Wastewater Enrichment Increases Mature Pondcypress Growth Rates

John K. Nessel, Katherine Carter Ewel, and Michael S. Burnett

ABSTRACT. Increment cores from 100-year-old pondcypress trees in a Florida cypress strand indicate that wastewater from a municipal septic tank increased tree growth rates (measured as basal area increment per tree) two-fold over a 41-year period. These trees were 55 to 60 years old when wastewater flow began. Trees in a nearby undisturbed cypress dome showed no such increase in growth rate. Forest Sci. 28:400–403.

ADDITIONAL KEY WORDS. Taxodium distichum var. nutans, cypress dome, cypress strand.

CYPRESS SWAMPS have been proposed as disposal sites for secondarily treated sewage in the southeastern United States (Odum and others 1977). Two kinds of cypress swamps are common: cypress domes, which are isolated bodies of water, and cypress strands, through which water flows at least part of the year. Pondcypress (Taxodium distichum var. nutans [Ait.] Sweet) dominates cypress domes and narrow strands, especially near their heads.

Studies on an experimental cypress dome near Gainesville, Florida, show that nitrogen and phosphorus are retained in the sediments and underlying clays after 5 years of sewage application at 2.5 cm/ wk (Dierberg 1980). Growth rates of mature trees and survival of planted seedlings have not been altered to date, but there may be as yet unmeasured long-term effects on the swamp ecosystem (Ewel and Odum 1978).

In this study, we evaluated the effect of domestic wastewater disposal on diameter growth of pondcypress trees over a 41-year period. The site that we investigated had received overflow from a community septic tank since 1934, providing us with an opportunity to determine what long-term effects wastewater disposal might have on pondcypress growth rates.

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FIGURE 1. Location on cypress strand in Waldo, Florida, into which wastewater from a septic tank has flowed since 1934, and of a nearby cypress dome studied as a control. Arrows indicate direction of flow during high water.

METHODS

Study Area.—The City of Waldo (pop. 1,000), located in north-central Florida, generates 20,000 to 30,000 gallons of wastewater per day. Sewage has flowed from the community septic tank since construction of the sewer system in 1934. Waldo has grown since then, and expanded its system in the 1960’s. The system serves not only residences but also businesses on U.S. 301, a major tourist route, and has apparently operated at capacity for several years. Wastewater from the septic tank flows into a ditch, which overflows into a cypress strand when water levels are high, normally in January through March and June through September.

The study area is a 2.6-ha portion of this strand, which separates into isolated swamps for most of the year. The headwaters of the strand (A), the study area (B), and part of the downstream portion (C) are shown in Figure 1. The arrows show the direction of flow during high water. The canopy is dominated by even-aged pondcypress trees, with red maple (*Acer rubrum* L.) and swamp blackgum (*Nyssa sylvatica* var. *biflora* [Walt.] Sarg.) forming a subcanopy. Total basal area is 50.1 m²/ha.

From September 1976 through September 1977, total phosphorus concentrations in the standing water were measured as an index to the degree of nutrient enrichment in the swamp. Seasonally flooded soils in Florida are frequently low in available phosphorus,
and slash pine (*Pinus elliottii* Engelm.) grown commercially under such conditions usually respond well to phosphate fertilizer (Pritchett 1979). Total phosphorus in the ditch averaged 3.73 mg/l, 3.97 mg/l just inside the cypress swamp (B), and 1.29 mg/l at the northern end, where water flows into the next portion of the strand. Nessel (1978) estimated annual inflow of 4.2 g P/m²·yr to cypress swamp (B) with wastewater in 1976–77.

There are no undisturbed cypress strands near the study area, so a large cypress dome 5 km to the southwest, in the University of Florida’s Austin Cary Memorial Forest, was selected for comparison. This 4.2-ha dome is dominated by pondcypress with swamp blackgum in the subcanopy. Total basal area is 70.8 m²/ha (Brown 1978). It is surrounded by natural longleaf pine (*P. palustris* Mill.) stands and slash pine (*P. elliottii* Engelm.) plantations. Total phosphorus concentration in this dome averaged 0.18 mg/l from March 1974 to July 1979 (Dierberg 1980).

**Growth Ring Analysis.**—In 1975, increment cores were removed from 20 trees at the south end of the enriched swamp near the point of sewage inflow and from 17 trees in the cypress dome. In 1977, cores were taken from an additional 9 trees in the south end of the cypress strand and from 26 trees at the north end. These trees were all dominants and were about 100 years old. Diameter at breast height averaged 33.7 cm (SE = 1.4); there were no significant differences in tree sizes between the sites.

Tree cores were mounted in grooved wooden blocks and sanded with 40 grit sandpaper, then 80, 120, 220, and 320 grit emory cloth. Growth rings on the cores were measured under a microscope with an ocular micrometer in order to detect false rings. Beaufait and Nelson (1957) reported the existence of numerous false rings in baldcypress (*T. distichum* [L.] Rich), and they are common in pondcypress as well. A dark resinous band, apparently resulting from changes in growth rate due to extreme climatic conditions such as drought, or defoliation by insects, may appear to the naked eye to be an additional ring, but can usually be detected with low (<20×–60×) magnification.

Because the septic tank was installed in 1934, average increase in basal area per tree was measured for a baseline period from 1919 to 1933 and for the subsequent period from 1934 to 1975. Comparisons of growth rates between time periods were made using Student’s *t*-test.

**RESULTS AND DISCUSSION**

The average ring width at the undisturbed cypress dome decreased significantly from the first time period to the second (Table 1), as might be expected since the widths of subsequent annual rings normally decrease as tree girth increase (Fritts 1976). Basal area increment per tree did not change significantly (*P* < 0.01) in the control area. However, in both south and north ends of the sewage-enriched swamp, average ring width after 1934 was not significantly different from the baseline years. Consequently, the amount of basal area added each year per tree increased significantly. The effect was more pronounced at the south end than the north end, although the difference was not significant.

**TABLE 1. Average growth rates of cypress trees in a cypress strand (B in Fig. 1) before (1919–33) and after (1934–75) sewage enrichment and in nearby undisturbed cypress dome.**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Cypress strand</th>
<th>Cypress dome</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>South end</td>
<td>North end</td>
</tr>
<tr>
<td>Average annual growth ring width, mm (SE)</td>
<td>1.8 (0.1)</td>
<td>2.0 (0.1)</td>
</tr>
<tr>
<td>Average annual basal area increment per tree, cm² (SE)</td>
<td>6.70 (0.51)</td>
<td>15.50 (1.07)*</td>
</tr>
</tbody>
</table>

* Significant difference at *P* < 0.01.
Mitsch and Ewel (1979) demonstrated that growth rates of cypress trees vary parabolically with drainage condition. Maximum growth occurs in river swamps and strands, where flowing water during part of the year may bring in more nutrients, and oxygen concentrations in the water may be higher than in domes. Nutrient turnover rates are presumably slower and hydroperiods are longer in cypress domes. The cypress strand at Waldo, however, is not large and appears to function like a series of domes during most of the year. Consequently, the differences in growth rates that one expects to find in comparing domes and strands are not evident here. Cypress trees in the dome actually grew more rapidly than in the strand during the pretreatment period. This may be related to the larger size of the Austin Cary dome, which is an indication of a larger watershed.

The fertilization effect of the wastewater is also manifested in plant tissues: cypress needles from eight trees in the Waldo study area averaged 1.76 (SE = 0.18) mg P/g dry weight, and cypress needles taken from eight trees in Austin Cary in the same month averaged 1.29 (SE = 0.15) mg P/g dry weight (P. Straub, Lab Technologist, personal communication). Surface sediments (to a depth of 20 cm) averaged 90.2 g P/m² at the Waldo study area (Nessel 1978), and 16.5 g P/m² at the Austin Cary cypress dome (Deghi 1977). These data suggest that the trees are responding to an increase in nutrient availability, rather than simply an increase in throughflow. As a tree ages, it depends increasingly on internal recycling of nutrients to meet its needs. For instance, Switzer and Nelson (1972) found that a major part of the phosphorus and nitrogen requirement of 17- to 20-year-old loblolly pine (P. taeda L.) plantations was met by translocation. Nevertheless, response of old stands to fertilization with a limiting nutrient (especially nitrogen) has been described for several commercial species (e.g., Mayer-Krapoll 1956, Hagner 1967, Miller and Reukena 1974). Increase in basal area in the cypress strand after sewage addition began strongly suggests that 55- to 60-year-old pondcypress trees can respond to increases in nutrient availability, and maintain increased growth rates for more than 40 years.

LITERATURE CITED