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

Microclimate

William C. Parker 2002

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

Background

The forest floor microenvironment is strongly influenced by the density of the overstory canopy. Interception of solar radiation and precipitation by intact forest canopies significantly reduces understory light levels and soil moisture availability, respectively (Anderson *et al*. 1969, Aussenac 2000). Forest canopies also reduce the amount of short wave radiation striking the understory, resulting in higher minimum and lower maximum air and surface soil temperatures. Lower air temperatures and wind velocity beneath forest canopies also increases the humidity of the understory. The combination of low light, reduced throughfall precipitation, and root competition for moisture with overstory trees beneath closed canopies strongly limits the establishment and growth of white pine natural and artificial regeneration (Korstian and Coile 1938, Shirley 1945, Messier *et al*. 1999, Parker *et al*. 2001).

Site preparation is typically used to create microsites for natural regeneration and/or plantable spots for artificial regeneration. The intensity of forest floor and understory disturbance by site preparation will influence seedling microclimate, resource availability, and therefore the success of regeneration efforts. White pine is intermediate in shade tolerance, with 20 to 25% sunlight required for satisfactory seedling establishment (Horton and Bedell 1960). Maximum seedling height occurs above 40 to 50% of full sunlight, but diameter and total seedling biomass are greatest under full sunlight (Logan 1966, Messier *et al*. 1999). Growth potential is significantly reduced at < 20% sunlight, with mortality increasing when light levels fall to ≤ 5-10% (Logan 1966, Wendel and Smith 1990, Messier *et al*. 1999). Silvicultural application of shelterwood systems in combination with site preparation is aimed at creating an understory environment that favours the establishment and initial growth of white pine, while providing suboptimal environmental conditions for growth of woody and herbaceous competing vegetation. The effectiveness of silvicultural practices selected to meet these objectives will determine the timing and future need for tending or vegetation management treatments.

Objective

To quantify the effect of site preparation treatments and overstory density on diurnal and seasonal trends in light intensity, air temperature, humidity, soil temperature, and soil moisture over several growing seasons.

Methods

Dataloggers and an array of microenvironmental sensors were installed in block 3 to monitor understory microclimate during the growing seasons (May-September) of 1998-2000. In each of the five treatment plots, above- and below-ground environmental parameters were monitored. Light intensity (photosynthetic photon flux density (PPFD)), air temperature (Ta), and relative humidity at 1 m above the forest floor were measured in one location per plot. Light intensity was also measured in an adjacent clearing to estimate total incoming PPFD at the forest canopy surface. Soil temperature (Ts) and soil moisture (i.e., soil water potential) at 5 and 30 cm depths in the mineral soil were measured in two locations per treatment plot. Daily rainfall (mm) was measured with tipping bucket rain gauges placed 1 m above ground in canopy openings in the M and MH treatment plots.

Results and discussion

On clear, sunny days, the dense overstory canopy and taller understory in the uncut stand reduced understory light levels to 5 to10% of full sunlight (full sunlight ~2000 umol m^{-2} s^{-1} PPFD). In contrast, mid-day PPFD beneath a shelterwood ranged from 40 to 80% of full sunlight. Reduction in PPFD is due to the influence of the canopy of overstory trees since understory vegetation was < 1 m in height at time of measurement. Variation in total daily PPFD associated with site preparation treatment effects on regrowth and abundance of understory vegetation in shelterwoods were apparent in year 2. Understory light levels in the H and C shelterwood plots were roughly similar (~ 40% of full sunlight) early in the growing season. However, comparatively greater height growth and leaf area development of understory vegetation in the C plots that did not receive site preparation gradually reduced light intensity to ~10% of full sunlight by the latter half of the growing season. These low light levels are comparable to that of the uncut, NC plot and significantly reduce photosynthesis and growth of white pine seedlings (Logan 1966, Parker and Bell 1997). Light levels in the H treatment plots exhibited a more gradual seasonal decline to an average of 25% sunlight due to the slower development of understory vegetation. These light levels are less than that needed for optimal diameter and height growth but are sufficient to support positive shoot growth of white pine. The presence of an intact canopy reduced Ta and Ts relative to the shelterwoods. Reduced canopy penetration of solar radiation in NC plots was associated with lower maximum daily Ta and VPD and higher minimum daily Ta. Forest canopies also decreased energy exchange between the understory and the night sky, increasing minimum daily Ts. Seasonal mean Ts was also lower in the uncut stand with the exception of the shelterwood that received no site preparation.

Seasonal soil moisture availability at 5 and 30 cm during year 3 was higher and less variable seasonally in shelterwoods than the uncut stands during periods of low rainfall in the warmer, summer months of July-September. The uncut stand exhibited a much larger reduction in soil moisture during periods of little or no rainfall. Higher precipitation throughfall and lower stand leaf area and transpiration of the residual shelterwood canopy resulted in higher soil moisture available in upper and lower soil horizons for pine regeneration. Increased soil moisture is often reported after thinning of conifer stands (Sucoff and Hong 1974, Brix and Mitchell 1986, Aussenac 2000). The effects of site preparation on soil water potential were also apparent. Scarified (M) plots with comparatively lower understory vegetation exhibited slightly higher soil moisture content than the C plots. Reduced infiltration of rainfall through the litter layer into the underlying mineral soil in the C plot may also have contributed to the lower soil water potential values observed.

References

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