some ecological effects of shelterwood harvesting and site preparation in white pine forests

Emergence, growth, and survival of seeded white pine

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Background

Variation in seed weight among individuals within a forest tree species is common, the result of both environmental and genetic factors. Seed weight is often positively related to rate of germination and seedling size, which may confer some competitive advantage to germinants arising from larger seeds (Righter 1945, Bonner 1987). Earlier emergence of seedlings effectively increases the length of the growing season, seedling growth potential, and seedling survival (Smith 1951, Jones *et al*. 1997). More rapid germination has been shown to improve growing season and overwinter survival of first-year white pine germinants (Graber 1968). This may result in part from the more rapid production of a large root system, providing an enhanced competitive potential to penetrate deeper, moister soil depths and survive periodic drought, a common source of mortality in natural regeneration (Larson 1963).

White pine seed weight varies over twofold both among and within families (Righter 1945, Sayward 1974). Results of previous studies examining white pine seed weight effects on germination and seedling growth and survival have been inconsistent. Most studies have reported a short-lived ($\leq$ 3 yr) positive effect of seed weight on seedling growth in greenhouse and nursery environments (Spurr 1944, Pauley *et al.* 1955, Demeritt and Hocker 1974). Little information is available on the effects of seed weight on white pine regeneration in a field setting (Graber 1968).

Objectives

The objectives of this study were to examine the effects of shelterwood harvesting with different site preparation methods and seed weight on eastern white pine seedling emergence, growth, and survival.

Methods

White pine seed were obtained from cone collections made in fall 1996 for genetic diversity investigations. Mean weight of individual seeds was estimated from the bulked weight of a known quantity of seeds (n=200-400) for each of 198 parent trees. Three weight classes were chosen for study: small (S) $\leq$16 mg, medium (M) 17-20 mg, large (L) $\geq$21 mg. Ten parent trees per seed weight class were selected, and 520 filled seeds per parent bulked to provide 5200 seeds per seed weight class (N=15,600). Seed was stratified at 2°C for 2 months. In May, a subsample of 400 seeds per weight class was used to determine percent germination potential in the laboratory.

In April 1998, 3 1 m x 1 m seeding plots were established in each of the 15 treatment plots. Seeding plots were placed in microsites representative of the site preparation treatment applied. Each seeding plot was split into 4 equal quadrants, and 100 seeds of each of 3 seed weight classes sown at 1 cm below the substrate surface in a randomly assigned quadrant. Each quadrant was sown in 10 rows of 10 seeds to facilitate tracking of individual seeds. The fourth quadrant was left unseeded to determine the presence of background white pine seed. Seeding was completed in early May 1998. During the growing season, date of emergence, mortality, and cause of mortality (drought/heat, mechanical, herbivory, unknown) were assessed twice weekly for 4-6 weeks and periodically thereafter. Seedling survival was determined in spring and fall of 1999 and 2000. In fall 1998, a subsample (N=288) of seedlings representing a range of seed weight, emergence date,
and site preparation treatments were excavated to assess growth and morphology. Analysis of variance, correlation analysis, and regression will be used to quantify site preparation and seed weight treatment effects on percent emergence, rate of emergence, mortality, and shoot growth as appropriate.

Results and Discussion

Seedbed microenvironment and substrate had a stronger influence on emergence and mortality than seed size (Figure 1). Percent emergence and the rate of seedling emergence were much higher for seeds planted on the M and MH plots. Mortality during the first growing season was also much lower on the exposed mineral soil seedbeds of the M and MH plots, with no apparent effect of seed weight. A significant negative linear relationship existed between day of emergence and total seedling dry weight, with the environment and substrate of M and MH seedbeds promoting earlier emergence and improving first-year seedling size (Figure 1). First-year seedlings differed only slightly in diameter and height, but seedlings grown on the M and MH plots had significantly larger leaf, root, and total dry mass at the end of the growing season. They also had much better root

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development. Seed weight effects were comparatively slight, although a trend toward higher dry mass in seedlings grown from L and M seeds is apparent. The thick litter layer and low light conditions in the understory of NC plots resulted in poor emergence and survival, and reduced size of first-year seedlings.

These preliminary data suggest that seedbed substrate and microenvironment have a much larger influence on first-year seedling performance of white pine than seed weight. The benefits of mineral soil substrates to first-year seedling performance are substantial, and are likely associated with their superior thermal and hydraulic properties for seed germination and seedling establishment. These results are in agreement with the work of others, as well the results of the on-site natural regeneration survey in 1998-99. The longer-term effects of site preparation on white pine seedling growth and survival, and ingress of competing vegetation, are being examined.

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