Western Root Disease Model extension to FVS/Prognosis

The Western Root Disease Model (WRDM) extension to FVS/Prognosis is a non-spatial model that simulates the impacts of *Armillaria mellea*, *Phellinus weiri*, and S- and P-type *Annosus* on the growth and mortality of trees in a stand. Stand and disease management options, such as clear cuts, partial cutting, planting, stumping, or borate application can affect the spread of the infection.

The model simulates the spread of disease patches ("centers") within the stand. New infections occur between trees within patches or as the center spreads into uninfected areas. Once a tree is infected, the disease spreads through its root system, spreading more slowly in larger trees. As the disease spreads, growth slows and the tree ultimately dies. Each tree species reacts differently to infection: species such as Douglas-fir, are highly susceptible, while others are immune. Thus, the impact of the disease in the stand is highly dependent on the species composition of the stand as well as the size and density of the trees.

The initial root disease conditions in the stand are set by the model user based on tree inventory damage codes, estimates of the density of infected and uninfected trees, and information about root disease centres present in the stand. The user also has access to a number of parameters which describe, among other options, the relative susceptibility of different tree species to the root disease, and the rate of progress of the disease in the tree.

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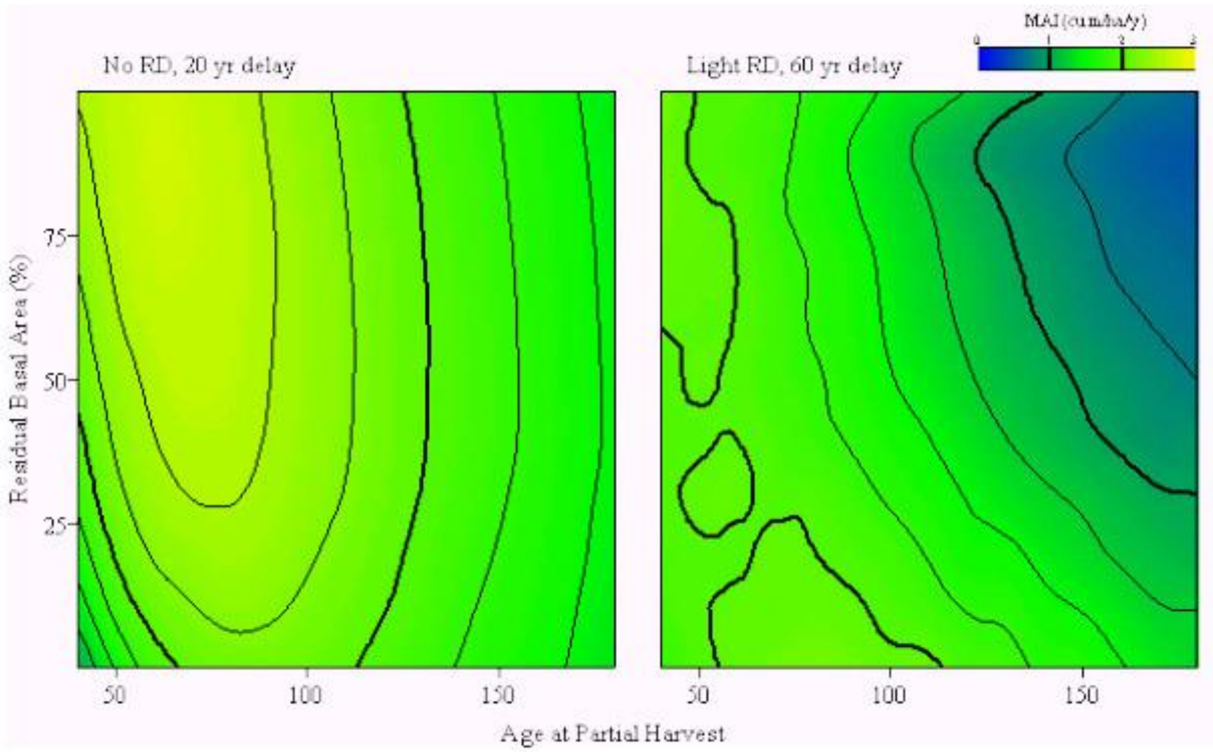
Because stands that contain root disease are often more susceptible to bark beetles or windthrow, the model also includes the ability to simulate these events with user-defined parameters. Since different species of bark beetles may attack the stands, four functionally different bark beetle types are available, and the user is thus able to simulate a range of different infestations.

This model was created by ESSA in cooperation with the USDA Forest Service and the BC Ministry of Forests. It is linked to most of the US western variants of FVS, and to Prognosis^{BC}.

Case study 1: Partial Harvesting in the Nelson Forest Region, British Columbia



Examples of changes in stand productivity (mean annual increment: m^3/ha/yr) in a lodgepole pine Douglas-fir stand from a montane spruce ecosystem. The response surfaces summarise the results of simulation runs with differences in root disease level, age at first entry (horizontal axis) and residual basal area (vertical axis). Contour lines in these plots connect combinations of residual basal area and entry age having the same first rotation MAI. Thick contour lines show integer levels of equal MAI, with thinner contour lines marking the 0.25, 0.50 and 0.75 levels between each integer value, as shown in the legend.

Projections of wood flow in the Nelson Forest Region indicated that there may be a near-term fall down in timber supply due in part, to provincial cutting constraints and green-up requirements. To alleviate some of the impacts of this projected fall down, partial cutting was proposed as one option that could provide timber in the short term, while not violating the green-up constraints that limit clear cut logging. Root diseases such as *Armillaria ostoyae* and *Phellinus weirii* are common in many ecosystem types in the Nelson Forest Region, and tree mortality caused by these root diseases and by windthrow may increase following partial cutting. These reductions may therefore limit the utility of partial cutting as a tool to alleviate timber supply problems.

One way to assess the possible impacts of partial harvesting is to develop “response surfaces” that describe changes in stand productivity (mean annual increment, or MAI) over a range of management actions and root disease levels. In this study, productivity was examined at 3 different levels of root disease across 3 variations of harvesting level:

1. stand age when the partial harvest is done;
2. amount of timber removed; and
3. stand age when the final harvest is done.

Examples of two of these response surfaces are shown in the figure above using contour plots. These are a small subset of the 180 response surfaces and almost 30,000 simulations used in the more comprehensive analysis, but they illustrate the key results:

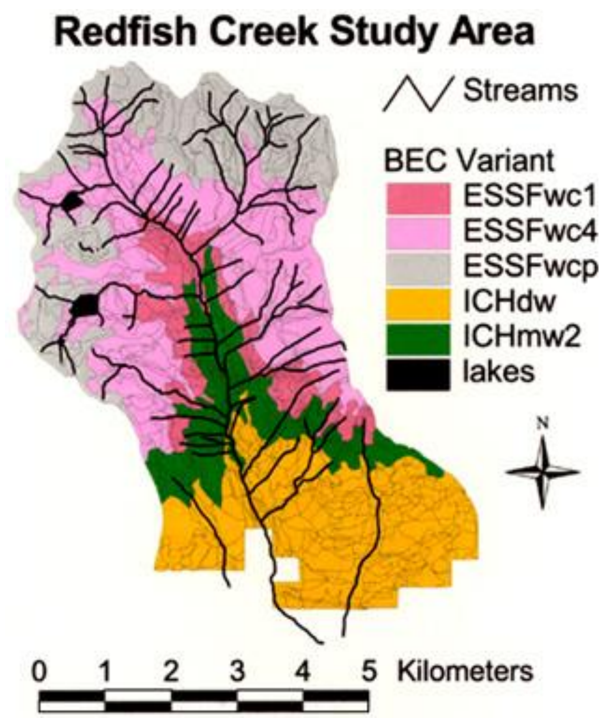
- yield projections are reduced in the presence of root disease;
- impacts are sensitive to timing of stand entries, level of removal and regeneration; and
- harvest strategies aimed at the highest productivity change in the presence of root disease.

In the panels, the lighter (yellow) areas are more productive than the darker (blue) ones, and contour lines connect points with the same productivity. The bottom axes show stand age when the partial harvest is made; vertical axes show the amount of timber retained during that harvest. The left panel shows a scenario taken from a lodgepole pine Douglas-fir stand with no root disease. In this case the highest productivity is achieved when the first harvest is done at about 60 years, retaining about 80% of the timber, followed by a final entry 20 years later at age eighty. In contrast, when light levels of root disease are present (right panel), the best productivity is about 20% lower: 2.17 m^3/ha/yr compared to 2.73 m^3/ha/yr in the disease-free case. Moreover, the best strategy (considering timber values only) in the presence of root disease is to carry out a clearcut harvest at around age 60-80, as shown by the high contours at the bottom of the panel. In this scenario a stand re-entry after a 60 year delay is basically a second full rotation. The change in strategy arises because of the flush of root disease brought on by the first entry. The contour lines at the top of the right panel also show a “right-hook.” This hook marks an abrupt decline in productivity when moving from a “no stand entry” to a “10% removal entry”, and clearly shows that any stand entry is able to bring about a flush of root disease.

Case Study 2: West Arm Demonstration Forest

The first case-study application of Prognosis EI used a 3,300 hectare study area in the West Arm Demonstration Forest (WADF) near Nelson, BC (see figure at left). This area is located on the north side of the west arm of Kootenay Lake. It includes the complete Redfish Creek watershed and two adjacent face units.

Due to variation in soils and current forest cover, the study area included 496 distinct ecological areas for which initial sample tree lists were required. These were obtained by a combination of field sampling and a statistical process in which areas that have not been field sampled are assigned tree-lists from the most comparable sampled areas. The initial 496 ecological areas were subsequently divided as required to simulate each management regime. In total, runs were conducted with either 699 stands or 1321 stands.



The case study considered 21 alternative scenarios. These included patch-cutting and partial-cutting scenarios of interest to the WADF working committee, as well as more extreme scenarios (e.g., no management, or implementation of large clearcuts) used to test model behaviour. These management scenarios were simulated under various assumptions, including both with and without the presence of root disease, recurrent underburns, snag retention, and snag poaching.

Additional Information

Use of the Prognosis EI model in balancing timber and environmental values at the watershed-level

USDA Forest Service Western Root Disease Model site

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