INFLUENCE OF GREENTREE RESERVOIR MANAGEMENT ON OVERSTORY COMPOSITION,CANOPY DENSITY, AND HARDWOOD REGENERATION ON NOXUBEE NATIONAL WILDLIFE REFUGE

Gary L. Young, Bob L. Karr, and John D. Hodges, Department of Forestry
Bruce D. Leopold and Richard M. Kaminski, Department of Wildlife and Fisheries University
Mississippi State University

Introduction

Greentree reservoirs (GTRs) are modified bottomland forest sites at least partly enclosed by a system of levees which serve to impound water between late fall and early spring. Greentree reservoirs are primarily managed for migrating waterfowl, particularly mallards (Anus platyrhynchos) and wood ducks (Aix sponsa). Historically, bottomland forests in concert with natural flooding regimes have provided this necessary habitat; however, the dramatic decrease in Mississippi's bottomland acreage and drainage and flood control projects have reduced the availability of this waterfowl habitat. It has been estimated that of the original 22.2 million acres of bottomland forests in the Mississippi deltaic plain only 5.4 million acres remained in 1978 (Fredrickson 1978). Between 1960 and 1975, Mississippi's remaining bottomland acreage was reduced by an average of 20,000 acres per year (Turner et al. 1981). Loss of this habitat is attributed primarily to drainage and flood control projects by various government agencies (Fredrickson 1978, Harris et al. 1984). These activities have allowed conversion of bottomland hardwood sites to agricultural and urban development interests. Klopatek (1979) reported that 63% of the southern floodplain forest (bottomland hardwoods) in the lower Mississippi River Valley (Louisiana, Mississippi, and Arkansas) has been replaced primarily by cotton and soybean crops. Degradation of wildlife habitat in the form of floral compositional changes and plant cover loss has been a major result of this trend (Harris et al. 1984). In an effort to mitigate losses in bottomland acreage and concomitant losses in waterfowl habitat, many public land managers have resorted to GTR management (Fredrickson 1980).

Acreage and species composition varies considerably among greentree reservoirs. These impoundments range in size from approximately 5 acres to 21,000 acres with an average size in Mississippi of 750 acres (Wigley and Filer 1989). Mississippi currently has 12 GTRs in operation (Smith 1990). Wigley and Filer (1989) also noted that 46% of GTRs in the United States are dominated by oaks, namely pin oak (Quercus palustris), willow oak (Quercus phellos), nuttall oak (Quercus nuttallii), overcup oak (Quercus lyrata), laurel oak (Quercus laurifolia), and water oak (Quercus nigra). The majority of the remaining GTRs are dominated by associations of oak-blackgum (Nyssa sylvatica), oak-hickory (Carya spp.), and red maple-ash (Acer rubrum-Fraxinus spp.)

Maintaining desirable tree species composition within these modified bottomland hardwood sites is crucial to the long-term productivity of these areas with respect to both waterfowl necessities and timber management interests. Some studies indicate that shifts in composition toward less desirable and more water tolerant species can occur (Fredrickson 1980, Newling 1981). Malecki et al. (1983) reported very little change in overstory composition after 12 years of spring flooding in a New York reservoir. This reservoir, however, was dominated initially by red maple and green ash (Fraxinus pennsylvanica) both of which are considered water tolerant species. Thomson and Anderson (1976) noted a pattern of replacement in pin oak communities within an Illinois greentree reservoir. Elm and ash increased in importance value as pin oak decreased. Site moisture conditions appeared to be responsible for determining which of the two replacement species would become more dominant.

Managers of Noxubee National Wildlife Refuge (NNWR) are concerned that 30 years of annual flooding in two of their GTRs may be causing a shift in composition toward water tolerant oak species, particularly overcup oak. A preliminary study conducted in 1986 reported overcup oak to be the dominant seedling within these reservoirs. A more extensive study is currently being conducted, and this paper presents findings concerning overstory composition, canopy density, and hardwood regeneration as affected by GTR management.

Study Area

The study area is located on Noxubee National Wildlife Refuge, Noxubee County, Mississippi. Study sites were selected within GTR 1, GTR 2, and an adjacent, naturally flooded bottomland hardwood site. The GTR study sites were located within the inundation zone defined by annual winter flooding, and the bottomland control site was located within the floodplain of the Noxubee River. Greentree reservoirs 1 and 2 at NNWR encompass approximately 380 acres and 300 acres, respectively. They were constructed in the late 1950's. Artificial winter flooding begins approximately October 15 each year and drawdown is initiated by March 1. The primary water source for winter flooding is the 1,200-acre Bluff Lake located west of GTR 1. These impoundments have been flooded annually through 1985 with the exception of the 1979-1980 winter season. In response to concerns about changes in vegetative species composition, refuge managers did not flood GTR 2 during 1985-1986 and 1986-1987 and GTR 1 during 1987-1988 and 1988-1989.

The soil in all three study areas is an Urbo-Mantachie association. The Urbo soil generally is found on broad flats. The Mantachie soil is found on slightly higher areas and generally occurs near stream channels. Both soils possess high water capacities with permeability being moderate to slow. Runoff is slow for both soils.

Methods

Tree-species composition within the GTRs and control area was sampled using the point-center quarter method (Cottam and Curtis 1956). Trees were defined as woody plants with a minimum dbh of 10.5 cm. A total of 5 kilometers of transect lines and 50 permanent sampling points were located in each GTR and the control area. Transect lines were located 200 m apart, and sampling points were located 100 m apart. The area sampled within in each study site was approximately 250 acres. Relative frequency (%), relative density (%), and relative dominance (%) of each species were determined for each GTR and the control area. The number of trees per acre was also determined using the point-center quarter method. A 2m-radius plot was established at each sample point and the number of seedlings (height $\leq$ 1m) and saplings (height > 1m) by species were recorded. The relative frequency and density of seedlings and saplings were computed from these data. Species importance values were used as the basis of comparison for overstory and regeneration vegetation composition. Importance values are the combined expression of relative frequency, relative density, and relative dominance (overstory only), and, therefore, serve as indicators of the relative contribution of a species to the community.

The importance value for each species was calculated as follows.

$$\text{relative density (RDe)} = \frac{\text{number of individuals of a species}}{\text{total individuals of all species}}$$

$$\text{relative frequency (RF)} = \frac{\text{frequency value for a species}}{\text{total frequency value for all species}}$$

$$\text{relative dominance (RDo)} = \frac{\text{total basal area of a species}}{\text{total basal area of all species}}$$

importance value = RDe + RF + RDo

Canopy density at each sample point was estimated with a densiometer (Strickler 1959). Four readings were taken at each sample point, one in each cardinal direction, and the average of these readings was used as a measure of canopy density.

Analysis of variance was performed on mean seedling, sapling, and canopy densities. A square root transformation was applied to seedling and canopy data to meet analysis of variance requirements.

Results and Discussion

Overstory Composition - The effect of GTR management on overstory species composition was expressed primarily among the dominant species on each study site (Table 1). The three highest ranked species in the bottomland control site were willow oak (1), cherrybark oak (*Quercus pagoda*) (2), and sweetgum (*Liquidambar styraciflua*) (3). The dominant species in both GTRs was overcup oak with cherrybark oak and sweetgum being ranked either second or third depending upon the GTR under consideration. In contrast to its dominance in the GTRs, overcup oak was ranked only fourth in the bottomland control area. Fredrickson (1979) concluded that GTR management can be expected to enhance the growth of overcup oak primarily because of increased soil moisture conditions. Broadfoot (1967) reported that overcup oak exhibited a 20% radial growth increase over control trees in a natural stand flooded annually from February to July for a period of 4 years. Furthermore, overcup oak is capable of surviving 4 years of complete inundation (Broadfoot and Williston 1973). Overstory data, coupled with evidence provided by previous research, suggest that GTR management on NNWR has modified soil moisture attributes in a similar fashion with the predictable consequence of increased community dominance in the overstory by overcup oak.

The greatest similarity in importance value rankings across study sites occurred with cherrybark oak and sweetgum. Even though minor differences in absolute importance values within each species existed, these species were consistently ranked either second or third on each study site. Cherrybark oak is considered to be intolerant to flooded or saturated soils which persist longer than a few weeks during the growing season; sweetgum is considered moderately tolerant, capable of surviving several months of flooded or saturated soil during the growing season (McKnight et al. 1980). There is a relative scarcity of data concerning overstory cherrybark oak response to flooding, but Broadfoot and Williston (1967) noted that cherrybark oak flooded in less than 12 inches of water died at the end of one year. Several studies have reported an increased growth rate in sweetgum as a result of flooding or irrigation (Conner and Day 1988, Broadfoot 1964, Broadfoot 1967). Despite these obvious differences in their abilities to tolerate flood conditions, no major shift in the relative contribution of either cherrybark oak or sweetgum was apparent.

Willow oak possessed the largest disparities in both importance values and relative rankings among study sites. It was the dominant species on the bottomland control site but was ranked only fifth and sixth on GTR 1 and GTR 2, respectively. Willow oak is considered moderately tolerant to flooding (Mcknight et al. 1980) and has exhibited a 10% radial growth increase over unflooded control trees (Broadfoot 1967). These previous research findings suggest that willow oak response to GTR management should have been somewhat comparable to overcup oak response; however, a dramatic decrease in willow oak has occurred. The relative densities of willow oak on GTR 1 (5%) and GTR 2 (6%) were considerably lower than on the bottomland control site (18%). Personal observations of windthrown willow oak and no observable symptoms of decreased vigor among the remaining willow oaks make windthrow the probable cause for the reduced contribution of willow oak. Windthrow problems are commonly associated with GTR management. Wigley and Filer (1989) found that 37% of GTR managers in the south and 52% of the managers with GTRs over 20 years of age considered windthrow a problem. Consistent patterns among the remaining species were not apparent with the exception of bald cypress (Taxodium distichum). This species was ranked fourth on GTR 2 and sixth on GTR 1, and its presence is associated with minor sloughs that exist in each area.

It is widely recognized that the relative water tolerance ranking of the three major oak species in the GTRs is: overcup oak > willow oak > cherrybark oak (Klimas et al. 1981, Broadfoot and Williston 1973, Hosner 1960, Hosner and Boyce 1962). However, the relative ranking based on the degree of deleterious effect with regard to community contribution was: overcup oak > cherrybark oak > willow oak. Moreover, sweetgum and cherrybark oak, despite tolerance differences, have maintained their relative contributions to the community under GTR management.

These findings can be reconciled by considering the ecology of bottomland hardwoods. Species occurrence is related to bottomland topography with minor differences in elevation resulting in stands of distinct composition (Hodges and Switzer 1979). Generally, overcup oak and willow oak are found on less well drained flats and cherrybark oak and sweetgum occur on better drained flats and low ridges. The hydrology of these GTRs has been modified primarily by impeding run-off. Additionally, there is evidence that overflow from the Noxubee River does occur on a periodic basis. For example, between March and September 1989 both GTRs were inundated 5 times with the length of inundation lasting approximately two days longer than the bottomland control site. The importance of the Noxubee River's overflow on overstory composition is uncertain but ultimately depends on establishing the timing and frequency of this episodic flooding. Regardless of the source of inundation, soils tend to remain saturated for a longer period of time in the GTRs particularly on sites which possess inherently poor drainage. Thus, species which occupy better drained sites will exhibit the influence of these flooding episodes to a lesser degree, whereas the magnitude and frequency of these influences are more likely to be expressed on less well drained sites. Cherrybark oak, sweetgum, and overcup oak have responded, at least during the time period considered, in a manner consistent with topographic position. However, some cherrybark oaks are exhibiting symptoms of crown deterioration, particularly decreased crown density. This suggests that a delayed cumulative effect may be occurring with the ultimate consequences of decreased growth and mortality and, hence, modification of community structure. Also, increased duration of saturated soils in less well drained areas has modified site conditions. This has apparently contributed to the increased susceptibility of willow oak to windthrow.

Canopy Density - Canopy density is the degree to which individual tree crowns are in general contact with one another. There is a progressive reduction in the amount of open space among tree crowns as canopy density increases with the canopy possessing a continuous and uniform appearance at 100% canopy density.

Mean canopy density and the frequency of different canopy densities within each study site were influenced by GTR management (Figure 1). Mean canopy density has been significantly reduced ($P < .05$) on both GTRs in relation to the bottomland control site. The mean canopy density of the control site was 93.0%, and the mean canopy densities of the GTRs were 88.6% and 88.2% for GTR 1 and GTR 2, respectively. Expressed in terms of canopy openness, 7% of the control area canopy, on average, was not occupied by tree crown, and a combined average of 11.6% of the GTR canopies was not occupied. The frequency of occurrence of various canopy densities was consistent between GTRs but markedly different between the GTRs and the bottomland control site. Eighty-two percent of the bottomland control site possessed a canopy density of 91% or greater compared to only approximately 47% within each greentree reservoir. The most prominent shift in the frequency of canopy densities occurred between the 81 to 90% and 91 to 100% density classes. Whereas the control site had a greater occurrence of canopy in the 91 to 100% density class, both GTRs had greater occurrences of canopy (36% compared to 10%) in the 81 to 90% canopy density class. The outcome of this modification in canopy structure was a discontinuous and nonuniform canopy appearance in the GTRs resulting in greater light penetration to the forest floor.

Regeneration - Regeneration data indicate a shift in seedling composition toward more water tolerant species. Overcup oak was clearly the dominant seedling on both GTRs (Table 2). It was only a minor component on the bottomland control site, being ranked sixth in importance. Overcup oak seedlings are among the most water tolerant oak seedlings (Hall and Smith 1955) and are potentially better able to tolerate increased anaerobic conditions associated with a shift toward increased flood frequency and duration. Willow oak seedlings are considered water tolerant also (Hall and Smith 1955, Hosner and Boyce 1962), but this species' relative contribution in the GTRs remained essentially stable compared to willow oak values for the bottomland control site. Interestingly, the relative contribution of green ash which is considered water tolerant (Hall and Smith 1955, Hosner 1959, Hosner and Boyce 1962), was substantially lower on the GTRs despite a higher relative importance value and ranking of green ash in the overstory on GTR 1. Green ash importance values were 18.06 on the control site and 3.01 and 2.35 on GTR 1 and GTR 2, respectively. Malecki et al. (1983) reported a similar finding in which there was a significant decrease in the mean density and frequency of occurrence of green ash seedlings in a New York GTR possessing green ash as a dominant component in the overstory.

In spite of similar water tolerance levels, overcup oak, willow oak, and green ash exhibited responses which were dramatically dissimilar. Overcup oak vastly increased its contribution primarily because of the inherent capability of its seedlings and seeds to tolerate extended periods of saturated soil conditions. Evidence of this capability is apparent in its association with bald cypress. Willow oak, unable to tolerate these conditions, has probably maintained its relative standing through a spatial shift of seedlings onto sites which were originally marginal in terms of soil moisture but which have become adequate due to impedance of run-off.

The decreased relative contribution of green ash, however, is probably mainly due to a combination of poor seed viability and premature germination of seed immersed in water rather than seedling mortality. Green ash is a fall (September - October) disseminator with the samaras normally landing on the forest floor and germinating in the spring. These GTRs are flooded in mid-October which results in the complete submersion of these relatively soft-coated seeds or dissemination of the seed directly onto the water surface. It is unlikely that the seeds are capable of maintaining viability through four months of complete submersion. Moreover, DuBarry (1963) found that 30% of green ash seed germinated while immersed in water (75° to 90° F) for 30 days. Therefore, a complete understanding of silvical characteristics of individual species is sometimes necessary rather than relying solely on relative water tolerance as a predictor of species response to artificial flooding regimes.

Clear trends among the remaining seedlings were difficult to distinguish. Red maple (Acer rubrum) and american elm (Ulmus americana) were important components on all three study sites, but GTR management has not defined a consistent influence. For example, the largest american elm and red maple importance values occurred in GTR 1; however, the smallest importance values for both species occurred in GTR 2. Furthermore, the high ranking of red maple in GTR 1 can be attributed to the large red maple component in the overstory. This is supported by a similar finding of Malecki et al. (1983).

Saplings were the least influenced component in terms of species composition. Among the sapling species possessing the largest importance values in each study site, American hornbeam (Caprinus caroliniana), shagbark hickory, deciduous holly (Ilex decidua), and swamp hickory (Carya leiodermis) were species common to all three sites (Table 3). American hornbeam was ranked first across all sites. Deciduous holly was the only other species that was consistently ranked (third or fourth) across all study sites. American hornbeam and deciduous holly are common floodplain species and capable of tolerating frequent short-term flooding. The modified flooding regime associated with GTR management has had little influence on the relative contribution of these species. Shagbark and swamp hickory were ranked third and sixth, respectively, on GTR 1 and the bottomland control site. While hickory rankings between GTR 1 and the control site were similar, hickory rankings between the GTRs were not, and, therefore, may simply reflect initial differences in composition rather than artificial flooding influence.

Red maple and sweetgum were important components only on GTR 1 . Red maple was ranked seventh on GTR 2 and ninth on the control site. The dominance of red maple on GTR 1 is probably associated with the overstory composition previously discussed. Sweetgum, on the other hand, was not sampled in GTR 2 and ranked twelfth on the control site. Reasons for the scarcity of sapling-sized sweetgum on GTR 2 are unclear, but the abundance on GTR 1 may be linked to the dissemination of seed from adjacent, abandoned agricultural fields which have developed into sweetgum dominated stands. As noted with green ash seedlings, sapling-sized green ash on both GTRs possessed importance values which were considerably smaller than the control site value. Green ash was ranked second on the control site but eighth on GTR 1 and eleventh on GTR 2. Some indication of increased relative contribution was also apparent. Black tupelo (Nyssa sylvatica), for example, was ranked fourth on GTR 2, fifth on GTR 1, and seventh on the control site.

Overall, the commonality of species among sites and consistency of relative rankings indicate that sapling species composition was influenced to a lesser degree by this modified flooding regime than overstory or seedling composition. This is particularly evident in the high relative rankings of water-intolerant shagbark hickory on the GTRs. The absence of sapling-sized overcup oak on the GTRs, despite its being water tolerant and dominating seedling composition, indicates a lack of seedling development into the sapling stage.

Vegetation Density - The mean number of trees per acre varied among sites with GTR 1 possessing 129 trees, GTR 2 102 trees, and the control site 124 trees per acre (Table 4). The larger number of trees per acre on GTR 1 can be partly attributed to the abundance of red maple. The mean number of saplings per acre was significantly greater ($P < .05$) on the control site. The control site had 895 saplings per acre while GTR 1 had 415 saplings per acre and GTR 2 had 294 saplings per acre. The mean numbers of seedlings per acre, however, were significantly greater ($P < .05$) on the GTRs. The mean numbers of seedlings per acre were 14,305 on GTR 1, 10,035 on GTR 2, and 6,682 on the bottomland control site.

Although sapling species composition was only modified slightly, sapling density was considerably less on both GTRs. This indicates that sapling mortality is related to relative location within the GTR rather than differential species mortality across the site. In general, high mortality of all species would, therefore, occur on the low elevation end of the GTR because of longer periods of flooding and saturated soil conditions.

Both GTRs possessed larger numbers of seedlings per acre, but overcup oak accounted for approximately 71% of the seedlings on GTR 1 and 62% on GTR 2. Overcup oak accounted for only 5% of the seedlings on the control site. Moreover, 80% of overcup oak seedlings were concentrated on approximately 22% of the land area on GTR 2. These percentages are not yet available for GTR 1, but assuming similar findings, approximately 80% of the GTRs were not dominated by the presence of overcup oak seedlings. Factoring out the contribution of overcup oak to the per acre seedling values results in the control site having approximately 2,200 and 2,500 more seedlings per acre than GTR 1 and GTR2, respectively.

Management Implications - Community structure has been modified as a result of GTR management. Shifts toward increased dominance by overcup oak were evident in the overstory and in seedling regeneration. Canopy density has been reduced resulting in a discontinuous and nonuniform canopy appearance. A marked decrease in saplings and a substantial increase in the number of seedlings have also occurred.

Existing data are insufficient to evaluate the current 2-year flooding cycle now being practiced. Francis (1983), however, recommended flooding every second or third year to maintain tree vigor. Minckler and McDermott (1960) noted that one to three years without floods may be required to regenerate pin oak. Therefore, current water management should allow for greater soil aeration and consequently increased tree vigor. Although current management may help prevent further willow oak and sapling losses, it may not allow a sufficient period of time for adequate oak regeneration to occur.

Red oaks, particularly cherrybark oak, are critical to the long-term productivity of these management areas. Red oaks, however, constitute a minor component of existing regeneration. Maintaining red oaks is predicated on establishing red oak seedlings and allowing these seedlings to develop into advanced regeneration. Several authors have concluded that heights of at least 4.5 feet are required of oak reproduction if it is to successfully develop into codominant and dominant positions in the future stand (Sander 1972, Loftis 1982, Hodges and Janzen 1986). Because damage to overtopped seedlings can be a decisive mortality factor (McDermott 1954), sufficient height is also required to protect against periodic overflow from the Noxubee River during the growing season. Reduced canopy and sapling density, combined with additional midstory removal on both GTRs, should provide suitable conditions for successful regeneration establishment and growth. An establishment period of 4 years without flooding, depending on environmental conditions, should be adequate to provide needed seedling regeneration. Successful regeneration is dependent on a good seed crop and, therefore, the establishment period should be preceded by a good seed crop year.

These findings also suggest that the initiation date and duration of water drawdown are critical. If waterfowl utilization is low, then drawdown should be initiated in late winter to allow sufficient time for soil water drainage. This becomes particularly important in years where drawdown is followed by periodic growing-season flooding by the Noxubee River's overflow. Water discharge into the GTRs from Bluff Lake after drawdown should also be prevented. Generally, the sooner the drawdown begins the longer the drawdown period can be.

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Table 1. Importance value (IV) and relative rank for the six highest ranked tree species on GTR 1, GTR 2, and bottomland control site, Noxubee National Wildlife Refuge, Mississippi.

	Study Area					
	GTR1		GTR2		Control	
Species	IV	Rank	IV	Rank	IV	Rank
Overcup Oak (Quercus lyrata)	58.66	1	56.98	1	26.95	4
Cherrybark Oak (Quercus pagoda)	41.77	3	38.42	2	49.09	2
Sweetgum (Liquidambar styraciflua)	46.60	2	32.62	3	44.79	3
Willow Oak (Quercus phellos)	19.42	5	23.03	6	65.89	1
Red Maple (Acer rubrum)	41.75	4	--		--	--
Swamp Chestnut Oak (Quercus michauxii)	--	-	23.83	5	18.53	5
Bald Cypress (Taxodium distichum)	16.83	6	24.81	4	--	-
Nuttall Oak (Quercus nuttallii)	-	-	-	-	17.00	6

Table 2. Importance values (IV) for the six highest ranked seedling species in GTR 1, GTR 2, and bottomland control site, Noxubee National Wildlife Refuge, Mississippi.

IV Ranking	Study Area: GTR 1	Study Area: GTR 2	Study Area: Control
	Species IV		
1	Overcup Oak (Q. lyrata) 89.28	Overcup Oak (Q. lyrata) 80.92	Nuttall Oak (Q. nuttallii) 54.38
2 Red Maple	American Hornbeam (A. rubrum) 30.43	Red Maple (C. caroliniana) 16.47	(A. rubrum) 22.96
3 American Elm	(U. americana) 21.74	American Elm (U. americana) 14.86	Green Ash (F. pennsylvanica) 18.06
4 Willow Oak	Red Maple (Q. phellos) 7.51	American Elm (A. rubrum) 13.58	(U. americana) 16.59
5 Green Ash	Willow Oak (F. pennsylvanica) 3.01	Willow Oak (Q. phellos) 10.75	(Q. phellos) 13.58
6 American Hornbeam	(C. caroliniana) 4.83	Cherrybark Oak (Q. pagoda) 8.31	Overcup Oak (Q. lyrata) 9.03

Table 3. Importance value (IV) for the six highest ranked sapling species in GTR 1, GTR 2, and control site, Noxubee National Wildlife Refuge, Mississippi.

	Study Area		
	GTR 1	GTR 2	Control
IV Ranking	Species IV		
1	American Hornbeam (C. caroliniana) 25.38	American Hornbeam (C. caroliniana) 36.12	American Hornbeam (C. caroliniana) 26.19
2	Red Maple (A. rubrum) 25.08	Swamp Hickory (C. leiodermis) 18.70	Green Ash (F. pennsylvanica) 23.01
3	Shagbark Hickory (C. ovata) 20.56 Sweetgum (L. styraciflua) 20.56	Deciduous Holly (I. decidua) 17.30	Shagbark Hickory (C. ovata) 21.93
4	Deciduous Holly (I. decidua) 18.12	Black Tupelo (N. sylvatica) 16.31	Deciduous Holly (I. decidua) 19.86
5	Black Tupelo (N. sylvatica) 15.31	American Silverbell (S. americana) 14.74	American Elm (U. americana) 17.06
6	Swamp Hickory (C. leiodermis) 11.41	Shagbark Hickory (C. ovata) 12.93	Swamp Hickory (C. leiodermis) 16.79

Table 4. Mean number of trees, saplings, and seedlings per acre on GTR 1, GTR 2, and a control site, Noxubee National Wildlife Refuge.

Study Area	Trees	Saplings 1/	Seedlings 2/
	per acre		
Control	124	895a	6,682a
GTR 1	129	415b	14,305b
GTR 2	102	294b	10,035b

1/ Analysis of variance was based on plot values. Means followed by the same letter were not significantly different at alpha = .05 .

2/ Values based on transformed data.

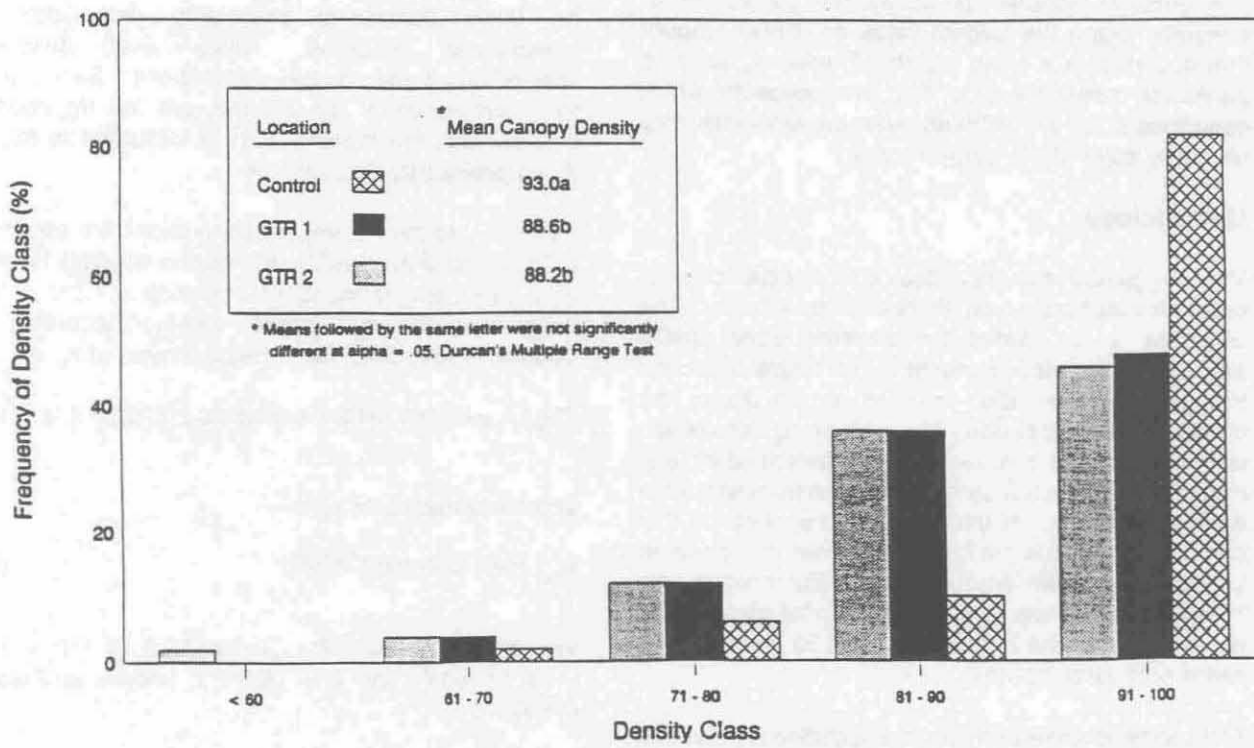

Figure I. Mean canopy density and frequency of canopy densities based on 10% density classes for GTR 1, GTR 2 and bottomland control area.