The Impact of Riparian Forest Management on Shade Production

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Average daily stream temperatures are regulated by many factors: ambient air temperature, relative humidity, groundwater influx, stream channel morphology (including discharge rate), and substrate composition (Adams and Sullivan 1989, Brown 1969, Byram and Jemison 1943, NCASI 2000, Patton 1974). Solar radiation has a relatively small impact on daily mean stream temperatures (Adams and Sullivan 1989). However, solar radiation is most responsible for deviations from average daily temperatures (Adams and Sullivan 1989, Ice 2001), and is almost the only factor that can be controlled by (active or passive) forest management. The impact of management change on shade can be modeled to support the development of better forest management plans.

Direct solar radiation can be transmitted, absorbed, or reflected. Only direct solar radiation (not diffused) can possibly affect stream temperatures (Ice 2001). Riparian vegetation is responsible for moderating how much direct solar radiation reaches the stream. Complete riparian canopies transmit about 10 percent of incident short-wave (light) solar radiation (Black 1985). Increases in direct solar radiation due to reduction (or absence) of riparian vegetation is most responsible for high stream temperatures (Barton et al. 1985, Brown and Krygiers 1970, Ice 2001). The only precise method of obtaining solar radiation input to a stream is to measure it for a specific site at a specific time (Adams and Sullivan 1989).

Canopy density along the path of incoming direct solar radiation best describes the ability of riparian forest vegetation to influence stream temperatures (Brazier and Brown 1973). Canopy density at any given height in the stand is a function of the stand's composition; specifically, the crown morphologies of all trees in the stand. Crown morphology is a function of many variables including: height, relative dominance, species, and density. Inventory data often contains measurements necessary for simplified models of crown shapes; while growth models account for changes over time.

The position of the sun in the sky is a function of latitude, time of year, and time of day. With this knowledge, the angular altitude and apparent azimuth of the sun can be calculated. Coupled with specific knowledge of the riparian system (stream width, stream slope, stream azimuth, and inventory information), the position of the sun relative to the stream and canopy can be calculated for any (and therefore every) time of day.

By varying only the composition of the riparian inventory, comparisons can be made regarding the impact of management intensity on riparian shade production. If comparisons between management alternatives reveal no significant change in shade production, it is reasonable to conclude that stream temperatures will not be affected. Whether or not a significant change in shade production will translate into changes in stream temperature will depend on the aggregate effect of the variables that regulate stream temperature (listed above) over the stream reach (which determines the exposure period).

Modeling the effect of management intensity on shade production requires knowledge of the following dimensions specific to the riparian system: Latitude, solar declination (time of year), hour angle (time of day), riparian inventory information (e.g. trees per acre, heights, crown ratios, crown widths), buffer width, buffer slope, stream width, stream reach, stream gradient, and stream azimuth. These variables combine in a unique fashion to create a solar exposure intensity matrix for every minute of the day, for a given day of the year.

The following figures illustrate how a model developed for use with the Landscape Management System accounts for a change in stand density (i.e. harvest intensity) on shade production. For this example, site conditions include: 47º N latitude, +23.5º N declination (summer solstice), 50 foot wide buffers, 5 percent slope, 15 foot wide stream, 500 feet of reach, 0 percent gradient, and 270º azimuth (East/West).

Figures 1 and 2 illustrate the shade produced by symmetric North and South buffers with identical inventories; the inventory in Figure 1 is relatively dense compared to Figure 2 (see figures for illustrations). Figures 3 and 4 illustrate the shade produced by North and South buffers where inventories are asymmetric. Figure 3 has a dense North buffer and a sparse South buffer; Figure 4 reverses these conditions.

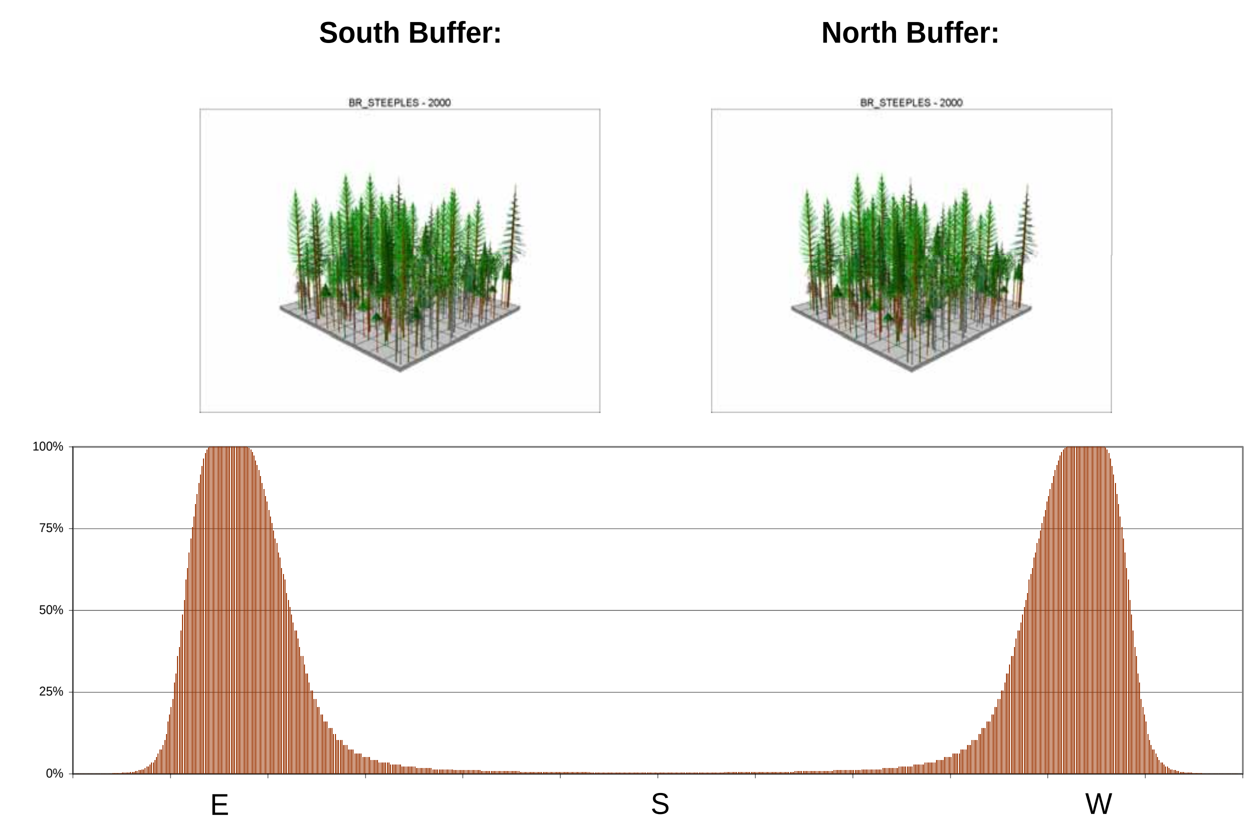

Figure 1. Percent of East-West Stream Reach Receiving Full Sunlight by Solar Azimuth (Time of Day)

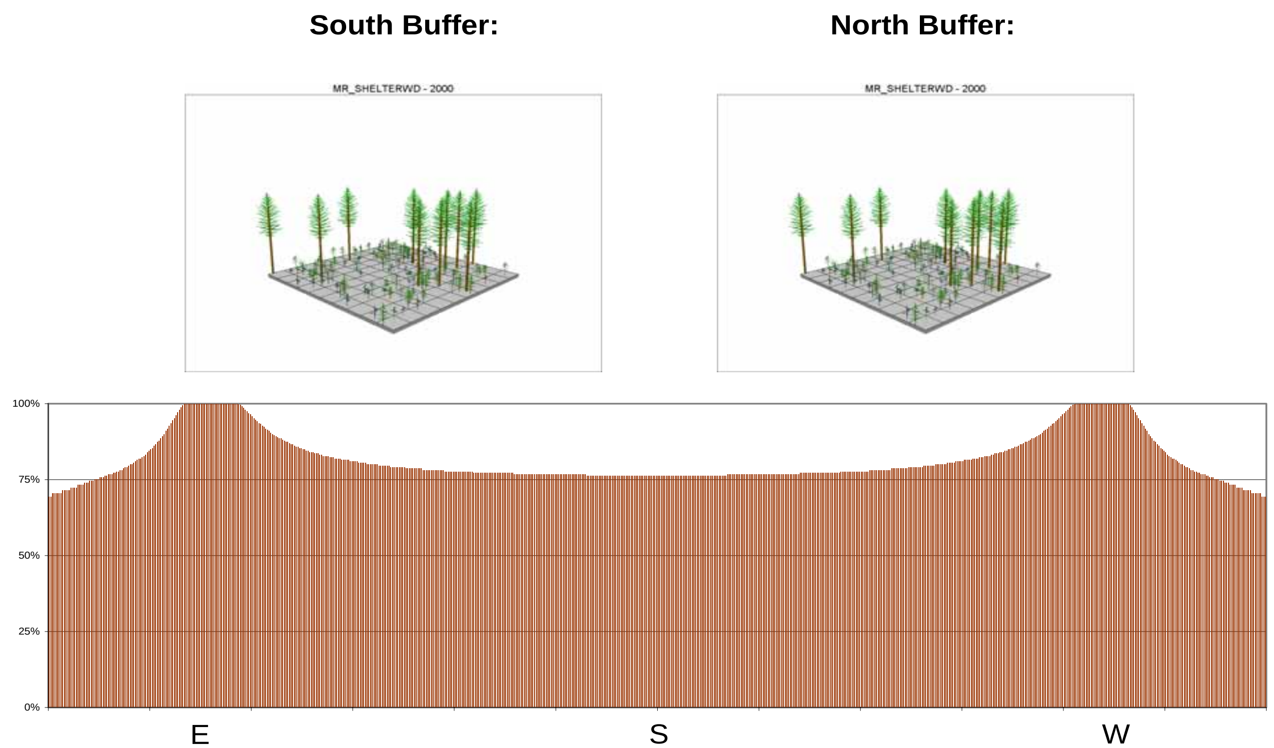

Figure 2. Percent of East-West Stream Reach Receiving Full Sunlight by Solar Azimuth (Time of Day)

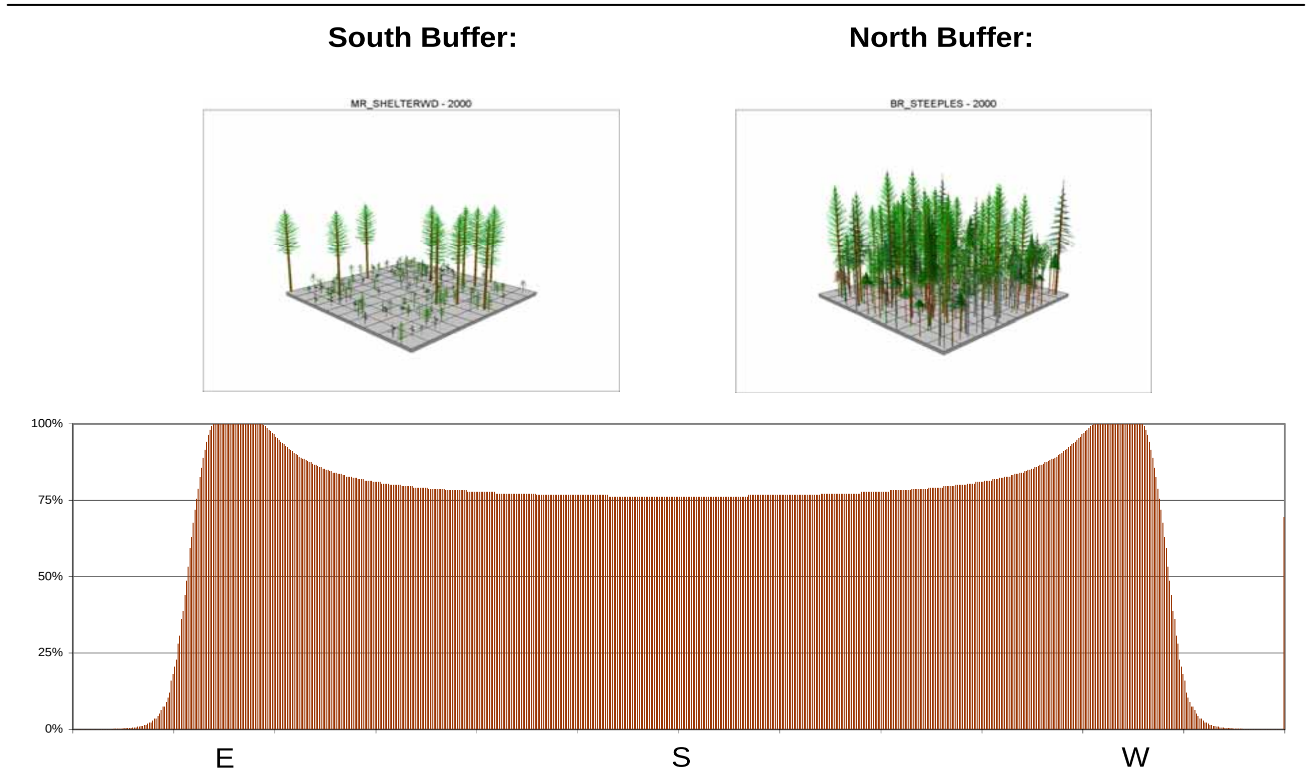

Figure 3. Percent of East-West Stream Reach Receiving Full Sunlight by Solar Azimuth (Time of Day)

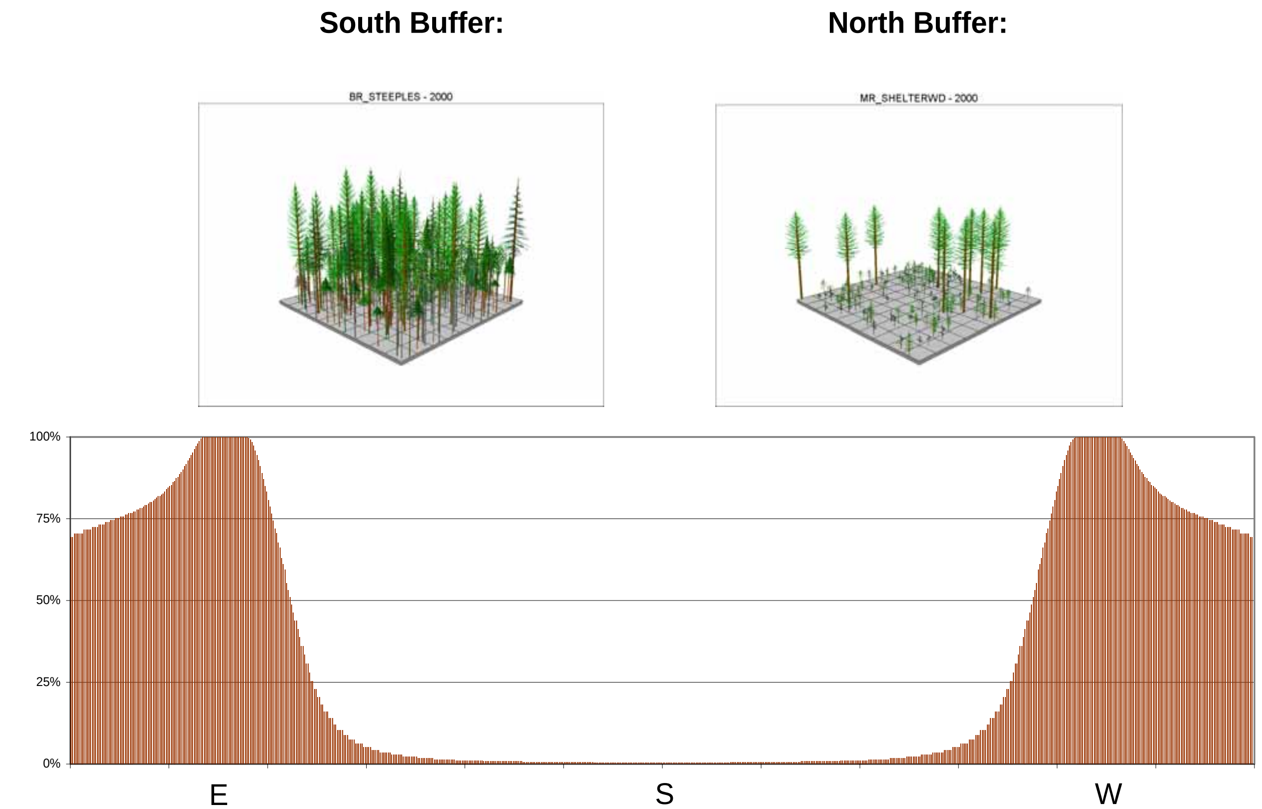

Figure 4. Percent of East-West Stream Reach Receiving Full Sunlight by Solar Azimuth (Time of Day)

These scenarios illustrate that uniform management prescriptions will not produce uniform results across riparian landscapes because of their unique geography. More importantly, uniform management prescriptions may not achieve the desired results. Grouping riparian systems by variables that exert the greatest influence on shade production (e.g. stream azimuth, stream width) can provide predictive functionality from templates developed using a shade model. Templates can then be used to design and evaluate management prescriptions that are appropriately tailored to riparian system-specific conditions without running models simulations such as above for every possible scenario.

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