Local Calibration of the Forest Vegetation Simulator (FVS) Using Custom Inventory Data

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Introduction

The Fort Bragg military reservation in North Carolina encompasses one of the largest remaining contiguous tracts of longleaf pine (*Pinus palustris* Mill.). It is also home to one of the largest populations of the endangered red-cockaded woodpecker (RCW; *Picoides borealis*). Management goals that include maintenance of stand composition and structure are accomplished through a combination of silvicultural manipulations and prescribed fire.

Current inventory data and the ability to project future stand conditions are needed to assess the suitability of forest conditions according to the RCW recovery guidelines (U.S. Fish and Wildlife Service 2003). However, existing models do not accurately project growth of southern pines on Fort Bragg. A recent forest inventory of Fort Bragg was deigned to provide data needed for evaluation and re-fitting of allometric and growth models contained in the Southern Variant of the Forest Vegetation Simulator (FVS; Johnson 1997). Our objective is to develop a "Fort Bragg version" of FVS that contains submodels fitted with local data.

Figure 1. Longleaf pine forest, Fort Bragg, North Carolina.

Methods

Inventory Design and Data Collection

FVS variants are composed of a series of submodels, each of which may be independent or linked to other submodels. Because we were primarily concerned with projection of large tree growth and mortality, we elected not to modify the establishment and small tree growth models on the Southern Variant. In addition, we restricted our species list to the common pines found on Fort Bragg: longleaf pine, loblolly pine (*P. taeda* L.), slash pine (*P. elliottii* Engelm.), pond pine (*P. serotina* Michx.), and shortleaf pine (*P. echinata* Mill.). Although over 50 tree species occur on Fort Bragg, non-pine species are typically a minor component of the upland stands that comprise most of the forest.

Using documentation of the Southern Variant (Donnelly 1997, Donnelly et al. 2001), we developed a list of variables that would be necessary for fitting the submodels to Fort Bragg data. This list was used when writing specifications for the 2000 inventory contract. By integrating the FVS-ready variables into the inventory design, we minimized the amount of effort required for data development (Fig. 2).

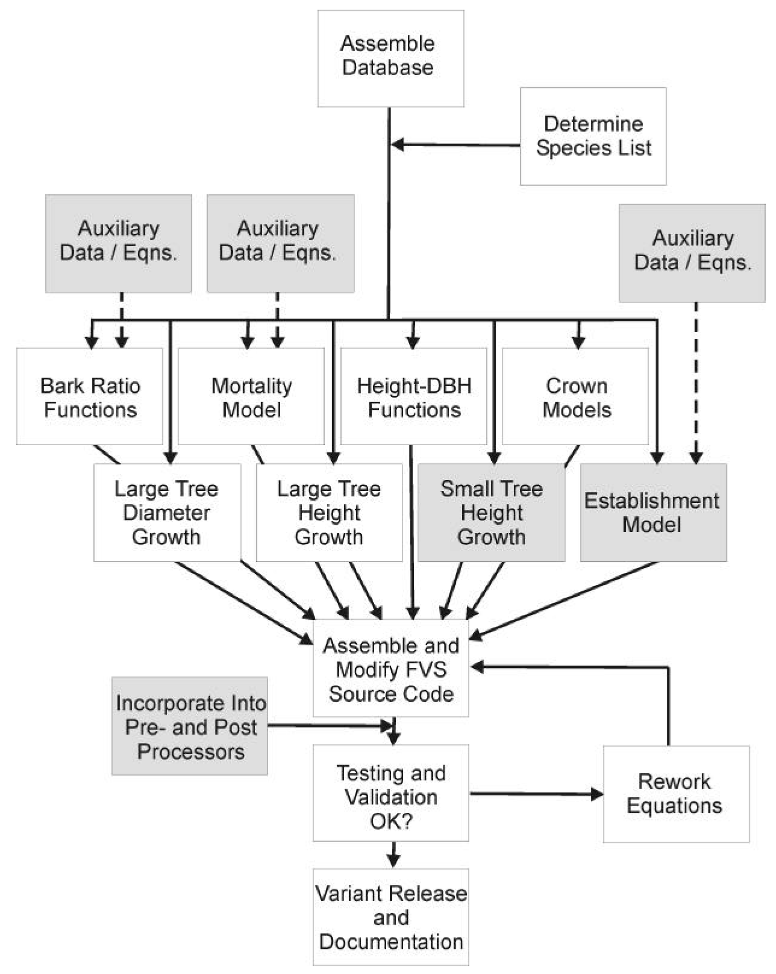

Figure 2. Work process for development of a Forest Vegetation Simulator (FVS) variant (after Johnson et al. 1998). Shaded steps will not be modified during development of the Fort Bragg Variant.

Evaluation and Re-fitting Submodels

Our original work plan called for evaluation of the existing submodels in the Southern Variant, using the Fort Bragg data as a validation data set. We intended to re-fit only the submodels that performed poorly against the Fort Bragg data. However, our experience with some of the simple submodels indicated that it would be more efficient to re-fit each submodel with Fort Bragg data and compare submodel performance afterward.

Fitting the simple submodels, such as those used for height dubbing and bark thickness estimation, was straightforward. We found that substantial improvements in model performance were gained by re-fitting these models with the local data. For example, the height-dubbing submodel of the Southern Variant over-predicted height by nearly 8 ft on average. In addition, height prediction bias varied widely across the range of stem diameter. By re-fitting this equation, we were able to reduce bias to less than ±0.2 ft over most of the range of diameter, with a maximum bias less than ±1.2 ft over any range of stem diameter from 2 to 25 inches (Fig. 3).

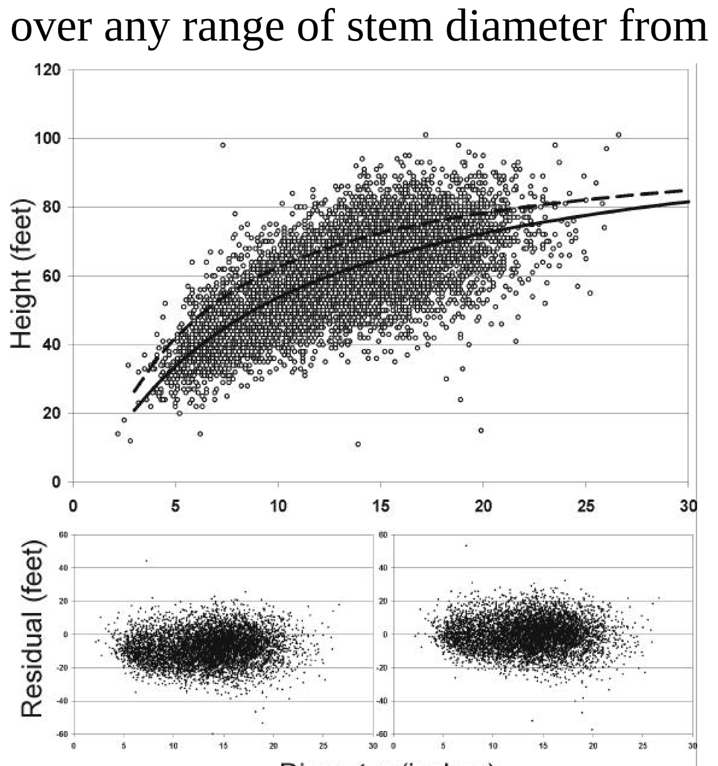

Figure 3 Results of re-fitting the height dubbing model. A. Fort Bragg diameter-height data for 7371 longleaf pines. Dashed curve represents diameter-height relationship for longleaf pine in the Southern Variant, which has a mean bias of 7.7 feet on Fort Bragg (B). Solid line represents re-fitted equation. Re-fitted equation has less than bias to less than +0.2 ft over most of the range of diameter, with a maximum bias less than +1.2 ft over any range of diameters from 2 to 25 inches.

Mortality Modeling

Perhaps the most challenging part of the model-building process will be development of the mortality submodels. The Southern Variant determines mortality rates 3 ways. When stand density index (SDI) is < 55 percent of the maximum SDI for the forest type, FVS uses a background mortality rate that is a function of diameter and age. If SDI is ≥ 55 percent of maximum SDI, mortality is density-dependent. When quadratic mean diameter is < 10 inches, mortality is mediated by maximum SDI, and when quadratic mean diameter is ≥ 10 inches, mortality is mediated by a maximum basal area for the forest type. The switch from background mortality to SDI-mediated mortality to basal area-mediated mortality is evident when quadratic mean diameter and stem density projections from an FVS simulation are plotted on a density management diagram (Figure 4).

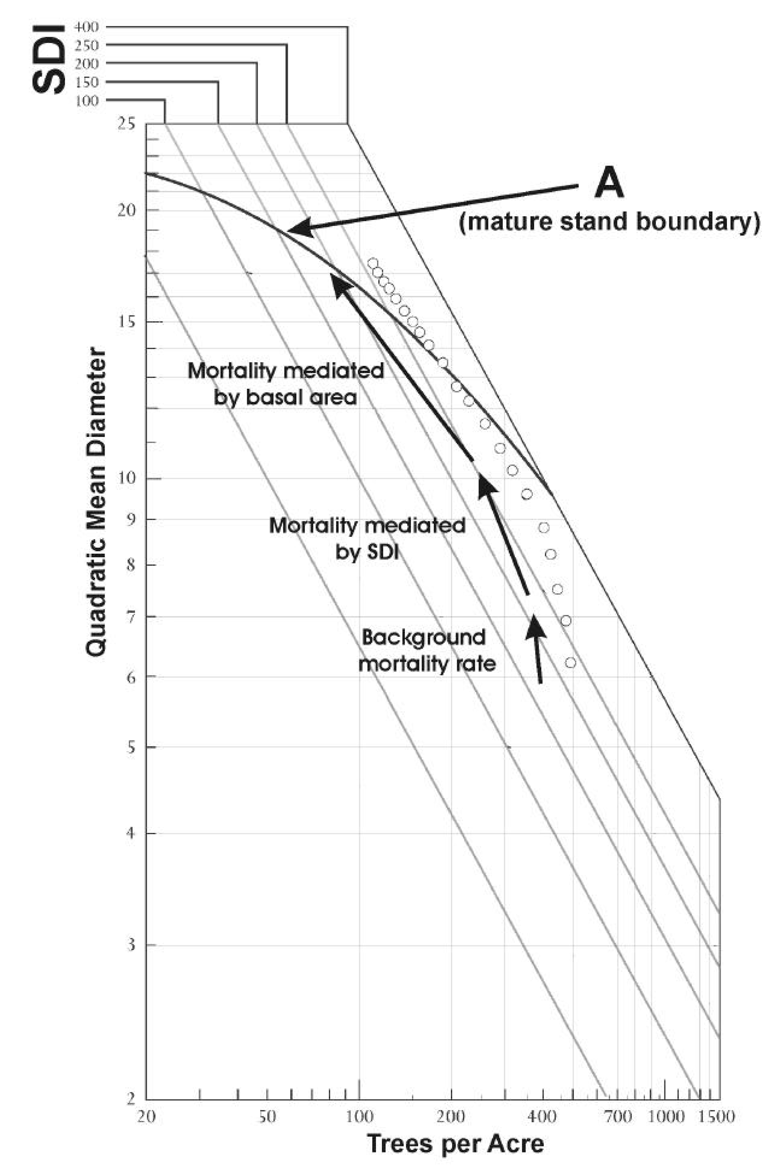

Figure 4. Density management diagram for longleaf pine showing FVS projections of a natural longleaf pine stand from 25 to 125 years of age (open circles). The inflection in stand trajectory between 9 and 11 inches mean diameter results from the shift from SDI-mediated mortality to basal area-mediated mortality in the FVS mortality submodel. Line A is the mature stand boundary for longleaf pine proposed by Shaw and Long (in press).

However, the density-dependent self-thinning dynamic projected in the Southern Variant of FVS may not be realistic for mature longleaf pine stands. Recent work on stand density and dynamics of longleaf pine stands suggests that the expected self-thinning trajectory does not hold for stands with a quadratic mean diameter greater than about 10 inches (Shaw and Long in press). Specifically, FVS projections of longleaf pine growth exceed the maximum limit of the size-density relationship, or "mature stand boundary", proposed by Shaw and Long (in press) for longleaf pine (Figure 4, Line A).

We will attempt to model the mature stand boundary using the existing FVS program logic and model forms. If stand dynamics cannot be modeled adequately using this approach, it may be necessary to modify program logic or form of mortality functions.

Discussion

This project will satisfy the long-standing need for an accurate growth model for longleaf and other southern pines on Fort Bragg. Because of the large amount of data obtained from mature (70+ years old) longleaf pine stands, the models should perform well under stand conditions that provide suitable habitat for the endangered red-cockaded woodpecker.

Although we have referred to this effort as development of a local version of FVS, the ultimate goal is to integrate the Fort Bragg submodels into the existing Southern Variant of FVS. The process we used for development of the local version can be repeated wherever adequate data are available. FVS has evolved since the development of the original Prognosis model (Stage 1973), and one mechanism by which this has occurred is user feedback and participation in model refinement.

Acknowledgements

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