A Reproducible Workflow to Refit FVS using the FIA Data Stream

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Overview:

- The emergence of FIA as a data stream motivates the development of a reproducible FVS refitting workflow to deliver calibrated software for management decisions and scenario comparisons based on the best available contemporary datasets.
- This opportunity is timely given a clear need for refitting Pacific coast variants given strong overpredictions of net growth under default FVS settings compared to traditional yield curves, FIA chronosequences, and long-term research plot records.
- The implementation of the Wykoff diameter growth function as hierarchical Bayesian state space model allows for FIA observations (and measurement errors) of both DBH and increment cores to be leveraged. This enables model parameters to be learned across ecoregions and confers several advantages compared to historical data selection and regression practices used to refit FVS variants.
- Using Douglas-fir as an illustrative example, we demonstrate the opportunity to simplify and consolidate the variety of diameter growth equations currently employed across Washington, Oregon, and California that are more difficult to interpret and maintain without offering any meaningful benefit in predictive performance.

Summary:

Forest conservation and management plans, decisions, and policy analyses are commonly developed and reported using the Forest Vegetation Simulator (FVS) software without substantial investment or attention to ensuring FVS is well-calibrated or unbiased for the decision(s) at hand. The emergence of repeated measurements from plots across the Forest Inventory & Analysis (FIA) network of the United States provides a unique opportunity for ensuring predictions of forest conditions and dynamics are grounded in software that is calibrated frequently against the best available contemporary data, particularly given broad and diverse interests in learning as quickly as possible about the effects of our changing climate on forest growth, mortality, disturbance, and regeneration.

We introduce a reproducible turn-key workflow that can be used to recalibrate FVS simultaneously across multiple regional FVS variants using FIA data. We illustrate the application of this workflow using both repeated DBH and radial increment measurements to recalibrate the FVS large tree diameter growth model on a five-year timestep using more than 40,000 repeated measurements of Douglas-fir trees across Washington, Oregon, and California. We find that the current variety of equations among eleven FVS variants across these three states employed to predict Douglas-fir growth appear to offer no benefit in predictive performance compared to a consolidated and simplified model. We advocate for the adoption of this simplified form of the Wykoff diameter growth model to improve

ecological interpretability, enable the propagation of uncertainty in model predictions, and facilitate the more frequent recalibration of FVS against the best available data.

Key Concepts for FVS Users:

- Default calibrations of FVS in Washington and Oregon (Diaz et al., 2018), as well as California (Herbert et al., 2023) have shown significant overpredictions of net volume growth compared to benchmarking datasets. These biases are likely to translate into substantially misleading estimates of timber, economic, and carbon sequestration potential among these forests if FVS adjustment or recalibration is not undertaken.
- We recommend a good practice of benchmarking FVS calibration by growing stands from bare ground for 50-100 years and comparing how FVS simulations compare to chronosequences from yield curves, permanent plot records, and/or observations of FIA plots of similar composition and productivity at each 5- or 10-year age class. See supplementary information in Diaz et al. (2018) and Hoover et al. (2021) for examples of this benchmarking approach. Supplementary information in Diaz et al. (2018) also provides an example of using BAIMULT and SDIMAX keywords to adjust FVS behavior to better align with benchmark datasets.
- The recalibration of basic growth, mortality, and other routines in the FVS software using equations that balance interpretability, predictive performance, and maintainability can and should be planned for as a frequent and recurring need and opportunity given the streaming nature of FIA data.

Management Applications/Future Directions:

- The reproducible model fitting approach illustrated here can be easily extended to annualized predictions of diameter growth, taking advantage of the increasing collection of tree cores from FIA plots and release of more precisely measured annual ring width data.
- The fundamental form of the Wykoff diameter growth equation can also be extended to incorporate climatic effects which could be introduced to FVS at runtime during each growth cycle through the use of BAIMULT or FIXDG keywords. This would be a significant advance and more direct approach to capturing climatic influences on forest growth compared to the current implementation of Climate-FVS.
- Open-source Python code to reimplement the findings and workflow presented are available on GitHub: https://github.com/d-diaz/refit_fvs.

References:

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