ECOLOGICAL ASSESSMENT of the RED GUM, OVERCUP OAK and GREEN ASH RESEARCH NATURAL AREA in the DELTA NATIONAL FOREST, MISSISSIPPI

by

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A PRELIMINARY REPORT

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INTRODUCTION

In 1943 three areas of virgin forest were set aside in the Delta National Forest as Research Natural Areas (RNA). These sites are designated the Red Gum, Overcup Oak and Green Ash RNAs after dominant tree species occurring on these respective sites. The intent in establishing RNAs is to "1) preserve a wide spectrum of pristine representative areas that typify important (communities)...; 2) preserve and maintain genetic diversity; 3) protect against serious environmental disruptions; 4) serve as reverence areas for the study of succession; 5) provide on site and extension edutational activities; 6) serve as baseline areas for measuring long-term ecological changes; 7) serve as control areas for comparing results from manipulative research; 8) monitor effects of resource management techniques and practices" (USDA, 1976).

The Delta National Forest is comprised of approximately 59,157 acres (23,940 ha) of bottomland hardwood forest. It is the only representation of a Southern Floodplain Forest (*sensu* Kuchler, 1964) in the National Forest system. Forest management began in 1938 with selective cutting and fire suppression.

The Red Gum RNA is a 16.2 ha area located in Section 9, T12N, R5W, Sharkey, Co., Mississippi. Forest Service road 706 borders the eastern edge of the RNA (approximately 10 meters separates the RNA boundary and road surface). The site is approximately 4.5 km east of the present course of the Big Sunflower River. Site elevation is between 90 and 95 ft above MSL, sloping <2% to the south.

The Overcup Oak RNA is a 16.2 ha area located approximately 1.5 km west of the Red Gum RNA in Section 8, T12N, R5W, Sharkey Co., Mississippi. Forest Service road 706-1 (closed to vehicular traffic) passes through the southern edge of the RNA. The site is approximately 3 km east of the present course of the Big Sunflower River. Site elevation is approximately 90 ft above MSL with a slope of <1% to the west.

The Green Ash RNA is a 28.3 ha area located in Section 18 and 19, T12N, R6W, Sharkey Co., Mississippi. Forest Service road 717 boarders the western edge of the RNA with approximately 80 meters between the road and RNA boundary. The site is approximately 2.5 km east of the present course of the Big Sunflower River. Site elevation is approximately 90 feet above MSL, sloping <1% to the north.

Investigations of these sites since the initial acquisition study in 1935 suggest that the three RNAs are undergoing a change in community structure (Table 1). Estimates of trees (>33 cm DBH) per ha has increased since 1935 in the Red Gum and Overcup Oak RNAs as has estimates of total basal area per ha in all three RNAs. Conversely, the proportion of basal area in the species for which each site is named has apparently declined over the past 50 years. Presently it is not clear whether these changes are real or are artifacts of the different sampling methods employed in these studies. The intent of the present study is to provide a comprehensive analysis of the existing community structure in each of these Research Natural Areas and to identify potential changes in community structure by examining the population structure of key species in the communities.

Topography and Soils - The Delta National Forest lies in a part of the Mississippi Alluvial Plain known as the Yazoo Basin. The basin is bordered by the Macon Ridge to the west (rising 20 to 40 feet above the floodplain) and by blufflands formed from Quarternary loess deposits to the east (rising 40 to 60 feet above the floodplain). At the latitude of the three RNAs in the DNF, the basin is approximately 80 km wide.

The individual RNAs were surveyed for their dominant topographic features, drainage patterns and soil types (Figures 1 - 3). Soils are relatively young Inceptisols of the Sharkey-Alligator-Dowling Association (Scott and Walton, 1962). These soils are poorly drained clay soils formed in slack-water areas and in depressions. Parent material is fine textured alluvium from the Mississippi River. When dry, these soils may form cracks from 1 to 5 inches wide and several feet deep. Soil pH was found to vary between 5.7 and 6.9 in the three RNAs.

Table 1. Changes in estimates of community parameters since 1935.

		Density Trees/ha[1]	Basal Area M^2/ha	% Basal Area in
				L. styraciflua
	1935	32	19.05	63
Red Gum	1959[2]	61	25.18	59
RNA	1982[3]	-	39.5	35
	1990	81	40.81	44
				Q. lyrata
	1935	64	22.5	40
Overcup Oak	1959	52	20.25	49
RNA	1982	-	-	-
	1990	97	27.44	24
				F. pennsylvanica
	1935	84	25.48	39
Green Ash	1959	90	30.53	34
RNA	1982	-	50.4	31
	1990	88	47.33	30

1 - Trees > 33 cm DBH
2 - Johnson and Price, 1959
3 - Wiseman, 1982

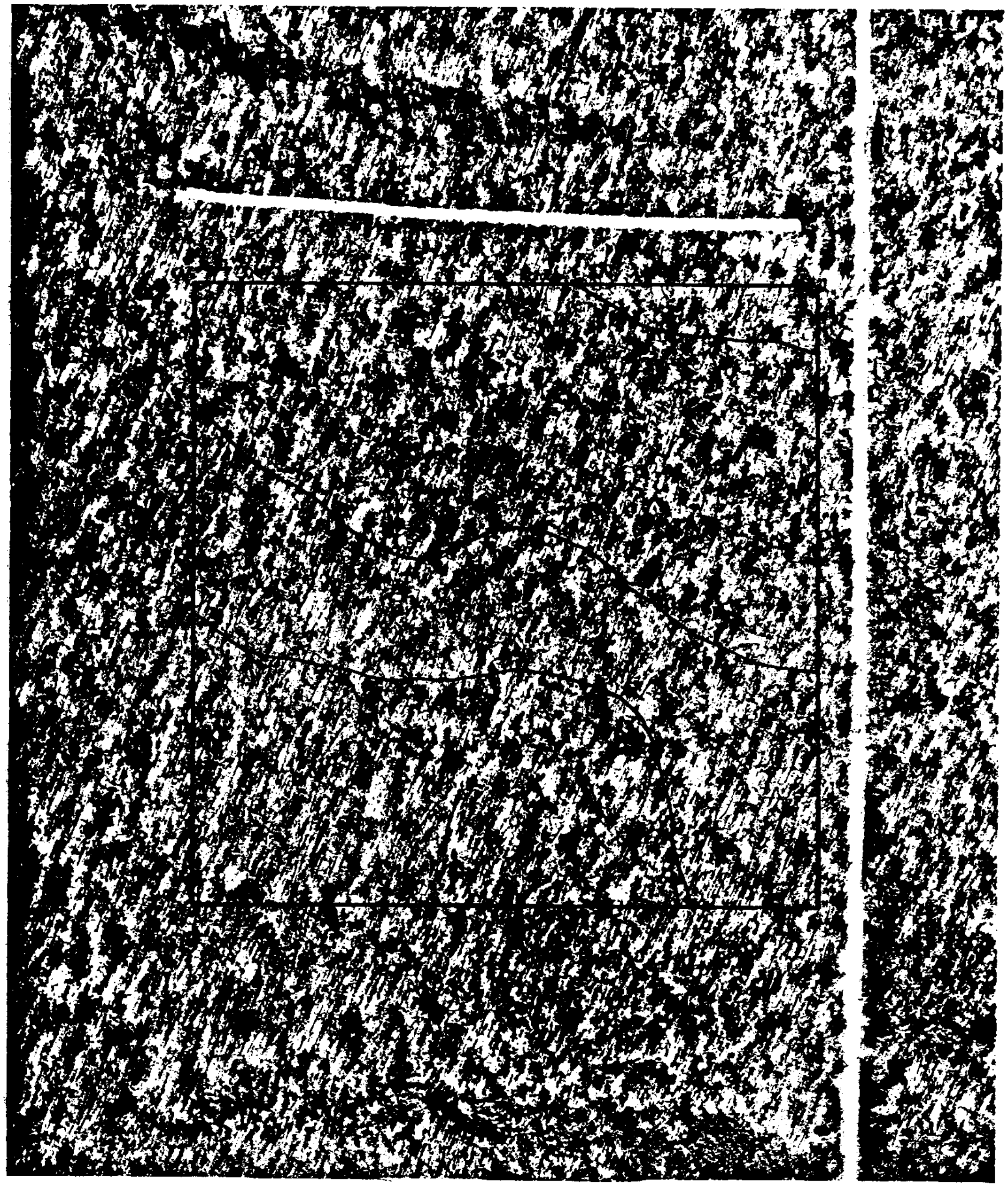


Figure 1. Topography and soils of the Red Gum Research Natural Area. Elevations are approximate. A = Alligator Soils

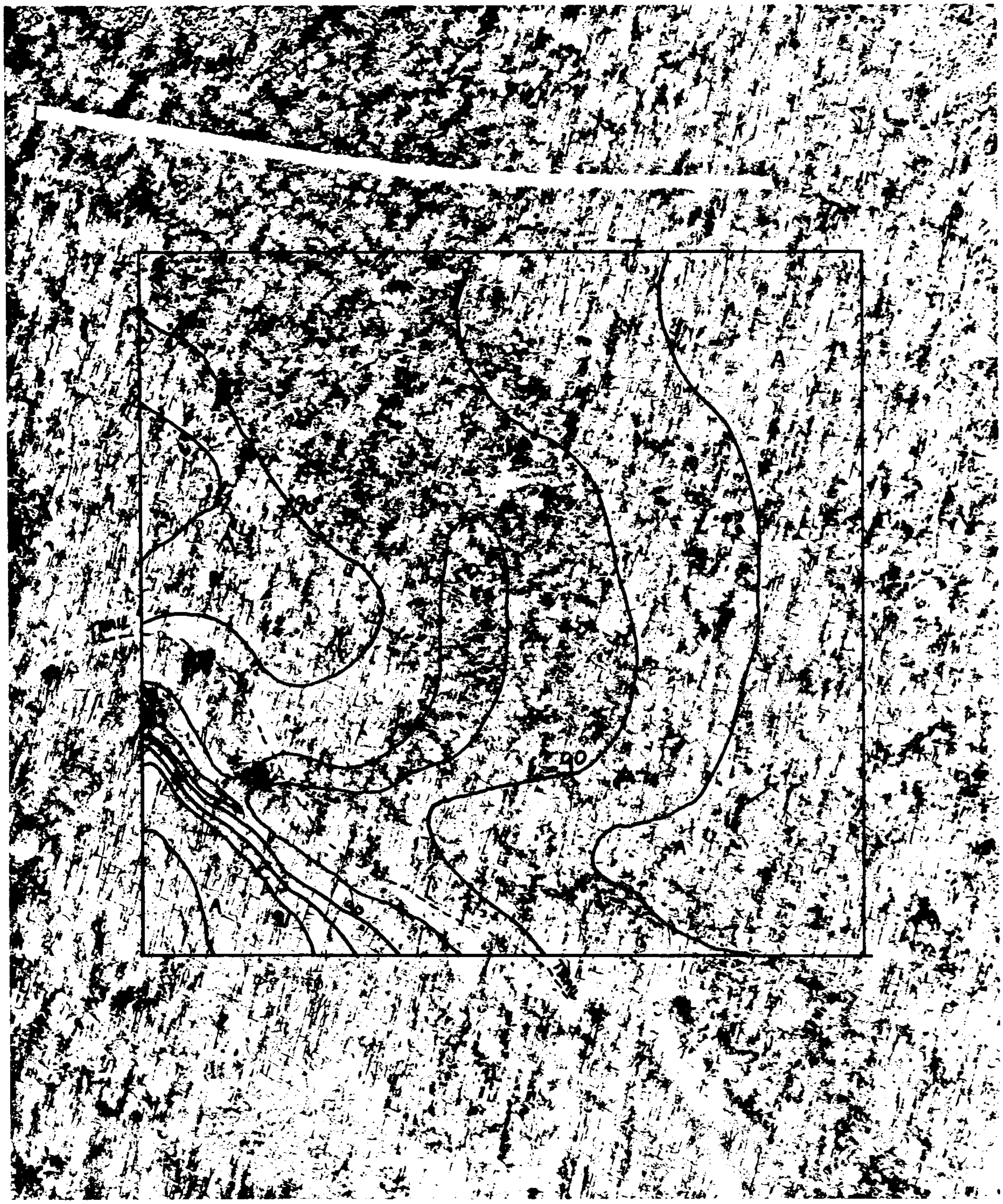


Figure 2. Topography and soils of the Overcup Oak Research Natural Area. Elevations are approximate. A- Alligator Soils, D - Dowling Soils

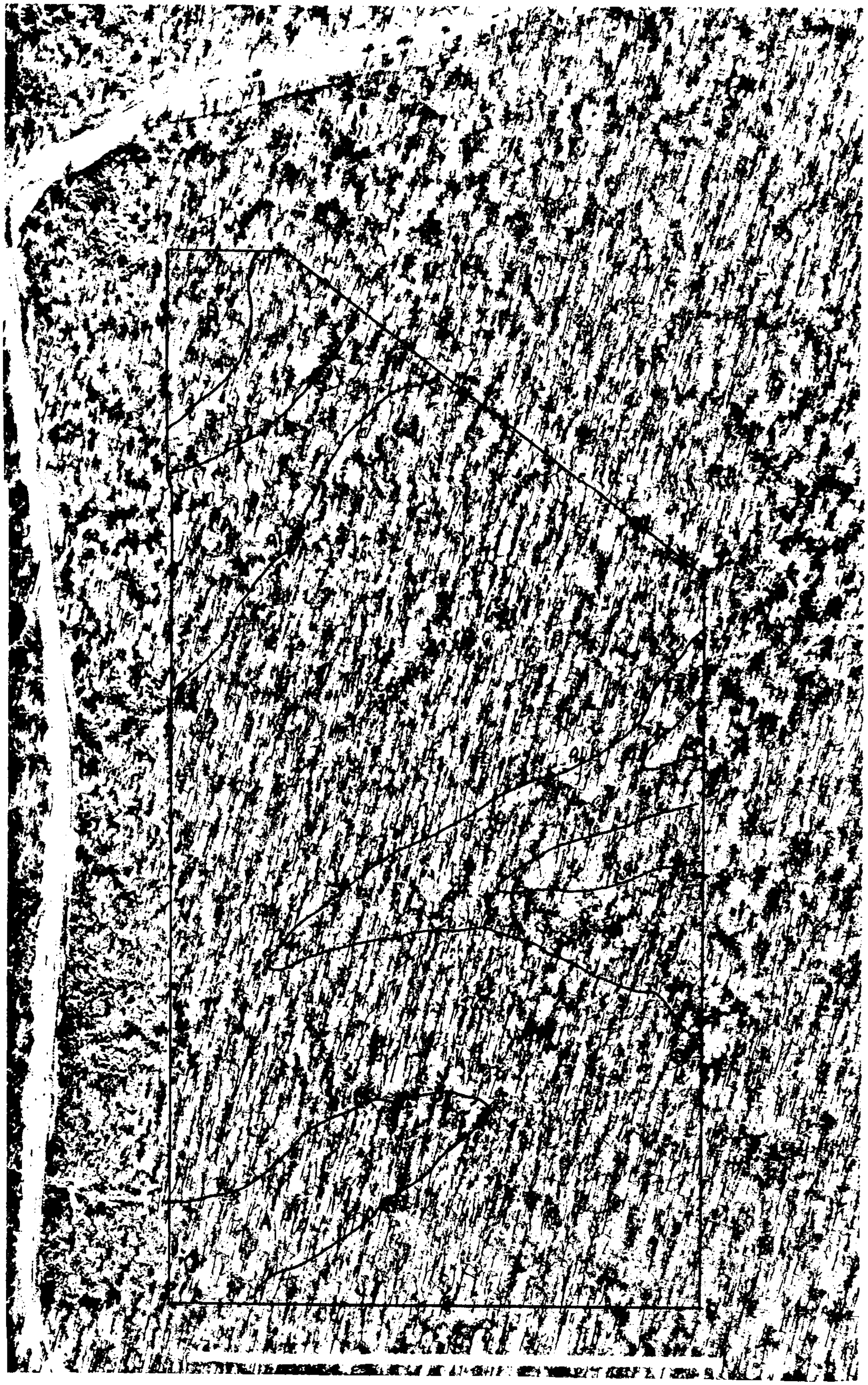


Figure 3. Topography and soils of the Green Ash Research Natural Area. Elevations are approximate. A- Alligator Soils , D- Dowling Soils

METHODS

Sampling Techniques - Vegetation in the Research Natural Areas was divided into four categories. The categories are 1) canopy trees, trees with a DBH of >10 cm; 2) subcanopy trees, trees with a DBH of 4.0 to 9.9 cm; 3) shrub layer vegetation, plants with a DBH of 1.0 to 3.9 cm; and 4) the forest floor vegetation, plants with a DBH <1 cm or less than 1.3 m tall. Sampling of these categories will utilize systematically located, nested plots in the RNAs. Plot sizes for sampling these vegetation categories will be 20x40 meters for canopy trees, 10x20 meters for subcanopy trees, 4x6 meters for shrub layer vegetation and 1x2 meters for forest floor vegetation. All nested plots will share a common Southeast corner.Twenty sampling sites were located in the Red Gum and Overcup Oak RNAs on a north-south oriented square grid with 50 meters separating plots. Sample sites were not located nearer than 45 meters of the RNA boundary. Thirty (approximately) plots were established using the same sample site grid in the larger Green Ash RNA. At the time of this preliminary report approximately 1/5 of the plots have been sampled.

Data Analysis - For each RNA, data was summarized as relative coverage (RC), relative density (RD), relative frequency (RF) and importance value (IV) for each species (only canopy tree data is analyzed in this preliminary report). These measures are defined as; RC_i = (species *i* basal area/total basal area of all species) x 100, RD_i = (number of stems of species *i*/total number of stems) x 100, RF_i=(#plots in which species *i* occurs/total #plots all species occur)x100, $IV_i = (RC_i + RD_i + RF_i)/3$.

Other community indices calculated are the Shannon diversity index, H' and species evenness, J'. H' is defined as $H' = -\Sigma p_i \ln p_i$, where p_i is the relative density of species *i*. J' is defined as $J' = H'/H_{max}'$ where $H_{max}' = \ln S$ and S is the number of species at the site.

Similarity between the three RNA communities was quantified using the proportion similarity, PS, and Morisita's index, I_M (Brower and Zar, 1984). Proportion similarity is defined as PS = Σ(the lower of x_i or y_i) where x_i and y_i are the RD of species *i* in communities x and y. Morisita's index is defined as $I_M = (2\Sigma x_i y_i)/((l_1 + l_2)N_1N_2)$ where l is the Simpson dominance index for communities 1 and 2 and N is the total number of individuals in communities 1 and 2.

RESULTS & DISCUSSION

Community Descriptions - Tree data from the three RNAs in the Delta National Forest is summarized as relative basal area, relative density, relative frequency and importance value in Table 2. In the Red Gum RNA, dominant species are *Acer negundo* (IV = 35.9) and *Liquidambar styraciflua* (IV = 26.0). The high importance value for *A. negundo* results from its relatively high density and frequency while the high IV of *L. styraciflua* is a consequence of its high relative basal area (44.5% of the basal area is in L. styraciflua). Species with intermediate importance values are *Celtis laevigata* and *Ulmus americana*. Tree species occurring in the site with low importance values or which have not been sampled to date include *A. rubrum*, *Quercus lyrata*, *Q. nuttallii*, *Fraxinus pennsylvanica*, *Carya aquatica*, *Morus rubra* and *Taxodium distichum*. Shannon's diversity for the tree community of the site is H' = 1.44 and species evenness is J' = 0.69. The principal species of the shrub layer are *Sabal minor* and *Arundinaria gigantea*. Principal lianas are *Rhus radicans*, *Campsis radicans* and *Amelopsis arborea*.

Dominant species of the Overcup Oak RNA are *Ulmus americana* (IV = 30.1) and *Quercus nuttallii* (IV = 21.9). Similar to the IVs of *Acer negundo* and *Liquidambar styraciflua* in the Red Gum site, the high importance value of *U. americana* is due to its relatively high density and frequency while the high IV of *Q. nuttallii* is the result of its large basal area (43.3% of the basal area is in *Q. nuttallii*). Species with intermediate importance values at this site are *Acer rubrum* and *Quercus lyrata*. Tree species occurring in the site with low importance values or not occurring in the sample plots include *Acer negundo*, *Liquidambar styraciflua*, *Fraxinus pennsylvanica*, *Celtis laevigata*, *Carya aquatica*, *Ilex decidua*, *Diospyros virginiana* and *Taxodium distichum*. Community diversity of this site is H' = 1.71 and species evenness is J' = 0.74. With the exception of the area disturbed by a road cut, the ground vegetation is sparse, reflecting the more frequent and longer duration of flooding at this site. Predominant species occurring in the ground vegetation layer are *Smilax* spp. and widely scattered individuals of *Sabal minor*.

Table 2. Importance values of trees occurring in the RNAs of the Delta National Forest.

	Red Gum RNA				Overcup Oak RNA				Green Ash RNA			
	RC[1]	RD[2]	RF[3]	IV[4]	RC	RD	RF	IV	RC	RD	RF	IV
Acer negundo	19.5	51.6	36.7	35.9	-	-	-	-	0.5	3.6	5.2	3.1
A. rubrum	0.5	2.2	4.1	2.3	5.6	19.0	13.0	12.5	-	-	-	-
Carya aquatica	11.1	3.3	6.1	6.8	5.5	6.3	6.5	6.1	2.5	2.7	3.9	3.0
Celtis laevigata	6.4	13.2	12.2	10.6	3.3	4.8	6.5	4.9	5.1	25.5	23.4	18.0
Diospyros virginiana	-	-	-	-	0.2	1.6	2.2	1.3	-	-	-	-
Fraxinus pennsylvanica	-	-	-	-	2.7	1.6	10.8	5.0	29.5	14.5	16.9	20.3
Ilex decidua	-	-	-	-	0.4	3.2	4.3	2.6	-	-	-	-
Liquidambar styraciflua	44.5	13.2	20.4	26.0	1.0	3.2	4.3	2.8	-	-	-	-
Morus rubra	0.5	2.2	4.1	2.3	-	-	-	-	-	-	-	-
Quercus lyrata	3.2	1.1	2.0	2.1	23.6	4.8	6.5	11.6	14.2	6.4	6.5	9.0
Q. nuttallii	-	-	-	-	43.3	9.5	13.0	21.9	26.4	15.5	18.2	20.0
Ulmus americana	13.9	9.9	14.3	12.7	11.7	46.0	32.6	30.1	3.4	27.3	20.8	17.2
Taxodium distichum	-	-	-	-	-	-	-	-	18.5	3.6	5.2	9.1

1 - RC is the relative coverage per species based on basal area at breast height.

2 - RD is the relative density per species based on the number of stems.

3 - RF is the relative frequency per species based on species occurence per plot.

4 - IV is the species importance value defined as (RC+RD+RF)/3.

The Green Ash RNA is dominated by *Fraxinus pennsylvanica* (IV = 20.3) and *Quercus nuttallii* (IV = 20.0). These importance values are nearly equaled by *Celtis laevigata* (IV = 18.0) and *Ulmus americana* (IV = 17.2). The high importance values of *F. pennsylvanica* and *Q. nuttallii* is principally due to their relatively high basal area (29.5 and 26.4% respectively) while the high importance values of *C. laevigata* and *U. americana* are principally the result of high relative density and frequency. *Quercus lyrata* has an intermediate importance value at this site (IV = 9.0). Species occurring in the study site but with low importance values or not occurring in a sample plot include *Acer negundo*, *Carya aquatica*, *Diospyros virginiana* and *Taxodium distichum*. Diversity for this site is H' = 1.78 and species evenness is J' = 0.86. Similar to the Overcup Oak site, the Green Ash site has sparse undergrowth with *Smilax* spp. and scattered *Sabal minor* as the principal species.

Comparisons with other Forests - Comparison of these three sites with tthree other forest sites in the Mississippi floodplain (Horseshoe Lake Island mesic and dry site data from Robertson and Weaver, 1978; Big Island site data from Wiseman, 1982; Table 3) indicates that although tree density is roughly equivalent (direct comparisons with the Horseshoe Lake Island populations is difficult due the inclusion of smaller trees in the data set), mean tree size (mean basal area per tree) is greater in the Red Gum and Green Ash RNA sites. The number of trees species found in the three RNA sites is 1/2 to 1/4 the number observed in the Horseshoe Lake Island sites and the Big Island site. This may result from the small sample size at present in the RNAs or may be due the the smaller size of the these sites. Community diversity is lower in the three RNAs than in these other forests studied in the southern floodplain forest. Species evenness is comparable.

The communities of the overcup Oak and Green Ash RNAs have the highest percent similarities (PS = 50.7) and highest Morisita's index (I_M = 0.707, Table 4). Least similar are the communities in the Red Gum RNA and the Overcup Oak RNA (PS = 24.5, I_M = 0.217).

Comparison of the IV curves for the three RNAs and three other floodplain forests of the Mississippi Delta (Fig. 4) suggests that gross community structure at these sites are

TABLE 3. Estimates of community parameters.

Site		Density[1]	Basal Area[2]	S	H'	J'
Red Gum RNA		264	37.2	14	2.01	0.76
Green Ash RNA		242	50.5	8	1.79	0.86
Overcup Oak RNA		394	28.5	10	1.74	0.76
Horseshoe	M	459	33.5	39	3.05	0.83
Lake Island[3]	T	423	35.7	41	2.84	0.77
(Mature Stand)	W	372	41.9	32	2.19	0.63
Big Island		372	23.9	19	2.25	0.76

1 - Trees/ha
2 - Meters^2/ha
3 - Trees > 6.6 cm dbh

Table 4. Similarity indices between the Red Gum, Overcup Oak and Green Ash Research Natural Areas.

Percent Similarity

	Overcup Oak	Green Ash
Red Gum	24.5	30.5
Overcup Oak		50.7

Morisita's Index

	Overcup Oak	Green Ash
Red Gum	0.217	0.327
Overcup Oak		0.707

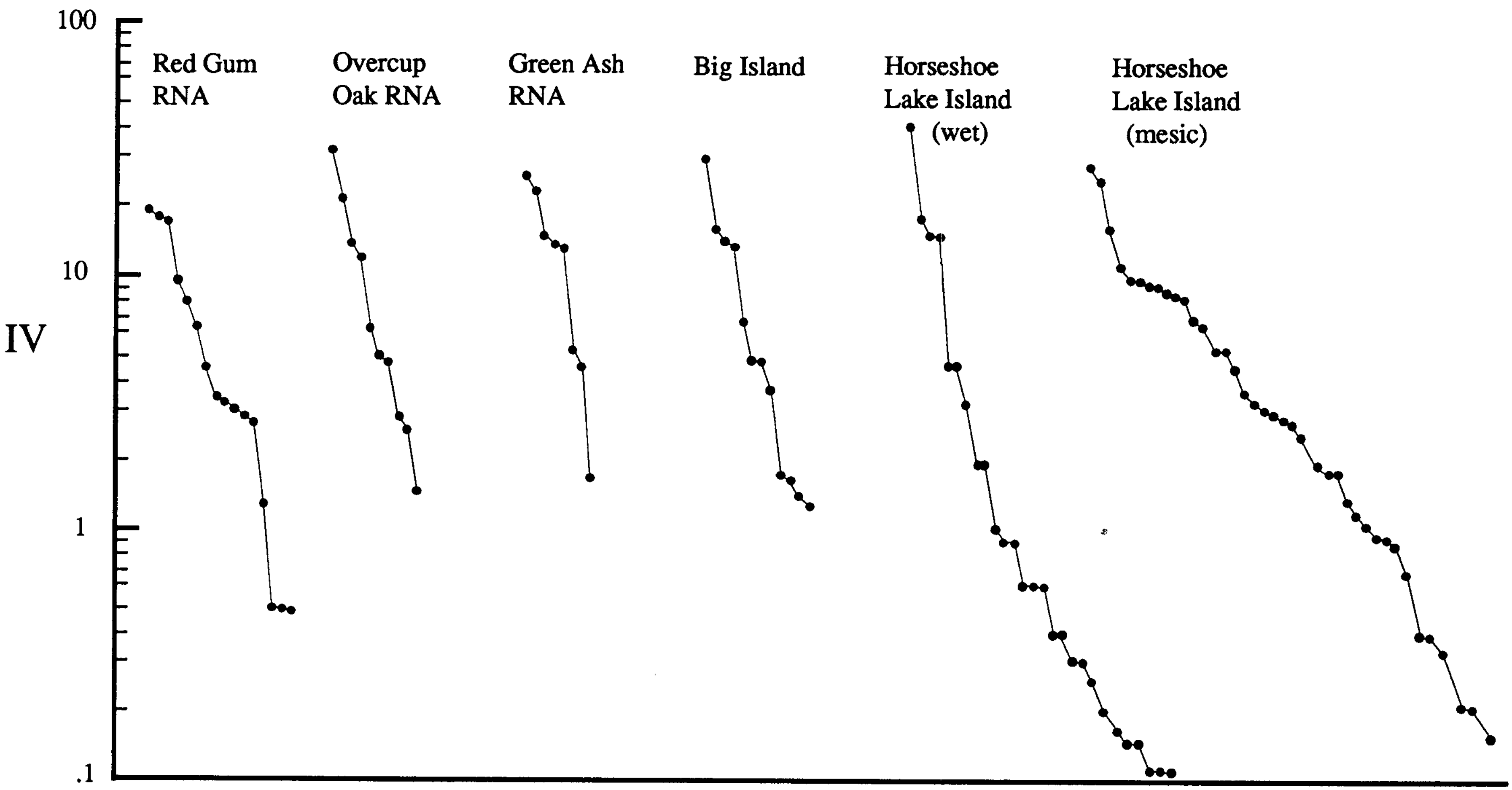

100
10
1
.1
IV
Red Gum RNA
Overcup Oak RNA
Green Ash RNA
Big Island
Horseshoe Lake Island (wet)
Horseshoe Lake Island (mesic)

Fig. 4

similar. The IV curves of the Overcup Oak RNA, Green Ash RNA, Big Island and the wet Horseshoe Lake Island sites closely follow a geometric series of species importance. Such a sequence of species importance is expected in severe environments (Whittaker, 1975). The lognormal distribution observed in the mesic Horseshoe Lake Island site is typical of species rich communities such as cove forests and tropical forests (Whittaker, 1975). The Red Gum RNA appears intermediate between these models of importance curves which reflects its intermediate position in a wet to mesic moisture continuum.

Community Structure - Analysis of the density-diameter-structure of a community has long been used as a descriptive tool in the evaluation of forest stands (i.e. Hough, 1932; Meyer and Stevenson, 1943; Parker, et al., 1985). One model to describe the relationship between density and diameter is the negative power function first employed by deLiocourt (1898) and formalized by Meyer (1952). This model implies that mortality rates, across all species, are constant in all diameter classes. Deviations from the stand structure predicted by this model has been used as evidence for past disturbance events (Schmelz and Lindsey, 1965). An alternative model by Goff and West (1975) proposes that there are three distinctive phases of mortality in the life history of forest trees which results in a rotated sigmoid curve of a semi-log plot of the density-diameter relationship. Explicit in this model is that the forests are small, structurally uniform old-growth stands. The density-diameter structure of the three RNAs in the Delta National Forest are examined here.

The density-diameter of all species in the three Research Natural Areas in the Delta National Forest apparently fail to be adequately described by either of these models (Fig. 5). Observed stand structure is poorly predicted by the negative power function (r^2 values range between 0.57 and 0.80) and does not appear to fit the rotated sigmoid curve form described by Goff and West (1975) for old-growth stands (the Green Ash RNA may fit this relationship most closely). Wiseman (1982) describes the Red Gum RNA as having a rotated sigmoid relationship however the analysis is incomplete (as is this analysis at this time).

One explanation for the apparent failure of these stands to be adequately modeled by either of these hypothesis is that the stands are large enough that they fail to fulfill the uniformity requirement of the rotated sigmoid model (due to tree gaps and changes in soil

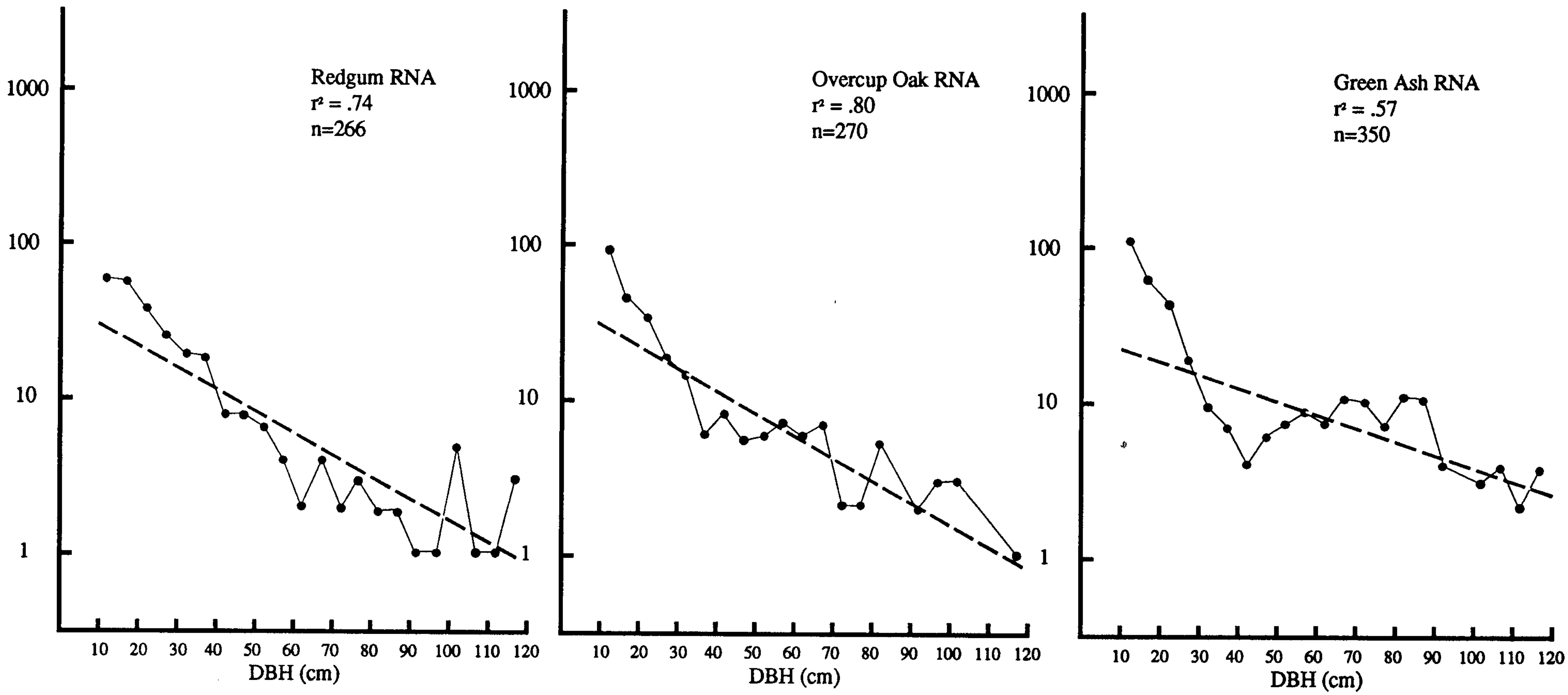


Table 5. Combined species size-class structure for stems > 10cm dbh. r^2 is the fit of the data to the negative function model of size distribution. n is the number of stems sampled.

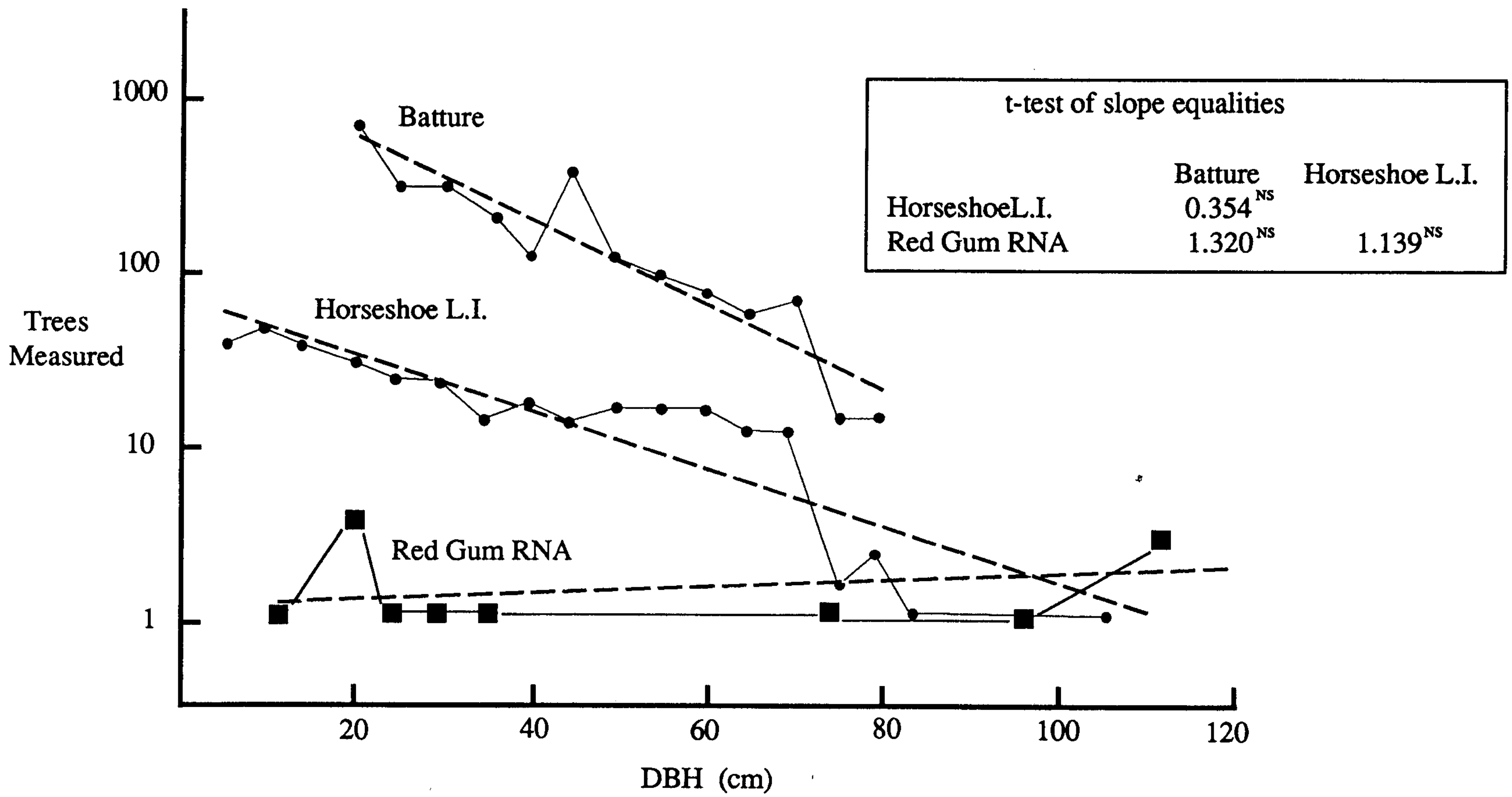
conditions) but no so large that disturbance effects (tree gaps) are adequately represented to fit the negative power model. The goodness of fit with one of these models may improve as sample size in increased.

Subcanopy community - Species observed in the RNAs are listed in the appendix. Distribution patterns of these species within the RNAs will be examined when site sampling is complete.

Individual Species Performance - Although community indices and importance value curves of the three RNAs in the Delta National Forest are similar to values found in other mature southern floodplain forests (Fig. 5), the population structure of individual species suggests that these sites may be undergoing a change in community structure. If the trends indicated by the small sample are maintained as sample size increases, it would appear that either the forest dominants *Fraxinus pennsylvanica* and *Liquidambar styraciflua* are not replacing themselves or that the population dynamics of these two species differ significantly from other populations in floodplain forests.

Liquidambar styraciflua has bee described as a flood tolerant species (defined as trees which can withstand flooding for most of one growing season, Teskey and Hinckley, 1977) but is intolerant of shade (Fowells et al., 1965). Since the initial acquisition data in the area of the Red Gum RNA, collected in 1935, the proportion of basal area in *L. styraciflua* has decreased from 69% to 59% in 1959 (Johnson and Price, 1959) to 44% at the present time. The density-diameter structure of *L. styraciflua* (Fig. 6) at the Red Gum site suggests that the population is not replacing itself in a manner similar to populations at Horseshoe Lake Island and in Mississippi batture populations (Wiseman, 1982), although present data does not show significant differences, statistically significant differences are anticipated with an increased sample size provided observed trends are maintained). In mature floodplain forests, gap-phase replacement appears to be the characteristic form of regeneration. Changes in the population structure of a shade intolerant species such as *L. styraciflua* may be indicative of a change in gap dynamics in the forest. As this study progresses, the relationship between community structure and gap dynamics will be investigated.

Density-Diameter Structure of *Liquidambar styraciflua*

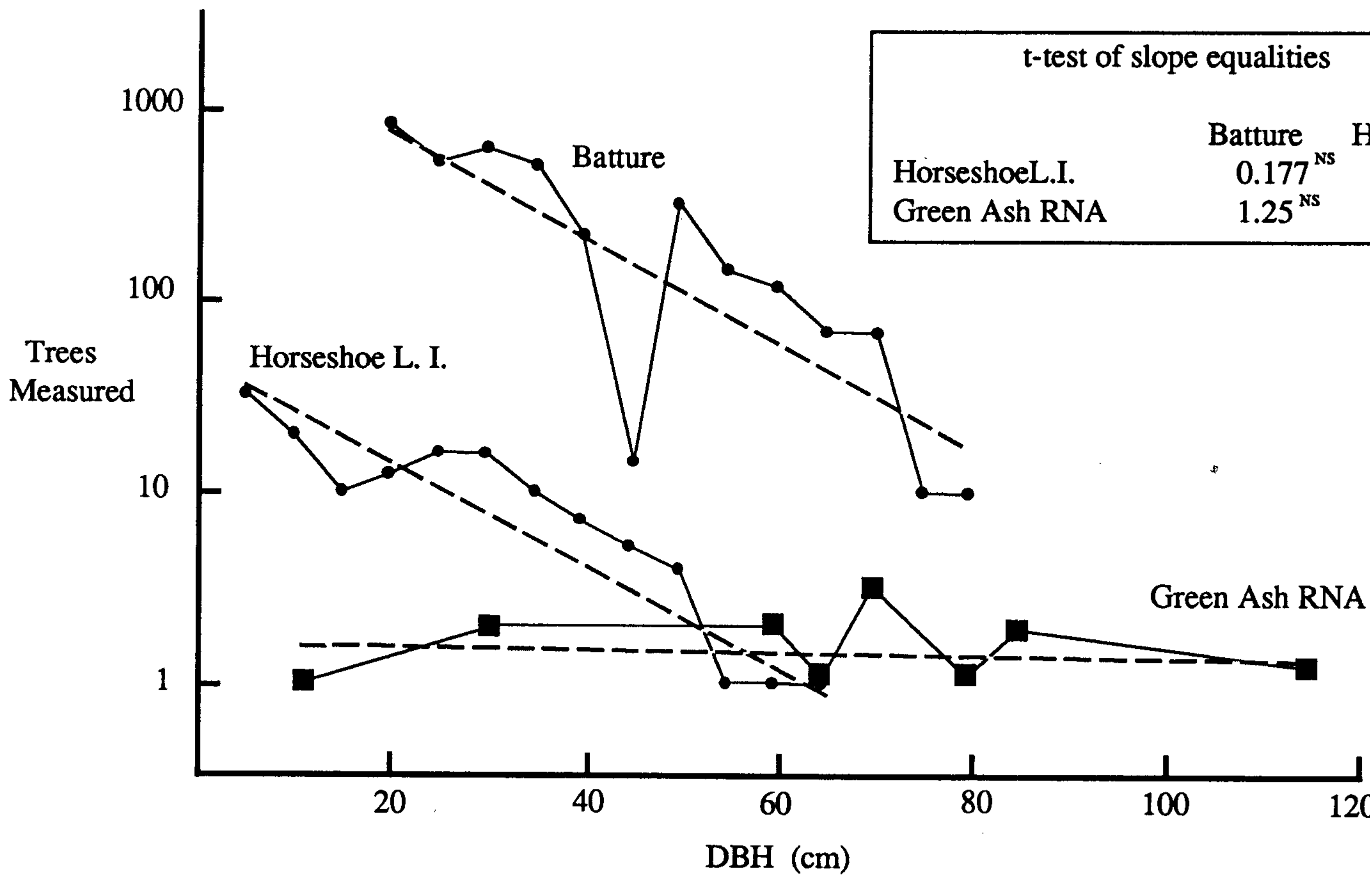


Fraxinus pennsylvanica is described as very tolerant to flooding (defined as trees which can withstand flooding for periods of two or more growing seasons Teskey and Hinckley, 1977) and intolerant to moderately tolerant of shade (Fowells et al., 1965). Because of its relatively low tolerance to shade, it has been observed that *F. pennsylvanica* frequently does not maintain its position in a community but is replaced by more shade tolerant species such as *Acer rubrum* or *Ulmus americana* (Fowells et al., 1965). This may be occurring in the Green Ash RNA. If the present sample reflects the actual population structure of *F. pennsylvanica* (Figure 7), it appears that the species is not replacing itself in the community. This differs from the population structures from the Horseshoe Lake Island and batture sites (population structures are anticipated to be significantly different with a larger sample size if current trends are maintained). At these sites it appears that the population structure of *F. pennsylvanica* is probably stable. Whether the difference between these sites is due to differences in disturbance frequencies or some other factor is unknown at this time.

Celtis laevigata is described as an intermediately flood tolerant species (defined as a species which can withstand flooding for a period of one to three months, Teskey and Hinckley, 1977). It is tolerant of shade and responds relatively quickly to release from growth inhibiting factor (Fowells et al., 1965). The population structure if *C. laevigata* in the Green Ash RNA (Figure 8) appears similar to the population structure in the batture sites. It suggests that *C. laevigata* is replacing itself in the community. Fowells et al. (1965) have observed that the ability of this species to respond to release from growth inhibiting conditions often results in the suppression of less tolerant species or species which respond less quickly.

Ulmus americana is described as a flood tolerant species (Teskey and Hinckley, 1977) and as intermediately tolerant to shade (Fowells et al., 1965). The population structure of *U. americana* in the Overcup Oak and Green Ash RNAs (Figure 9) suggests that tree replacement is occurring. The population structure at these sites is similar to that of the batture populations. This species responds quickly to release from removal of growth inhibiting conditions. Although trees with diameters of four to five feet (122 - 152 cm) and ages of up to 300 years are known from the Midwest states, individuals in the three RNAs of a smaller stature. The largest individual encountered occurred in the Red Gum RNA

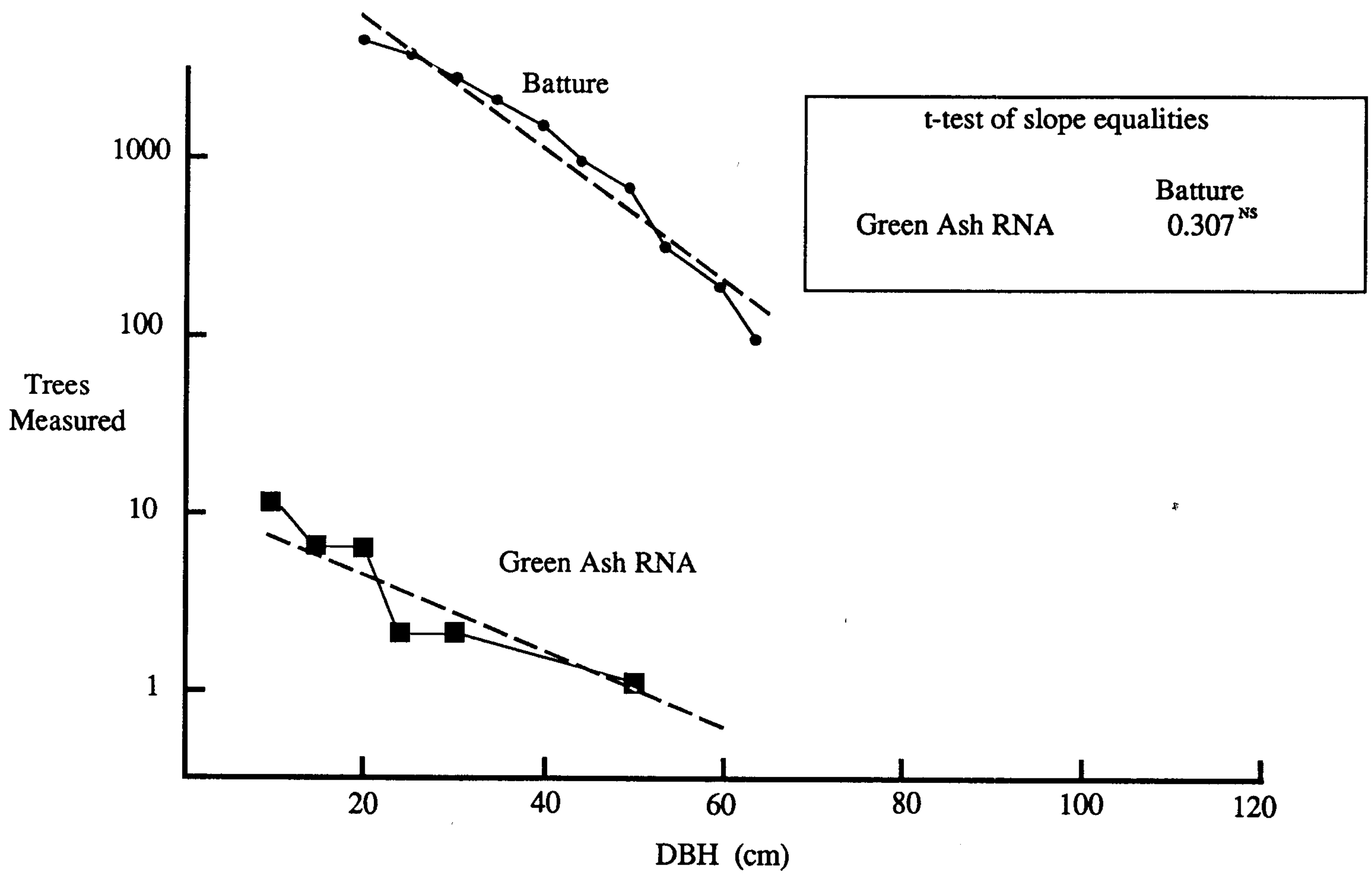
Density-Diameter Structure of *Fraxinus pennsylvanica*

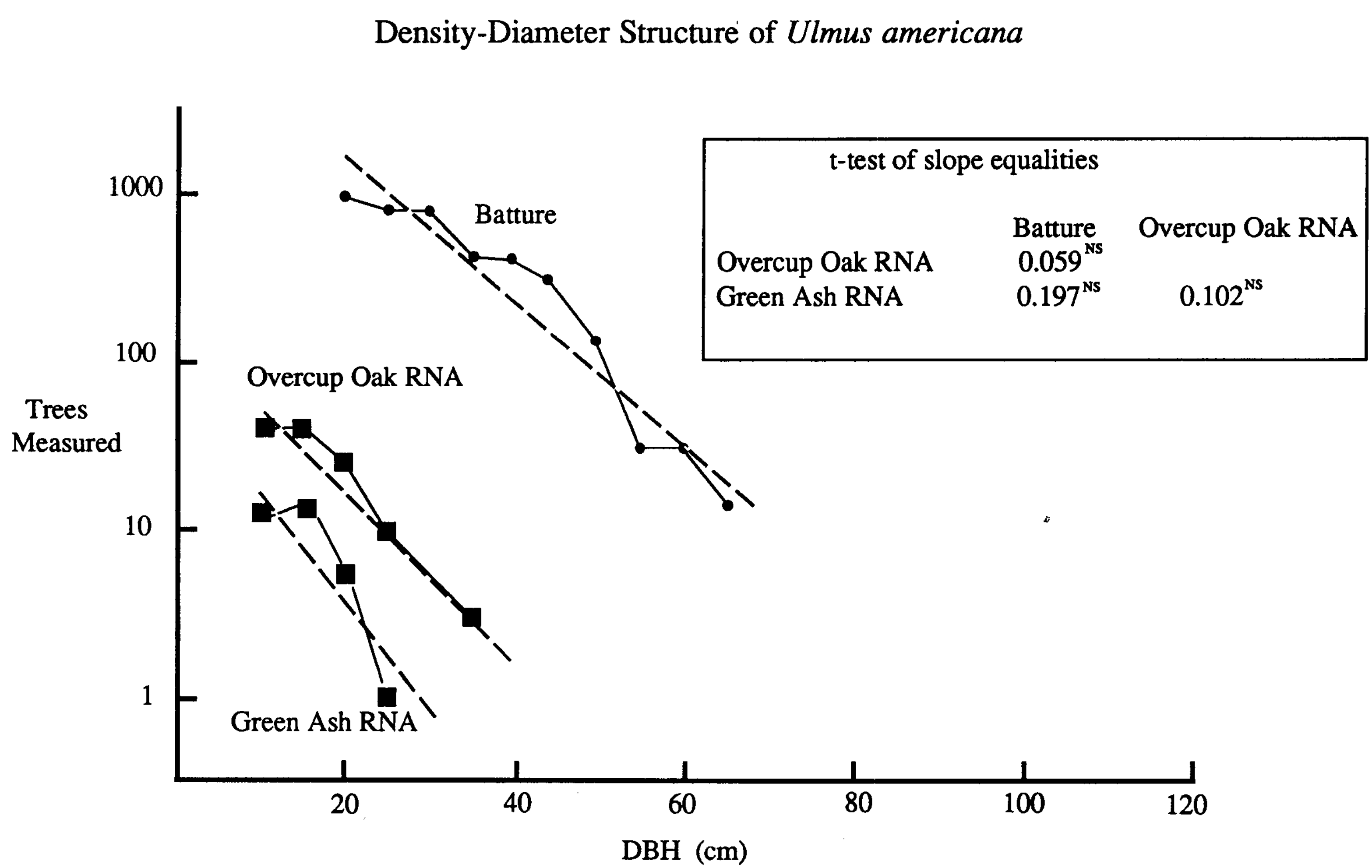


t-test of slope equalities

	Batture	Horseshoe L.I.
HorseshoeL.I.	0.177 NS	
Green Ash RNA	1.25 NS	0.945 NS

Density-Diameter Structure of *Celtis laevigata*





Density-Diameter Structure of *Ulmus americana*
t-test of slope equalities
Batture
Overcup Oak RNA
Overcup Oak RNA 0.059^NS
Green Ash RNA 0.197^NS 0.102^NS
Batture
Overcup Oak RNA
Green Ash RNA
Trees Measured
1000
100
10
1
20
40
60
80
100
120
DBH (cm)

with a DBH of 68.8 (2.26 ft). The lack of large individuals of U. americana may be due to removal by the Dutch elm disease or by phloem necrosis.

LITERATURE CITED

Brower, J.E. and J.H. Zar. 1984. Field and laboratory methods for general ecology. Wm C. Brown Publishers, Dubuque, Iowa, 226 p.

Carter, J.R., Jr. 1978. A floristic ttudy of the Delta National Forest and adjacent areas. Masters Thesis. Mississippi State University. 79 p.

DELiocourt, F. 1898. De l'amenagement des Sapinieres. Bul Soc Forest Franch-Conte Belfort. Besancon. P. 396-409.

Fowells, H.A.(ed.). 1965. Silvics of forest trees of the United States. Agriculture Handbook No. 271. U.S. Department of Agriculture. 762 p.

Goff, F.G. and D. West. 1975. Canopy-understory interaction effects on forest population structure. Forest Science 21: 98-108.

Hough, A.F. 1932. Some diameter distributions in forest stands of northwestern Pennsylvania. Ecology 17: 9-28.

Johnson, R.L. and T.L. Price. 1959. Resume of 20 years of hardwood management on the Delta Purchase Unit. Unpublished, Stoneville Research Center, Stoneville, Mississippi. 74 p.

Kuchler, A.W. 1964. Potential natural vegetation of the counter-minous United States. Map and accompanying handbook. American Geographical Society Special Publication, New York.

Meyer, H.A. 1952. Structure, growth and drain in balanced uneven-aged forests. J. Forest 50: 85-92.

Meyer, H.A. and D.D. Stevenson. 1943. The structure and growth of virgin beech-birch-maple-hemlock forests in northern Pennsylvania. J. Agric Res 67: 465-484.

Parker, G.R., D.J. Leopold and J.K. Eichenberger. 1985. Tree dynamics in an old-growth, deciduous forest. Forest Ecology and Management 11: 31-57.

Robertson, P.A. and G.T.Weaver. 1978. Vegetation and tree species patterns near the Northern terminus of the Southern Floodplain Forest. Ecological Monographs 48: 249-267.

Schmelz, D.V. and A.A. Lindsey. 1965. Size-class structure of old-growth forests in Indiana. Forest Sci 11: 731-743.

Scott, F.T. and L.B. Walton. 1962. Soil survey of Sharkey County, Mississippi. United States Department of Agriculture Soil Conservation Service.

Teskey, R.O. and T.M. Hinckley. 1977. Impact of water level changes on woody riparian and wetland communities. Vol II, The Southern Forest Region. Fish and Wildlife Service, U.S. Department of the Interior. FWS/OBS-77/59.

USDA. 1976. Final environmental statement and unit p.an, Delta National Forest. USDA Forest Service, National Forests in Mississippi, Jackson. 196 p.

Whittaker, R.H. 1975. Communities and ecosystems. MacMillan Publishing Co., Inc. 385 p.

Wiseman, J.B., Jr. 1982. A study of the composition, successional relationships and floristics of Mississippi River floodplain forests in parts of Washington, Bolivar and Sharkey Counties, Mississippi. Ph.D. Dissertation, Mississippi State University.

APPENDIX
VASCULAR PLANTS OF THE DELTA NATIONAL FOREST
(from J.R. Carter, Jr., 1978)

	Occurrence in the Research Natural Area Sites		
	RG	OcO	GA
PTERIDOPHYTA			
ASPIDIACEAE			
Athyrium asplenioides (Michaux) A.A. Eaton	X		
ASPLENIACEAE			
Asplenium platyneuron (L.) Oaks			
AZOLLACEAE			
Azolla caroliniana Willd.		X	
OPHIOGLOSSACEAE			
Botrychium dissectum Sprengel			
Ophioglossum vulgatum L. var. *pycnostichum* Fernald			
POLYPODIACEAE			
Polypodium polypodioides (L.) Watt	X	X	
GYMNOSPERMAE			
CUPRESSACEAE			
Juniperus virginiana L.			
Taxodium distichum (L.) Richard	X	X	X
MONOCOTS			
ALISMATACEAE			
Echinodorus cordifolius (L)			
Sagittaria latifolia Willd. var. *ogtusa* (Muhl. & Willd.)			
AMARYLLIDACEAE			
Hymenocallis liriosme (Raf.)			

	RG	OcO	GA
ARECACEAE			
Sabal minor (Jacquin) Persoon.	X	X	X
BROMELIACEAE			
Tillandsia usneoides L.			
COMMELINACEAE			
Commelina diffusa Burman	X		
Commelina virginica L.			
CYPERACEAE			
Carex amphibola Steudel.			
Carex anectens Bicknell.			
Carex blanda Dewey.			
Carex dephalophora Mujl. ex Schkuhr.			
Carex cherokeensis Schweinitx			
Carex crus-corvi Schuttlew. ex Kuntze			
Carex flaccosperma Dewey			
Carex frankii Kunth			
Carex hyalinolepis Steudel			
Carex louisianica Bailey			
Carex lupulina Muhl. ex Schkuhr			
Carex reniformis (Bailey) Small			
Carex tribuloides Wahlenberg			
Carex typhina Michaux			
Cyperus aristatus Rottboel			
Cyperus erythrorhizos Muhl			
Cyperus exculentus L.			
Cyperus globulosus Aublet.			
Cyperus iria L.			
Cyperus ovularis (Michaux) Torrey			
Cyperus pseudovegetus Steudel			
Cyperus rotundus L.			
Cyperus strigosus L.			
Eleocharis obtusa (Willd.) Schultes			
Fimbristylis vahlii (Lam.) Gray var. interior Fern			
HYDROCHARITACEAE			
Limnobium spongia (Bosc.) Steudel.			

	RG	OcO	GA
IRIDACEAE			
Sisyrinchium mucronatum Michaus.			
JUNCACEAE			
Juncus acuminatus Michx.			
Juncus diffusissimus Buckley			
Juncus effusus L.			
Juncus tenuis Willd.			
Juncus validus Cov.			
LEMNACEAE			
Lemna perpusilla Torrey			
Spirodela polyrhiza (L.) Schleid.			
Wolffia columbiana Karsten			
Wolffiella floridana (J.D. Smith) Thompson			
LILIACEAE			
Allium canadense L. var. *canadense*			
Smilax bona-nox L.			
Smilax glauca Walt			
Smilax hispida Mulh.	X		
Smilax rotundifolia L.	X		
ORCHIDACEAE			
Listera australis Lindley			
Spiranthes ovalis Lindl.			
POACEAE			
Agrostis hyemalis (Walter) BSP			
Alopecurus carolinianus Walt.			
Andropogon glomeratus (Walt.) BSP			
Andropogon virginicus L.			
Arundinaria gigantea (Walter) Muhl.	X		
Brachiaria platyphylla (Grisebach) Nash.			
Bromus commutatus Schrad.			
Cynodon dactylon (L.) Pers.			
Digitaria sanguinalis (L,) Scopoli			

	RG	OcO	GA
Echinochloa crusgalli (L.) Beauv. var *crusgalli*			
Echinochloa crusgalli (L.) Beauv. var *mitis*			
Echinochloa crusgalli (L.) Beauv. var *zelayensis*			
Eleusine indica (L.) Gaertn.			
Elymus virginicus L.			
Eragrostis capillaris (L.) Nees			
Eragrostis cilianensis (All.) Lutati			
Eragrostis glomerata (Walt.) Dewey			
Eragrostis hypnoides (Lam.) BSP			
Eragrostis pilosa (L.) Beauv.			
Erianthus giganteus (Walter) Muhl.			
Erianthus strictus Baldwin			
Festuca elatior L.			
Hordeum pusillum Nuttall.			
Leersia lenticularis Michx.			
Leersia virginica Willd.			
Leptochloa filiformis (Lam.) Beauv.			
Leptochloa panidoides (Presl.) Hitchc.			
Lolium multiflorum Lam.			
Lolium perenne L.			
Manisurus cylindrica (Michaux) Kuntze			
Muhlembergia schreberi J.F. Gmelin			
Panicum anceps Michx.			
Panicum commutatum Schutt.			
Panicum dichotomiflorum Michaux.			
Panicum dichotomum L.			
Panicum laxiflorum Lam.			
Panicum lindheimeri Nash.			
Paspalum dilatatum Poiret.			
Paspalum fluitans (Ell.) Kunth.			
Paspalum laeve Michx.			
Paspalum notatum Flugge			
Paspalum pubiflorum Rupr.			
Paspalum urvillei Steud.			
Phalaris caroliniana Walt.			
Poa annua L.			
Staria geniculata (Lam.) Beauvois			
Setaria lutescens (Weigel) Hubb.			
Sorghum halapense (L.) Persoon			
Sphenopholis obtusata (Michx.) Scribn			
Tridens flava (L.) Hitchc.			

	RG	OcO	GA
Tridens strictus (Nuttall) Nash			
Triticum aestivum L.			
PONTEDERIACEAE			
Heteranthera limosa (Sw.) Willd.			
DICOTYLEDONEAE			
ACERACEAE			
Acer negundo L.	X	X	X
Acer rubrum L. var. *drummondii* Sarg.	X	X	
AIZOACEAE			
Mollugo verticillata L.			
AMARANTHACEAE			
Amaranthus tamariscinus (Nutt.) Wood			
Amaranthus retroflexus L.			
ANACARDIACEAE			
Rhus radicans L.	X	X	X
APIACEAE			
Chaerophyllum tainturieri Hooker			
Cicuta maculata L.			
Cyanosciadium digitatum DC			
Hydrocotyle verticillata Thunberg			
Limnosciadium pinnatum (DC) Math. & Const.			
Sanicula canadensis L.			
Trepocarpus aethusae Nuttall			
APOCYNACAE			
Amsonia tabernaemontana Walter			
Apocynum cannabinum L.			
Trachelospermum difforme (Walter) Gray			

	RG	OcO	GA
AQUIFOLIACEAE			
Ilex decidua Walter		X	
ASCLEPIADACEAE			
Asclepias perennis Walter			
Cynanchum laeve (Michaux) Persoon			
Matelea gonocarpa (Walter) Shinners			
ARISTOLOCHIACEAE			
Aristolochia serpentaria L.			
ASTERACEAE			
Ambrosia artemisiifolia L.			
Ambrosia trifida L.			
Anthemis cotula L.			
Aster dumosus L.			
Aster exilis Ell.			
Aster pilosus Willd			
Aster simplex			
Baccharis halimifolia L.			
Bidens aristosa (Michx.) Britton			
Bidens discoidea (T. & G.) Britt.			
Boltonia caroliniana (Walter) Fern			
Carduus discolor (Muhl. ex Willd.) Nuttall			
Carduus spinosissimus Walter.			
Coreopsis tinctoria Nuttall			
Dracopsis amplexicaulis (Vahl) Cass			
Eclipta alba (L.) Hasskarl			
Erigeron annuuss (L.) Persoon			
Erigeron canadensis L.			
Erigeron philadelphicus L.			
Eupatorium capillifolium (Lam.) Small			
Eupatorium coelestinum L.			
Eupatorium rugosum Hottuyn			
Eupatorium werotinum Michx.			
Gnaphalium obtusifolium L.			
Gnaphalium purpureum L.			
Helianthus annuus L.			
Iva annua L.			

	RG	OcO	GA
Krigia oppositifolia Raf.			
Lactuca floridana (L.) Gaertner			
Lactuca scariola L.			
Mikania scandens (L.) Willd			
Pluchea camphorata (L.) DC			
Polymnia uvedalia L.			
Pyrrhopappus carolinianus (Walter) DC			
Senecio glabellus Poiret	X		
Solidago altissima L.		1	
Sonchus asper (L.) Hill			
Spilanthes americanum (Nuttall) Heiron	X		
Vernonia altissima Nuttall			
Xanthium strumarium L.			
BETULACEAE			
Betula nigra L.			
BIGONONIACEAE			
Anisostichus capreolata (L.) Bureau.			
Campsis radicans (L.) Seemann	X	X	X
BORAGINACEAE			
Heliotropium indicum L.			
Heliotropium procumbens Mill.			
Myosotis macrosperma Engelm.			
BRASSICACEAE			
Capsella bursa-pastoris (L.) Medicus			
Cardamine hirsuta L.			
Lepidium virginicum L.			
Rorippa islandica (Oeder.) Borbas.			
Rorippa sessiliflora (Nuttall) Hitchc.			
Sibara virginica (L.) Rollins			
CALLITRICHACAEA			
Callitriche deflexa A. Braun			
Callitriche heterophylla Pursh.			

	RG	OcO	GA
CAMPANULACEAE			
Specularia biflora			
Specularia perfloiata			
Lobelia cardinalis L.			
CAPRIFOLACEAE			
Lonicera japonica Thunberg	X		
Sambucus canadensis L.			
CARYOPHYLLACEAE			
Cerastium glomeratum Thuiller			
Stellaria media (L.) Cyrillo			
CONVOLVULACEAE			
Cuscuta compacta Jussieu			
Ipomoea hederacea (L.) Jacquin var. *hederacea*			
Ipomoea hederaceae (L.) var *integriuscula*			
Ipomoea lacunosa L.			
Ipomoea lacunosa L. f. *purpurata* Fern.			
Ipomoea wrightii Gray			
CORNACEAE			
Cornus drummondii C.A. Meyer			
Cornus stricta Lam.			
CUCURBITACEAE			
Cayaponia boykinii (T.&G.) Cogn			
Cucumis melo L.			
Melothria pendula L.			
Sicyos angulata L.			
EBENACEAE			
Diospyros virginiana L.		X	
ERICACEAE			
Monotropa uniflora L.			

EUPHORBIACEAE	RG	OcO	GA
Acalypha gracilens Gray			
Acalypha rhomboideae Raf.			
Acalypha ostryaefolia Riddell.			
Croton capitatus Michaux.			
Euphorbia maculata L.			
Euphorbia nutans Lag.			
Phyllanthus caroliniensis Walter			
FABACEAE			
Albizia julibrissin Durazzini			
Amorpha fruticosa L.			
Apios americana Medicus			
Cassia fasciculata Michaux			
Centrosoma virginianum (L.) Bentham			
Desmanthus illinoenis (Michaux) MacM.			
Desmodium canescens (L.) DC.			
Desmodium paniculatum (L.) DC.			
Desmodium perplexum Schubert			
Dioclea multiflora (T.&G.) C. Mohr			
Galactia volubilis (L.) Britton			
Gleditsia aquatica Marshall			
Gleditsia triacanthos L.			X
Lathyrus aphaca L.			
Lathyrus hirsutus L.			
Medicago arabica Hudson.			
Melilotus alba Desr.			
Mimosa strigillosa T.&G.			
Sesbania exaltata (Raf.) Rydberg ex A.W. Hill			
Strophostyles helvola (L.) Ell.			
Trifolium campestre Schreber.	X		
Trifolium incarnatum L.			
Trifolium repens L.			
Vicia angustifolia Reichard			
Vicia dasycarpa Tenora.			
Vicia grandiflora Scopoli	X		
Vicia ludoviciana Nutt.			
Wisteria macrostachya Nutt.			