From Forest Nursery Notes Winter 2013

139. © Influence of herbaceous and woody vegetation control on seedling microclimate, leaf gas exchange, water status, and nutrient relations of *Pinus strobus* L. seedlings planted in a shelterwood. Parker, W. C., Pitt, D. G., and Morneault, A. E. Forest Ecology and Management 271:104-114. 2012.

Forest Ecology and Management 271 (2012) 104–114

Contents lists available at SciVerse ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

Influence of herbaceous and woody vegetation control on seedling microclimate, leaf gas exchange, water status, and nutrient relations of *Pinus strobus* L. seedlings planted in a shelterwood

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ARTICLE INFO

Article history:
Received 23 November 2011
Received in revised form 27 January 2012
Accepted 29 January 2012
Available online 3 March 2012

Keywords:
Leaf conductance
Leaf nutrients
Net carbon assimilation
Soil moisture
Vegetation management
Water use efficiency

ABSTRACT

The influence of herbaceous and woody vegetation control applied over four consecutive growing seasons (GS) on microclimate, leaf gas exchange, water status, nutrient relations, and growth of planted eastern white pine (*Pinus strobus* L.) seedlings was examined in a central Ontario shelterwood. Treatment effects on pine seedling ecophysiology were closely associated with temporal changes in the structure and species composition of the developing understory plant communities. Vegetation control had minimal influence on air temperature, but herbaceous control, sometimes in combination with woody control, improved the soil thermal regime in every GS. Herbaceous vegetation control increased soil moisture availability in GS one and two, but only during mid-summer periods of little precipitation. Light availability showed a relatively large treatment response, with highest light levels created where both herbaceous and woody vegetation were suppressed. Herbaceous and woody vegetation control had additive or interactive effects on net carbon assimilation (A_n) and leaf conductance to water vapour (G_{wv}) in a given GS, while water use efficiency and midday leaf water potential (ψ_m) were largely independent of treatment. The effects of vegetation control on A_n, G_{wv}, and ψ_m were often correlated with treatment-induced changes in total vegetative cover, light, and soil moisture availability. Vector analysis of leaf nutrient (N, P, K, Ca, and Mg) relations suggested that herbaceous vegetation control relieved foliar N, P, and K deficiencies in 5-year-old white pine seedlings, woody vegetation control did not affect leaf nutrient relations, and total vegetation control provided non-limiting conditions. In GS four, white pine growth responses were highest where both herbaceous and woody vegetation control had been conducted, likely in response to improved microclimate, resource availability, leaf gas exchange, and foliar nutrition.

1. Introduction

Interspecific competition strongly influences the structure of early secondary successional plant communities through effects on resource availability, the physical environment, and the physiological response of plant species to changes in growth resources and environmental conditions (Radosevich and Osteryoung, 1986; Goldberg, 1990). In managed forests, timely, effective vegetation management is integral to balancing the negative effects of woody and herbaceous competition on establishment and growth of crop tree regeneration (Wagner et al., 2006) with the beneficial effects of understory vegetation on, for example, ecosystem function, biodiversity, and wildlife habitat (Balandier et al., 2006; Gilliam, 2007). Since interactions among crop tree and understory plant species vary with environmental conditions, vegetation management should be tailored to site and stand conditions (Goldberg, 1990; Paquette et al., 2006; Wagner et al., 2011). Moreover, knowledge of the temporal dimension of the underlying biological mechanisms through which competitive interactions occur can help to optimize vegetation management regimes, allowing for targeted control of specific, detrimental plant functional groups (Radosevich and Osteryoung, 1986; Balandier et al., 2006).

Over the past few decades, increased knowledge of the role of natural processes and past management practices on the regeneration of white pine (*Pinus strobus* L.)-dominated forests in eastern Canada and the northern United States has led to increased operational use and study of the uniform shelterwood system (Lancaster and Leak, 1978; Hannah, 1988; Burgess and Wetzel, 2002; Pinto, 2003) and other partial harvesting silvicultural systems (Raymond et al., 2006; Powers et al., 2008; Major et al., 2009a). In Ontario, a two- to four-cut uniform shelterwood silvicultural system is recommended (OMNR, 2004) and currently being applied to about 80% of the managed area of the red (*Pinus resinosa* Ait.) and white

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doi:10.1016/j.foreco.2012.01.042