DEVELOPMENT OF FOREST REGENERATION IMPUTATION MODELS USING PERMANENT PLOTS IN OREGON AND WASHINGTON

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Abstract—Imputation models were developed and tested to estimate tree regeneration on Forest Service land in Oregon and Washington. The models were based on Forest Inventory and Analysis and Pacific Northwest Regional NFS Monitoring data. The data was processed into sets of tables containing estimates of regeneration by broad plant associations and spanning a large variety in forest cover conditions. The output tables were organized to facilitate their use within variants of FVS commonly used in the Pacific Northwest region. The methods were implemented in a highly reproducible fashion to ensure future model adaptability.

INTRODUCTION

Growth and yield models are an important tool for foresters and land managers. They are often used to assess the impacts of different management actions on tree growth and mortality through time. The Pacific Northwest Region of the National Forest System uses the Forest Vegetation Simulator (FVS) growth and yield model to analyze information at multiple scales, from stands of a few acres in size to entire watersheds. Currently FVS requires users to specify forest regeneration densities for all variants applicable in Oregon and Washington. A need exists to have forest regeneration models that are standardized and can be easily incorporated into FVS.

An alternative to traditional predictive model-based methods for estimating regeneration is imputation. Imputation involves replacing missing measurements with realistic measurements from one or more stands with similar characteristics (Ek and others 1997, Hassani and others 2004). Imputation approaches offer advantages over traditional modeling approaches in that they can easily provide estimates of multiple species simultaneously and are not subject to parametric assumptions regarding the distributions of response variables.

STUDY AREA

The study area is all National Forest System lands in Oregon and Washington. Coastal and dry inland effects combine with the topographic effect of numerous mountain ranges and valleys to produce a wide range of climatic zones and vegetation types. This highly diverse region contains seven distinct ecological variants, over 850 plant associations and totals just over 25.0 million acres of NFS land (U.S. Department of Agriculture, Forest Service 2014). The majority of Oregon and Washington's forests are dominated by coniferous forest types, predominantly Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), ponderosa pine (*Pinus ponderosa*), and lodgepole pine (*Pinus contorta*).

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METHODS

Forest Inventory and Analysis and Pacific Northwest Regional NFS Monitoring plot data from Oregon and Washington were combined into a single data set. The data were then subset based on a list of criteria in preparation for imputation. Subplots sampled after 2001 on Forest Service lands were targeted to ensure sampling protocols were standardized. Additional criteria included natural origin with no evidence of artificial seeding, planting, or site preparation and each microplot associated with a subplot need to be dominated by a single condition class. If a subplot was sampled between 2001 and 2003 and was remeasured in the next measurement period (2011 to 2013) then both subplots were only included in the final data set if there was evidence of a significant disturbance 5 to 10 years prior to the most recent measurement; otherwise only the recent remeasurement was included.

Plot and tree data were used to calculate subplot level attributes including estimates of tree density, forest canopy, and fuels. Due to the high number of plant associations and variants, plant associations were grouped resulting in 402 distinct plant association-variant combinations (VPAG). Based on these VPAGs, the data were further subset to ensure an adequate sample size for the development of imputation models, resulting in 64 VPAGs. Although the resulting 64 VPAGs were only 16 percent of the original VPAGs, they represent 78 percent of the subplots in that original data.

Lastly, and to aid in validating our models, the data were split into two groups: a “training” data (75 percent) and a “testing” data (25 percent). The training data was treated as a complete set and used to develop models, whereas the testing data was treated as missing regeneration measurements, candidates for imputation, and utilized as a validation data set.

Empirical knowledge along with generalized linear model procedures and correlation analysis were used in preliminary analysis to determine the attributes most related to regeneration. Based on the resulting important attributes, tabular imputation tables were compiled and validated. Additionally, performance and predictive capability of the tabular imputation model was compared with results using various nearest neighbor approaches.

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