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Agricultural and Forest Meteorology 86 (1997) 107–125

AGRICULTURAL AND FOREST METEOROLOGY

Radiation regime and canopy architecture in a boreal aspen forest

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Received 16 September 1996; accepted 26 September 1996

Abstract

This study was part of the Boreal Ecosystem–Atmosphere Study (BOREAS). It took place in a mature aspen forest in Prince Albert National Park, Saskatchewan, Canada. The aspen trees were 21.5 m high with a 2–3 m high hazelnut understory. The objectives were: (1) to compare the radiation regime beneath the overstory before and after leaf emergence; (2) to infer the structural characteristics of the aspen canopy leaf inclination and clumping; (3) to determine the seasonal course of the leaf area index (L) for both the overstory and understory. Above-stand radiation measurements were made on a 39 m walk-up tower, and understory radiation measurements were made on a tram which moved horizontally back and forth at 0.10 m s^{-1} on a pair of steel cables 65 m in length suspended 4 m above the ground. In addition, several LI-COR LAI-2000 Plant Canopy Analyzers were used to determine the effective leaf area index and the zenith angle dependent extinction coefficient ($G(\theta)$) for both the aspen and the hazelnut throughout the growing season. These measurements were supplemented with destructive sampling of the hazelnut at the peak of the growing season. Before leaf emergence, the ratios of below- to above-aspen solar radiation (S), photosynthetic photon flux density (PPFD) and net radiation (R_n) during most of the day were 0.58, 0.55 and 0.47, respectively. By midsummer, these ratios had fallen to 0.33, 0.26 and 0.26, respectively. The aspen $G(\theta)$ was relatively invariant with θ, within ± 0.05 of 0.5 throughout the growing season, indicating a spherical distribution of leaf inclination angles (i.e. the leaves were randomly inclined). The hazelnut $G(\theta)$ has a cosine response with respect to θ, which was consistent with the generally planophile leaf distribution for hazelnut. Using canopy gap size distribution theories developed by Chen and Black (1992b, *Agric. For. Meteorol.*, 60: 249–266) and Chen and Cihlar (1995a, *Appl. Opt.*, 34: 6211–6222) based on Miller and Norman (1971, *Agron. J.*, 63: 735–738), the foliage clumping index (Ω) of the aspen canopy was derived from high-frequency tram measurements of PPFD. The aspen Ω was fairly constant with θ, but showed a small seasonal variation, with a minimum value of 0.70 in the midsummer. The hazelnut Ω was found to be 0.98 determined using the L from the destructive sampling, indicating no clumping. After corrections for clumping and the wood area index (α), the seasonal course of L near the tower for both aspen and hazelnut was determined, with maximum L of 2.4 and 3.3 for the aspen and hazelnut, respectively. © 1997 Published by Elsevier Science B.V.

Keywords: Aspen forest; Radiation regime; Canopy; *Populus tremuloides*

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PII S0168-1923(96)02402-1