Assessment of Crown Base Recession in Uneven-Aged Ponderosa Pine Forests of Colorado and Arizona

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Overview:

- Due to the importance of crown length/crown ratio in capturing forest dynamics, reliable prediction of changes in crown length/crown ratio in future time periods is vital for subsequent processes dependent on these metrics like tree growth or crown fire initiation at future time points.
- The Forest Vegetation Simulator Central Rockies variant seems to provide reasonable estimates of missing crown length observations at the start of simulations (fig. 1). Refitting the model did not provide substantial improvements in prediction accuracy.
- While model prediction accuracies of how crown length will change over time seem to capture general trends (fig. 2), the accuracies substantially worsen as simulations become longer (fig. 3). Literature suggests that revising the model to use a two-step modeling strategy of first predicting the probability of a tree's crown receding and then predicting how much the crown should recede could improve temporal predictions.

Summary:

The structure of forest canopies from the individual tree crown to the stand canopy level informs a range of ecologically significant factors from photosynthetic capacity and tree vigor to wildlife habitat quality and crown fire potential. However, the data needed for characterizing the crown length/crown ratio is often, at best, subsampled during forest inventories. Therefore, it is important for forest growth and yield models to estimate these missing forest inventory values and to project future changes in crown structure. However, the wide range of tree and stand attributes impacting crown length and its temporal changes have proven to make this difficult in many forest systems. The work used two long-term research stem maps in Colorado (Manitou) and Arizona (Kaibab) ponderosa pine forests to evaluate the reliability of the Forest Vegetation Simulator Central Rockies (FVS-CR) variant for predicting missing crown lengths and projected changes in crown length. Additionally, we provide preliminary thoughts on alternative modeling strategies. FVS-CR prediction accuracy of missing crown lengths at the start of a simulation differed for the two sites (fig. 1), with mean absolute errors of 1.57 and 3.29 m for the Kaibab and Manitou stands, respectively. These differences might be attributed to the two sites being recommended to use different sub-models from FVS-CR. The fitting of a new model to predict missing crown lengths suggests

modifying to a slightly simpler model form that includes height and the interaction of height and plot basal area as predictors, although accuracies were only mildly improved. The projection of future crown lengths by FVS-CR seemed to capture most crown change dynamics (fig. 2). However, initiating simulations without inventoried crown length data reduced the range of future predicted crown lengths. There were notable increases in mean error through time for both study sites, with these errors seeming to be worst when simulated without the inventoried crown ratio to begin with (fig. 3).

Key Concepts for FVS Users:

- FVS-CR is relatively reliable at predicting missing crown length from forest inventory data (fig. 1). However, the use of the Lodgepole Pine sub-model at the Manitou study site resulted in substantially larger errors in crown length predictions.
- Fitting a new crown length prediction model only resulted in small improvements in model accuracy, with most of the improvements seen at the Manitou study site.
- Prediction of future crown lengths by FVS-CR tended to have increased errors as the simulations became longer (fig. 3), with errors tending towards over-predicting the length of a tree's crown.

Management Applications/Future Directions:

- Currently, FVS-CR provides reasonable estimates of crown length at the start of a simulation when these observations are missing from forest inventory data (fig. 1). This accuracy provides confidence in the model's ability to describe current crown fire hazard as a function of crown architecture.
- However, FVS-CR projected future crown lengths (fig. 2) tended to be overly long at Kaibab and to have lengths underpredicted at Manitou, with these errors becoming worse the longer a simulation runs. While these errors indicate the model represents general trends in crown length through time, projection trying to understand things like future crown fire hazard should be cautious about the magnitude of changes and more trust the direction of changes.
- Further work is ongoing to test alternative model forms for predicting future changes in crown length to improve model reliability.

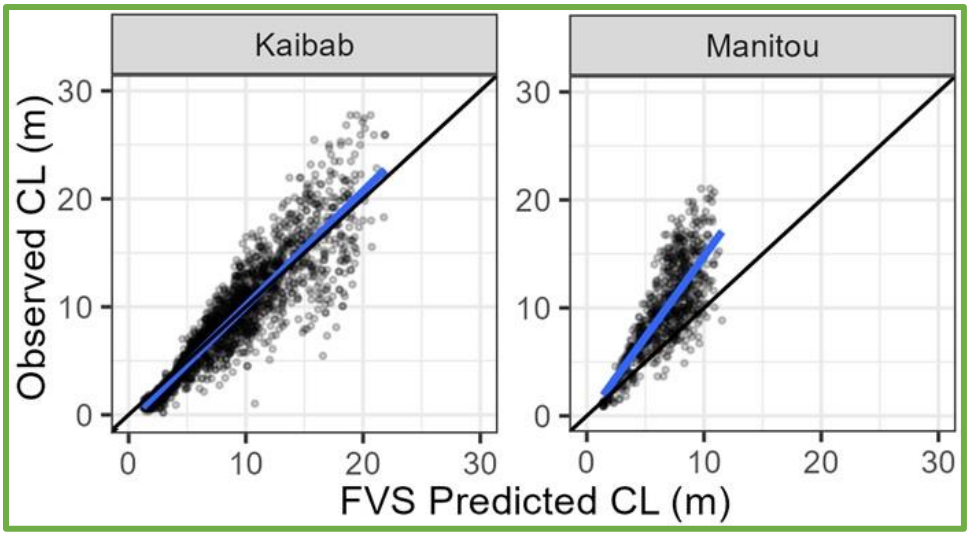

Figure 1—Forest Vegetation Simulator predicted crown length (CL) at the start of simulation compared to field-observed values for the two study sites.

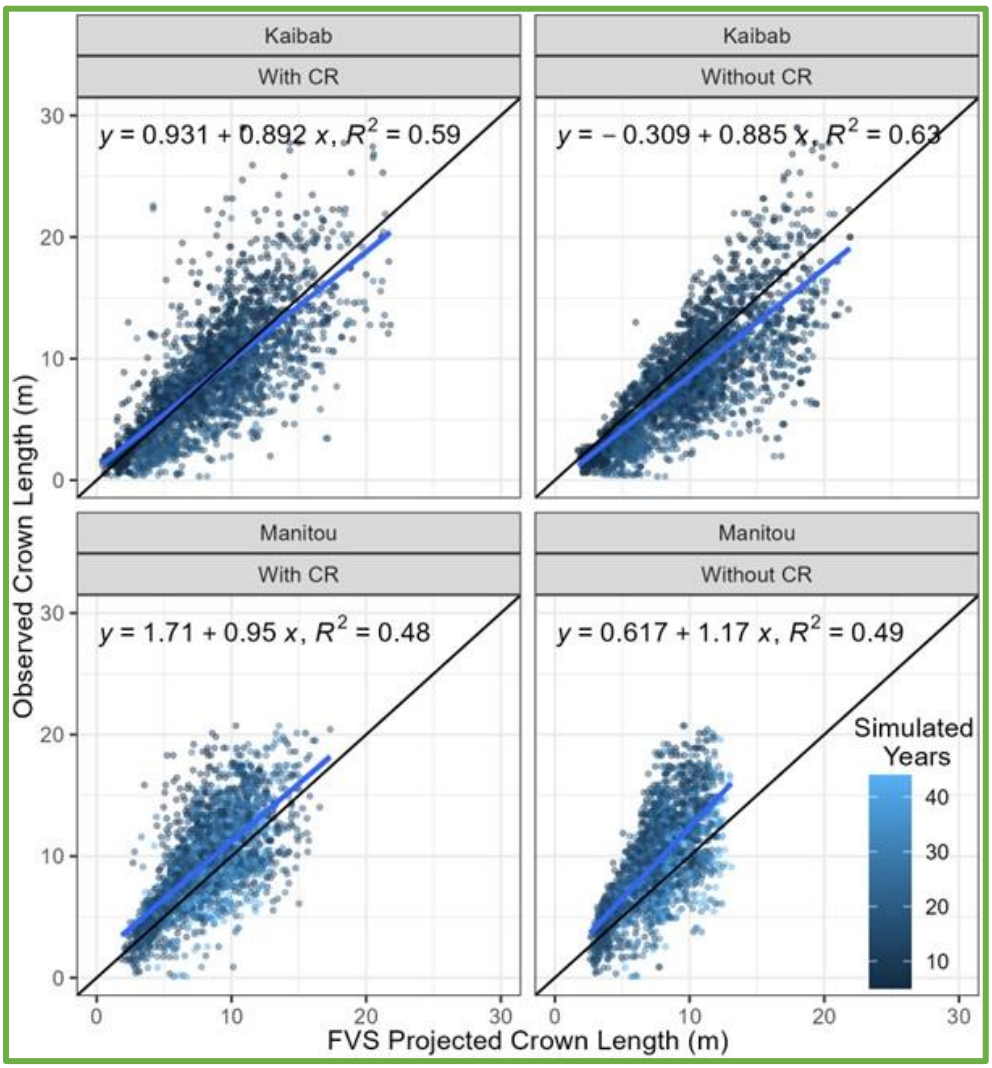

Figure 2—Forest Vegetation Simulator predicted crown length (CL) at different points in the future compared with field-observed crown length for the same trees. Additionally, this compares the effect of initiating the simulations either (left) with crown ratio (CR) or (right) without crown ratio information for the two study sites.

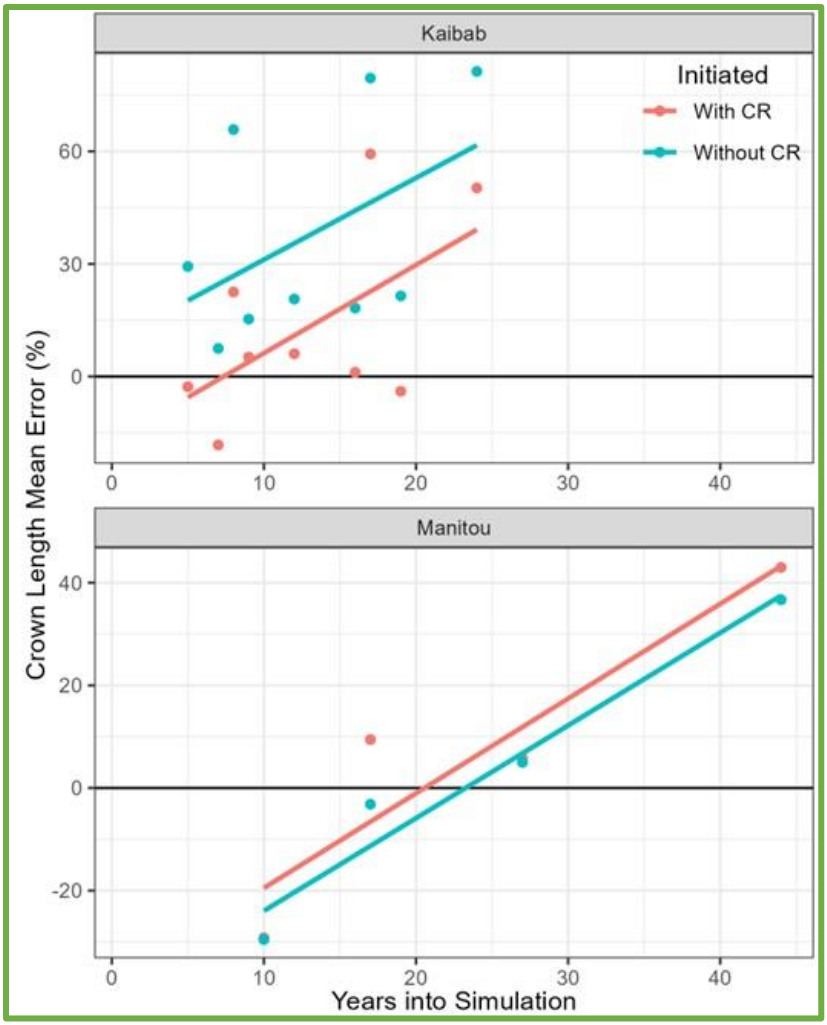

Figure 3—Relative mean error in Forest Vegetation Simulator predicted crown length at different future time points for the two study sites, comparing the effect of initiating the simulations either (red) with crown ratio (CR) or (blue) without crown ratio information.