radiation within *Pinus radiata* D. Don canopies. Plant Cell Environ. **8**: 201–206

Oke, T.R. 1987. Boundary layer climates. 2nd ed. Methuen, London.

Parent, S., and Messier, C. 1996. A simple and efficient method to estimate microsite light availability under a forest canopy. Can. J. For. Res. **26**: 151–154.

Poulson, T.L., and Platt, W.J. 1989. Gap light regimes influence canopy tree diversity. Ecology, **70**: 553–555.

Runkle, J.R., Stewart, G.H., and Veblen, T.T. 1995. Sapling diameter growth in gaps for two *Nothofagus* species in New Zealand. Ecology, **76**: 2107–2117.

Reply—The effects of direct-beam light on overcast-day estimates of light availability: On the accuracy of the instantaneous one-point overcast-sky conditions method to estimate mean daily %PPFD under heterogeneous overstory canopy conditions[1]

Christian Messier and Sylvain Parent

This paper constitutes a short response to the discussion paper by Stadt et al. (1997) in which they concluded that "The instantaneous overcast-day measurement is indeed useful and efficient for microsites in closed, homogeneous canopies and perhaps for stand-average light availability, but for other situations it should be applied with caution."

The paper discussed the possible effects that heterogeneous canopies in terms of species composition and openings might have on the accuracy of the instantaneous overcast-day measurement as an estimate of mean daily photosynthetic photon flux density (%PPFD), and in theory their discussion is mostly correct. Indeed, Parent and Messier (1996) wrote "More research is needed to evaluate the effects of gap sizes, position within gaps, topography, and monthly variation during the growing season on the accuracy of this method..." However, the overstory canopy of the stand in which Parent and Messier (1996) did their study was not homogeneous in terms of species composition and openings. The stand was a mixture of black spruce (*Picea mariana* (Mill.) BSP), white spruce (*Picea glauca* (Moench) Voss), and white birch (*Betula papyrifera* Marsh.) with a very heterogeneous mosaic of canopy gaps of various sizes. The locations of the measurements were not random, but systematic. They were taken every 5 m from the edge of a 15-year-old clearcut to 50 m inside the canopy (see Parent and Messier 1995) along 11 transect lines. Therefore, the results apply to a situation with heterogeneous overstory species composition and various sizes of gaps. The highest %PPFD value recorded in this paper was around 60%. The study by Messier and Puttonen (1995) was done in Scots pine (*Pinus sylvestris* L.) stands of various ages, with small gap sizes and with several single spruce and birch trees within the canopy. The overstory tree conditions were therefore not homogeneous. It is true, though, that the measurements compared only three types of microsites: (1) 50 cm from the southern side of a dominant Scots pine stem, (2) between adjacent groups of dominant pine trees, and (3) in the center of an adjacent 20–50 m^2 gap. These small gaps in the 7-year-old stands produced conditions that were almost the same as those of larger gaps in taller stands. Indeed, %PPFD values were as high as 80% in gaps of the 7-year-old stands.

It is true that the main assumption of the overcast-day technique is, as stated by Stadt et al. (1997), "that a spatial average of sky view is a reasonable substitute for a temporal average of integrated %PPFD, and the validity of this assumption has yet to be tested." However, in a paper in preparation (F. Gendron, C. Messier, and P. Comeau), we tested the overcast-day method and four other methods in various extreme conditions with the mean seasonal %PPFD obtained from photodiodes (that were properly calibrated with LI-COR quantum sensors) that recorded

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[1] In response to the comment by K.J. Stadt, S.M. Landhäusser, and J.D. Stewart. 1997. Can. J. For. Res. This issue.

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light continuously from April to October in 52 randomly distributed microsites under a 10 m tall stand of bigleaf maple (*Acer macrophyllum* Pursh) that resprouted from cut stumps in coastal British Columbia. The four other methods were (1) the instantaneous one-point midday measurement made on sunny days, (2) the instantaneous one-point LI-COR LAI-2000 diffuse light value, (3) the hemispherical photograph, and (4) a recent model developed by P. Comeau (LITE). This was done across a wide range of canopy gap sizes (from very closed canopy up to gaps of 500 m^2), positions within gaps, and overstory tree species composition (there were many individual overstory conifer tree species interspersed within the stand). The results from this study are clear, and confirmed those reported by Parent and Messier (1996) and Messier and Puttonen (1995), that the instantaneous one-point overcast-day method gives values that are very close to the "real" mean seasonal value ($R^2 = 0.92$). The regression line had a slope of 0.98 with the origin not statistically different from zero. The method was actually as good as the hemispherical photograph method ($R^2 = 0.94$). There was no indication that the method is less accurate under open canopy conditions, and position within gap did not seem to reduce the accuracy of the method. Furthermore, the presence of single conifer trees within 10 m of the measuring point did not seem to affect the accuracy of the results. There was, of course, some variations around the mean seasonal value, but the variations were not greater than with the hemispherical photograph.

One of the main points made by Stadt et al. (1997) is that the accuracy of a one-point measurement on a cloudy day might be low in a situation where individuals or clumps of relatively opaque species are sparsely distributed through a more transparent canopy. I do not disagree with this, and it is possible that in that particular condition the value obtained by a one-point measurement made on cloudy days might not produce accurate results. However, as discussed previously, results from several studies done in various forest types and conditions indicate that in most situations under both homogeneous and heterogeneous canopy conditions (both in terms of species composition and gap sizes), the instantaneous one-point overcast-sky condition method provides a simple and very efficient method to estimate microsite light availability under a forest canopy (almost as good as the hemispherical photograph).

References

Messier, C., and Puttonen, 1995. Spatial and temporal variation in the light environment of developing Scots pine stands: the basis for a quick and efficient method of characterizing light. Can. J. For. Res. **25**: 343–354.

Parent, S., and Messier, C. 1995. Effets d'un gradient de lumière sur la croissance en hauteur et la morphologie de la cime du sapin baumier régénéré naturellement. Can. J. For. Res. **25**: 878–885.

Parent, S., and Messier, C. 1996. A simple and efficient method to estimate microsite light availability under a forest canopy. Can. J. For. Res. **26**: 151–154.