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An American beech-dominated original growth forest in southeast Louisiana[1]

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WHITE, D. A. (Dept. Biol. Sci., Loyola Univ., New Orleans, LA 70118). An American beech-dominated original growth forest in southeast Louisiana. Bull. Torrey Bot. Club 114:127–133. 1987.—An old-growth (more than 150 years old) forest in southeastern Louisiana was studied during 1982–1983 using nested quadrats to quantify the ecological importance of the woody species. The canopy of +35 m height is dominated by American beech (*Fagus grandifolia* Ehrhart) with 3 other co-dominants: spruce pine (*Pinus glabra* Walter), southern magnolia (*Magnolia grandiflora* L.) and sweetgum (*Liquidambar styraciflua* L.). The relict angiosperm star anise (*Illicium floridanum* Ellis) is a very common shrub. Twenty-eight woody species were found, within a forest basal area of 39.8 m^2/ha. The overstory species were underrepresented in the smaller size classes, while the shrub and understory species showed typical reverse J-shaped size class distributions. The forest is thought to be climax.

Key words: arborescent analysis, climax forest, Louisiana, magnolia-beech forest.

Within the coastal plain of the southeastern United States, remnants of climax forests are very rare. Most often knowledge about their ecology and species composition has developed either from the study of small, old-growth forests, relatively free from the signs of recent disturbance (Quarterman and Keever 1962; Blaisdell *et al.* 1974), or from the study of original land survey records from the 1800's (Delcourt and Delcourt 1974, 1977; Schafale and Harcombe 1983). Quarterman and Keever (1962) described a "Southern Mixed Hardwood Association," roughly equivalent to Braun's (1950) "Southeastern Evergreen Forest," as the climax forest on mesic coastal plain areas. From updated literature, Quarterman (1981) corroborated, but also refined her concept of a ubiquitous mixed hardwood climax on mesic sites, suggesting that the Beech-Magnolia climax might occur locally as a "segregate" on wetter, mesic sites. Additional data and current analysis of an exceedingly rare old-growth forest located in southeastern Louisiana, originally studied by Quarterman and Keever (1962), is presented here.

Study Area. The site is a 35 ha forest at the confluence of 2 streams which form Chappepeela Creek and within what was once the Zemurray estate (30°37′N and 90°21′W), about 80 km north of New Orleans, Louisiana in Tangipahoa Parish. A very old, narrow, gravel-surfaced road bisects the site. Elevation is 15 m above MSL, 2 m above the narrow, steep-banked channels of the meandering streams. The level, to nearly level, acid floodplain soils, developed from late Pleistocene and Tertiary sediments, are of the Caddo-Beauregard Group of the well-drained Vicksburg Association (USDA 1985). Poorly-drained Waverly Association soils exist in the infrequent and scattered depressions of old stream beds and support a more hydric plant community. Loblolly pine (*Pinus taeda*) plantations grow on gently sloping, moderately well-drained Providence Association soils across the streams from the site. According to Quarterman and Keever (1962), the site is moisture class 8, and floods only during the heaviest local rains that occur approximately once every 3 years.

Average annual precipitation is about 162 cm. The mean annual temperature is 19.9°C, ranging from a January mean of 12.2°C to a July mean of 27.3°C. The growing season is about 255 days (Sanders 1978).

Methods. The woody vegetation was divided into 3 size classes based upon diameter at breast height (DBH). The first 2 size classes (10 cm + DBH and from 6 cm

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Table 1. Zemurray forest importance values based on density and basal area data for trees and shrubs of 3 size classes. All species with I.V.'s exceeding 1.0 are presented. Evergreen species are denoted with *.

Species	Size class (cm) +10	6–10	1–6
Fagus grandifolia	22.1	1.4	1.5
*Pinus glabra**	16.0	–	–
*Magnolia grandiflora**	14.6	–	1.4
Liquidambar styraciflua	10.3	6.5	–
Carpinus caroliniana	6.4	32.7	5.6
Nyssa sylvatica	6.1	1.8	1.9
Liriodendron tulipifera	5.6	–	–
Quercus nigra	4.9	–	–
*Pinus taeda**	3.1	–	–
Quercus michauxii	2.9	1.5	–
Halesia diptera	2.2	19.3	15.1
*Symplocos tinctoria**	1.4	17.3	23.3
Ilex opaca	–	11.2	1.2
*Osmanthus americana**	–	1.8	–
Acer rubrum	–	1.8	–
Oxydendrum arboreum	–	1.1	–
Vaccinium arboreum	–	1.1	–
*Illicium floridanum**	–	–	47.9
Total	95.6	97.5	97.9

to 10 cm DBH) were sampled over a total area of 2.0 ha by recording species, DBH and height within 10 plots of 40 m × 50 m, oriented long axis east–west. The plots were scattered throughout the 35 ha. Significant depressions which held standing water were avoided. Such a large total sample area was used because of the low density of the trees. Within the northeast corner of each larger plot, a 20 m × 25 m plot was nested to sample the vegetation 1 to >6 cm DBH.

Density and basal area were determined for all species. Importance values were calculated based upon combined totals of relative density and relative dominance values (Cox 1985). Nomenclature generally follows Radford *et al.* (1968), and specimens were deposited in the Herbarium of Tulane University, New Orleans, Louisiana.

Results. The Zemurray forest is dominated by American beech (*Fagus grandifolia*) (Table 1). Spruce pine (*Pinus glabra*), southern magnolia (*Magnolia grandiflora*) and sweetgum (*Liquidambar styraciflua*) are the other dominants. These 4 species have a combined importance value of 63 out of 100 in the greater than 10 cm size class (Table 1). In addition, blackgum (*Nyssa sylvatica*), water oak (*Quercus nigra*), yellow poplar (*Liriodendron tulipifera*), loblolly pine (*Pinus taeda*) and swamp chestnut oak (*Quercus michauxii*) are important species of the canopy. These 9 trees contribute 86% of the total importance value for plants greater than 10 cm DBH.

The small tree and large shrub component (6–10 cm DBH) is almost exclusively ironwood (*Carpinus caroliniana*), silverbell (*Halesia diptera*), sweetleaf (*Symplocos tinctoria*) and American holly (*Ilex opaca*), as evidenced in their summed importance value of 80.5. The forest has a conspicuous evergreen, shrub layer (1–6 cm DBH) of sweetleaf and star anise (*Illicium floridanum*), a relict angiosperm. With the occasional silverbell, these 2 shrubs dominate this forest layer, with a combined importance value of 86.

These 18 species, distributed among all size classes, characterize the forest. This is quantified in their combined importance value of 285 out of 300 (from Table 1). In addition to these species, there are 10, uncommon to rare, woody species within the Zemurray forest (Table 2). These 28 species have a total basal area in the forest of 39.8 m^2/ha with 3072 stems/ha, of which over half (1722 stems/ha) is the shrub, star anise. Total density for each of 3 stratal groups is as follows (Table 2); canopy trees = 334 stems/ha; sub-canopy trees = 221 stems/ha; shrubs/small trees = 2515 stems/ha. These values reveal the sparseness of the larger species (height = +30 m) and the coverage of star anise (height = 2.5 m). The cathedral-like nature of the forest is revealed by the average canopy height (35 m), with an occasional tree taller than 40 m. The largest southern magnolia in the state is found within the forest (126 cm DBH and 42 m height).

Among the 4 dominant canopy species, American beech with 87 stems/ha and southern magnolia with 67 stems/ha are the most frequent. Coincidentally, they are of the same average size (19 cm DBH). In contrast, the spruce pine is the largest of the 4 (average DBH = 22 cm), but not as numerous (45 stems/ha), while the sweetgum is even less common (42 stems/ha) and smaller (17 cm DBH).

Of the subdominant canopy species, blackgum, with 41 stems/ha, and water oak, with 21 stems/ha, are most common and of mean sizes 13 cm and 17 cm DBH. Even

Table 2. Density and basal area for all woody trees and shrubs (DBH ≥ 1.0 cm) encountered within the Zemurray forest. Stratal designations: [a] denotes canopy trees; [b] denotes subcanopy trees; [c] denotes shrubs and small trees.

Species	Common name	Density (stems/ha)	Basal area (m^2/ha)
Fagus grandifolia Ehrhart[a]	American beech	86.5	9.3259
Pinus glabra Walter[a]	Spruce pine	45.0	6.8906
Magnolia grandiflora L.[a]	Southern magnolia	66.5	7.4371
Liquidambar styraciflua L.[a]	Sweetgum	41.5	3.7461
Carpinus caroliniana Walter[b]	Ironwood	157.5	0.7845
Nyssa sylvatica Marshall[a]	Blackgum	40.5	2.2638
Liriodendron tulipifera L.[a]	Yellow poplar	12.0	2.7336
Quercus nigra L.[a]	Water oak	20.5	1.8756
Pinus taeda L.[a]	Loblolly pine	7.0	1.4641
Quercus michauxii Nuttall[a]	Swamp chestnut oak	10.5	1.0632
Halesia diptera Ellis[c]	Silver bell	276.5	0.4647
Symplocos tinctoria (L.) L'Her.[c]	Sweetleaf	471.5	0.4339
Illicium floridanum Ellis[c]	Star anise	1722.0	0.2286
Acer rubrum L.[b]	Red maple	10.5	0.0727
Magnolia virginiana L.[b]	Sweet bay	4.5	0.1013
Ilex opaca Aiton[b]	American holly	33.0	0.2850
Prunus serotina Ehrhart[a]	Black cherry	2.5	0.1666
Quercus alba L.[a]	White oak	1.5	0.2289
Oxydendrum arboreum (L.) DC.[b]	Sourwood	5.0	0.0510
Sassafras albidum (Nuttall) Nees.[b]	Sassafras	5.0	0.0287
Vaccinium arboreum Marshall[c]	Sparkleberry	30.5	0.0461
Cornus florida L.[c]	Dogwood	1.5	0.0098
Quercus phellos L.[a]	Willow oak	0.5	0.0120
Persea borbonia (L.) Sprengel[b]	Red bay	2.5	0.0127
Osmanthus americana (L.) Gray[b]	Wild olive	3.0	0.0269
Callicarpa americana L.[c]	French mulberry	2.0	0.0002
Ilex verticillata (L.) Gray[c]	Winterberry	4.0	0.0013
Stewartia malacodendron L.[c]	Silky camellia	8.0	0.0020
Total		3071.5	39.7569

though they did not occur in great numbers, yellow poplar with 12 stems/ha and loblolly pine with 7 stems/ha are on average the largest 2 species encountered (27 cm DBH and 26 cm DBH, respectively). Swamp chestnut oak is found at about the same density (11 stems/ha), but is smaller in size on average (18 cm DBH).

Star anise has the greatest density of all species and is most dense in areas of quick-draining soils. Interspersed are individuals of sweetleaf (472 stems/ha). Silverbell is most dense on somewhat less well-drained soil, with an average density throughout the forest of 277 stems/ha. Sparkleberry (*Vaccinium arboreum*) is scattered and at a much lower density (30 stems/ha). Most common on the wettest mesic sites is ironwood, with a density of 158 stems/ha. It is considered a tree by most, but in this forest it is of small size (4 cm DBH). American holly is restricted to mesic soils in one particular area of the forest. It has a mean density throughout of 33 stems/ha and an uncharacteristically small size (5 cm DBH).

Size class data indicate that silverbell, sweetleaf and ironwood have characteristic J-shaped distributions (Table 3), and that these shrubs and small tree species, plus star anise, never attain a large size. American holly can be of considerable size, but in the Zemurray forest this species is never large; it has J-shaped distribution, also. Lumping the 9 overstory species into one size class distribution illustrates the similar and low number of individuals that are present from the 11–15 cm class to the 66–70 cm class (Table 3).

Discussion. The Zemurray forest is an American beech-dominated, "original growth" (*sensu* Porcher 1981) and probably climax forest which most likely exists because of its fire-protected location between stream meanders. Such an island hardwood forest among pine woods has been labeled

Table 3. Size class data within a 2 ha sampled area for the common species of Zemurray forest. Numbers given for the size classes are the lower limit of each class.

	Size class (cm)								
	1*	6	11	16	21	26	31	36	41
I. **Overstory species**									
Fagus grandifolia	28	9	7	9	5	10	9	13	13
Pinus glabra	4	1	1	5	7	3	5	6	8
Magnolia grandiflora	38	2	2	2	5	2	6	3	4
Liquidambar styraciflua	2	18	15	6	6	5	7	5	6
Nyssa sylvatica	20	8	6	4	4	3	4	2	2
Liriodendron tulipifera		2	2		3	2	1		1
Quercus nigra	6	1	1	8	2	2	1	5	2
Pinus taeda						1	1	2	2
Quercus michauxii		4	4	1	1	1	2	1	2
Subtotal	98	45	38	35	33	29	36	37	40
II. **Understory species****									
Carpinus caroliniana	80	101	45	5	1				1
Ilex opaca	18	24	3	1			1	2	
Halesia diptera	238	58	11	5		1			
Symplocos tinctoria	440	53	7	4					
Subtotal	776	236	66	15	1	1	1	2	1
Total	874	282	104	50	34	30	37	39	41

* The 1>6 cm data were extrapolated to 2 ha from a sampled area of 0.5 ha.
** *Illicium floridanum* had 3444 stems/2 ha up to 6.0 cm.

"mesic hammock" (Delcourt and Delcourt 1977). Upstream and downstream the unprotected forests are successional loblolly pine-dominated stands growing up to the stream edge; a few areas support more and larger species.

Because of its streamside location and the fact that American beech, spruce pine, sweetgum and southern magnolia are the most important trees, the Zemurray forest could be classified within the Floodplain Hardwood Pine type of Marks and Harcombe (1981) or the Beech-Magnolia type of Delcourt and Delcourt (1977). Quarterman and Keever (1962) determined the Zemurray forest to be considerably more hydric (moisture class 8) than the 10 middle mesic (class 4) sites they used to typify their Southern Mixed Hardwood Association. But, 7 of the top 9 most important trees within the Zemurray forest are in the 14 core hardwoods which make up their association. The remaining 2 trees (spruce pine and swamp chestnut oak; Table 1) in the top 9 are listed by Quarterman and Keever as important "accessory" species. Therefore, the Zemurray forest could be classified within the Southern Mixed Hardwood Association. Abiding by Quarterman (1981), this forest would be most succinctly labeled a "segregate" of the association because of the more hydric (streamside) location. Marks and Harcombe (1981) state that there should be "no contradiction between the occurrence" of 2 (or several) somewhat different climax associations throughout the mesic range; each "may be equally valid climax types on the coastal plain." Forest associations develop temporally and spatially into continuums simply because the environment rarely changes abruptly.

Though it does have several noteworthy characteristics, the species composition of the Zemurray forest is typical of other coastal plain streamside forests. Its appearance is striking due to the presence of 3 evergreen canopy species (southern magnolia, spruce pine and loblolly pine), whose summed importance value comprises one-third of the total importance value for all species over 10 cm DBH; and the presence of 4 evergreen shrubs or small trees (star anise, sweetleaf, American holly and wild olive—*Osmanthus americana*) which make up more than one-half the importance value for all species less than 10 cm DBH. As Braun (1950) states, in reference to the Southeastern Evergreen forest, the evergreenness could be "related to the low latitude and is indicative of a transition (continuum) to the subtrop-

Table 3. Continued.

Size class (cm)															
46	51	56	61	66	71	76	81	86	91	96	101	106	111	116	121
11	11	10	6	3	2	1	2	1							
9	15	9	4	4			1								
4	3	3	4	5	3	2	2	1	1	1		1			1
4	2	1	3	1		1		1	1						
1		1	2	1	1	1	1								
3	4	1	1	1	1	1	1							1	
3	3		1	1		1									
1	4		1	1		1									
1	1	2	1												
37	43	27	23	27	7	8	7	3	2	1		1		1	1
37	43	27	23	17	7	8	7	3	2	1		1		1	1

ical forest of southern Florida"; or according to Monk (1966), the evergreenness could indicate a sterile edaphic site.

The range of star anise follows closely the distribution of Braun's (1950) Beech-Magnolia forest (Thien *et al.* 1983). According to Braun (1950), the Beech-Magnolia type is well represented in the Florida panhandle, southern Georgia and Alabama and in the ravine slopes and "loess bluffs" of southern Mississippi and southeastern Louisiana. The studies by Kurz (1944), Delcourt and Delcourt (1974, 1977) and Blaisdell *et al.* (1974) describe the seres and climax of this Beech-Magnolia type.

The abundance of pine in a forest is conventionally thought to relate to its successional status (Quarterman and Keever 1962), i.e., the closer to climax the less abundant. This is not true for spruce pine, the second most important tree in the Zemurray forest (21% or 8.3 m^2/ha of the forest's total basal area is in pine; of which 83% is spruce pine). According to Quarterman and Keever (1962) this species should be listed with the hardwoods because of its tolerance for shade and other ecological considerations. Brown (1945) noted that extensive stands of spruce pine were found in the unmanaged (fire free) forests of Tangipahoa Parish. In east Texas, where spruce pine is absent, it seems that loblolly pine is an important component of old-growth forests (McLeod 1971; Harcombe and Marks 1983) and was important in the presettlement forest (Schafale and Harcombe 1983).

Yellow poplar is another species present in the Zemurray forest and other coastal plain forests, but not in the east Texas forests (Marks and Harcombe 1975; Nixon *et al.* 1980). It apparently was once abundant in the "well-drained coves" of Louisiana (Foster 1912). The Zemurray forest does have affinities with the east Texas forests in that species of hickory (*Carya*) are absent from both (Marks and Harcombe 1975) and American holly is not a major component (Schafale and Harcombe 1983). Of the available forest descriptions for the southern coastal plain, the Zemurray forest appears most similar to the Weir forest of east Texas (Harcombe and Marks 1977).

It seems that in southern coastal plain forests underrepresentation of the smaller size classes of overstory trees is common (Harcombe and Marks 1978; Golden 1979), particularly for American beech and southern magnolia (Fowells 1965; Kurz 1944; Nixon *et al.* 1980; Blaisdell *et al.* 1974). The present study is no exception, not only for the sampled size classes (Table 3), but paucity of seedling/saplings was personally observed, too. Apparently, mortality is low after an overstory species attains 11–15 cm DBH (for the spruce pine in the Zemurray forest this is an old age of about 40 years). In contrast, understory species do exhibit a very contracted, but normal exponential distribution (Table 3).

Conventional demographic principles might not always be applicable to overstory species in southern coastal plain forests. It may be that in mature forests, diameter growth and establishment of hardwoods is so slow and sporadic that size class distributions do not accurately portray age distributions (Caswell 1982). Each size class may include trees of very different ages which could reflect sporadic mast cycles, microtopographic growth effects and yearly climatic differences, among others.

Is the Zemurray forest a climax forest? A climax forest must be free from recent significant perturbations to develop stability. In southeastern Louisiana such perturbations could come in 3 forms: cutting, hurricanes and fires. No evidence of any of these kinds of disturbance exist within the Zemurray forest. The abundance of the fire intolerant spruce pine (Dial *et al.* 1976) among other intolerant species confirms that this forest has not been affected by fire.

A climax forest should possess very old and large trees. In 1962, Quarterman and Keever listed the forest at over 125 years, which would establish existing trees prior to 1840. Before that time few human settlements existed in this part of the coastal plain, so human-induced perturbations are unlikely. The canopy height of 35 m and low density of trees indicate a very mature forest. In addition, 98% of the total basal area (38.3 m^2/ha) includes trees over 10 cm DBH. This number agrees well with Held and Winstead's (1975) hypothesis that truly mesic climax forests consistently have about 30 m^2/ha total basal area of 10 cm + DBH individuals and that more hydric sites should have slightly higher values. The climax status of the Zemurray forest therefore seems likely.

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