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Survival of Planted Tupelo Seedlings in F- and H-Area Tree-Kill Zones (U)

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SUMMARY

Swamp tupelo seedlings were planted in four areas which experienced previous tree mortality at the seeplines of the F- and H-Area Seepage Basins. The sites represented a range in severity of impact and stage of recovery. Seedlings were planted in February of 1994 and followed through the first growing season in the field. Survival on all sites through the first growing season was excellent, with greater than 92% of the seedlings still alive. Most seedlings appeared healthy with few external signs of stress. The performance of the seedlings will be followed in subsequent years to determine the physical state of the soil environment on seedling growth. Hopefully, the results will indicate that artificial reforestation can begin on similarly impacted sites prior to the beginning of natural revegetation of the site.

INTRODUCTION

Vegetation in several wetland areas below the F- and H-Area Seepage Basins were heavily impacted by the seepline contamination. When the damage first became evident in the late 1970's and early 1980's the areas were examined and described to try to establish the cause of the extensive tree mortality (Loehle and Gladden, 1988; Mackey, 1988; Haselow et al., 1990; LeBlanc and Loehle, 1990; Greenwood et al., 1990). The impacted stands were nearly pure stands of swamp tupelo (*Nyssa sylvatica* var. *biflora*) growing on highly organic, saturated soils. The F- and H-Area seepage basins above the wetland areas received waste products from the separation areas beginning in 1955. The operation, estimated loading, and current status of the basins were summarized by Killian et al. (1987a, 1987b). Analysis of soil and water at the affected seeplines where the tree-kill was occurring confirmed that the surface water was strongly influenced by constituents of the F- and H-Area seepage basins (Looney et al., 1988). While no single cause of the forest mortality was defined, alterations in the hydrology and siltation patterns, pH changes, increased conductivity, and increased levels of sodium, nitrogen compounds, and aluminum were considered to be possible causes of mortality. Soil and water concentrations of certain metals (other than sodium and aluminum) were somewhat elevated but were not considered likely causes of the observed mortality. A review of plant toxicity data by Greenwood et al. (1990) revealed no data for toxic responses to metals in *Nyssa sylvatica*, except for aluminum.

The results of subsequent sampling (Dixon and Rogers, 1993) have shown that the contamination at the seeplines from the basins (as indicated by tritium and specific conductivity measurements) has begun to subside as the plume moves into the wetlands and down gradient towards Fourmile Branch. Data in that report shows aluminum concentrations to have been 78,800 μg/L in 1989 and 856 μg/L in 1992 at sampling location F14 along the seepline. The same trend for aluminum at location F204 was seen, where the 1989 concentration was 35,900 μg/L and the 1992 value was 443 μg/L. Characterization of natural revegetation that is occurring in two of the most impacted areas has been described (Nelson and Irwin, 1994; Westbury and Nelson, 1994). In an effort to reestablish the climax species of the area, swamp tupelo (*Nyssa sylvatica* var. *biflora*) seedlings were planted in four of the impacted areas.

METHODS AND MATERIALS

Four areas which have experienced tree mortality at the seeplines of the F- and H-Area Basins were selected for inclusion within this study. They were named for the quarterly tritium sampling location (Dixon and Rogers, 1993) nearest the edge of the area and were designated F14, F47, F204, and H38 (Figures 1 and 2). The areas represented a gradient of impact level to the vegetation, with F14 and F47 being most severely damaged, F204 the least damaged, and H38 as intermediate. Natural revegetation of the areas reflects the original damage level, with little revegetation at F14 and F47, early successional species invasion of H38, and a moderate shrub and herbaceous layer occurring in F204.

Soils varied in degree of impact among the four sites tested. F14, F47, and F204 have soils classified in the Great group, Fluvaquents. Characteristic of this great group are a number of sandy or loamy layers of recent alluvium in the top 150 cm of the profile. A small percent of the areas have surface or buried mucky horizons 10 to 25 cm thick. F204 is the only one of the "F" group with recent (past 50 years) deposition resulting from erosion. There appears to be sufficient overburden to have caused tree mortality. Sites F14 and F47 show no impact from recent deposition, but there is evidence of destruction of normal soil structure, apparently by dispersion of the soil particles. Sodium values in the range of 118,000 µg/L were recorded by Haselow et al. (1990) in the edge of the wetlands. This concentration of sodium may have caused the dispersion.

Soils in site H38 are classified in the Great group, Paleaquults. Characteristic of this great group is a sandy surface layer over loamy subsoil material. The wetland soils down gradient from H-Area Seepage Basins have areas which have received recent (past 30 years) sediment deposition 1 to 20 cm thick, which eroded from excavated spoil piles adjacent to the basins. Texture of this material ranges from medium sand at the edge of wetland soil to clay in the lower part of the site. The amount of sediment may have been sufficient to impact vegetation in the H38 wetland.

Each of the study areas was planted with swamp tupelo seedlings in early February 1994. The seedlings used were two-year old container grown stock. The stock ranged from 20 to 60 cm in height and 2 to 6 mm in root collar diameter. They had been raised in tanks under near-surface flooded conditions during most of the year. Seedlings were selected for uniformity within each of the planting sites, based mainly on root collar diameter of the seedling. Seedlings were extracted from their container, the root ball broken up slightly, and planted with a standard planting bar. Seedlings were planted at a density of approximately 150 seedlings per acre. Seedlings were planted on better planting locations rather than on a strict spacing basis because of the highly variable nature of the soils and debris in each area. No other site preparation took place at the planting spot. Each of the seedlings was marked with a pin-flag to aid in relocating and identifying the planted seedlings for later evaluation.

An initial survival tally of the seedlings was taken on June 7, 1994. This tally was taken to determine initial budbreak and vigor of the seedlings. This tally would provide an indication of the quality of the planted stock. Much of the initial spring performance is a carryover of prior nursery conditioning (Sutton, 1988). Seedlings at each site were found and placed into one of five condition classes. Class 1 were vigorous, healthy seedlings. Class 2 seedlings had broken bud and were growing, but showed slight stunting or discoloration of the leaves or other stress symptoms. Class 3 plants had resumed growth but had died shortly thereafter. Class 4 seedlings were dead with no indication of budbreak. These seedlings probably were not in good condition for field planting. Class 5 seedlings were missing. In this class, the seedling may have died and been broken off or have been cut off by the animal populations (e.g. deer, beaver, feral hogs, etc.).

A late season tally of the seedlings was conducted September 13, 1994. This tally was used to determine how well the seedlings had performed in their new environment after their initial budbreak. Performance after budbreak through the first growing season would be indicative of how well the root system had been able to utilize it's environment. The same five classes were used. Because of the time between the two tallies, most of the seedlings in class 3 in the initial tally were expected to be class 4 or 5 in the year end tally. Seedlings in class 3 at the year-end tally were ones which had died during the growing season.

In both tallies, nearly 85% of the planted seedlings were found and assessed. Unaccounted for seedlings were either located in thick vegetation and the pin-flag not visible or had had the pin-flag removed or displaced for some reason. Most of the unaccounted for seedlings were in the F204 and H38 sites, which had some dense areas of vegetation within them.

RESULTS AND DISCUSSION

Of all seedlings assessed in the initial budbreak tally, over 93% were class 1 or 2 seedlings (Table 1), and only 6.5% were in classes 3, 4, and 5. Little difference was seen among the individual planted areas regarding healthy seedlings (Figure 3). Classes 3, 4, and 5 (dead or missing) have been combined for graphical purposes. The F204 site had higher percentages of class 4 and 5 seedlings. This site still has some overstory trees and light was more limiting in this area than the other three. Some instances of browsing and clipping of seedlings at site F204 were seen, probably due to deer and rabbit populations. The high percentage of seedlings that broke bud after planting (94.2%) indicates the quality of the container-grown seedlings was not reduced prior to their being planted.

Condition of the seedlings after the first growing season, as indicated by class 1 and 2 seedlings, continued to be very good. The percentage of all seedlings in classes 1 and 2 continued to be high (92.1%) (Table 2). Site F14 had a slightly higher percentage of class 1 seedlings, while site H38 had the lowest instances of class 3, 4, and 5 seedlings (Figure 3). At all sites, the percentage of seedlings in class 1 increased between the two tallies. This increase came from class 2 seedlings being able to establish themselves after the initial shock of planting and produce more vigorous growth than was seen during the first tally. Some mortality occurred over the growing season, but was very minimal. Of all seedlings planted and assessed, only 7.9% of the seedlings were dead or missing. This mortality rate is considerably below that of a normal forestry operation, even on productive, non-contaminated soils. Subsequent years of growth will be very informative to determine whether these type of tree-kill zones can be reforested in this manner.

Between the two tallies, the root systems of the seedlings had to expand and begin to uptake nutrients and water from their soil environment. Much of any seedlings energy during the year after it is transplanted from one environment to another is directed towards the root system to produce new root mass, balance out the biomass proportion of the seedling, and acquire resources necessary for growth (Hobbs, 1988). Height growth during the first year is therefore only minimally correlated with the seedling establishment process. Height growth of most of the seedlings during the growing season was generally only 10 to 20 cm, and many individuals had dieback of the original stem. Starting with measurements after the second growing season, seedling height may be useful to describe how well the seedlings are responding to the soil chemistry and physical conditions of the four different sites.

The level of initial damage and soil disruption was not a good predictor of seedling performance. Sites F14 and F47 had nearly 100% vegetation mortality and considerable soil disruption. Initial impacts of chemical and physical stressors was greatest on these sites and the residual affects continue to be most pronounced. Revegetation has been very limited and seed that has germinated is producing very stressed plants with slow growth and poor leaf color. It was anticipated that these sites would have little survival of the planted seedlings after the first year. We anticipated sites H38 and F204 to have a better chance of success due to the early successional species that were establishing themselves. This, however, has not been the case through the first growing season. The most impacted site (F14) had the highest proportion of seedlings in class 1 condition at the end of the first growing season. Because seedlings were planted in the more favorable planting locations of the sites, we had hoped to improve initial survival and give the seedlings a chance to get established. The root zone that the seedlings have occupied may be less stressful than the general sites. If this is the case, during the next cycle of root growth, seedling roots may be growing into the more contaminated surrounding areas and show a response to the stress in subsequent years.

Seedlings planted in the two most impacted area (F14 and F47) had leaves with a deeper shade of green than the other two areas. This is probably an indication of the higher nitrogen availability at these two sites as a carryover of the seepline contamination that caused the original tree mortality.

Tallies are scheduled to occur shortly after the 1995 spring budbreak to estimate overwinter damage to the seedlings, and after the 1995 growing season to determine second season performance. Depending on the second year growth characteristics of the seedlings on the different sites, some destructive sampling of the seedlings may be done to assess root growth and health, as well as biomass accumulation and distribution.

CONCLUSIONS

Survival of swamp tupelo seedlings after the first field growing season has been excellent on all four of the affected sites examined. The first year after planting is characteristically spent by the seedling establishing contact with it's new environment. Measurements in the next few years will give information on how well the seedlings tolerate an environment which still has some of the original stressors that are believed to have caused the initial tree mortality to occur.

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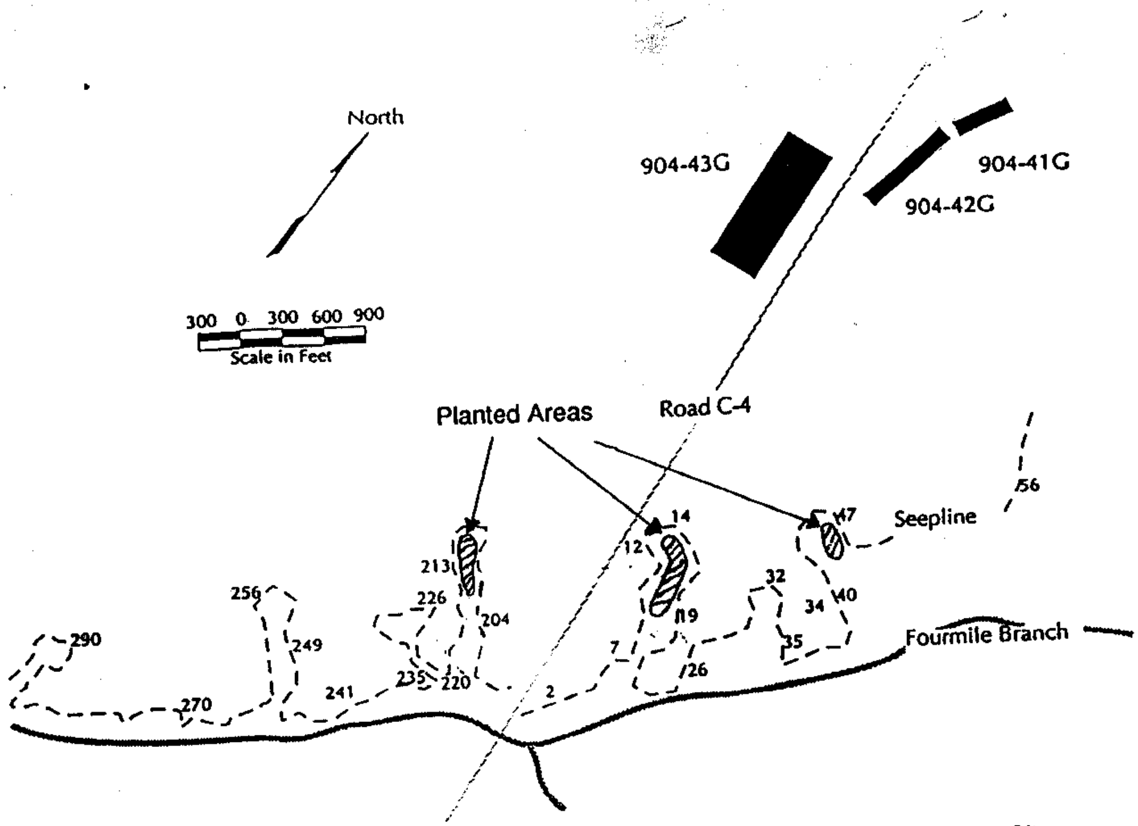


Figure 1. Location of F-Area Seepage Basins, Seepline Sampling Points, and Planting Sites.

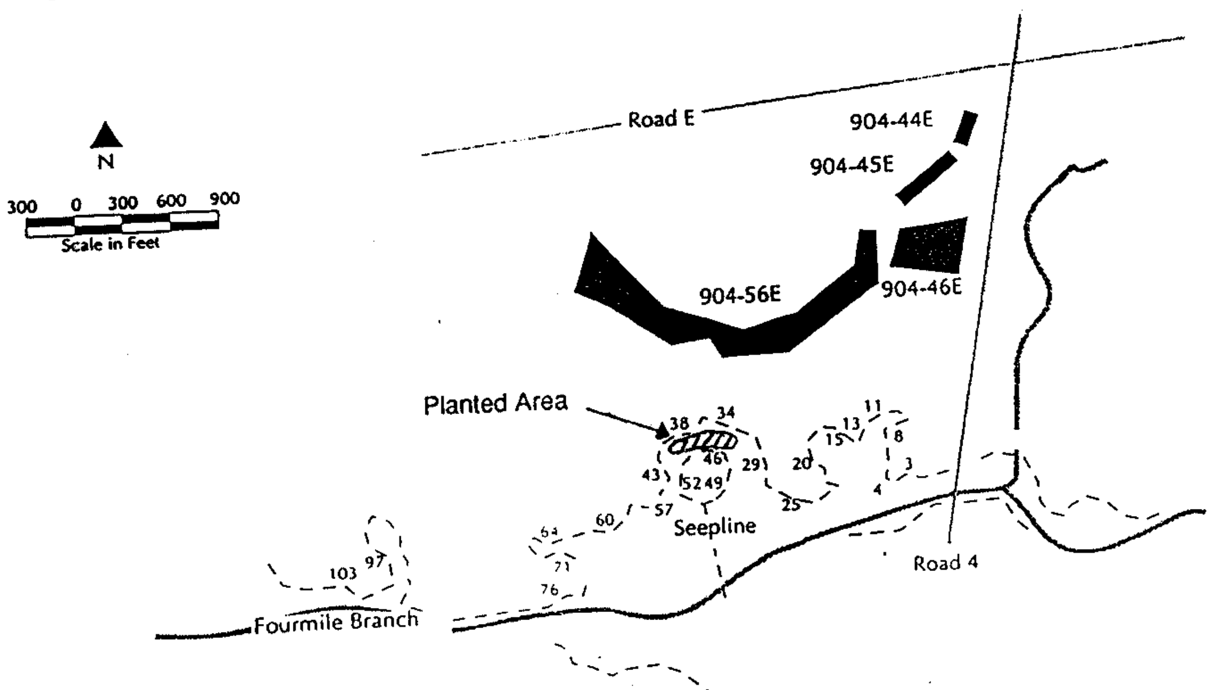
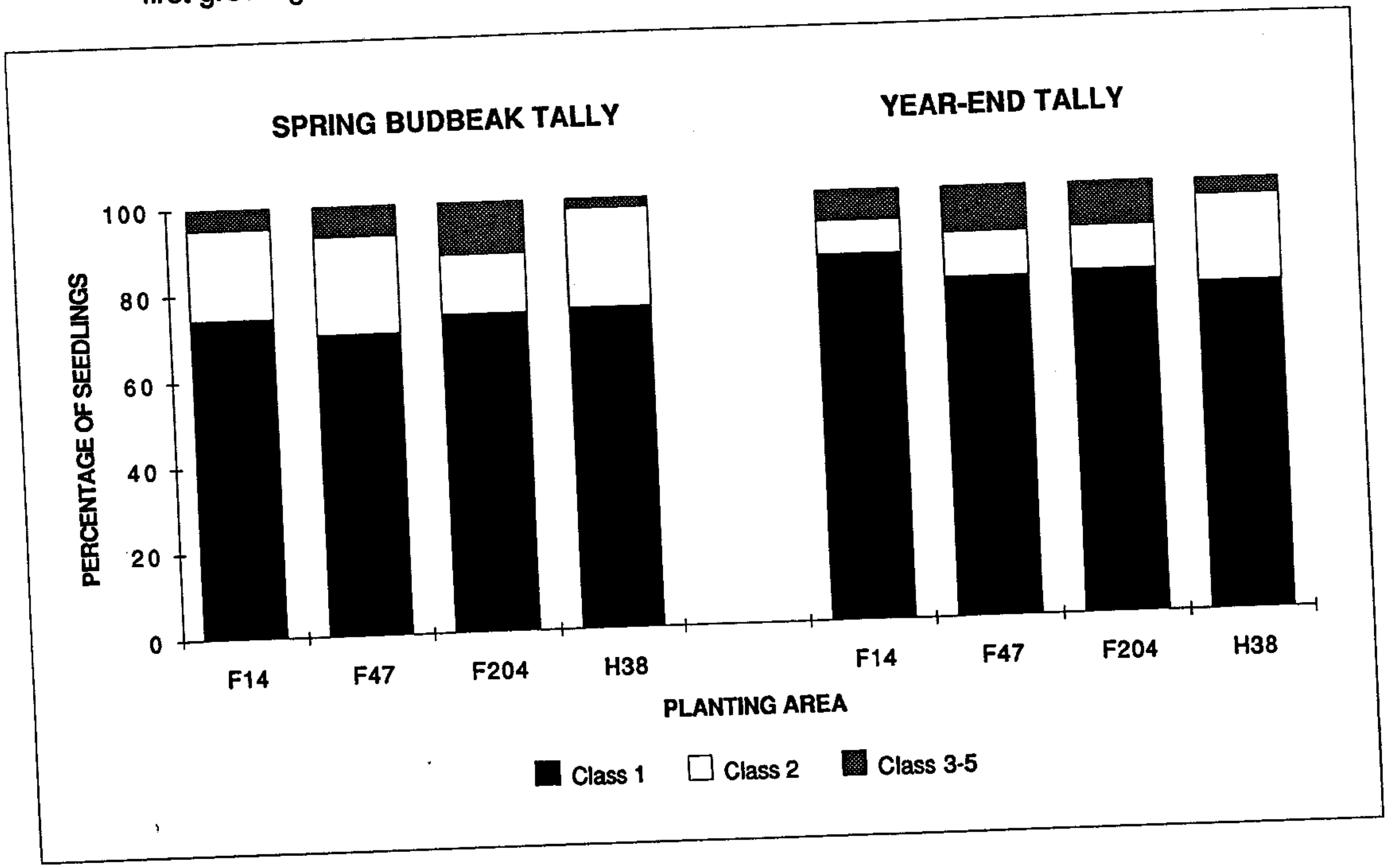


Figure 2. Location of H-Area Seepage Basins, Seepline Sampling Points, and Planting Site.

Figure 3. Percentage of seedlings in each class at the test sites at spring budbreak tally and after first growing season tally.



CONDITION CLASS KEY

1 = Healthy
2 = Leafed out but stressed
3 = Leafed out but dead
4 = Dead, not leafed out
5 = Missing

Table 1. Percentage of seedlings in each condition class during initial budbreak tally.

			CLASS		
SITE	1	2	3	4	5
F 14	74.4	20.8	0.0	4.8	0.0
F 47	70.4	22.5	2.8	1.4	2.8
F 204	74.1	13.8	0.0	5.2	6.9
H 38	74.7	23.1	0.0	0.0	2.2
AVERAGE	73.4	20.1	0.7	2.8	3.0

Table 2. Percentage of seedlings in each condition class during end of growing season tally.

			CLASS		
SITE	1	2	3	4	5
F 14	85.2	7.8	0.8	2.3	3.9
F 47	78.9	10.5	2.6	5.3	2.6
F 204	79.7	10.1	1.3	6.3	2.5
H 38	76.3	20.0	0.0	1.3	2.5
AVERAGE	80.0	12.1	1.2	3.8	2.9

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