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

White pine seed production, characteristics, and dispersal patterns

William C. Parker[1] and Thomas L. Noland[1] 2002

Background

Seed production of *Pinus* sp. is influenced by climate, inherent genetic characteristics of the mother tree, and various stand factors (Sarvas 1962, Owens and Blake 1985, McDonald 1992). Generally, warm spring and summer temperatures combined with adequate seasonal precipitation favours seed production. Reproduction is also under strong genetic control, with certain individuals being consistent producers of high quality seed, while others yield little seed regardless of environmental conditions. Seed production is typically higher for open-grown and dominant canopy trees with large crowns, and stand and site features that increase tree vigour and contribute to crown development have been linked to enhanced seed production (Owens and Blake 1985). Operational treatments to increase resource availability and stimulate crown expansion (e.g., thinning, crop tree release, wider initial spacing) have been successfully used to increase seed production of *Pinus* sp. on both a per tree and land area basis (Wenger 1954, Phares and Rogers 1962, Stiell 1971).

The uniform shelterwood system is the primary silvicultural system recommended for the management of white pine-dominated stands in Ontario (OMNR 1998). In the initial cuts of the shelterwood system, tree marking is used to select individuals as future seed trees and the spacing of residuals is aimed at stimulating crown expansion and seed production. Unfortunately, our knowledge of white pine seed production is quite limited. White pine produces abundant seed crops every 3 to 5 years with as many as 3 to 4 million viable seeds ha^{-1} (Wendel and Smith 1990). These bumper seed crops are separated by years of negligible seed production. Mature stands in northwest Wisconsin with white pine basal area of 51 m^2 ha^{-1} produced 825,000 to 2.4 million seeds ha^{-1} in average and above average seed years (Heckman *et al*. 1986). Peak seed production for white pine in eastern Canada is unknown, although at least 0.7 million seeds ha^{-1} were reported for a “heavy pine cone crop” in western Quebec (Horton 1962).

The only detailed examination of seed production of natural white pine stands was conducted in southwestern Maine (Graber 1970). Seed production and quality of 80-year-old, second-growth, pure white pine stands that varied in density (i.e., basal area) were monitored in years with both poor and good seed crops. In both years, seed dispersal began mid-September, peaked in early October, and was 98% complete by late November. This pattern of dispersal was similar among stands of different densities. Peak seed fall coincided with the time when seeds were of greatest weight and highest viability. Stands of moderate density (28 m^2 ha^{-1}) had higher seed production on an area basis as compared with the high (42 m^2 ha^{-1}) and low density stands (18.4 m^2 ha^{-1}) and seed production per tree was greatest in the low density stands.

This study was established to address the serious lack of information on white pine seed production in Ontario. Here we present preliminary findings on seed production and dispersal in uncut and shelterwood harvested stands. Examination of variation in seed characteristics is ongoing and will be reported elsewhere.

Objective

The objective of this study was to determine the effects of partial cutting on white pine seed production, seed characteristics, and seed dispersal patterns.

Methods

In August 2000, 15 seed traps were placed in the understory of a shelterwood (SW) and an uncut (NC) treatment plot in each of 3 blocks. The shelterwood plots in each block were harvested in fall 1995 and received mechanical and chemical site preparation treatments in 1996 and 1997, respectively. In each treatment plot, seed traps were positioned 5- to 10-m apart along a transect running through the plot centre along the longitudinal (i.e., 100 m) axis. Seed traps used in this project are conical and constructed of flexible, vinyl fabric. Circular openings (0.28 m^2) at the top are covered by a metal grid frame to prevent seed and cone predation by birds and small mammals. Seeds falling through the grid are deposited in a screen-lined collection jar fastened to the base of the trap. Seed was collected every 7 days from September 15 to November 8. Seed were returned to the laboratory, separated from leaf litter and other canopy debris, and counted by species. White pine seeds are currently being analyzed to determine effects of site, partial cutting, and collection date on seed weight, seed development, and seed viability. A prism sweep was performed at each trap location to estimate

[1]Ontario Ministry of Natural Resources, Ontario Forest Research Institute, Sault Ste. Marie, ON

the basal area of white pine trees potentially contributing seed to each trap.

Results

White pine seed dispersal began September 15, peaked in early October, and was essentially complete by November 8. Seed dispersal pattern did not differ among sites in either the uncut or shelterwood stands. Seed production varied among blocks, due in part to the number of pine present (Table 1). Seed production was strongly related to pine basal area for both uncut and shelterwood stands. Total seed production was 1.5 to 2.5 million ha^{-1} in Blocks 2 and 3. Total seed production on Block 1, with fewer pine, was less than half of that observed on Blocks 2 and 3.

Block differences in seed production may also have been due to site features affecting soil moisture availability. The blocks may be ranked as 1 < 3 < 2 with respect to their potential for seasonal soil moisture deficits. The reproductive cycle of *Pinus* sp. occurs over 3 consecutive calendar years. Formation of reproductive buds in the fall of year 1 is followed by flowering and pollination in year 2, and fertilization, seed formation, and seed dispersal in year 3. Differentiation of reproductive buds in many conifer species is favoured by warm, dry growing seasons in year 1 (Owens and Blake 1985). The summer of flower bud initiation in our stands (1998) was characterized by above average temperatures and below average precipitation. On the wetter, more mesic Block 1, this climatic stimulus for reproduction may not have been as strong as on the drier sites of Blocks 2 and 3, thus fewer flower buds were formed.

Contrary to expectations, seed production in the uncut stand in Block 1 was higher than in the shelterwood (Table 1). This is probably related to the size and form of the white pine in the uncut stand. Although basal area of white pine (in the seed trap areas) is lower in the uncut stand than in the residual shelterwood overstory, these pine are larger in diameter and have very large, branchy crowns. Higher seed production per unit basal area, despite fewer trees present, may be due to enhanced seed production potential by the large crowns of these trees.

To our knowledge, this is the first report on seed production of white pine for Ontario. The fall of 2000 was viewed as a good seed year for white pine, both at the study area and many other locations in Ontario. Production of 1.5 to 2.5 million seeds ha^{-1} agrees with that reported in the northern US for a good seed year by Heckman *et al*. (1986) and falls between the 0.7-1.0 million seeds ha^{-1} and 2.8-3.9 million seeds ha^{-1} reported for a poor and good seed year, respectively (Graber 1970).

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Table 1. Total stand basal area; white pine (Pw) basal area, density, and mean diameter (DBH); and seed fall in 2000 expressed per unit area and per unit Pw basal area for uncut (NC) and shelterwood (SW) plots in 3 blocks.

Block	Trt	Total basal area (m^2 ha^{-1})	Pw basal area (m^2 ha^{-1})	Pw trees (# ha^{-1})	Mean Pw DBH (cm)	Seeds (thousands) (ha^{-1})	Seeds (thousands) (ha^{-1} m^{-2} ba)
1	SW	17.6	16.0 (0.0)	140	28.4	579 (55)	37.2 (4.0)
	NC	34.5	9.6 (1.0)	116	39.3	576 (101)	61.8 (11.2)
2	SW	23.8	20.1 (1.4)	128	44.4	2,531 (119)	136.2 (12.7)
	NC	39.4	21.7 (1.1)	284	32.2	1,495 (146)	69.1 (5.6)
3	SW	25.8	15.2 (1.1)	136	41.5	1,866 (123)	130.9 (12.5)
	NC	38.1	22.3 (1.4)	208	36.7	2,126 (114)	101.0 (7.8)

Note: Mean white pine basal area was determined using prism sweeps at each trap location (n=15). Total stand basal area, number of white pine trees, and mean DBH of white pine refer to measurements of all trees on a treatment plot. Numbers in parentheses are standard errors.