.032609	0.001087	0.003375	0.017992
***	1	0.016304	0.000543	0.019123	0.017713
***	1	0.016304	0.000543	0.01631	0.016307
Cephalanthus occidentalis	0.166667	0.002717	9.06E-05	0.021372	0.012045
Proserpinaca palustris	1.166667	0.019022	0.000634	0.003937	0.011479
Boehmeria cylindrica	1	0.016304	0.000543	0.006187	0.011246
Parthenocissus quinquefolia	1	0.016304	0.000543	0.005062	0.010683
Diospyros virginiana	1	0.016304	0.000543	0.00225	0.009277
Eupatorium perfoliatum	1	0.016304	0.000543	0.000562	0.008433
***	1	0.016304	0.000543	0.000562	0.008433
Typha spp	0.5	0.008152	0.000272	0.003375	0.005763
Bidens coronata	0.333333	0.005435	0.000181	0.005624	0.00553
Taxodium distichum	0.5	0.008152	0.000272	0.00225	0.005201
Poaceae spp	0.166667	0.002717	9.06E-05	0.004499	0.003608
***	0.166667	0.002717	9.06E-05	0.003937	0.003327

Rhexia mariana	0.166667	0.002717	9.06E-05	0.003375	0.003046
Penthorum sedoides	0.166667	0.002717	9.06E-05	0.001687	0.002202
Hypericum mutilum	0.166667	0.002717	9.06E-05	0.001125	0.001921
Lobelia puberula	0.166667	0.002717	9.06E-05	0.001125	0.001921
Eupatorium capillifolium	0.166667	0.002717	9.06E-05	0.001125	0.001921
Lonicera japonica	0.166667	0.002717	9.06E-05	0.000562	0.00164
Betula nigra	0.166667	0.002717	9.06E-05	0.000562	0.00164
Acer rubrum	0.166667	0.002717	9.06E-05	0.000562	0.00164
Dirca palustris	0.166667	0.002717	9.06E-05	0.000562	0.00164
Populus heterophylla	0.166667	0.002717	9.06E-05	0.000562	0.00164

***** - unidentified species**

Site 3a understory	Meter^2/ Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	0.650179	1	10293.33	1	0.023316	1
Taxodium distichum	0.353429	0.543588	6666.667	0.647668	0.032	0.595628
Liquidambar styraciflua	0.097389	0.149789	1280	0.124352	0	0.13707
Diospyros virginiana	0.052098	0.080129	880	0.085492	0.030303	0.082811
Salix nigra	0.043066	0.066237	533.3333	0.051813	0	0.059025
Populus heterophylla	0.035736	0.054963	106.6667	0.010363	0	0.032663
Myrica cerifera	0.030631	0.047111	80	0.007772	0	0.027441
***	0.006414	0.009865	293.3333	0.028497	0	0.019181
Clethra alnifolia	0.005629	0.008657	186.6667	0.018135	0	0.013396
Pinus taeda	0.01165	0.017918	53.33333	0.005181	0	0.01155
Acer rubrum	0.007461	0.011476	80	0.007772	0	0.009624
Cephalanthus occidentalis	0.003272	0.005033	53.33333	0.005181	0	0.005107
***	0.002094	0.003221	26.66667	0.002591	0	0.002906
Quercos phellos	0.001178	0.001812	26.66667	0.002591	0	0.002201
Platanus occidentalis	0.000131	0.000201	26.66667	0.002591	0	0.001396

Site 3a - no overstory

*** - unidentified species

Site # - 3b

Location (Coordinates) - 36°39'41" W 77°28'27"

Owner and Contact - Union Camp (experimental site)

Nearest Stream - Meherrin River

River Basin - Meherrin River

NWI Classification -

Approximate Size of Site - 160 acres

Age of Site - 3 years

Site 3b herbaceous	Mean Cover	Relative Dom	Density/ 0.5 m ²	Relative Density	Importanc Values
Total	67.6	1	73.8	1	1
Polygonum punctatum	15.5	0.22929	38.4	0.520325	0.374808
Toxicodendron radicans	16	0.236686	8.8	0.119241	0.177964
Commelina virginica	15.5	0.22929	7.4	0.100271	0.16478
Boehmeria cylindrica	14	0.207101	6.4	0.086721	0.146911
Campsis radicans	3	0.044379	1.4	0.01897	0.031674
***	0.5	0.007396	2.8	0.03794	0.022668
***	0.5	0.007396	2.4	0.03252	0.019958
Lysimachia nummularia	0.5	0.007396	2	0.0271	0.017248
Cephalanthus occidentalis	0.5	0.007396	1	0.01355	0.010473
Carex lurida	0.5	0.007396	1	0.01355	0.010473
***	0.5	0.007396	0.8	0.01084	0.009118
***	0.5	0.007396	0.4	0.00542	0.006408
***	0.02	0.000296	0.4	0.00542	0.002858
Commelina commelina	0.02	0.000296	0.2	0.00271	0.001503
***	0.02	0.000296	0.2	0.00271	0.001503
Lycopus virginicus	0.02	0.000296	0.2	0.00271	0.001503
***	0.02	0.000296	0	0	0.000148

*** - unidentified species

Site 3b understory	Meter ² / Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	4.210127	1	16320	1	0.107843	1
<i>Cephalanthus occidentalis</i>	2.745359	0.652085	9440	0.578431	0.076271	0.615258
<i>Fraxinus</i> spp.	0.733169	0.174144	2720	0.166667	0.176471	0.170405
<i>Salix nigra</i>	0.590619	0.140285	2560	0.156863	0.21875	0.148574
<i>Platanus occidentalis</i>	0.098175	0.023319	960	0.058824	0	0.041071
<i>Liquidambar styraciflua</i>	0.031416	0.007462	400	0.02451	0	0.015986
<i>Populus heterophylla</i>	0.007854	0.001865	160	0.009804	0	0.005835
<i>Liriodendron tulipifera</i>	0.003534	0.000839	80	0.004902	0	0.002871

Site 3b overstory	Meter ² / Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	1.03162	1	1280	1	0.4375	1
<i>Salix nigra</i>	0.559989	0.542825	800	0.625	0.4	0.583912
<i>Fraxinus</i> spp	0.432362	0.419109	400	0.3125	0.6	0.365805
***	0.03927	0.038066	80	0.0625	0	0.050283

*** - unidentified species

Site # -5a

Location (Coordinates) -

Owner and Contact - Union Camp

Nearest Stream - Potecasi Creek

River Basin - Chowan River

NWI Classification -

Approximate Size of Site - 18 acres

Age of Site - 5

Site 5a herbaceous	Mean Cover	Relative Dom	Density/ 0.5 m ²	Relative Density	Importanc Values
Total	85.45714	1	364.7143	1	1
Murdania keisak	46.07143	0.539117	302.4286	0.829221	0.684169
Juncus effusus	8.214286	0.096122	35	0.095966	0.096044
Boehmeria cylindrica	10.35714	0.121197	3.285714	0.009009	0.065103
Impatiens capensis	5.357143	0.062688	3.428571	0.009401	0.036044
Carex spp.	2.142857	0.025075	10.42857	0.028594	0.026835
Toxicodendron radicans	2.5	0.029254	2.857143	0.007834	0.018544
Lonicera spp.	2.5	0.029254	1.142857	0.003134	0.016194
Saururus cernuus	2.142857	0.025075	1.285714	0.003525	0.0143
Campsis radicans	2.142857	0.025075	1.142857	0.003134	0.014104
Ampelopsis cordata	2.142857	0.025075	0.428571	0.001175	0.013125
Hypericum walteri	0.357143	0.004179	0.285714	0.000783	0.002481
***	0.357143	0.004179	0.285714	0.000783	0.002481
Parthenocissus quinquefolia	0.357143	0.004179	0.285714	0.000783	0.002481
Platanus occidentalis	0.357143	0.004179	0.142857	0.000392	0.002235
Smilax spp.	0.357143	0.004179	0	0	0.00209
***	0.014286	0.000167	0.571429	0.001567	0.000867
Galium obtusum	0.014286	0.000167	0.571429	0.001567	0.000857
Carex stricta	0.028571	0.000334	0.428571	0.001175	0.000755
***	0.014286	0.000167	0.428571	0.001175	0.000671
***	0.014286	0.000167	0.142857	0.000392	0.000279
Acer rubrum	0.014286	0.000167	0.142857	0.000392	0.000279

*** - unidentified species

site 5a understory	Meter^2/ Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	1.066178	1	6685.714	1	0.538462	1
Salix nigra	0.333233	0.312549	3085.714	0.461538	0.648148	0.387044
Taxodium distichum	0.202521	0.18995	971.4286	0.145299	0.882353	0.167625
Acer rubrum	0.169422	0.158906	457.1429	0.068376	1	0.113641
***	0.14025	0.131544	342.8571	0.051282	0	0.091413
Liquidambar styraciflua	0.095931	0.089976	457.1429	0.068376	0	0.079176
Leucothoe racemosa	0.026367	0.02473	514.2857	0.076923	0	0.050827
***	0.023001	0.021573	285.7143	0.042735	0	0.032154
Nyssa sylvatica	0.024964	0.023415	114.2857	0.017094	1	0.020254
***	0.014025	0.013154	171.4286	0.025641	1	0.019398
Toxicodendron radicans	0.008134	0.00763	114.2857	0.017094	0	0.012362
Platanus occidentalis	0.013744	0.012891	57.14286	0.008547	0	0.010719
Cephalanthus occidentalis	0.010098	0.009471	57.14286	0.008547	0	0.009009
Quercus muhlenbergii	0.004488	0.004209	57.14286	0.008547	0	0.006378

site 5a overstory	Meter^2/ Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	1.194927	1	685.7143	1	0.33	1
Ulmus americana	0.587927	0.492019	171.4286	0.25	1	0.371009
Acer rubrum	0.250486	0.209624	171.4286	0.25	0	0.229812
***	0.12931	0.108216	171.4286	0.25	0	0.179108
Salix nigra	0.115005	0.096244	114.2857	0.166667	0	0.131455
Taxodium distichum	0.1122	0.093897	57.14286	0.083333	1	0.088615

*** - unidentified species

Site # -5b

Location (Coordinates) - 36°39'37" W 77°26'51" N

Owner and Contact - Union Camp exp. site

Nearest Stream - Meherrin River

River Basin - Meherrin River

NWI Classification -

Approximate Size of Site - 10

Age of Site - 5

Site 5b herbaceous	Mean Cover	Relative Dom	Density/ 0.5 m^2	Relative Density	Importanc Values
Total	57.02	1	80.8	1	1
Polygonum punctatum	20.04	0.351456	33.6	0.415842	0.383649
Juncus effusus	3	0.052613	16	0.19802	0.125316
Scirpus cyperinus	7.5	0.131533	5.6	0.069307	0.10042
Boehmeria cylindrica	6	0.105226	2.6	0.032178	0.068702
***	3.5	0.061382	1.8	0.022277	0.04183
***	3	0.052613	2.4	0.029703	0.041158
***	3.5	0.061382	1.4	0.017327	0.039354
Campsis radicans	3	0.052613	1.6	0.019802	0.036208
***	0.04	0.000702	5.6	0.069307	0.035004
Leucothoe racemosa	3	0.052613	0.2	0.002475	0.027544
Toxicodendron radicans	1	0.017538	2.6	0.032178	0.024858
***	0.5	0.008769	2	0.024752	0.016761
***	0.8	0.01403	0.2	0.002475	0.008253
Viola spp	0.5	0.008769	0.4	0.00495	0.00686
Arundinaria gigantea	0.02	0.000351	1	0.012376	0.006363
Carex lupulina	0.02	0.000351	1	0.012376	0.006363
***	0.02	0.000351	1	0.012376	0.006363
Acer rubrum	0.52	0.00912	0.2	0.002475	0.005797
Sagittaria latifolia	0.5	0.008769	0.2	0.002475	0.005622
***	0.5	0.008769	0.2	0.002475	0.005622
Galium obtusum	0.02	0.000351	0.4	0.00495	0.002651
***	0.02	0.000351	0.4	0.00495	0.002651
Ludwigia glandulosa	0.02	0.000351	0.4	0.00495	0.002651

*** - unidentified species

Site 5b understory	Meter ² / Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	2.399391	1	10880	1	0.279412	1
Acer rubrum	0.944049	0.393453	3440	0.316176	0.55814	0.354815
Fraxinus spp	0.601222	0.250573	1520	0.139706	0	0.195139
Leucothoe racemosa	0.214021	0.089198	3040	0.279412	0	0.184305
Populus heterophylla	0.342041	0.142553	1600	0.147059	0.65	0.144806
***	0.154723	0.064484	480	0.044118	0	0.054301
Cephalanthus occidentalis	0.076576	0.031915	400	0.036765	0	0.03434
***	0.023955	0.009984	240	0.022059	0	0.016021
Salix nigra	0.03927	0.016367	80	0.007353	1	0.01186
Alnus rugosa	0.003534	0.001473	80	0.007353	0	0.004413

Site 5b overstory	Meter ² / Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	2.403711	1	2080	1	0.461538	1
Acer rubrum	1.533097	0.637804	960	0.461538	0.833333	0.549671
Fraxinus spp	0.550957	0.229211	720	0.346154	0	0.287682
Populus heterophylla	0.193601	0.080542	160	0.076923	1	0.078733
Carpinus caroliniana	0.047517	0.019768	80	0.038462	0	0.029115
***	0.03927	0.016337	80	0.038462	0	0.027399
Salix nigra	0.03927	0.016337	80	0.038462	0	0.027399

*** - unidentified species

Site # 7a

Location (Coordinates) - _____

Owner and Contact - Pope

Nearest Stream - Blackwater River

River Basin - Blackwater River

NWI Classification - PF01E

Approximate Size of Site - 8 acres

Age of Site - 7 years

Site 7a herbaceous	Mean Cover	Relative Dom	Density/ 0.5 m ²	Relative Density	Importanc Values
Total	68.46667	1	178	1	1
Polygonum punctatum	33.33333	0.486855	92.16667	0.51779	0.502323
Ludwigia repens	8.75	0.127799	45.16667	0.253745	0.190772
Scirpus cyperinus	19.58333	0.286027	7.666667	0.043071	0.164549
Lemna spp	0.416667	0.006086	18.66667	0.104869	0.055477
Echinodorus cordifolius	2.5	0.036514	0.333333	0.001873	0.019193
***	0.016667	0.000243	3.333333	0.018727	0.009485
Limonium spp	0.016667	0.000243	3.333333	0.018727	0.009485
Hydrocotyle umbellata	0.433333	0.006329	2	0.011236	0.008783
***	0.416667	0.006086	1.333333	0.007491	0.006788
***	0.416667	0.006086	1.166667	0.006554	0.00632
Carex jorii	0.416667	0.006086	0.5	0.002809	0.004447
Saururus cernuus	0.433333	0.006329	0.333333	0.001873	0.004101
***	0.433333	0.006329	0.333333	0.001873	0.004101
Carex spp	0.416667	0.006086	0.333333	0.001873	0.003979
***	0.416667	0.006086	0.166667	0.000936	0.003511
***	0.416667	0.006086	0	0	0.003043
***	0.016667	0.000243	0.5	0.002809	0.001526
***	0.016667	0.000243	0.5	0.002809	0.001526
***	0.016667	0.000243	0.166667	0.000936	0.00059

*** - unidentified species

Site 7a understory	Meter^2/ Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	2.272746	1	8266.667	1	0.427419	1
Taxodium distichum	1.518764	0.668251	3933.333	0.475806	0.372881	0.572028
Nyssa aquatica	0.294197	0.129446	2066.667	0.25	0.612903	0.189723
Salix nigra	0.319395	0.140533	866.6667	0.104839	0.769231	0.122686
Acer rubrum	0.044833	0.019726	400	0.048387	0.333333	0.034057
Cephalanthus occidentalis	0.036979	0.016271	266.6667	0.032258	0	0.024264
Hypericum walteri	0.005563	0.002448	333.3333	0.040323	0	0.021385
***	0.021271	0.009359	133.3333	0.016129	0	0.012744
Carpinus caroliniana	0.014726	0.006479	133.3333	0.016129	0	0.011304
Populus heterophylla	0.011781	0.005184	66.66667	0.008065	0	0.006624
Fraxinus spp	0.005236	0.002304	66.66667	0.008065	0	0.005184

Site 7b overstory	Meter^2/ Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	1.094321	1	933.3333	1	0.642857	1
Salix nigra	0.82565	0.754486	533.3333	0.571429	0.75	0.662957
Taxodium distichum	0.19635	0.179426	266.6667	0.285714	0.75	0.23257
Populus heterophylla	0.039597	0.036184	66.66667	0.071429	0	0.053806
Betula nigra	0.032725	0.029904	66.66667	0.071429	0	0.050666

*** - unidentified species

Site # -8a

Location (Coordinates) - 36°42'45" 76°52'45"

Owner and Contact -Clara B. Worrell

Nearest Stream - Beaverdam Swamp

River Basin - Blackwater River

NWI Classification - PF01A

Approximate Size of Site - 27 acres

Age of Site - 8

Site 8a herbaceous	Mean Cover	Relative Dom	Density/ 0.5 m ²	Relative Density	Importanc Values
Total	30.2	1	38.42857	1	1
Typha spp	14.64286	0.484863	7.857143	0.204461	0.344662
Leersia oryzoides	2.5	0.082781	6.428571	0.167286	0.125034
Polygonum punctatum	1.085714	0.035951	8.142857	0.211896	0.123923
Saururus cernuus	5	0.165563	2.428571	0.063197	0.11438
Proserpinaca palustris	2.5	0.082781	3.285714	0.085502	0.084142
Ludwigia palustris	0.014286	0.000473	2.142857	0.055762	0.028118
Carex spp.	0.357143	0.011826	1.285714	0.033457	0.022642
***	0.714286	0.023652	0.714286	0.018587	0.02112
Hydrocotyle umbellata	0.014286	0.000473	1.571429	0.040892	0.020683
Polygonum pensylvanicum	1.1	0.036424	0.142857	0.003717	0.020071
Phragmites australis	0.714286	0.023652	0.571429	0.01487	0.019261
Galium obtusum	0.028571	0.000946	1.285714	0.033457	0.017202
***	0.357143	0.011826	0.714286	0.018587	0.015207
***	0.028571	0.000946	0.714286	0.018587	0.009767
Boehmeria cylindrica	0.357143	0.011826	0.285714	0.007435	0.00963
Hypericum spp	0.357143	0.011826	0.142857	0.003717	0.007772
Pontedaria cordata	0.357143	0.011826	0.142857	0.003717	0.007772
Carex spp	0.014286	0.000473	0.142857	0.003717	0.002095
Acer rubrum	0.014286	0.000473	0.142857	0.003717	0.002095
Nyssa sylvatica	0.014286	0.000473	0.142857	0.003717	0.002095
Polygonum hydropiperoides	0.014286	0.000473	0.142857	0.003717	0.002095
Juncus effusus	0.014286	0.000473	0	0	0.000237

*** - unidentified species

Site 8a understory	Meter^2/ Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	5.245338	1	28114.29	1	0.113821	1
Salix nigra	4.398791	0.83861	24742.86	0.880081	0.12933	0.859345
Acer rubrum	0.461421	0.087968	1257.143	0.044715	0	0.066342
Fraxinus spp	0.189057	0.036043	914.2857	0.03252	0	0.034282
Ilex verticillata	0.082186	0.015668	400	0.014228	0	0.014948
Rhododendron spp	0.063393	0.012086	400	0.014228	0	0.013157
Taxodium distichum	0.04516	0.00861	228.5714	0.00813	0	0.00837
Nyssa sylvatica	0.005329	0.001016	171.4286	0.006098	0	0.003557

Site 8a overstory	Meter^2/ Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	0.566048	1	742.8571	1	0.230769	1
Salix nigra	0.240107	0.424182	400	0.538462	0.428571	0.481322
Acer rubrum	0.285548	0.50446	285.7143	0.384615	0	0.444538
Fraxinus spp	0.040392	0.071358	57.14286	0.076923	0	0.07414

*** - unidentified species

Site # -8b

Location (Coordinates) - 36o42'30" 77o22'45"

Owner and Contact -Union Camp

Nearest Stream- Browns Branch

River Basin - Nottoway River

NWI Classification - PF01A

Approximate Size of Site - 24 acres

Age of Site - 8

Site 8b herbaceous	Mean Cover	Relative Dom	Density/ 0.5 m^2	Relative Density	Importanc Values
Total	86.45	1	88.25	1	1
Murdania keisak	15.625	0.18074	16.25	0.184136	0.182438
***	13.125	0.151822	13.5	0.152975	0.152398
Polygonum hydropiperoides	7.5	0.086755	12	0.135977	0.111366
Sparganium americanum	4.375	0.050607	12.75	0.144476	0.097542
Saururus cernuus	9.375	0.108444	3.75	0.042493	0.075469
Boehmeria cylindrica	3.75	0.043378	3.75	0.042493	0.042935
Leersia oryzoides	3.75	0.043378	3.75	0.042493	0.042935
***	0.025	0.000289	6.75	0.076487	0.038388
Fraxinus spp	3.75	0.043378	2.75	0.031161	0.03727
Commelina virginica	4.375	0.050607	0.75	0.008499	0.029553
***	3.75	0.043378	1.25	0.014164	0.028771
Typha spp	3.75	0.043378	1	0.011331	0.027355
Sagittaria latifolia	3.75	0.043378	0.75	0.008499	0.025938
***	3.75	0.043378	0.25	0.002833	0.023105
Acer rubrum	1.25	0.014459	2.5	0.028329	0.021394
Campsis radicans	0.625	0.00723	2	0.022663	0.014946
Pontedaria cordata	1.25	0.014459	0.5	0.005666	0.010062
***	0.625	0.00723	0.75	0.008499	0.007864
Hydrocotyle umbellata	0.65	0.007519	0.5	0.005666	0.006592
***	0.625	0.00723	0.5	0.005666	0.006448
Leersia oryzoides	0.025	0.000289	1	0.011331	0.00581
***	0.625	0.00723	0.25	0.002833	0.005031
Rhynchospora inundata	0.025	0.000289	0.5	0.005666	0.002977
***	0.025	0.000289	0.25	0.002833	0.001561
Ludwigia palustris	0.025	0.000289	0.25	0.002833	0.001561
***	0.025	0.000289	0	0	0.000145
***	0.025	0.000289	0	0	0.000145

*** - unidentified species

site 8b understory	Meter ² / Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	3.716406	1	30500	1	0.170492	1
Acer rubrum	2.273728	0.611808	16500	0.540984	0.909091	0.576396
Fraxinus spp	1.053415	0.28345	9300	0.304918	0.946237	0.294184
Nyssa aquatica	0.091303	0.024567	1300	0.042623	0.692308	0.033595
Gaultheria procumbens	0.107992	0.029058	500	0.016393	0.8	0.022726
Carpinus caroliniana	0.043197	0.011623	800	0.02623	0.25	0.018926
Cephalanthus occidental	0.057432	0.015454	400	0.013115	0	0.014284
Cornus stricta	0.054978	0.014793	400	0.013115	1	0.013954
Quercus lyrata	0.015217	0.004095	600	0.019672	0.5	0.011883
Liquidambar styraciflua	0.002945	0.000792	300	0.009836	0.666667	0.005314
Rhus glabra	0.012272	0.003302	200	0.006557	0	0.00493
Itea virginica	0.001963	0.000528	100	0.003279	0	0.001904
Taxodium distichum	0.001963	0.000528	100	0.003279	0	0.001904

Site 8b overstory	Meter ² / Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	9.531298	1	2600	1	0.730769	1
Acer rubrum	6.617961	0.69434	1400	0.538462	0.928571	0.616401
Fraxinus spp	2.307598	0.242107	500	0.192308	0.6	0.217208
Nyssa aquatica	0.255745	0.026832	300	0.115385	0	0.071108
Gaultheria procumbens	0.208621	0.021888	200	0.076923	1	0.049406
Carpinus caroliniana	0.070686	0.007416	100	0.038462	1	0.022939
Taxodium distichum	0.070686	0.007416	100	0.038462	0	0.022939

*** - unidentified species

Site # -9a

Location (Coordinates) - 36°33'45" 76°49'50"

Owner and Contact -Union Camp

Nearest Stream - Somerton Creek

River Basin - Chowan River

NWI Classification -PF01E

Approximate Size of Site -17 acres

Age of Site - 9

Site 9a herbaceous	Mean Cover	Relative Dom	Density/ 0.5 m ²	Relative Density	Importanc Values
Total	63.18	1	46.8	1	1
Hydrocotyle umbellata	7	0.110795	12.8	0.273504	0.192149
Saururus cernuus	18	0.2849	3.8	0.081197	0.183048
Polygonum punctatum	9.5	0.150364	4.8	0.102564	0.126464
***	7.5	0.118708	3	0.064103	0.091406
Mikania scandens	6	0.094967	1	0.021368	0.058167
Leersia oryzoides	3.02	0.0478	3	0.064103	0.055951
Lycopus virginicus	3.5	0.055397	2.2	0.047009	0.051203
***	0.5	0.007914	3.6	0.076923	0.042418
***	3.02	0.0478	1.6	0.034188	0.040994
***	0.5	0.007914	1.8	0.038462	0.023188
Boehmeria cylindrica	0.5	0.007914	1.2	0.025641	0.016777
***	0.5	0.007914	1.2	0.025641	0.016777
Carex lurida	1	0.015828	0.8	0.017094	0.016461
Galium obtusum	0.52	0.00823	1	0.021368	0.014799
Carex spp	0.5	0.007914	1	0.021368	0.014641
Bidens laevis	0.5	0.007914	0.8	0.017094	0.012504
***	0.02	0.000317	0.8	0.017094	0.008705
***	0.04	0.000633	0.6	0.012821	0.006727
Ludwigia palustris	0.02	0.000317	0.6	0.012821	0.006569
***	0.5	0.007914	0.2	0.004274	0.006094
Nyssa aquatica	0.5	0.007914	0.2	0.004274	0.006094
Acer rubrum	0.02	0.000317	0.4	0.008547	0.004432
Sparganium americanum	0.02	0.000317	0.4	0.008547	0.004432

*** - unidentified species

Site 9a understory	Meter ² / Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	2.059707	1	17520	1	0.821918	1
Salix nigra	0.589834	0.286368	5200	0.296804	0.753846	0.291586
Acer rubrum	0.6562	0.318589	3360	0.191781	0.928571	0.255185
Nyssa aquatica	0.349109	0.169495	2960	0.16895	0.72973	0.169222
Taxodium distichum	0.281173	0.136511	2800	0.159817	0.914286	0.148164
Liquidambar styraciflua	0.132732	0.064442	2400	0.136986	1	0.100714
Rubus spp	0.040841	0.019828	480	0.027397	0	0.023613
Populus heterophylla	0.003534	0.001716	240	0.013699	1	0.007707
***	0.006283	0.003051	80	0.004566	0	0.003808

Site 9a overstory	Meter ² / Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	10.45522	1	2800	1	0.828571	1
Acer rubrum	3.884972	0.371582	1760	0.628571	0.863636	0.500077
Taxodium distichum	3.358755	0.321252	240	0.085714	1	0.203483
Nyssa aquatica	1.594751	0.152532	480	0.171429	0.666667	0.16198
Salix nigra	1.616742	0.154635	320	0.114286	0.75	0.13446

*** - unidentified species

Site # -10a

Location (Coordinates) -36°33'45" 76°50'00"

Owner and Contact -Union Camp

Nearest Stream -Somerton Creek

River Basin - Chowan River

NWI Classification -PF01E

Approximate Size of Site -10 acres

Age of Site - 10

Site 10a herbaceous	Mean Cover	Relative Dom	Density/ 0.5 m^2	Relative Density	Importanc Values
Total	60.18	1	54.2	1	1
Carex lupulina	15.5	0.257561	18	0.332103	0.294832
Boehmeria cylindrica	7.5	0.124626	8.2	0.151292	0.137959
Saururus cernuus	10.5	0.174477	2.6	0.04797	0.111224
Polygonum punctatum	6.5	0.108009	4	0.073801	0.090905
Lycopus virginicus	6	0.099701	3	0.055351	0.077526
Ludwigia palustris	0.52	0.008641	7.8	0.143911	0.076276
Carex lobelia	3.5	0.058159	2.4	0.04428	0.05122
***	3.02	0.050183	1.6	0.02952	0.039852
Campsis radicans	3	0.04985	0.8	0.01476	0.032305
***	0.5	0.008308	1	0.01845	0.013379
Hypericum spp	0.52	0.008641	0.8	0.01476	0.0117
Typha angustifolia	1	0.016617	0.2	0.00369	0.010153
Sagittaria latifolia	0.5	0.008308	0.6	0.01107	0.009689
***	0.5	0.008308	0.4	0.00738	0.007844
***	0.02	0.000332	0.8	0.01476	0.007546
Bidens laevis	0.5	0.008308	0.2	0.00369	0.005999
Impatiens capensis	0.5	0.008308	0.2	0.00369	0.005999
Taxodium distichum	0.04	0.000665	0.6	0.01107	0.005867
Toxicodendron radicans	0.02	0.000332	0.6	0.01107	0.005701
Hydrocotyle umbellata	0.02	0.000332	0.4	0.00738	0.003856
Mikania scandens	0.02	0.000332	0	0	0.000166

*** - unidentified species

Site 10a understory	Meter ² / Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	0.9574	1	10160	1	0.787402	1
Nyssa aquatica	0.377777	0.394586	2480	0.244094	0.83871	0.31934
Fraxinus spp	0.142942	0.149303	2320	0.228346	1	0.188825
Liquidambar styraciflua	0.121737	0.127153	1520	0.149606	1	0.13838
Taxodium distichum	0.100924	0.105414	560	0.055118	0	0.080266
Alnus rugosa	0.063225	0.066038	960	0.094488	1	0.080263
Carpinus caroliniana	0.067544	0.07055	480	0.047244	0.166667	0.058897
Betula nigra	0.020028	0.020919	800	0.07874	0.8	0.049829
Salix nigra	0.017671	0.018458	320	0.031496	0.75	0.024977
Acer rubrum	0.016493	0.017227	320	0.031496	0.5	0.024362
Cephalanthus occidentalis	0.013352	0.013946	240	0.023622	0	0.018784
Ilex opaca	0.014137	0.014766	80	0.007874	0	0.01132
Itea virginica	0.001571	0.001641	80	0.007874	0	0.004757

Site 10a overstory	Meter ² / Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	0.943	1	3040	1	0.868421	1
Liquidambar styraciflua	13.5609	0.664707	1040	0.342105	1	0.503406
Taxodium distichum	4.510542	0.221091	640	0.210526	0.875	0.215808
Nyssa aquatica	0.860404	0.042174	720	0.236842	0.777778	0.139508
Alnus rugosa	0.479093	0.023483	480	0.157895	1	0.090689
Betula nigra	0.94287	0.046216	80	0.026316	0	0.036266
***	0.047517	0.002329	80	0.026316	0	0.014322

*** - unidentified species

Site # - 14a

Location (Coordinates) -36o51'00" 76o59'15"

Owner and Contact - Union Camp

Nearest Stream - Round Hill Swamp

River Basin - Blackwater River

NWI Classification - PF01E

Approximate Size of Site - 27 acres

Age of Site - 14

Site 14a herbaceous	Mean Cover	Relative Dom	Density/ 0.5 m^2	Relative Density	Importanc Values
Total	12.74	1 0	7.8	1 0	1 0
Itea virginica	3.5	0.274725	0.6	0.076923	0.175824
Clethra alnifolia	3	0.235479	0.8	0.102564	0.169021
Woodwardia aquatica	3	0.235479	0.6	0.076923	0.156201
Dulichium spp	0.5	0.039246	1.4	0.179487	0.109367
Lemna spp	0.02	0.00157	1.6	0.205128	0.103349
Lycopus virginicus	0.5	0.039246	0.8	0.102564	0.070905
***	0.5	0.039246	0.4	0.051282	0.045264
***	0.1	0.007849	0.6	0.076923	0.042386
Proserpinaca palustris	0.5	0.039246	0.2	0.025641	0.032444
***	0.5	0.039246	0.2	0.025641	0.032444
Ilex opaca	0.5	0.039246	0.2	0.025641	0.032444
Saururus cernuus	0.1	0.007849	0.4	0.051282	0.029566
Carex spp.	0.02	0.00157	0	0	0.000785

*** - unidentified species

Site 14a understory	Meter ² / Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	1.769895	1	11440	1	1	
Magnolia virginiana	0.26193	0.147992	2480	0.216783	0.182388	
Acer rubrum	0.376991	0.213002	1600	0.13986	0.176431	
Fraxinus spp	0.406051	0.229421	1120	0.097902	0.163661	
Ilex opaca	0.333009	0.188152	1280	0.111888	0.15002	
Clethra alnifolia	0.092677	0.052363	2080	0.181818	0.117091	
***	0.065188	0.036832	560	0.048951	0.042891	
***	0.025525	0.014422	800	0.06993	0.042176	
Liquidambar styraciflua	0.033772	0.019081	480	0.041958	0.03052	
Liriodendron tulipifera	0.058119	0.032838	160	0.013986	0.023412	
***	0.03927	0.022188	80	0.006993	0.01459	
Rhododendron spp	0.031809	0.017972	80	0.006993	0.012483	
***	0.003534	0.001997	240	0.020979	0.011488	
***	0.019242	0.010872	80	0.006993	0.008932	
***	0.006676	0.003772	160	0.013986	0.008879	
***	0.001963	0.001109	160	0.013986	0.007548	
Platanus occidentalis	0.014137	0.007988	80	0.006993	0.00749	

Site 14a overstory	Meter ² / Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	21.64047	1	5920	1		1
Liquidambar styraciflua	11.11181	0.512065	2480	0.418919		0.465492
Acer rubrum	6.374291	0.293746	1520	0.256757		0.275251
Fraxinus spp	1.367771	0.063031	1040	0.175676		0.119353
Ilex opaca	1.100343	0.050707	480	0.081081		0.065894
Quercus alba	1.255459	0.057855	240	0.040541		0.049198
Quercus phellos	0.33026	0.015219	80	0.013514		0.014366
Quercus palustris	0.100531	0.004633	80	0.013514		0.009073

*** - unidentified species

Site # - 15a

Location (Coordinates) -36o36'00" 76o49'30"

Owner and Contact -Union Camp

Nearest Stream -Black (or Chapel) Swamp

River Basin - Blackwater River

NWI Classification -PF01A

Approximate Size of Site - 7 acres

Age of Site - 15

Site 15a herbaceous	Mean Cover	Relative Dom	Density/ 0.5 m^2	Relative Density	Importanc Values
Total	25.56667	1	42.66667	1	1
Boehmeria cylindrica	6.666667	0.260756	16.5	0.386719	0.323737
***	2.95	0.115385	15	0.351563	0.233474
Saururus cernuus	9.583333	0.374837	2.166667	0.050781	0.212809
***	2.933333	0.114733	3.5	0.082031	0.098382
Impatiens capensis	0.416667	0.016297	1.5	0.035156	0.025727
Campsis radicans	0.833333	0.032595	0.666667	0.015625	0.02411
Acer rubrum	0.45	0.017601	1	0.023438	0.020519
Viola spp	0.433333	0.016949	0.666667	0.015625	0.016287
***	0.433333	0.016949	0.666667	0.015625	0.016287
***	0.416667	0.016297	0.333333	0.007813	0.012055
***	0.416667	0.016297	0.166667	0.003906	0.010102
Smilax spp	0.016667	0.000652	0.333333	0.007813	0.004232
Fraxinus spp	0.016667	0.000652	0.166667	0.003906	0.002279

*** - unidentified species

Site 15a understory	Meter^2/ Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	0.866229	1	4200	1	0.793651	1
Fraxinus spp	0.733038	0.846241	3000	0.714286	0.866667	0.780263
Acer rubrum	0.053014	0.061201	400	0.095238	0.5	0.07822
Taxodium distichum	0.020617	0.023801	333.3333	0.079365	0.8	0.051583
Magnolia virginiana	0.018653	0.021534	266.6667	0.063492	1	0.042513
Liquidambar styraciflua	0.037961	0.043823	133.3333	0.031746	0	0.037785
Ilex verticillata	0.002945	0.0034	66.66667	0.015873	0	0.009637

Site 15a overstory	Meter^2/ Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	36.47618	1	4533.333	1	0.852941	1
Fraxinus spp	17.17535	0.470865	2733.333	0.602941	0.804878	0.536903
Nyssa aquatica	16.20735	0.444327	933.3333	0.205882	0.928571	0.325105
Nyssa sylvatica	1.159771	0.031795	466.6667	0.102941	1	0.067368
Acer rubrum	1.84994	0.050716	333.3333	0.073529	1	0.062123
Magnolia virginiana	0.083776	0.002297	66.66667	0.014706	0	0.008501

*** - unidentified species

Site # - 15b

Location (Coordinates) - 36o41'50" 77o26'00"

Owner and Contact -J.W. Pollard

Nearest Stream - Three Creek

River Basin - Nottoway River

NWI Classification -PF01A

Approximate Size of Site - 82 acres

Age of Site - 15

Site 15b herbaceous	Mean Cover	Relative Dom	Density/ 0.5 m ²	Relative Density	Importanc Values
Total	0.625	1	0.25	1	1
Ilex opaca	0.625	1	0.25	1	1

*** - unidentified species

Site 15b understory	Meter^2/ Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	1.665044	1	7300	1	0	1
Acer rubrum	0.793743	0.47671	3600	0.493151	0.166667	0.48493
Fraxinus spp	0.330358	0.198408	1200	0.164384	0.083333	0.181396
Quercus laurifolia	0.032398	0.019458	300	0.041096	0	0.030277
***	0.251818	0.151238	800	0.109589	0.125	0.130414
Carpinus caroliniana	0.239546	0.143868	1000	0.136986	0	0.140427
***	0.004418	0.002653	100	0.013699	0	0.008176
Quercus lyrata	0.008345	0.005012	200	0.027397	0	0.016205
Platanus occidentalis	0.004418	0.002653	100	0.013699	0	0.008176

Site 15b overstory	Meter^2/ Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	31.4174	1	8300	1	0.39759	1
Acer rubrum	5.736352	0.182585	2700	0.325301	0.481481	0.253943
Fraxinus spp	5.838454	0.185835	2300	0.277108	0.391304	0.231472
Salix nigra	10.57588	0.336625	900	0.108434	0.444444	0.222529
Populus heterophylla	4.635322	0.14754	300	0.036145	0	0.091842
Carpinus caroliniana	0.887009	0.028233	900	0.108434	0.777778	0.068333
Quercus laurifolia	1.573742	0.050091	700	0.084337	0	0.067214
Liquidambar styraciflua	1.89281	0.060247	200	0.024096	0	0.042172
***	0.277835	0.008843	300	0.036145	0	0.022494

*** - unidentified species

Site # -17a

Location (Coordinates) - 36°48'00" 76°55'00"

Owner and Contact - Rose Estate

Nearest Stream - Black Creek Swamp

River Basin - Blackwater River

NWI Classification - PF01E

Approximate Size of Site - 15 acres

Age of Site - 17

Site 17a herbaceous	Mean Cover	Relative Dom	Density/ 0.5 m ²	Relative Density	Importanc Values
Total	55.61667	1	131.3333	1	1
Murdania keisak	35.83333	0.644291	78.83333	0.600254	0.622273
Eleocharis spp	2.5	0.044951	26	0.19797	0.12146
Saururus cernuus	7.5	0.134852	2.166667	0.016497	0.075675
***	0.416667	0.007492	14.16667	0.107868	0.05768
Hypericum walteri	2.516667	0.04525	0.666667	0.005076	0.025163
Acer rubrum	2.5	0.044951	0.666667	0.005076	0.025013
Polygonum punctatum	0.433333	0.007791	2.666667	0.020305	0.014048
Hypericum virginicum	0.85	0.015283	1.666667	0.01269	0.013987
Lycopus virginicus	0.833333	0.014984	0.5	0.003807	0.009395
Toxicodendron radicans	0.416667	0.007492	0.833333	0.006345	0.006918
Boehmeria cylindrica	0.433333	0.007791	0.666667	0.005076	0.006434
Woodwardia areolata	0.416667	0.007492	0.5	0.003807	0.005649
***	0.416667	0.007492	0.333333	0.002538	0.005015
Zizania aquatica	0.416667	0.007492	0.166667	0.001269	0.00438
***	0.033333	0.000599	0.333333	0.002538	0.001569
***	0.016667	0.0003	0.333333	0.002538	0.001419
***	0.016667	0.0003	0.166667	0.001269	0.000784
Smilax spp	0.016667	0.0003	0.166667	0.001269	0.000784
Salix nigra	0.016667	0.0003	0.166667	0.001269	0.000784
Taxodium distichum	0.016667	0.0003	0.166667	0.001269	0.000784
Nyssa sylvatica	0.016667	0.0003	0.166667	0.001269	0.000784

*** - unidentified species

Site 17a understory	Meter^2/ Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	2.718787	1	15000	1	0.518241	1
Taxodium distichum	1.444151	0.531175	6400	0.426667	0.677083	0.478921
Acer rubrum	0.342303	0.125903	933.3333	0.062222	0.214286	0.094062
Viburnum nudum	0.164279	0.060424	1400	0.093333	0.52381	0.076879
Alnus serrulata	0.160352	0.058979	1133.333	0.075556	0.941176	0.067267
Clethra alnifolia	0.05825	0.021425	1000	0.066667	0	0.044046
Toxicodendron radicans	0.081812	0.030091	866.6667	0.057778	0	0.043935
Platanus occidentalis	0.095884	0.035267	333.3333	0.022222	0.6	0.028745
Ilex glabra	0.100138	0.036832	266.6667	0.017778	0	0.027305
Fraxinus spp	0.049415	0.018175	533.3333	0.035556	0.625	0.026865
Clethra alnifolia	0.034688	0.012759	600	0.04	0	0.026379
Leucothoe racemosa	0.069377	0.025518	400	0.026667	0	0.026092
Liquidambar styraciflua	0.050724	0.018657	466.6667	0.031111	0	0.024884
Nyssa sylvatica	0.040906	0.015046	200	0.013333	0	0.01419
Salix nigra	0.016035	0.005898	333.3333	0.022222	0	0.01406
Nyssa aquatica	0.010472	0.003852	133.3333	0.008889	0	0.00637

Site 17a overstory	Meter^2/ Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	20.36014	1	3133.333	1	0.595745	1
Nyssa aquatica	11.79341	0.57924	733.3333	0.234043	0.909091	0.406641
Acer rubrum	1.213113	0.059583	800	0.255319	0.666667	0.157451
Platanus occidentalis	2.453388	0.1205	533.3333	0.170213	0.375	0.145356
Fraxinus spp	0.778526	0.038238	466.6667	0.148936	0.857143	0.093587
Taxodium distichum	0.852484	0.04187	266.6667	0.085106	0.25	0.063488
Salix nigra	1.840777	0.090411	66.66667	0.021277	0	0.055844
Nyssa sylvatica	1.217694	0.059808	66.66667	0.021277	0	0.040542
Ilex glabra	0.1309	0.006429	66.66667	0.021277	0	0.013853
Liriodendron tulipifera	0.047124	0.002315	66.66667	0.021277	0	0.011796
Alnus serrulata	0.032725	0.001607	66.66667	0.021277	0	0.011442

*** - unidentified species

Site # - 20a

Location (Coordinates) -36o44'15" 76o19'00"

Owner and Contact - Jack W. Vick

Nearest Stream - Three Creek

River Basin - Nottoway River

NWI Classification -PF01A

Approximate Size of Site -

Age of Site - 20

Site 20a herbaceous	Mean Cover	Relative Dom	Density/ 0.5 m^2	Relative Density	Importanc Values
Total	3.985714	1	4.571429	1	1
Arundinaria gigantea	2.5	0.62724	2.142857	0.46875	0.547995
Acer rubrum	0.371429	0.09319	1	0.21875	0.15597
Smilax spp	0.042857	0.010753	1	0.21875	0.114751
Saururus cernuus	0.357143	0.089606	0.285714	0.0625	0.076053
Campsis radicans	0.357143	0.089606	0.142857	0.03125	0.060428
Fraxinus spp	0.357143	0.089606	0	0	0.044803

*** - unidentified species

Site 20a understory	Meter^2/ Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	0.490874	1	1542.857	1	0.481481	1
Acer rubrum	0.243754	0.496571	685.7143	0.444444	0.833333	0.470508
Quercus lyrata	0.102382	0.208571	400	0.259259	0	0.233915
Fraxinus spp	0.095089	0.193714	285.7143	0.185185	0.4	0.18945
Cornus stricta	0.031696	0.064571	114.2857	0.074074	0.5	0.069323
Quercus laurifolia	0.017952	0.036571	57.14286	0.037037	0	0.036804

Site 20a overstory	Meter^2/ Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	18.8086	1	3942.857	1	0.362319	1
Salix nigra	7.38667	0.392728	285.7143	0.072464	0.6	0.232596
Acer rubrum	2.11216	0.112298	971.4286	0.246377	0.647059	0.179337
Liquidambar styraciflua	2.023803	0.1076	514.2857	0.130435	0	0.119017
Populus heterophylla	2.497847	0.132803	285.7143	0.072464	0	0.102634
Quercus lyrata	0.844023	0.044874	628.5714	0.15942	0.272727	0.102147
Betula nigra	1.548917	0.082352	342.8571	0.086957	0	0.084654
Fraxinus spp	1.189598	0.063248	400	0.101449	0.571429	0.082348
Ulmus americana	1.165194	0.06195	400	0.101449	0.571429	0.0817
Quercus laurifolia	0.040392	0.002148	114.2857	0.028986	0	0.015567

*** - unidentified species

Site # - 20b

Location (Coordinates) - 36°39'41" W 77°28'27"

Owner and Contact - Union Camp (experimental site)

Nearest Stream - Meherrin River

River Basin - Meherrin River

NWI Classification - PFO1A

Approximate Size of Site - 30 acres

Age of Site - 20 years

no herbaceous data

Site 20b understory	Meter^2/ Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	0.138623	1	1600	1	0.75	1
Acer rubrum	0.118988	0.858357	640	0.4	0.75	0.629178
Fraxinus spp	0.009817	0.070822	880	0.55	1	0.310411
Ostrya virginiana	0.009817	0.070822	80	0.05	0	0.060411

Site 20b overstory	Meter^2/ Hectare	Relative Dom	Density/ Hectare	Relative Density	Percent Sprouts	Importanc Values
Total	35.27969	1	4400	1	0.654545	1
Acer rubrum	15.67262	0.444239	2400	0.545455	0.633333	0.494847
Fraxinus spp	8.862433	0.251205	1360	0.309091	0.882353	0.280148
Liquidambar styraciflua	6.031072	0.17095	240	0.054545	0.666667	0.112748
Salix nigra	3.771875	0.106913	160	0.036364	0	0.071639
T2-20b2	0.567057	0.016073	80	0.018182	0	0.017128
Quercus lyrata	0.286278	0.008115	80	0.018182	0	0.013148
T2-20b1	0.088357	0.002504	80	0.018182	0	0.010343

Vita

David Randolph Spencer

Born in San Francisco, California, on February 7, 1970. Graduated from Chapin High School in Chapin, South Carolina, in 1988. Earned a Bachelor of Science in Criminal Justice from Appalachian State University in December of 1991. Following the completion of a cooperative position with the National Marine Fisheries Service in Charleston, South Carolina, entered the master's program at the College of William and Mary, School of Marine Science in 1994. Currently employed as the Water Resources Coordinator for the Southeast Region of the National Park Service.