ESTABLISHMENT OF FOUR SPECIES OF NATIVE HARDWOODS ON RECLAIMED MINED LANDS IN PENNSYLVANIA[1]

by

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Abstract. Native hardwoods are seldom used in mined land reclamation in Pennsylvania due to a variety of ecological factors, such as competition with herbaceous plants. We evaluated the first year survival of 4 species of native hardwood seedlings planted into low and high competition areas on 6 mined sites, 3 each in 1991 and 1992, in northcentral Pennsylvania. The herbaceous vegetation planted consisted of K-31 tall fescue or perennial ryegrass, birdsfoot trefoil, red clover, and white clover. The tree species were black locust, quaking aspen, red maple, and red oak. Measurements of herbaceous ground cover and seedling survival were taken at the end of 1 growing season. Herbaceous ground cover was less in low than in high competition areas on 5 of 6 study sites. Survival of all 4 species of seedlings planted in 1991 had higher survival in low compared to high competition areas, whereas only red maple and red oak seedlings planted in 1992 had higher survival in low competition areas. Black locust and quaking aspen had the highest survival for combined low and high competition areas, whereas red oak had the lowest survival. Red maple survival was intermediate. Climatic conditions may have influenced survival of seedlings in 1991 and 1992. Initial results indicated that reducing the amount of herbaceous cover increased seedling survival after 1 growing season.

Additional key words: Competition, hardwoods, reforestation

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Introduction

Revegetation of mined lands currently focuses on establishing dense herbaceous cover to stabilize soil and control erosion and sedimentation. However, previous research has shown dense herbaceous cover may reduce the survival and growth of tree seedlings (Ashby 1990, Ashby et al. 1988, Davidson et al. 1984, Hughes and Garthe 1989, Smith 1980, Strock 1980, Vogel 1980). Wade (1989) found that grasses used in reclamation are very competitive and impede the invasion of native herbaceous and tree species. Woods et al. (1978) found that grasses caused mortality in pitch pine (Pinus rigida) and Virginia pine (Pinus virginiana) seedlings planted on reclaimed mined lands.

Recontouring, liming and fertilizing, seeding with grasses and legumes, and mulching are cost-effective ways to satisfy current regulatory requirements and recover bond monies. Grasses and legumes are commonly used in reclamation because of their vigor, availability of seed sources, and reported success in erosion control (Ashby et al. 1988).

A variety of tree species have been used to reforest mined lands for forest and wildlife management in Pennsylvania. Tree species typically used are exotics such as Japanese larch (Larix japonica). Black locust (Robinia pseudoacacia) and red pine (Pinus resinosa) are also used, but Pennsylvania is on the northern edge of the black locust range and the southern end of the red pine range (Ashby et al. 1985, Kolar and Ashby 1978). Native hardwoods are seldom used in reclamation, and marginal success was reported when they were used (Davidson et al. 1990). To promote the use of native trees on reclaimed mine lands, research is needed to determine how to minimize any adverse effects of various ecological factors on tree growth and survival. The objective of our study was to determine and compare the survival and growth of 4 species of native hardwoods planted into 2 levels of herbaceous cover and 2 levels of potential deer browsing.

Methods

Six study sites, 3 each in 1991 and 1992, were established in the bituminous coal region of western Pennsylvania. At each site, we created 2 levels (low and high) of herbaceous seeding. After the first growing season, deer exclosures were constructed around one-half of each site, resulting in a randomized split-split plot design with 2 replications per site. Herbaceous mixtures were seeded in April and May of 1991 and 1992. High competition areas were planted using a seed drill with no ports plugged so that the area was completely (100%) seeded. Low competition areas were planted using a seed drill with 1/2 of the ports plugged so that the area consisted of seeded and unseeded strips, with 50% of the area being seeded. Herbaceous seed mixtures consisted of K-31 tall fescue (Festuca arundinacea) or

perennial ryegrass (Lolium perenne), birdsfoot trefoil (Lotus corniculatus), and clovers (Trifolium spp.). Herbaceous communities included plant species in the seeded mixture, other seeds contaminating the mixture, and species invading from areas adjacent to the study sites.

We measured herbaceous communities to quantify differences in plant development in the low and high competition areas; sites planted in 1991 were monitored during August and September 1991 and sites planted in 1992 were measured during July and August 1992. The percent cover of each species and all species combined was estimated by locating and sampling in 0.5-m x 1.0-m plots. One hundred and twenty-eight plots were measured in the high competition condition on each study site. Two hundred and fifty-six plots, 128 each in the seeded and unseeded strips, were measured in the low competition condition on each study site.

One-year-old seedlings of 4 species were handplanted in each high competition area and in unseeded strips of each low competition area in May and June of 1991 and 1992. Species planted were red oak (Quercus rubra), red maple (Acer rubrum), quaking aspen (Populus tremuloides), and black locust.

We examined each seedling and recorded whether it was alive or dead after 1 growing season. Survival was determined in September of 1991 on sites planted in 1991 and in September of 1992 on sites planted in 1992. Because deer exclosures were not completed until after survival measurements were taken, an evaluation of the effects of deer on seedling survival is not included in this report.

Results and Discussion

Herbaceous ground cover in the unseeded portion of the low competition areas was lower than in high competition areas on 5 of 6 study sites (Table 1). The one exception was at the Harmony site where herbaceous cover in low competition areas was the same as in high competition areas. This exception may be due to greater invasion of plants from surrounding areas as compared to the other study sites. Herbaceous ground cover was markedly higher at all sites in 1992 compared to 1991 (Table 1).

Survival of all 4 species of hardwoods was higher in low competition areas compared to high competition areas after 1 growing season at sites established in 1991 (Figure 1). In 1992, survival of red maple and red oak was also higher in the low competition areas; survival of black locust and quaking aspen, however, was the same for the low and high competition areas. Quaking aspen planted in 1991 and red oak planted in 1991 and 1992 exhibited the greatest difference in survival between the low and high competition areas (Figure 1).

Seedling survival, based on the combined data for low and high competition areas, indicated that over 74% of the black locust were alive after 1

Table 1. Average percent herbaceous cover in low and high competition areas after 1 growing season on 3 mined sites reclaimed in 1991 and 3 sites reclaimed in 1992.

	COMPETITION			
	LOW			HIGH
	UNSEEDED STRIPS	SEEDED STRIPS	SEEDED & UNSEEDED	
1991 SITES				
Kylertown I	7	28	18	20
Brandy Camp	13	44	29	32
Harmony	24	45	35	24
1992 SITES				
Kylertown II	41	72	57	75
Brockport	46	79	63	75
Clearfield	19	79	49	71

growing season (Figure 1). Survival of quaking aspen exceeded 90% in 1992, compared to only 53% in 1991. Survival of red oak seedlings was lower than that of other species, whereas survival of red maple was intermediate among the other species.

Differences in survival of seedlings between 1991 and 1992 may have been due to differences in climatic conditions between years. Air temperature was above normal and precipitation was below normal during 1991 (Figures 2 and 3). Cooler air temperatures persisted throughout 1992 and there was more precipitation in July, August, and September of 1992 (Figures 2 and 3) than in 1991; these conditions may have provided better growing conditions during 1992.

Because of a unique life history strategy, each tree species may have responded differently to herbaceous cover, climatic conditions, or a combination of both factors. Black locust and quaking aspen are early successional species that are shade intolerant and grow best on moist, rich soils (Harlow et al. 1979). The increased precipitation and cooler temperatures in 1992 may have created more favorable growing conditions for these species and increased their survival during 1992.

Red oak is intermediate in shade tolerance and grows best on fine-textured, well-watered soils (Harlow et al. 1979). The course structure and poor water-holding capacity of mine soils may create conditions less than favorable for red oak, resulting in relative poor survival. Red maple is

Figure 1. Average first year survival of 4 species of native hardwoods planted in 2 levels of herbaceous cover at 3 study sites established in 1991 and at 3 sites established in 1992 in northcentral Pennsylvania.

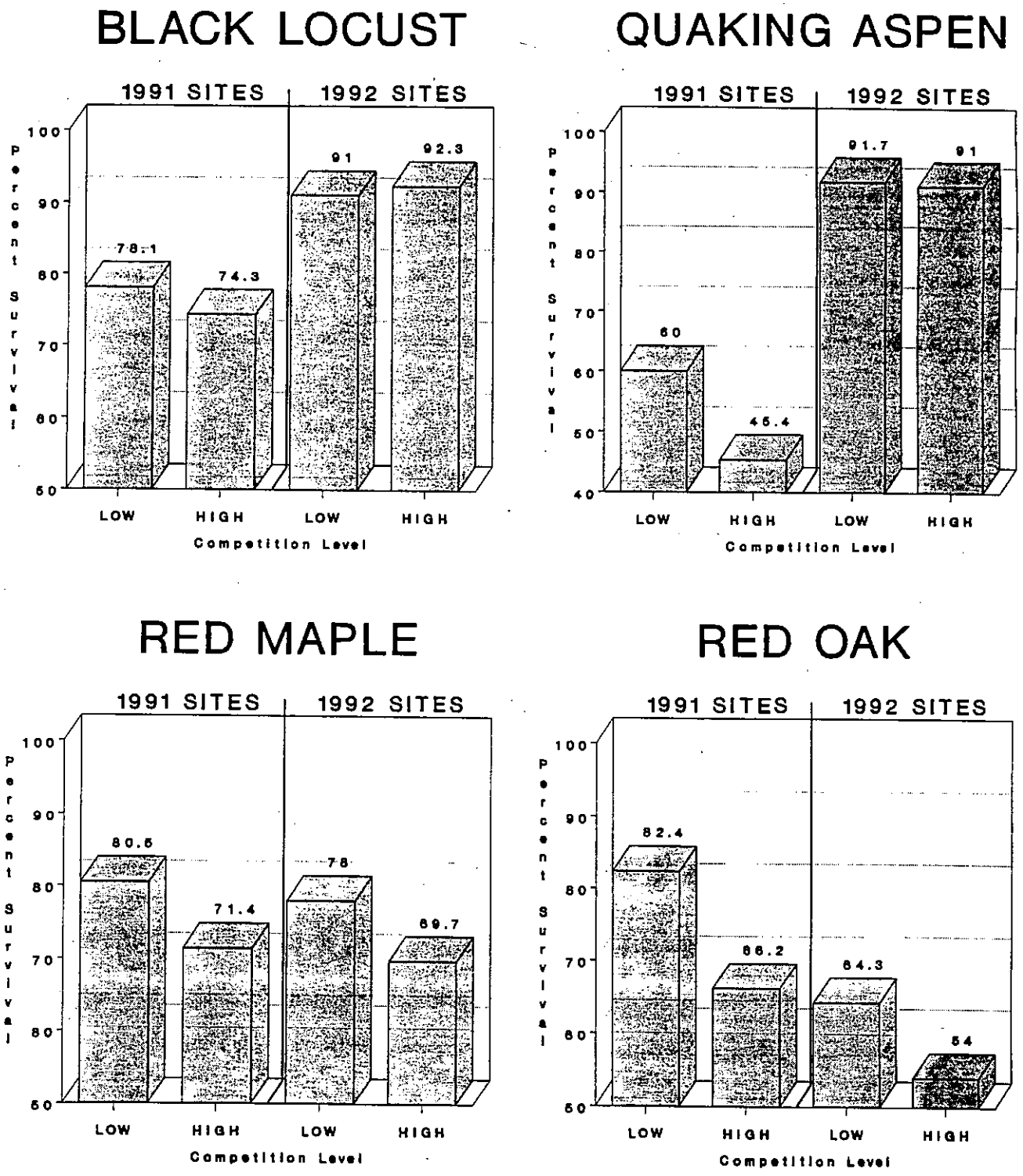


Figure 2. Average monthly air temperature for March thru September, 1991 and 1992, and normal temperatures for the 6 study areas in northcentral Pennsylvania.

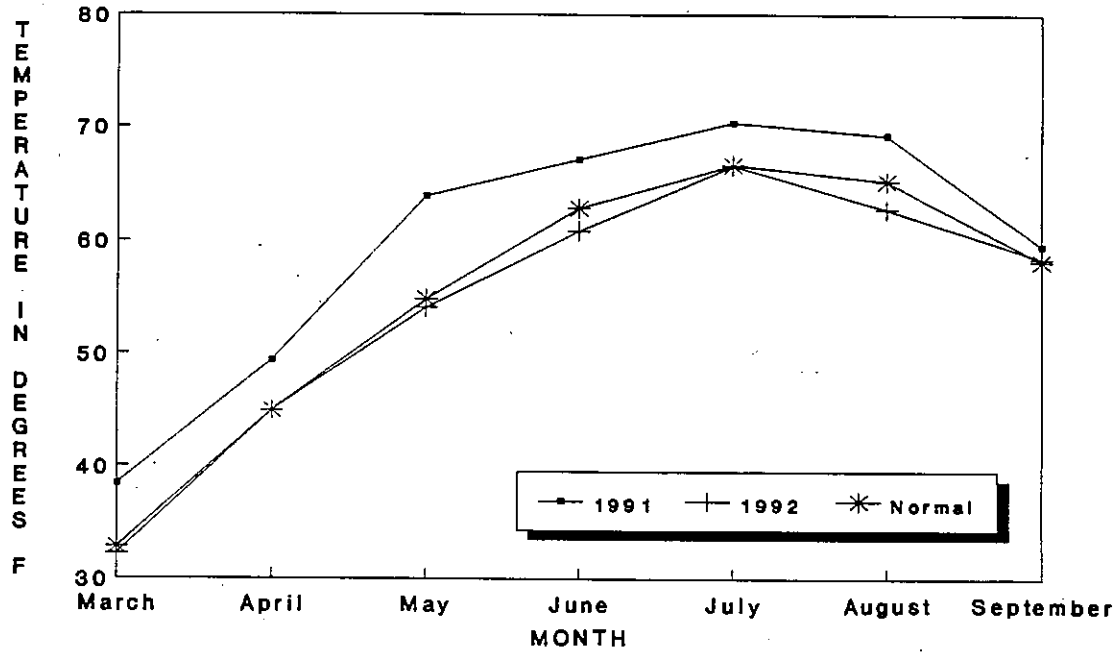
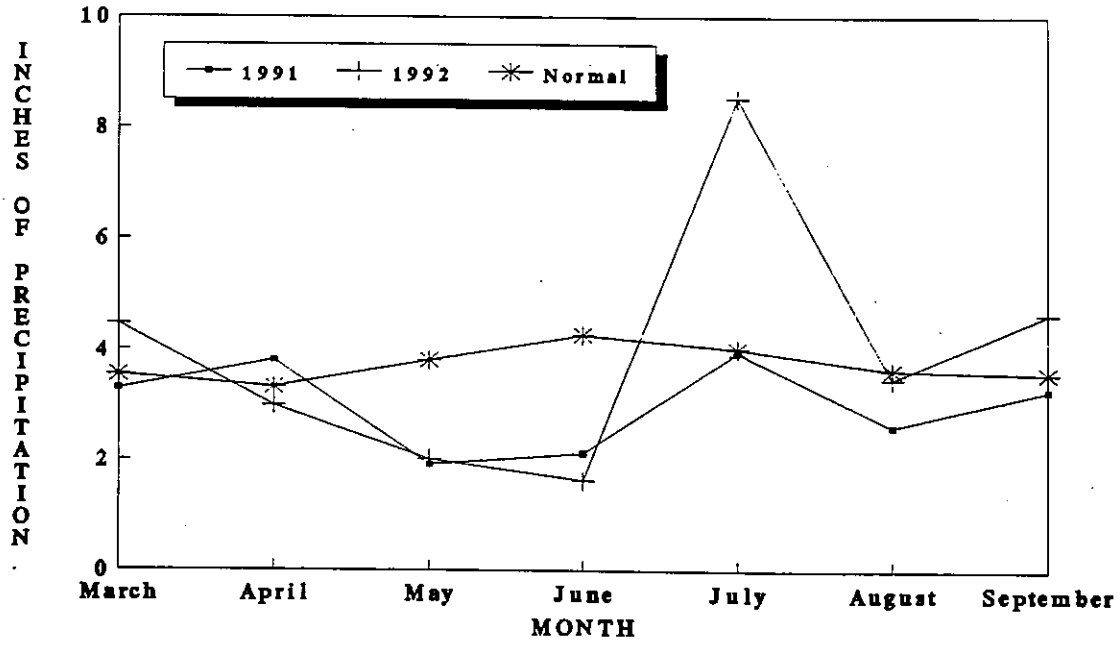


Figure 3. Average total monthly precipitation in inches for March thru September, 1991 and 1992, and normal precipitation for the 6 study areas in northcentral Pennsylvania.



intermediate with respect to shade tolerance and grows in a variety of moisture regimes (Harlow et al. 1979). Therefore, the intermediate survival we observed seems consistent with what would be expected from this species.

Conclusions

Survival of native hardwood seedlings was higher in areas with less competition from herbaceous cover; red maple and red oak in particular seemed to benefit from the reduction in herbaceous competition. Black locust and quaking aspen survival was relatively high for the combined low and high competition areas. Survival of black locust and quaking aspen was over 90% in 1992 when the ambient temperature was cooler and precipitation was higher compared to 1991.

Our study indicated that procedures for reducing herbaceous competition during reclamation efforts may be useful to promote survival and growth of native hardwoods planted on reclaimed mined lands. Furthermore, we recognize that differences in survival among hardwood seedlings is also related to the life history strategy of each species, and to differences among species in their response to ecological conditions.

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