Extension Note

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LITE: A Model for Estimating Light under Broadleaf and Conifer Tree Canopies

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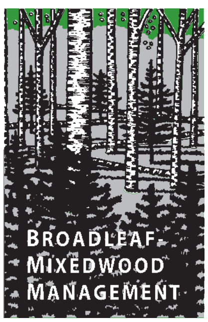

This extension note briefly describes LITE, a model developed for estimating light penetration in the broadleaf- and conifer-dominated forests of British Columbia. A complete description of the model and instructions for use are provided by Comeau et al. (1998).

Why are we Interested in Light?

Tree growth requires favourable temperatures and adequate light, water, and nutrients. In forests, light is commonly considered to be the factor most limiting to growth of seedlings when they are overtopped by trees or other vegetation. When other factors are not limiting, tree growth generally increases with increasing light. Understorey light is also one factor that can be manipulated through stand-tending practices such as brushing, spacing, thinning, or harvesting.

Measuring Light

Light is commonly measured as Photosynthetic Photon Flux Density (PPFD). Plants utilize light within a prescribed range of wavelengths (400–700 nm), referred to as photosynthetically active radiation (PAR). This range nearly corresponds to the wavelengths visible to the human eye. Light is also expressed as a percentage of open-sky light, commonly referred to as percent transmittance.

Obtaining direct measurements of light over an entire growing season—or over several growing seasons—requires installation and maintenance of data-loggers and sensors. Because this equipment is expensive, the number of points that can be measured is limited. Spot measurements of light at individual points are reasonably easy to obtain using a pair of light sensors: one for recording open-sky PPFD and one for recording light at the sample points. However, several studies suggest that one-time spot measurements may be less robust than other techniques for estimating understorey light. Consequently, the measurement method must be selected with care.

Light levels at a particular spot depend on the sun's position in the sky (which changes with the date and time of day) and on whether the sky is overcast or clear. In the northern hemisphere, maximum light is available at midday on June 21 when the sun reaches the highest point in the sky. Within a forest, other factors also influence light levels. Overtopping vegetation or tree cover reduces the amount of light reaching a point in the understorey (Figure 1). At the centre of a gap in a forest, light generally increases with increasing gap size, but location within the gap is also important—less light is received on the southern edge than on the northern edge.

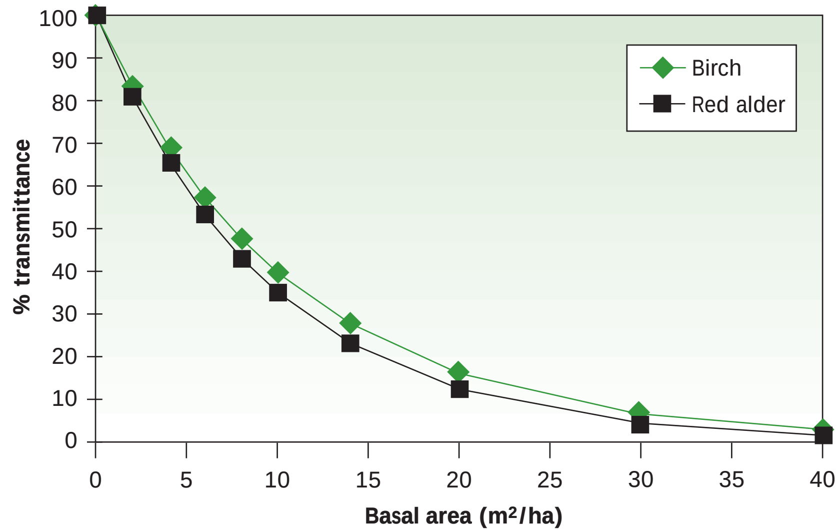

figure 1 *Relationship between light transmittance and basal area observed in some red alder and paper birch stands in B.C. Light reaching a point in the understorey decreases as the amount of sky obscured by overtopping canopy increases. In single-species stands, percent transmittance can generally be related to the basal area of the stand.*

Models that use routinely collected stand data (such as stand density, dbh, and height) are useful for examining the impacts of stand-tending and harvesting practices on understorey light and for designing field studies. Such models also provide an alternative method for estimating understorey light.

The LITE Model

lite is a model that can be used to estimate ppfd and transmittance over time periods ranging from one hour to one year. The model can be used with MS-Windows 3.11, Windows 95, or Windows NT 4.0.

Input Data Required by LITE

Location lite requires the latitude and longitude of the study site in order to model the sun's path across the sky throughout each day of the year.

Canopy generation lite generates a tree canopy consisting of 1-m³ cells using stand information, lai-2000 data, or both.

Canopy generation using stand information requires a tree list that includes stem location, lean, diameter at breast height (dbh), height, and height to crown base. Using published regression estimators, the model estimates crown radius and leaf area for each tree from dbh and height. The parameters used in these equations can be modified when local equations are available.

Canopy generation using lai-2000 data requires a grid of sample points in the stand. Measurements are taken at each grid point in the four cardinal directions using an lai-2000 plant canopy analyzer (li-cor 1992). A 90° view restrictor is usually placed over the sensor of the lai-2000. In addition, for each grid point, location (*x* and *y* coordinates) and height to crown base and top of the canopy are required. The model then calculates the amount of leaf area in each m³ cell of the canopy.

Above-canopy PPFD If the data are available, the model will use above-canopy ppfd (hourly averages) in the simulations. Otherwise, the model can estimate above-canopy ppfd from information on sky conditions. The model partitions total ppfd into two components: beam and diffuse light. The beam fraction represents light coming directly from the sun when the sky is clear or partially overcast, and the diffuse component represents light coming from the rest of the sky.

Modelling Light

For each time-step in the simulation (which can be set from one second to one hour), the model calculates the amount of beam and diffuse light coming from each of 480 segments of the sky, estimates the fraction of light from each of these sky segments that reaches the ground, and determines the total.

Sample Output and Results

lite is currently being tested at several locations in British Columbia. The model gives consistent results, but tends to underestimate light levels under some conditions. Figure 2 provides a map of percent transmittance generated by lite for a 15-year-old stand of red alder. Light levels reach 50% in the gap located near the centre of the figure.

Figure 3 illustrates how light levels change from south to north across a gap in a paper birch stand. On the southern side of the gap, the adjoining stand casts a substantial amount of shade; on the northern side, light penetrates beneath the adjoining stand. As a consequence of these patterns, trees established towards the southern edge of gaps generally receive less light than trees established a similar distance from the northern edge of the gap.

The amount of light reaching the centre of a gap increases with increasing gap width (Figure 4). For this simulated 10-m-tall canopy, there is little increase in percent transmittance until the gap is wider than seven metres. When the gap is 20 m wide (two times tree height), light levels at the centre of the gap reach 55%.

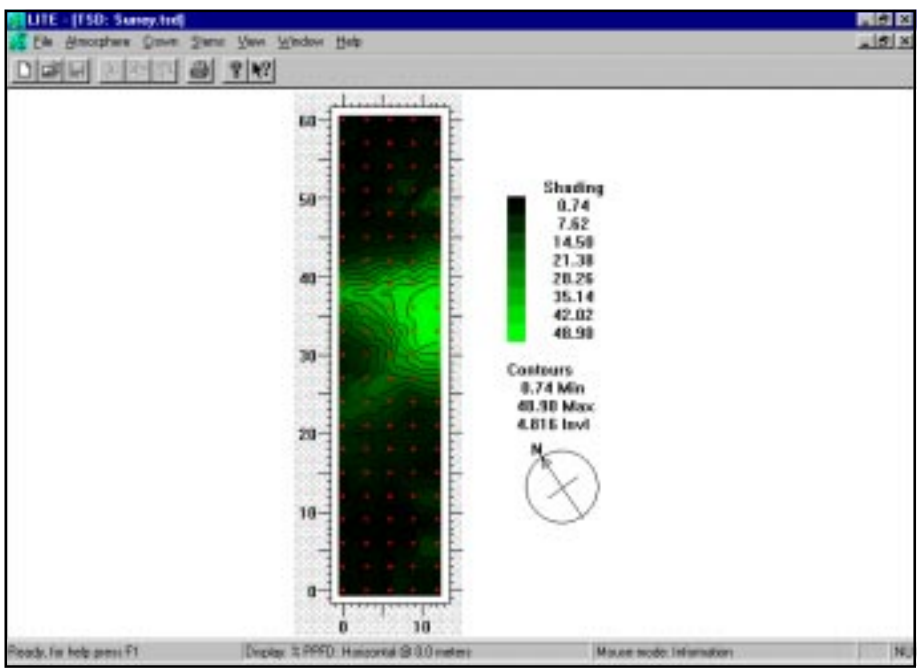

figure 2 *Map generated by* lite *showing the pattern of percent transmittance at a height of one metre in a stand of 15-year-old red alder at 12:00 noon on June 21.*

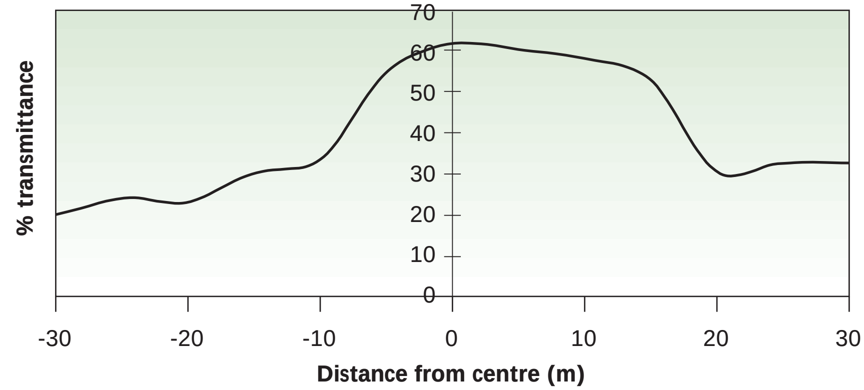

figure 3 *Simulated growing season percent transmittance across a 24-m-wide gap within a 10-m-tall paper birch stand. The gap edges are located at -12 and +12 m. Values were estimated by* LITE *using data from a site near Prince George, B.C., for the period May 1 to October 31.*

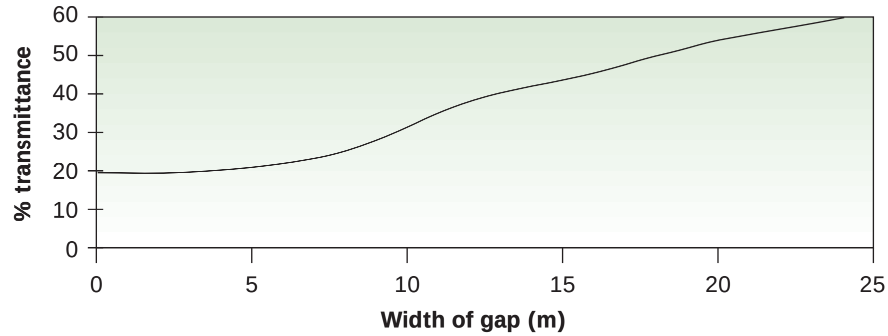

figure 4 *Simulated effect of gap width on growing season percent transmittance in a 10-m-tall paper birch stand. Values were estimated by* LITE *for a square gap using data from a site near Prince George, B.C., for the period May 1 to October 31.*

Model Development

Future versions of lite will permit use of fish-eye photographs in place of lai-2000 data. Work is also under way to permit simulation of sloping ground, improve the representation of the tree canopy, resolve problems with underestimation of light by the model, and incorporate the influence of understorey vegetation.

Copies of the model and documentation are available from the author.

Literature Cited

Comeau, P., R. Macdonald, R. Bryce, and B. Groves. [1998]. lite - A model for estimating light interception and transmission through forest canopies – Users manual and documentation. B.C. Min. For., Victoria, B.C. Working Paper (in press).

li-cor, Inc. 1992. lai-2000 plant canopy analyzer: Operating manual. li-cor Inc., Lincoln, Nebraska.

Acknowledgements

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