USDA Forest Service Research Note SE- 249 October 1977

INITIAL RESPONSE OF PINE SEEDLINGS AND WEEDS TO DRIED SEWAGE SLUDGE IN REHABILITATION OF AN ERODED FOREST SITE

Abstract. --Dried sewage sludge was applied at rates of 0, 17, 34, and 69 metric tons/ha on a badly eroded forest site in the Piedmont region of northeast Georgia. Production of weed biomass varied directly with amount of sludge applied. Height growth for both shortleaf and loblolly pine seedlings appeared to be greater on plots receiving 17 metric tons of sludge/ha, but differences between treatments were not statistically significant. High mortality of pine seedlings on plots receiving heavy sludge applications was attributed to competition from weeds whose growth had been stimulated.

Keywords: Ambrosia artemisifolia, Digitaria sanguinalis, organic amendments, Pinus taeda, Pinus echinata.

Applications of dried sewage sludge have been shown to benefit forest sites of low fertility including drastically disturbed surface-mine spoils, eroded areas, and even agricultural land by improving fertility and soil structure (King and Morris 1972; Sopper and others 1970). Most soils appear to be suitable for controlled sludge applications. Those of questionable suitability, however, include extremely coarse textured, extremely fine textured, very shallow and frozen soils (Evans 1973). Applications of dried sludge to forest land have been studied by Gagnon (1974), who increased growth of jack pine (Pinus banksiana Lamb.) and white spruce (Picea glauca (Moench) Voss) by applying dry sewage sludge to established stands. Smith and Evans (1976) discussed in depth the problems associated with the disposal of several kinds of wastes on forest land.

The most serious disease of shortleaf pine (Pinus echinata Mill.), littleleaf, also affects loblolly pine (P. taeda L.). Littleleaf is found almost exclusively on badly eroded or otherwise disturbed sites and is severe on at least 2 million hectares in the Piedmont regions of Alabama, Georgia, and South Carolina (Zak 1961). Although a fungus root pathogen, Phytophthora cinnamomi Rands, was indicted as a causal agent (Campbell and Copeland 1954), typical littleleaf sites are generally unfavorable for good growth of trees even when P. cinnamomi is not present (Zak 1961). Most littleleaf sites have a thin or absent topsoil and a poorly drained subsoil. Although the effect of any treatment on the occurrence of littleleaf cannot be fully ascertained for 15 to 20 years, it is believed that any treatment which will have a lasting and positive effect on site productivity will lessen the severity of the disease.

Southeastern Forest Experiment Station - Asheville, North Carolina
U.S. Department of Agriculture-Forest Service

This study was made to determine the effects of dried sewage sludge on survival and growth of two important forest species on a poor site. The stimulation of weed growth and associated reduction in pine seedling survival was unexpected and of such magnitude that this preliminary report is considered timely and should serve to alert those engaged in reforestation of the inadvisability of applying an excess of sewage sludge.

MATERIALS AND METHODS

INSTALLATION

The experiment was installed in Elbert County, Georgia, on a site where low-quality mixed pines and hardwoods had recently been harvested. Soil is in the Cecil series and is severely eroded with all the A horizon and upper B horizon gone. The experiment was arranged in a split-block design with three replicate blocks, each 26.8 m X 143.3 m. Half of each block (13.4 m x 143.3 m) was subsoiled with furrows 1.2 m apart and 0.60 to 0.75 m deep. Each block was then divided into eight plots.

Anaerobically digested, dried sewage sludge was obtained from sewage treatment plants in Athens, Georgia, and chemically analyzed by the Soil Testing and Plant Analysis Laboratory[1] (table 1). Metallic elements were extracted with a double acid solution (0.05 N HCl in 0.025 N H_2SO_4) and analyzed as follows: P, B, and Mg by colorimetric procedures; K and Ca by flame emission spectroscopy; and Zn, Mn, Fe, Na, Cu, and Al by atomic absorption spectroscopy. Total nitrogen was analyzed by the Kjeldahl method and nitrate nitrogen by s t e am distillation. Organic matter was determined by ashing. Total amounts of metallic elements were dry-ashed at 500° C for 4 hours and determined by flame emission spectroscopy.

Table 1. --Plant nutrients and organic matter in dried sludge from sewage treatment plants at Athens, Georgia[1]

Element	Acid extractable"	Total[3]
	- - - p/m - - - -	
N		21,500
NO_3-N		3,613
	161	9,034
K	41	4,034
Ca	580	13,750
Mg	147	284
Zn	205	1,105
B	1.14	17.5
Mn	59	133
Fe	101	7,608
Na	205	344
CU	18	414
Al	134	5,945
Organic matter (percent)		48.9

[1]Each value is the average of six analyses.
[2]Double acid extraction method (0.05 N HCl in 0.025 N H_2SO_4).
[3]Total nitrogen analyzed by Kjeldahl method; NO_3-N by steam distillation procedures, organic matter determined by ashing; and metallic elements dry-ashed and determined by flame emission spectroscopy.

Sludge, applied 1 year after subsoiling at rates of 0, 17, 34, and 69 dry metric tons/ha, was spread by a tractor-mounted front-end loader and disked into the upper 10 cm of soil. Each sludge treatment was applied to two

‘According to methods in "Laboratory Procedures for the Analysis of Soils, Feed, Water and Plant Tissue," Soil Testing and Plant Analysis Laboratory, Extension Service, University of Georgia, 2400 College Station Road, Athens 30602.

plots in each block. One plot was then planted with loblolly pine and one with shortleaf pine. Trees were planted by hand in early April. Rows are 2.4 m apart and spacing within rows is 1.5 m. Each plot contains 16 permanent experimental trees, 30 trees that are in border rows, and 20 trees that will be removed by thinning if additional long-range observations are desired.

BIOMASS COLLECTION

By the end of summer 1973, growth of weeds, principally common ragweed (Ambrosia artemisifolia) and hairy crabgrass (Digitaria sanguinalis), had been greatly stimulated on plots where sludge had been applied, so weed biomass was sampled to determine whether survival of pine seedlings was correlated with weed growth. In October, after one growing season, three one-half m2 subsamples of aboveground weed biomass were clipped from each plot. Samples were weighed fresh in the field and dried at 80" C for 12 hours to determine dry weights. An analysis of variance was performed and least significant differences (LSD) were calculated to determine whether biomass production was correlated with rate of sludge application.

SURVIVAL AND GROWTH DATA

In April, 1 year after planting, survival and growth of pine seedlings were recorded. Effects of application rate on pine seedling survival were subjected to analyses of variance and means separated by Duncan's Multiple Range Test.

RESULTS

WEED BIOMASS

Biomass production was stimulated significantly (fig. 1) by applying sludge, and plots could easily be identified in photographs taken from low-flying aircraft (fig. 2). Ragweed, approximately 1 m high in control plots and surrounding fields, grew to over 2 m in plots where the highest sludge rate was applied. Total weed biomass production was five times greater on plots receiving the higher sludge rate than in the control plots. Effects of subsoiling could not be detected.

SURVIVAL AND GROWTH OF PINE SEEDLINGS

Both shortleaf and loblolly pine seedlings planted in early spring had high initial survival rates and no indications of toxicity or mineral deficiency by June. By late August, however, growth of weeds where sludge had been applied was profuse and many pine seedlings, particularly shortleaf, were dying. Survival of both loblolly and shortleaf pine seedlings was lowest on plots receiving the most sludge. Only 22 percent of the shortleaf seedlings survived on plots receiving 69 met! :c tons/ha. Loblolly, while not as severely affected as shortleaf, also had lower survival rates in plots receiving higher rates of sludge application (fig. 3).

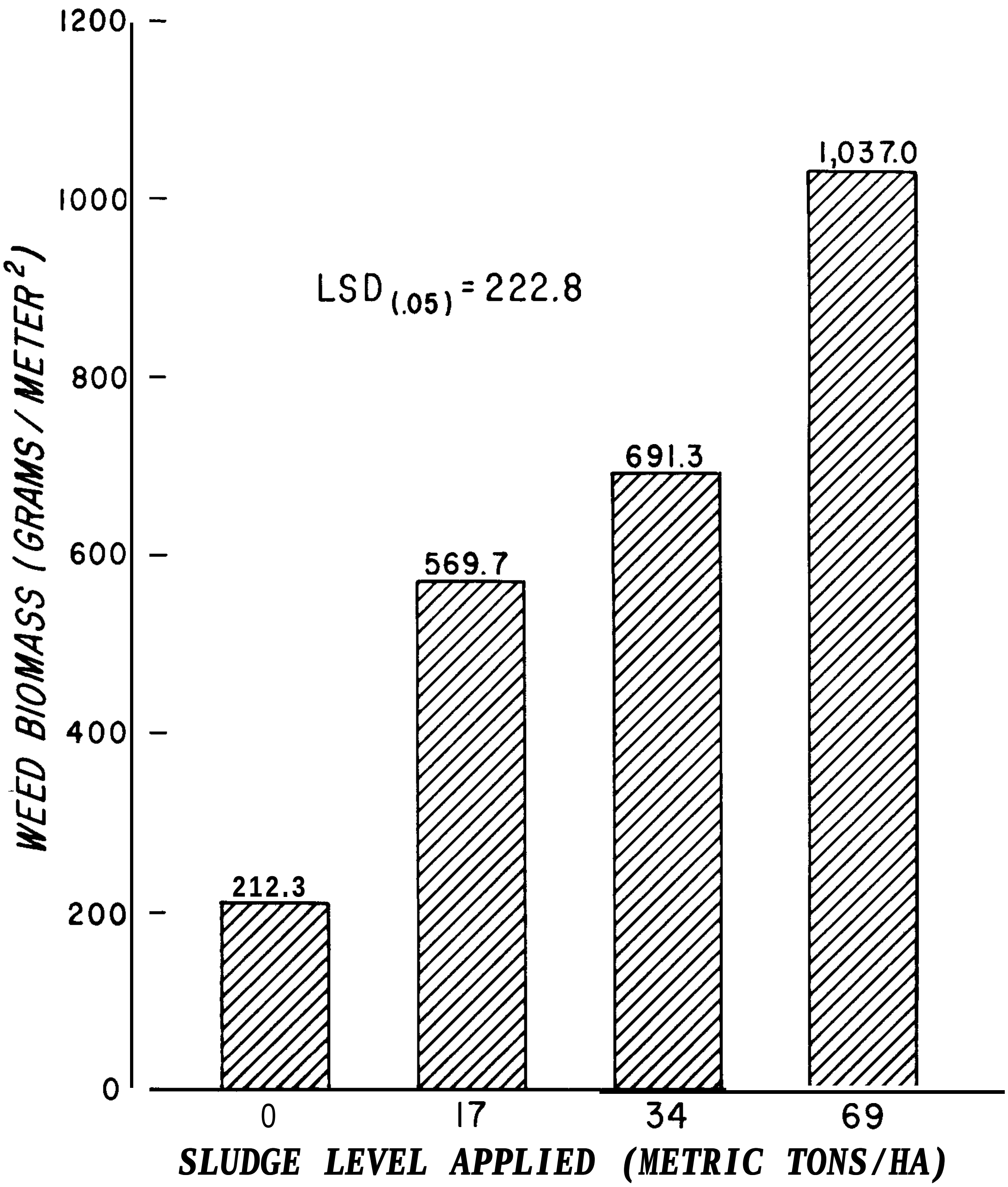

Figure 1. --Production of biomass by different rates of application of dried sewage sludge. NOTE: Each value represents the average for four subplots in each of three blocks; i. e. , those planted with both loblolly and shortleaf and those subsoiled and not subsoiled.

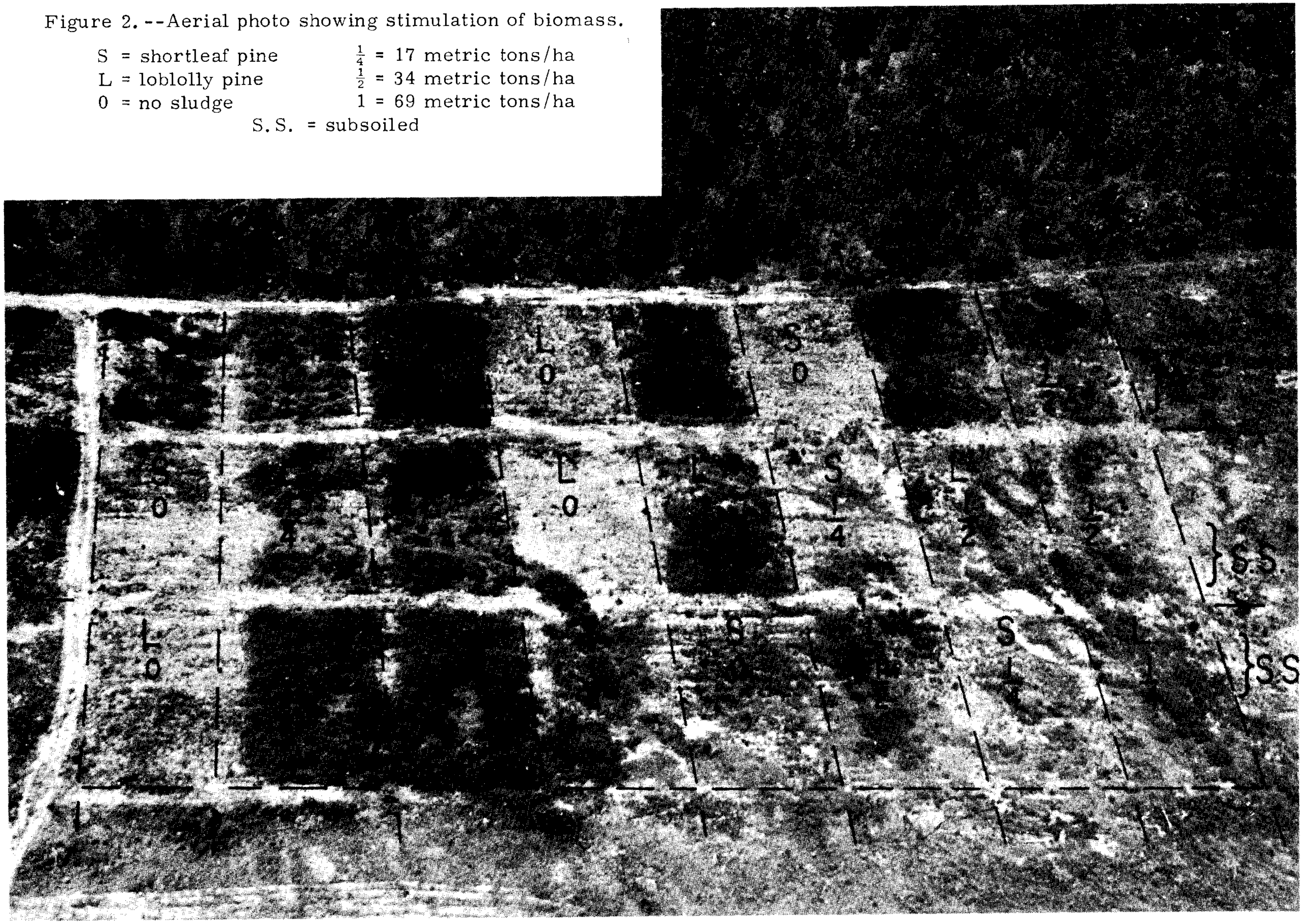

Figure 2. --Aerial photo showing stimulation of biomass.

S = shortleaf pine $\frac{1}{4}$ = 17 metric tons/ha
L = loblolly pine $\frac{1}{2}$ = 34 metric tons/ha
0 = no sludge 1 = 69 metric tons/ha
S.S. = subsoiled

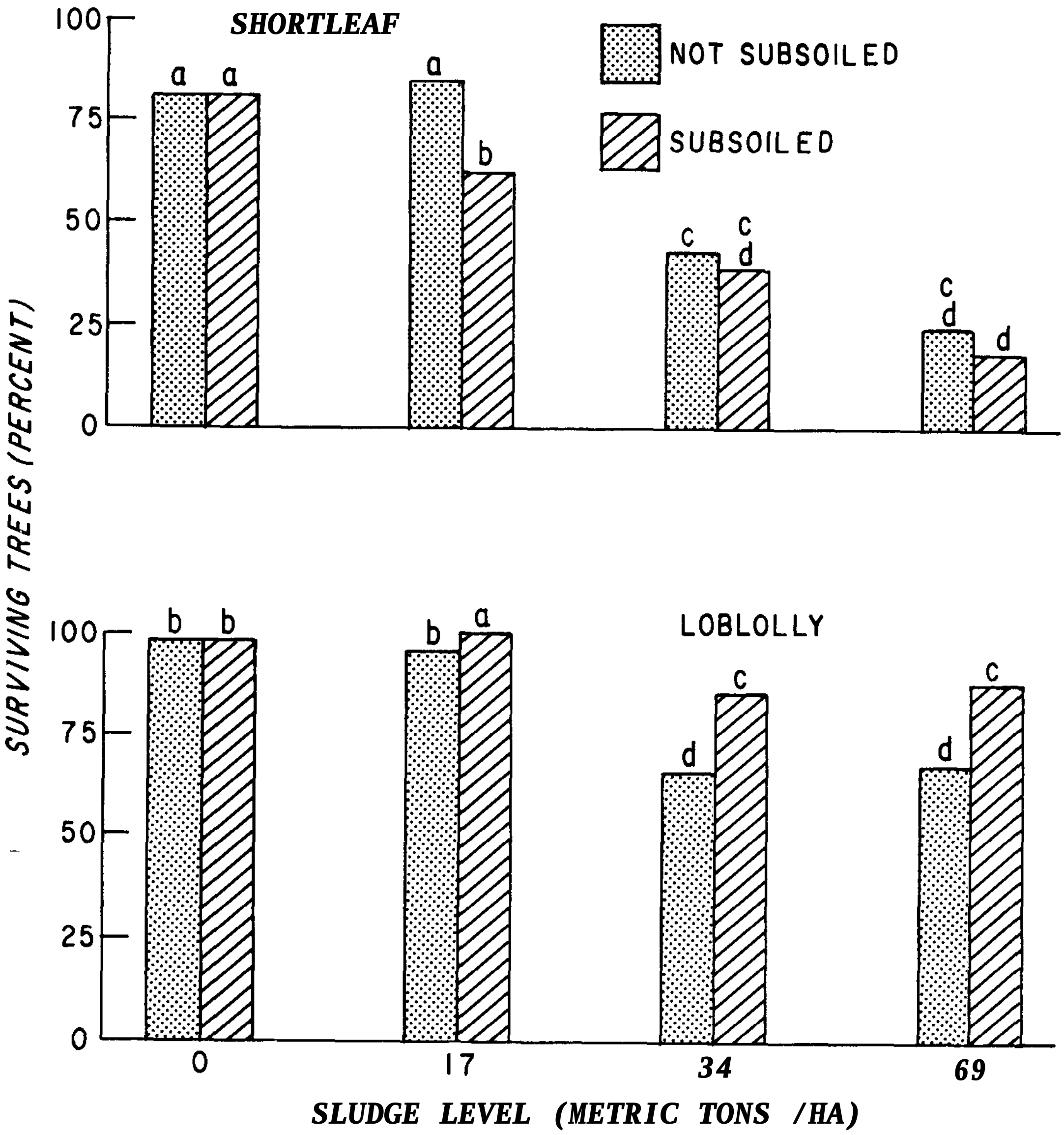

Figure 3. --Survival of pine seedlings on plots treated with dried sewage sludge. Bars capped with dissimilar letters differ statistically ($P \leq 0.05$).

Although height growth for both loblolly and shortleaf pine was slightly better on plots receiving the low sludge application rate (17 metric tons/ha), differences between treatments were not statistically significant. As with weed biomass production, no effect of subsoiling on pine seedling growth could be determined. There was, however, a slight improvement in survival of loblolly attributable to subsoiling on plots where sludge was applied (fig. 3).

CONCLUSIONS

Mortality of both pine species increased with increasing sludge levels, but shortleaf was affected much more than loblolly. Survival of loblolly on plots receiving the higher sludge rates, while statistically less than on control plots, was not regarded as poor. Survival of shortleaf on the control plots was also fairly good for a poor site, but the reduction to only 22 percent on the high sludge plots was completely unexpected. No signs of nutrient imbalance or toxicity were noted during the summer, indicating that competition was probably the main cause of seedling mortality.

The somewhat greater mean heights of seedlings of both pine species on plots receiving 17 metric tons/ha of sludge were not statistically different from heights on other plots. It is significant, however, that seedling growth was at least as good on plots receiving the lowest sludge application rate as on plots receiving the higher rates.

Stimulation of natural vegetation, even without a planted crop, will do much to reclaim eroded sites such as that studied. Encouraging growth of any vegetation, even crabgrass and ragweed, on many sites helps control erosion, and the organic matter produced will improve both physical and chemical characteristics of poor soils.

Before dried sewage sludge can be used most effectively as a soil amendment on poor forest sites, we need to know more about optimum levels for both short- and long-term effects. In this experiment, the best short-term effect (good survival of pines with good weed biomass production) was achieved by the lowest rate of sludge application (17 metric tons/ha). The exact amount of sludge needed for optimum growth for any given site will no doubt depend on soil and site characteristics and the species desired.

Subsoiling is becoming increasingly popular for the improvement of internal drainage of certain soils prior to tree planting. Although only a slight effect of subsoiling could be detected in this study, the timing of treatment may have been poor. Much of the effect of subsoiling was lost when the furrows were badly eroded before sludge application and planting 1 year after subsoiling,

LITERATURE CITED

Campbell, W. A., and 0. L. Copeland. Jr.
1954. Littleleaf disease of shortleaf and loblolly pines. U.S. Dep. Agric. Circ. 940, 41 p.

Evans, J. 0.
1973. Soils as sludge assimilators. Compost Sci. 14:16-21.

Gagnon, J. D.
1974. Results of fertilizer experiments in Quebec. In Proceedings workshop on forest fertilization in Canada. Can. Dep. Environ. Can. For. Serv. Tech. Rep. 5, p. 83-91.

King, L. D., and H. D. Morris
1972. Land disposal of liquid sewage sludge: 1. The effect on yield, *in vivo* digestibility and chemical composition of coastal Bermuda grass (*Cynodon dactylon* (L.) Pers.). J. Environ. Qual. 1:325-329.

Smith, W. E., and J. 0. Evans
1976. Application and disposal of wastes on forest land: Opportunities and problems. CRIFF Publ. 76-3. Univ. Fla., Gainesville.

Sopper, W. E.
1970. Revegetation of strip mine spoil banks through irrigation with municipal sewage effluent and sludge. Compost Sci. 11:6-11.

Zak, B.
1961. Littleleaf disease of shortleaf pine (*Pinus echinata* Mill.). p. 1525-1528. *In* Recent advances in botany. Univ. Toronto Press, Canada.

Charles R. Berry, Principal Plant Pathologist
Forestry Sciences Laboratory
Athens, Georgia