Spatial Statistical Model for the Spread & Intensification of Dwarf Mistletoe

In collaboration with scientists from the USDA Forest Service we developed a spatial statistical model of dwarf mistletoe spread and intensification, linking the model to the Dwarf Mistletoe Impact Modelling (DMIM) extension of the Forest Vegetation Simulator.

Because it is designed to work with spatial models like TASS and non-spatial models like FVS, the spatial statistical model incorporates a novel combination of explicit tree information with statistical spatial information. The explicit tree information includes standard FVS variables: species, stem density, tree height, and crown length; all of which contribute to estimates of stand and crown transparency. In contrast, the statistical components of the model represent the small-scale spatial clumping of tree stems and the spatial clumping of disease patches in a mathematical framework. Tree clumping is approximated using simulated stem maps, while a simple spatial autocorrelation model describes the patchy spatial nature of dwarf mistletoe infestations.

The tree and spatial information are used to simulate the propagation of dwarf mistletoe within an infested tree and between trees through the ballistic spread of dwarf mistletoe seeds. As a result, species composition, tree size and density, and tree or stand management all have an impact on the spread of the dwarf mistletoe.

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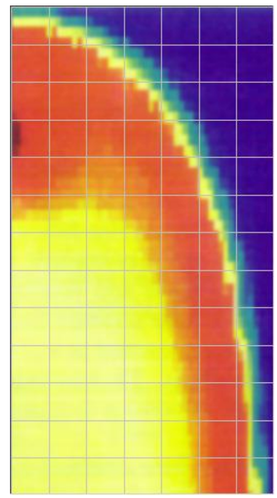
In a recent paper, Robinson and Geils (2006) provide a detailed description of the model and demonstrate its behaviour in a light-limited western hemlock forest from the Wind River Canopy Crane site, and in moisture limited ponderosa pine stands from the Grand Canyon National Forest. The model has been linked to a number of FVS variants for a variety of studies, and has performed well in tests in even and uneven-aged stands. It has also been used to explore a number of management options in coastal western hemlock stands.

Simulation of ballistic dispersal of DM seeds



In a precomputed simulation embedded in the spatial statistical model, 1,000 trajectories emanate from a point 19m above the ground. Gridlines are drawn every 2m and red-to-blue shading indicates higher-to-lower seed density. Ignoring crown interception effects, dispersal can move seeds upward by as much as 6m and outward as far as 14m. Below the source, most trajectories converge 12m outward from the source, as indicated by the red shading. See Robinson and Geils (2006) for more details.

Dwarf Mistletoe in Coastal Western Hemlock Stands

Traditional silvicultural treatment of mistletoe includes the removal of infected stands through clear cut harvest, a practice that is effective at minimising or eliminating residual infection. The quantitative impacts of management practices other than clear cut harvesting are not yet fully understood from empirical observations, and long-term data collection efforts comparing mistletoe dynamics under alternative management regimes are rare or absent. There is, however, a concern that mistletoe infestation may not be adequately controlled following partial harvest entries. For example, residual overstorey infections can potentially propagate into regenerating understorey growth.

In the absence of comprehensive knowledge, we used a simulation modelling approach to do a preliminary evaluation of potential long-term impacts in coastal western hemlock stands in BC. To accomplish this, the spatial statistical model of dwarf mistletoe spread and intensification was linked to a coastal variant of the FVS stand projection model. The model was used to explore a number of management options, including different regeneration assumptions.

The resulting simulations produced plausible projections of stand growth and infection dynamics and demonstrated the key aspects of the model dynamics – sensitivity to:

- overstorey and understorey structure;
- different management activities; and
- different regeneration assumptions.

The model generally shows a dramatic decline in DMR and in the number of infected trees after the first entry. The degree of decline depends on the regeneration assumptions: if regeneration is present prior to the entry, there is less impact on the DMR. After the thinning, the model shows a rebound of infection as the infection is transferred from the residual overstorey to the new understorey trees. As expected, scenarios with a higher residual overstorey always transmit more mistletoe than do scenarios with low residual overstorey since they contain more overstorey trees. Likewise, regeneration scenarios that incorporate western red cedar (which is not infested by dwarf mistletoe) all result in lower transmission success. This reduction is achieved through the physical blocking of seeds and because the infection measures are based on summing over both western red cedar (which is never infected) and western hemlock.

Additional Information

Robinson, D.C.E and B.W. Geils. 2006. Modelling dwarf mistletoe at three scales: life history, ballistics and contagion. Ecological Modelling 199:23-28.

USDA Forest Service Interim Dwarf Mistletoe Impact Modelling System

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