INTERPLANTING LOBLOLLY PINE WITH NITROGEN-FIXING NURSE TREES ON A RECLAIMED SURFACE MINE IN VIRGINIA [1]

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Abstract: In 1980, an experiment was established to study the effect of interplanting loblolly pine (*Pinus taeda*) with nitrogen-fixing nurse-trees. The study area was surface mined and reclaimed in 1979. In accordance with current reclamation regulations, the site was revegetated with an herbaceous ground cover which included perennial legumes. Loblolly pine was planted on a 3 m by 1.5 m spacing and interplanted with either 1) black locust (*Robinia psuedoacacia*), 2) black alder (*Alnus glutinosa*), or 3) no nurse-tree (control treatment). After nine years, the growth of the pines was not improved by the nurse-trees. Soil nitrogen and forest floor litter nitrogen contents were about 10% higher in the nurse-tree treatments, but the additional nitrogen did not result in improved nitrogen nutrition for the pines as evidenced by foliar nutrient analysis. Apparently the herbaceous legumes provided enough nitrogen to serve the needs of the loblolly pine during this nine year study.

Additional Key Words: reclamation, productivity.

Introduction

Nitrogen is the nutrient element required in greatest quantity by most trees and other plants. Unlike all other plant nutrient elements, plant available nitrogen is not derived from the weathering of soil parent material. Nitrogen must enter the soil indirectly from the atmosphere, through fixation by micro-organisms and by incorporation of plant biomass. An important consideration for forest land reclamation is the need to establish a plant community which includes some species capable of fixing nitrogen such that soil organic matter and nitrogen levels will increase through time and be able to support long-term forest productivity.

Conceptually it seems logical that revegetation of reclaimed forest land should include herbaceous and woody nitrogen fixing species. Perennial herbaceous legumes such as birdsfoot trefoil (*Lotus corniculatus*), Serecia lespedeza (*Lespedeza cuneata*), and crown vetch (*Coronilla varia*) are able to survive on minesoils and are capable of fixing substantial amounts of nitrogen in the first few years after reclamation. Nitrogen fixing shrubs and trees could provide additional nitrogen, especially in later years when the ground cover declines because of shading by the trees and from the accumulation of a leaf litter layer.

The benefits of nitrogen fixing nurse-trees such as black locust and black alder are well known. Both species have the ability to substantially increase minesoil nitrogen levels. In a study of soil nitrogen on reclaimed sites that had been seeded with black locust in West Virginia, Jencks

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et al. (1982) reported soil nitrogen levels of 2,964 kg/ha under the black locust at year 18 compared with a soil nitrogen level of 2,808 kg/ha in the adjacent native forest soil. In a 30-year-old reclaimed site with 80% black locust cover in southwestern Virginia, Li (1991) reported a soil nitrogen level of 2,558 kg/ha in the surface 5 cm. Vogel (1981) cited examples where the growth of crop trees such as loblolly pine was improved by the presence of interplanted black alder.

Most of the published research concerning the interplanting benefits of black locust and black alder, however, was conducted before the enactment of the Surface Mining Control and Reclamation Act (SMCRA). SMCRA requires the establishment of an herbaceous ground cover, and most coal operators include perennial legumes in the ground cover mixture. It is unknown if nitrogen-fixing trees and shrubs can significantly increase soil nitrogen availability above the levels provided by herbaceous legumes. Consequently, this study was established in 1980 to study the benefits of interplanting loblolly pine with two nitrogen fixing species (black locust and black alder) on a site revegetated with a standard reclamation ground cover which included Kentucky-31 tall fescue (*Festuca arundinacea*) and Serecia lespedeza.

The objective of this study was to determine if interplanting with black locust or black alder would increase soil nitrogen levels, increase nitrogen availability to loblolly pine, and increase the growth of loblolly pine.

Methods

This experiment was established as part of an ongoing 15-year forestry reclamation research and extension program sponsored by the Powell River Project. The study is located near Wise Virginia. The area was surface mined and reclaimed in 1979. The study area had approximately 5% slope with a northwesterly aspect. The overburden type was a mixture of sandstone and siltstone. The site was hydroseeded with a standard reclamation ground cover which included Kentucky-31 tall fescue and Serecia lespedeza. Loblolly pine was planted across the entire study area on a 3-meter X 1.5-meter spacing. Three interplanting treatments were replicated with three blocks. Loblolly pine was interplanted with either: 1) no nurse-tree (control), 2) black locust, or 3) European black alder. Each plot had five rows of loblolly pine, approximately 100 meters long. Rows of nurse trees were planted between the rows of pine, with 3 meters spacing in rows of nurse trees.

After nine years, total height and diameter at breast height (1.5 meters high) were measured on loblolly pine. A composite loblolly pine foliage sample was collected from each plot during the winter. Foliage was collected from each tree by sampling the last fully elongated flush of needles from the south side of the upper crown. The foliage was dried to a constant weight at 65 C and ground to pass a 1mm screen. Foliar nitrogen was extracted using a Kjeldahl digestion procedure and analyzed with a Technicon AutoAnalyzer II.

To determine nitrogen content in the forest floor, litter samples were collected from nine sample points in each plot. All litter from a 50 cm x 50 cm area was collected, dried to a constant weight, ground, and analyzed for nitrogen content.

To determine nitrogen content in the surface 5 cm of soil, soil samples were collected from below the nine litter sampling points in each plot. All soil within a 25 cm x 25 cm area was collected. After sieving coarse fragments (>2mm), air-dried soil was weighed. Total nitrogen was determined using a Kjeldahl digestion procedure. For a comparative assessment of relative nitrogen availability, anaerobic mineralizable nitrogen was extracted following the methods of Keeny (1982).

The experiment was statistically analyzed with analysis of variance procedures for a complete randomized block design, with three treatments and three blocks. Treatment effects were considered statistically significant if the probability of occurrence by random chance (alpha level) was less than 5%.

Results

After nine years, the average loblolly pine height was approximately 5.6 meters. Based on published site index curves for loblolly pine (Amateis and Burkhart, 1985), the land has an estimated loblolly pine site index (based age 50) of about 21 meters (70 ft), which is an average level of productivity for loblolly pine on the southern Piedmont where loblolly pine is grown commercially.

The interplanting treatments had no beneficial effect on loblolly pine height, diameter, or stem volume (Table 1). Although there were no statistically significant treatment effects, there was a tendency for pines in the control plots to have a greater stem diameter and live-crown ratio, indicating that the nurse-trees may be starting to have a negative competitive influence on the pine.

Table 1. Effect of interplanting treatment on loblolly pine height, diameter and volume.

Interplanting Treatment	Tree Height	Stem Diameter	Stem Volume
	-m-	-cm-	-m^3-
Control	5.4	9.9	0.262
Black locust	5.7	9.6	0.261
Black alder	5.6	9.4	0.248

The amount of nitrogen in the soil and litter of the black locust and black alder plots was about 10% greater than the control plots, but the differences were not statistically significant (Table 2), and they didn't correspond with increased nitrogen uptake or improved growth by the pines. Based on foliar nitrogen levels, nitrogen was not a growth limiting factor. The average nitrogen concentration for all trees was above 1.2%, a commonly accepted critical foliar nitrogen concentration for loblolly pine (Hockman and Allen, 1980).

Table 2. Foliar, litter, and soil nitrogen as affected by interplanting treatment.

Interplanting Treatment	Foliar Nitrogen	Litter Nitrogen	Total Soil Nitrogen	Mineralizable Nitrogen
	%	kg/ha	kg/ha	ppm
Control	1.26	180	680	60.5
Black locust	1.34	240	777	68.6
Black alder	1.26	193	779	68.1

The lack of a beneficial nurse-tree effect attributable to improved nitrogen nutrition is contrary to results for black locust reported by Finn (1953) and for black alder reported by Campbell and Dawson (1989) and Plass (1977). It is likely that the herbaceous legumes, particularly Serecia lespedeza, contributed enough nitrogen to meet the needs of the pines during the nine years of this study. Some perennial legumes can provide large and rapid inputs of nitrogen to minesoils (Bradshaw, 1987). Schoenholtz (1990) reported that a reclamation ground cover which included birdsfoot trefoil, appalow lespedeza (*Lespedeza cuneata* cv. *"appalow"*), and kobe lespedeza (*Lespedeza stipulacea*) increased minesoil nitrogen levels at annual rates of greater than 250 kg N/ha/yr for the first three years of a lysimeter study.

When a vigorous, leguminous ground cover is established on surface mined land, the nitrogen input from the herbaceous legumes may be adequate to meet the needs of some planted crop tree species. It is still conceivable, however, that nurse-trees may be important in future years of this study when the loblolly pines reach stand closure and they have a greater demand for nitrogen. When stand closure results, the ground cover will become almost non-existent from overstory shading and the accumulation of a dense litter layer. At that point in time, the additional soil nitrogen in the nurse-tree plots may be utilized by the pines. It should also be noted that loblolly pine has a relatively small nitrogen demand compared to other crop tree species, especially some hardwoods. Results of this study should not be interpreted to conclude that there would probably be no nurse-tree benefit to some of the more nutrient demanding tree species.

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