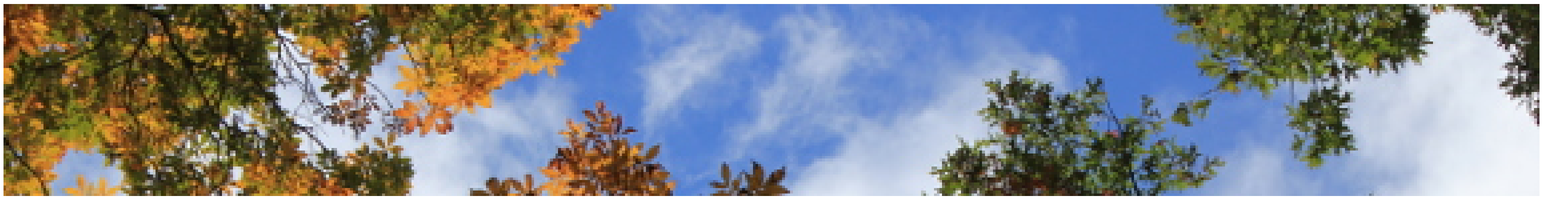

2017 Forest Vegetation Simulator (FVS) e-Conference

Abstracts

Presenter Name in Bold

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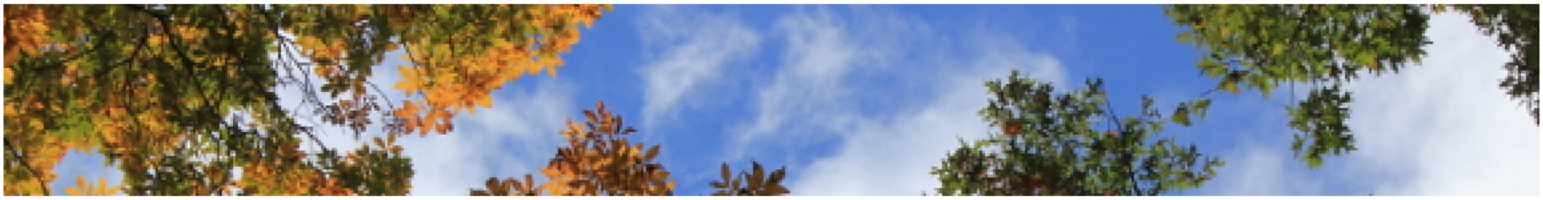
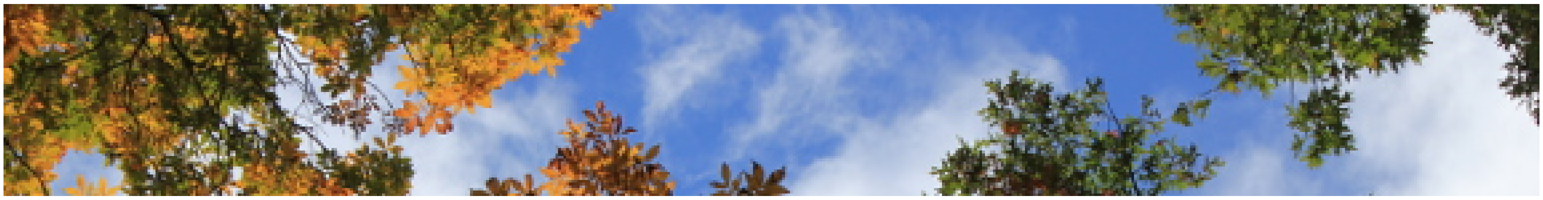
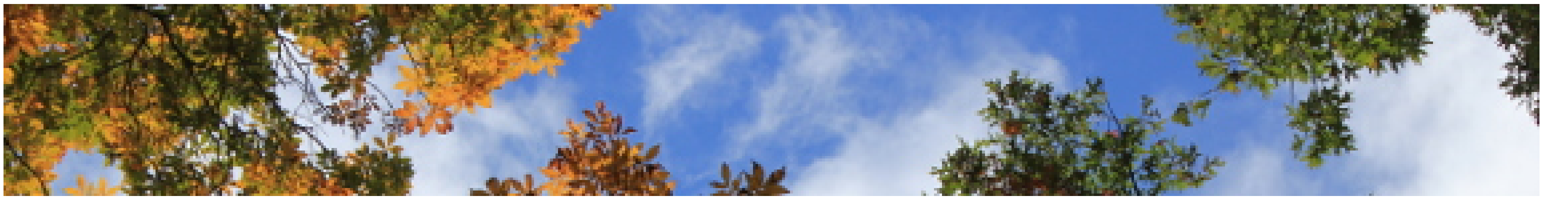




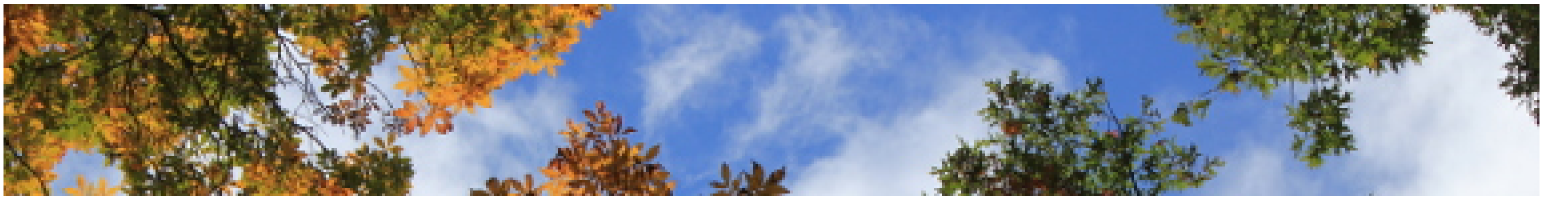


FVS Development: Modernization

User Needs Assessment for the Modernization of the Forest Vegetation Simulator

Wade Tinkham, Molly Roske and Linda Nagel

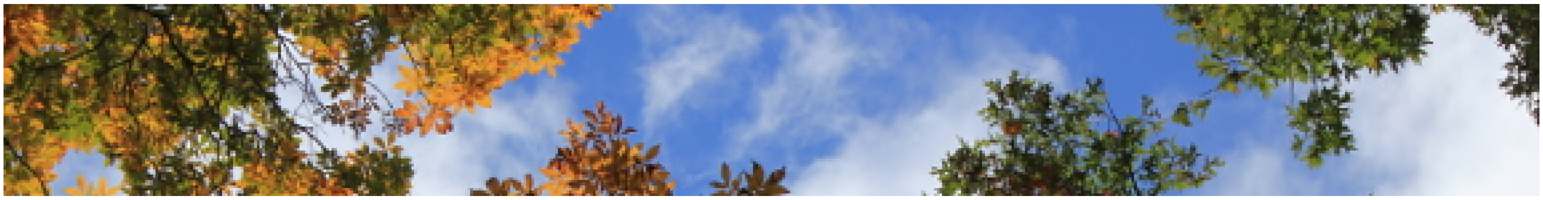
The Forest Vegetation Simulator (FVS) is the most widely used growth and yield modeling platform within the United States for assessing how vegetation will respond to natural succession, disturbances, and proposed management actions. The US Forest Service has undertaken a multi-year process of modernizing FVS so that it can meet the computational and performance demands of modern forest management. This process is seeking to address issues with user interface needs, model output structures, and improving the model code to be more efficient and easier to maintain. As part of this process a cross-section of management and research users are being interviewed to help identify areas where users see potential to improve the modeling system. These interviews are being followed by a workshop that will further refine recommendations for how FVS can be modernized to meet the demands of twenty-first century users. Lastly, a wide spectrum of FVS users are completing a survey to secure feedback about the potential areas this modernization process might seek to improve the model's usability. This presentation will outline some of the key themes that arise from this user input process and that serve as a first step towards guiding FVS modernization recommendations.



Introducing FVSOnline as a Replacement to Suppose

Nicholas Crookston

FVSOnline can do most of the useful tasks Suppose does and much more. You interact with the software through a web browser and all your data and software resides on a server computer, or you can load the software on your Windows, Unix (MAC OSX for example), or Linux computer and run it locally. The software contains tools for building and making FVS runs supporting many features found in Suppose. It has been tested on large (ca 20,000 stands) runs and performs well. In addition, it automatically manages the output database--that is, you don't have to remember to delete obsolete data--and contains tools for exploring the outputs of FVS in tabular and graphical formats. The ability to easily compare the outputs from different runs is well supported.

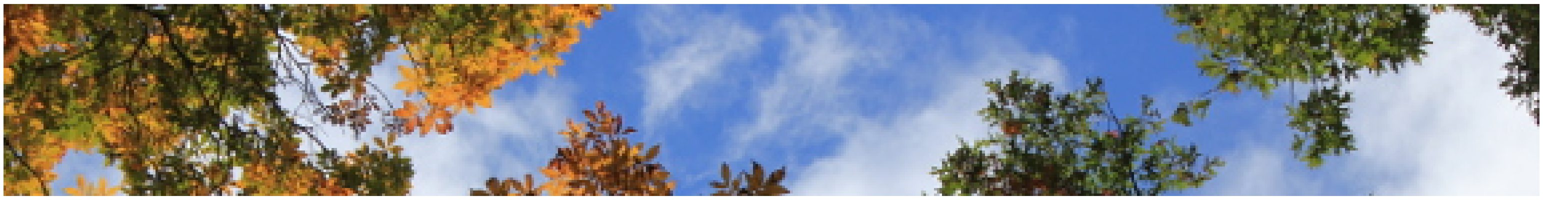


FVS Development: New Variants

Development of the ORGANON based FVS Variants, FVSop and FVSoc

Erin Smith-Mateja

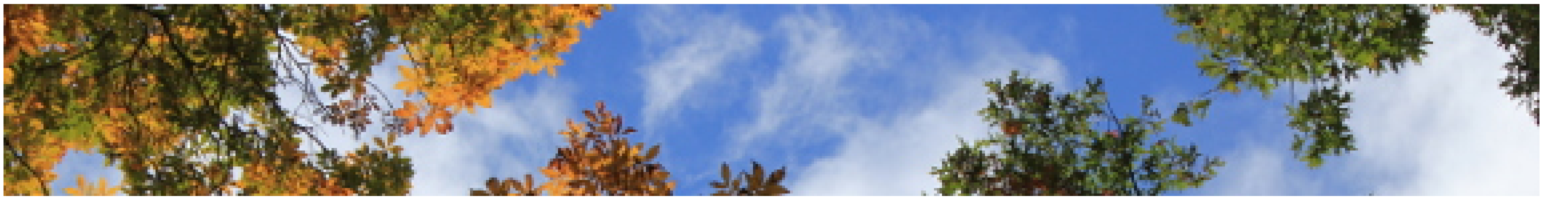
ORGANON (ORegon Growth ANalysis and projectiON) is an individual-tree distance independent growth and yield model developed at Oregon State University (Hann 2009, Ritchie Hann 1984). There are 4 version of ORGANON that cover growth for specific geographic areas or forest types, they include; the Southwest Oregon version (SWO-ORGANON), northwest Oregon version (NWO-ORGANON), and the Stand Management Coop Version (SMC-ORGANON), specifically built for Northwest industrial landowners for shorter rotations, and the Red Alder Plantation (RAP-ORGANON), built specifically for red alder plantations in the Northwest. ORGANON is used in the Pacific Northwest by both BLM, Industrial landowners, consultants and Universities. In general the model is stable and trusted among users in the Pacific Northwest. Oregon State University provides two versions of ORGANON, a DOS Version and DLL version. The DOS version is cumbersome and only allows for single stand processing, because of this most consultants and companies have built their own interface that calls the DOS executable or runs the DLLS. In addition, ORGANON does not have growth equations for trees less than 4.5 feet tall and has poor error processing. This additional overhead makes ORGANON frustrating and time consuming for the small landowner, small consultant, or public agencies to use. Through an interagency agreement with BLM the Forest Service has incorporated the growth equation of the SWO, NWO and SMC version of ORGANON into the base FVS code. Allowing users to have ORGANON growth through the Suppose interface, have the functionality of FVS error processing, the use of FVS keywords for management and robustness of the Event Monitor and FVS post processing.



The Acadian Variant of the Forest Vegetation Simulator: continued development and evaluation

Aaron Weiskittel, *John Kershaw, Nick Crookston and Chris Hennigar*

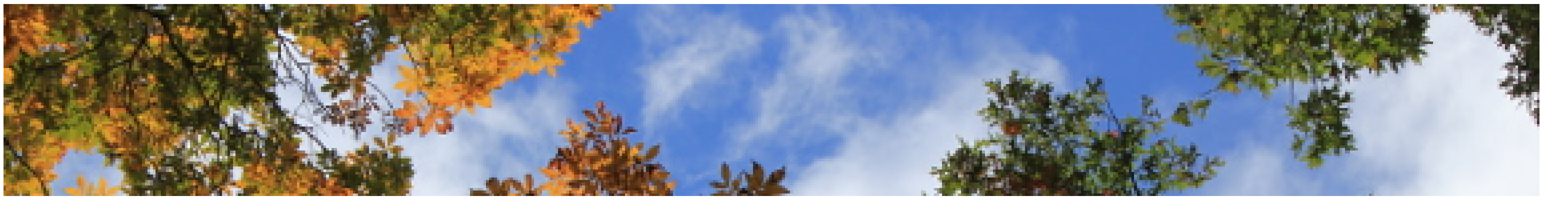
The Acadian Region of Maine and the Maritime Provinces of Canada is characterized by an extensively managed, naturally-regenerated stands comprised of mixed species and multi-cohort structures. This area is quite distinct when compared to the rest of the Northeastern US as it is the transition zone for several species as the hardwood forests of the temperate zone mingle with the softwood forest of the boreal zone. A complex of topography, soil parent material, and climatic zones also creates a diverse forest. The Northeast Variant of the Forest Vegetation Simulator (FVS-NE) has a long history and covers a broad geographic region with previous testing indicating potential shortcomings in the Acadian Region. Since 2008, efforts at the University of Maine and New Brunswick have focused on developing a FVS variant specific to the Acadian Region (FVS-ACD). The FVS-ACD model has recently been updated and compared to FVS-NE across a range of forest type typical for the region. Important changes include the projection of ingrowth dynamics, influence of commercial thinning on spruce-fir growth, and the potential effects of spruce budworm defoliation on spruce-fir growth and mortality. In general, FVS-ACD stand net growth is often higher than FVS-NE, particularly when ingrowth is incorporated. The equations have been fully incorporated into FVS-Online (http://forest.moscowfsl.wsu.edu:3838/FVSOnline/). This oral presentation will review the progress to date, provide comparisons to FVS-NE, and discuss future directions for model development.



Development and Evaluation of an Individual Tree Growth and Yield Model for the Adirondacks Region of New York

*Aaron Weiskittel, **Christian Kuehne**, John Paul McTague and Mike Oppenheimer*

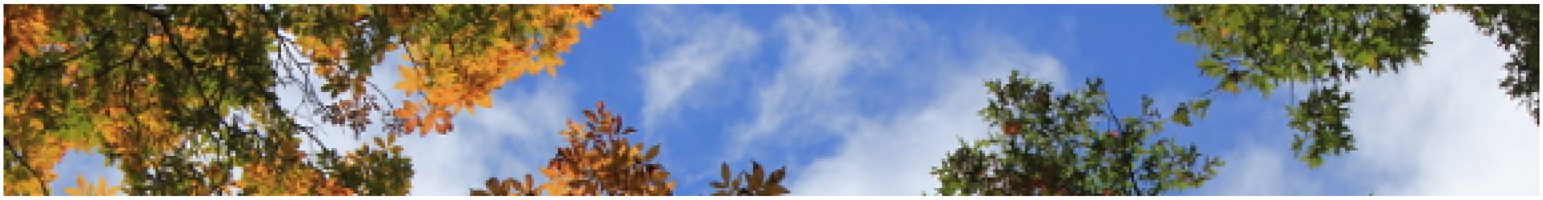
Growth and yield models are important tools for forest planning. Due to its geographic location, topology, and history of management, the forests in the Adirondacks Region of New York are unique and complex. However, only a relatively limited number of growth and yield models can be reasonably extended to this region currently. In this analysis, 559 long-term continuous forest inventory plots with 7 – 52 years of measurement data from 4 experimental forests maintained by the State University of New York College of Environmental Science and Forestry and 1 nonindustrial private forest were used to develop an individual tree growth model for the key hardwood and softwood species in the region. Equivalence tests indicated that the Northeast variant of the Forest Vegetation Simulator was biased in its estimation of tree total and bole height, diameter and height increment, and mortality. Annualized species-specific equations were developed using the available data and the system was tested for long-term behavior. Overall, the growth model showed reasonable behavior and is a significant improvement over existing models for the region.



Modeling Future Dynamics of European Beech Forests for Ground Beetle Conservation

Giorgio Vacchiano, Roberta Berretti, Elena Regazzoni, Flavio Ruffinatto and Matteo Negro

European beech forests are of particular importance for biodiversity, although relatively little is known about how beech forest management affects invertebrate communities. In this work we investigate the influence of beech forest management on ground beetle diversity in Northern Italy. We measured total abundance, species richness, Shannon diversity and abundance of the endangered endemic species Carabus olympiae in 30 plots managed as either coppice or high forest, and modelled diversity metrics as a function of stand structure and management history. Then, we calibrated the Forest Vegetation Simulator to pure beech forests using field measurements, forest inventory data and keyword-based multipliers, and projected the stands 100 year into the future to compare the effect of alternative management options on ground beetle diversity. Currently, over mature coppices are favorable to ground beetles, including C. olympiae, although succession over time can lead to a progressive homogenization of the vegetation structure, with negative consequences for their conservation. Based on our results, we suggest that the traditional management of beech coppice and its conversion to high forest be modified by promoting structural and microhabitat diversity such as retention of large trees, creation of canopy gaps, retention of coarse wood debris and the preservation of 'islands' of older trees in the managed stands.



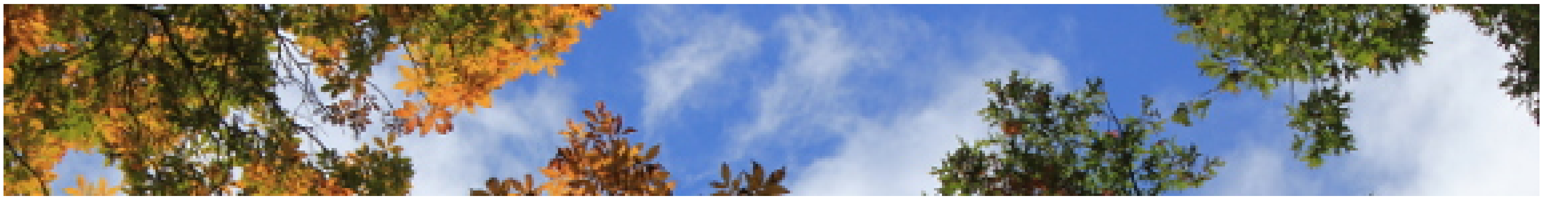
FVS Development: Extensions, Post Processors and Links to Other Models

Climate and Soils Driven Growth and Yield for Eastern Variants of the Forest Vegetation Simulator

Huiquan Jiang and ***Philip Radtke***

Concern over climate change effects on forest vegetation has raised the need for growth and yield models responsive to climate and edaphic variables specified as predictors. Models designed to be incorporated into the Forest Vegetation Simulator (FVS) modeling system were developed to address this need. National forest inventory measurements from Forest Service FIA plots from 37 states in the eastern United States were merged with 30-year average climate variables and soils data from SSURGO for use in fitting new models. Individual tree diameter increment and periodic mortality regression models were fitted to remeasurement data for the twenty most abundant species in the eastern U.S., which comprise over two-thirds of the region's growing stock. A set of over 50 predictors were selected that included climate, soils, and forest inventory measurements. Regression model accuracy compared favorably to predictive models developed using nonparametric methods including artificial neural networks and random forests. Implementation should be straightforward following a similar architecture as Climate-FVS developed by Crookston et al. (2010) for western FVS variants; namely, users will be able to specify vegetation inputs from forest inventory or stand exam data, and query climate and soils predictors from a web-based service based on plot geographic coordinates.

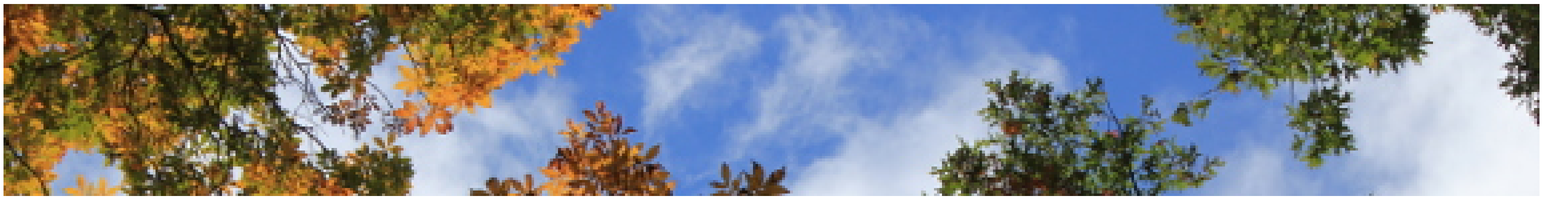
Crookston NL, Rehfeldt GE, Dixon GE, Weiskittel AR, 2010. Addressing climate change in the forest vegetation simulator to assess impacts on landscape forest dynamics. Forest Ecology and Management 260:1198-1211.



The FVS-WRENSS Water Yield Post-Processor: validation of snow-dominated procedures

Robert N. Havis

Forests provide about two thirds of the Nation's freshwater supply, with about half originating on federal forests and grasslands in the West. To assist forest managers in increasing the delivery of freshwater supplies from forested land, a water yield post-processor for the Forest Vegetation Simulator (FVS) model, the most widely used forest management tool available, has been developed for the contiguous US. Validation of the FVS-WRENSS water yield post-processor used data from a harvest experiment in the Fool Creek watershed at the Fraser Experimental Forest in the Colorado Rocky Mountains where one half of the forested land was cut-block harvested in a paired watershed study. FVS was initialized with stand inventory data and used to simulate undisturbed forest growth, the historic harvest, and the subsequent forest regeneration and regrowth. Minor adjustment of the meteorological input data to FVS-WRENSS was required to accurately simulate the magnitude and trends in water yield change over 21 years. Simulated average stream flow was within 10 % of field measurements.

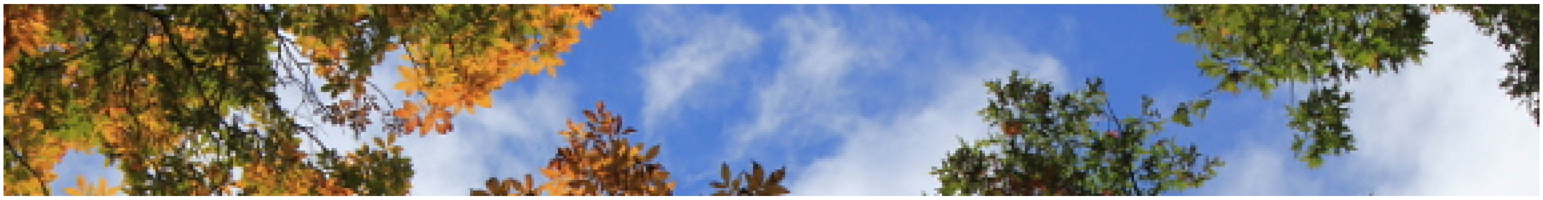


Linking FVS and TELSA via the API

Sarah Beukema and *Donald Robinson*

The FVS Application Program Interface (API) was created to allow developers to be able to use FVS in close conjunction with other simulation tools. To date the API has been incorporated into applications written in VB.Net, R, and Python.

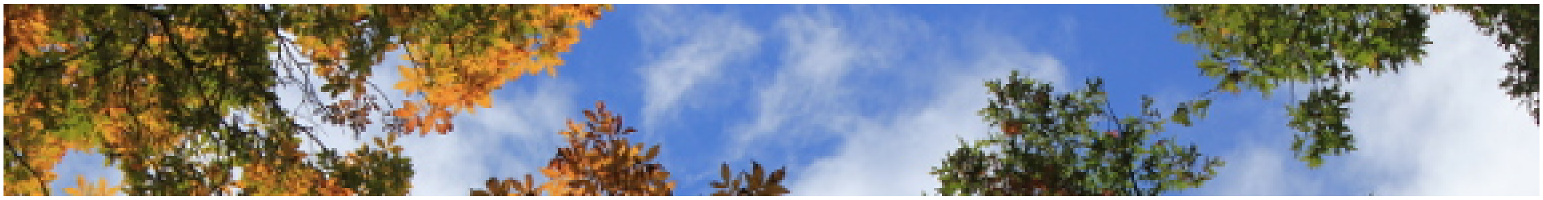
We used the VB.Net API to link FVS to TELSA, a state-transition landscape simulation model written in C++ . In the linked system, TELSA is the driving model that provides a treelist and site information and calls FVS to grow the stand in each landscape polygon each year. FVS then passes back to TELSA information such as stand volume that can then be used by TELSA to schedule harvesting. TELSA also initiates natural disturbances and regeneration and may pass changed treelists back to the FVS program. Landscapes of up to 180,000 stands have been run in test simulations.



Linking FVS to 3D Fire Models: introduction to STANDFIRE, a platform for stand scale fuel treatment analysis

Russell Parsons

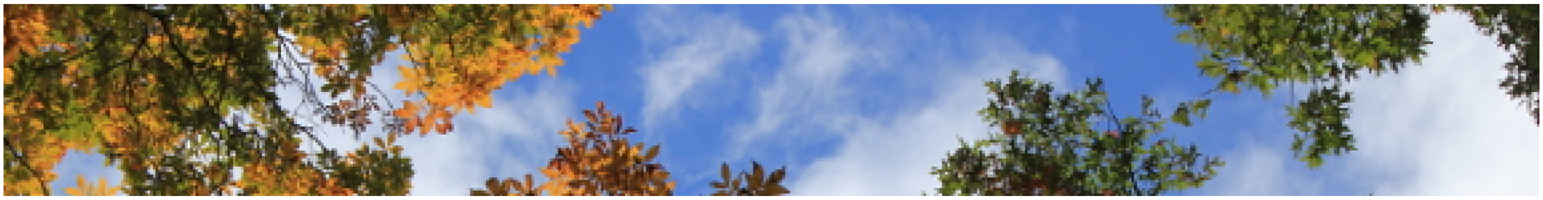
Managers are increasingly called upon to implement fuel treatments to reduce potential fire behavior, or to support restoration efforts. The FFE-FVS system plays a key role in such analyses. However, much of the detail of real world fuels in FFE-FVS cannot be used to full effect in the simple fuel and fire models within FFE-FVS and other systems, making it difficult to relate real fuels on the ground to how they might burn. This presentation introduces a new platform for stand scale fuel treatment analysis, called STANDFIRE. STANDFIRE builds upon and extends the capabilities of FFE-FVS, enabling us to use real world fuels data, test spatially explicit fuel treatments, and assess their effectiveness in altering fire behavior using dynamic 3D physics-based fire models to calculate both fire behavior and effects. STANDFIRE connects directly to the existing FFE-FVS model using FFE-FVS for biomass and growth over time, facilitating analysis of fuel treatment longevity. A modular design permits incorporation and testing of new components as they become available, paving the way for continuing refinement applying next generation science knowledge to help managers more confidently assess fuel treatments to improve firefighter safety and restore our ecosystems.



Bioregional Inventory Originated Simulation Under Management: a framework for evaluating forest restoration alternatives and their outcomes, over time, to inform monitoring at the assessment phase, and beyond

Jeremy Fried*, Terrie Jain, Sara Loreno, Robert Keefe and Conor Bell*

We developed BioSum as a landscape planning decision-support system to summarize current and prospective future forest conditions under alternative kinds of forest management along with the costs, revenues and product yields associated with each management option. BioSum feeds publicly available FIA tree inventory and other data, parameters and assumptions to FVS, OpCost (for treatment cost estimation) and HaulTime (for estimating costs of log and chip delivery) to 1) implement multi-decade sequences of silvicultural prescriptions; 2) generate lists of harvested trees to estimate wood produced and treatment cost, by decade; and 3) calculate decadal stand descriptors to predict outcomes of management trajectories with respect to forest resilience and carbon dynamics. Hundreds of alternative management sequences and their outcomes can be simulated and formally compared and ranked for each forested acre using any criteria desired. A BioSum project dataset can support monitoring at Forest and Regional scale by providing initial conditions (via FIA data), and a testbed for evaluating assumptions and potential prescriptions and how they play out over time (via FVS, etc.). This dataset also provides a baseline against which broad-scale monitoring data, collected as plots that continue to be remeasured, ad infinitum, can be compared, leading to better knowledge about latent effects of management and improvements to future versions of FVS and BioSum parameterization. Like a LeathermanTM, BioSum is a versatile multi-purpose tool that informs managers charged with sorting through myriad options and making best choices. Examples of BioSum application to fire resilience in the west coast states are presented and discussed.

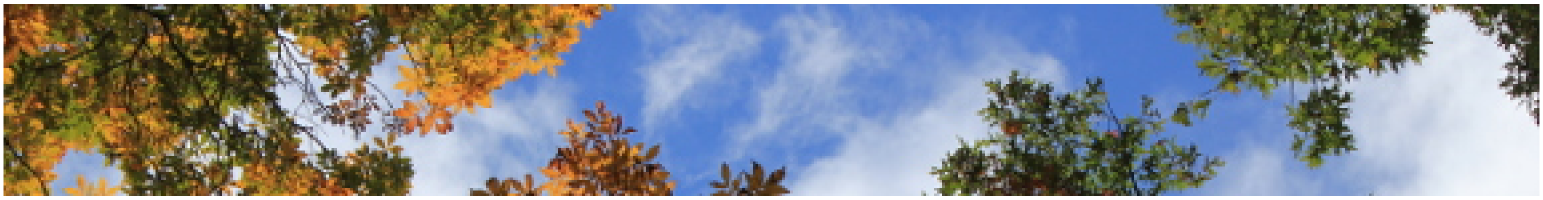


FVS Computational Techniques

An Evaluation of Predicted Site Index in Large-Tree Diameter Growth Modeling of Selected Tree Species in the Great Lakes Region

Ram K. Deo, Robert E. Froese and Matt E. Russell

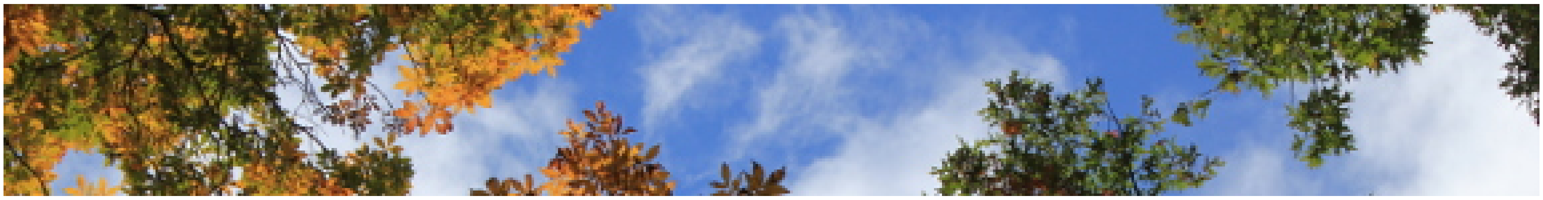
Forest site index (SI) is a widely used productivity metric in forest growth and yield projection models. However, SI estimates using allometric models are prone to error due to inaccuracy in tree age and height data, particularly from uneven-aged mixed species stands comprising of shade tolerant species. Since site productivity depends on numerous biotic and abiotic factors, field sampling SI data can be extended spatially over a large-area by using multiple bio-geo-climatic (BGC) spatial layers. This study integrated SI data of the US national forest inventory (NFI) with a suite of spatial layers comprising temperature, precipitation, soil, and canopy reflectance properties in a k nearest neighbor (kNN) imputation framework to produce SI maps for five major species in the Lake States. The accuracy of imputed SI values was validated against an independent set of measured SI, and performance of the predicted SI was also tested in large-tree diameter growth models formulated using the NFI online database. As an attempt to decouple growth models from the error-prone SI variable, an approach of directly including BGC variables in the models was also tested with the ultimate goal of improved accuracy and climate sensitivity of models. The random forest based kNN imputation modeling of SI revealed good fit to the training data (R2 > 0.90); however, accuracy of imputed SI varied with species and was poor for shade tolerant species. The alternative way of including site factors in the growth models revealed that BGC variables are the most promising compared to the measured or imputed SI. The success of imputed SI was either similar to or worse than the measured SI and varied with species. The negative coefficient of imputed SI in the growth model for northern white cedar suggests that the spatial model is not reliable for such species that grow over a wide range of sites, remain dormant for several years and respond quickly to release operation at any age. The SI models for intolerant species such as red pine, quaking aspen and northern red oak were found to be satisfactory, but the models for sugar maple and northern white cedar were not trustworthy.



Adjusting Canopy Cover Estimates for Non-Random Spatial Distributions in FVS

Michael Shettles and Erin Smith-Mateja

Estimates of percent canopy cover are increasingly used as a target metric in silvicultural prescriptions. The Forest Vegetation Simulator (FVS) is a powerful tool that can project estimated differences in forest stand development given a range of alternative prescriptions, with percent canopy cover being one key metric used to distinguish differences. Estimates of percent canopy cover calculated by FVS are corrected for crown overlap, and are assumed to represent stand conditions where trees are randomly spaced. This assumption of a random spatial distribution has been observed to produce biased estimates of percent canopy cover when trees are from stands with non-random spatial distributions (e.g., clumped or uniform). Using tree-level measurements and empirical values of percent canopy cover on 4,599 Forest Inventory and Analysis plots within nine US States, relationships between field-measured percent canopy cover and FVS-calculated values of uncorrected percent canopy cover were used to develop non-linear regression models for predicting overlap corrections for non-random spatial distributions. These results have subsequently been implemented into the FVS keyword framework. CCADJ (corrected percent Canopy Cover ADJustment) allows users to change the overlap assumption using these predicted overlap corrections based upon a range of user-defined spatial distributions. Values of percent canopy cover for non-random distributions can now be used as a target metric in conjunction with the "Thin to a residual percent canopy cover" management action.



Live Tree Carbon Stock Equivalence of Fire and Fuels Extension and FIA Inventory Approaches

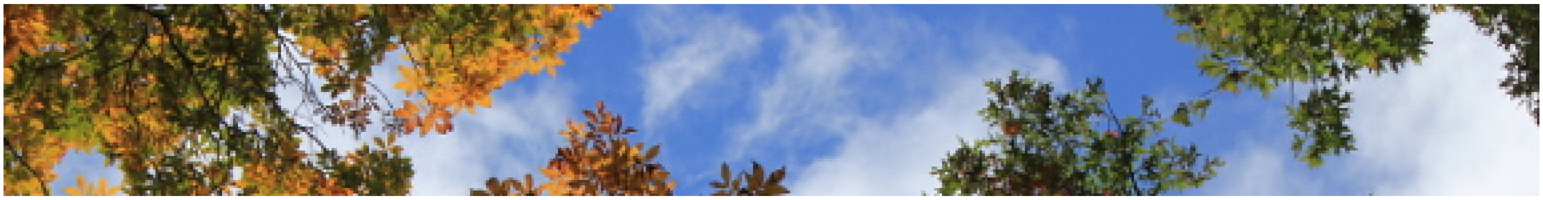
Coeli M. Hoover and *James E. Smith*

The carbon reports in the Forest Vegetation Simulator provide two alternate approaches to carbon estimates for live trees. These are (1) the Fire and Fuels Extension (FFE) estimates, which are volume-based biomass equations, and (2) those commonly termed the Jenkins equations, which are diameter based.

Here, we compare FVS based carbon in aboveground live trees with the component ratio method approach provided in the FIADB and focus on identifying where alternate approaches produce equivalent estimates of stand level carbon. For this, we established FVS stands from FIA data and tested for equivalence at the 5 and 10% level in paired plot estimates. We compared Jenkins and FFE pairs by forest type group and FVS variant, and repeated the comparison for CRM and FFE pairs.

A preliminary analysis over six western variants identified some forest type groups within some FVS variants as equivalent – no consistent trends are apparent for the variants reviewed up to this point.

In general, the CRM-FFE paired approaches are more often equivalent than are the Jenkins-FFE. For example, with CRM-FFE the Douglas-fir type group is equivalent in Utah, Central Idaho, and Tetons but not in Northern California or Eastern Montana. The Jenkins-FFE pairs were not equivalent in any of these variants. Very few type groups were identified as having consistently higher carbon estimates (i.e., all plots) via one approach versus another.



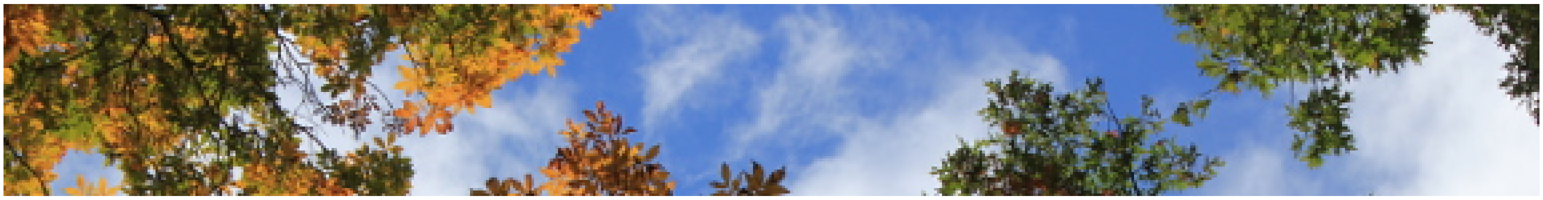
Theoretical Foundation of Stage's Formulation of Stand Density Index

H. Bryan Lu, Fred Martin and Ralph Johnson

Stand density index (SDI) is calculated in all variants of Forest Vegetation Simulator (FVS) software and displayed in output tables. In addition, it is also used to drive the mortality function in a number of variants of FVS. Hence, it is important to understand how SDI was implemented in FVS.

Reineke (1933) developed SDI to measure the density of an even-aged stand. Stage (1968) showed that the Reineke's SDI can be computed tree by tree. However, he never mentioned the theoretical foundation of his SDI formulation. Stage's SDI formulation was written as a Fortran subroutine (see https://sourceforge.net/p/open-fvs/code/HEAD/tree/branches/FMSCrelease/base/src/sdical.f) in FVS software.

The purpose of this paper is to reveal the theoretical foundation of Stage's SDI formulation. The theoretical foundation is based on the fact that the Reineke's SDI is a real-valued homogeneous function of degree 1 (Silberberg and Suen 2001). By Euler's theorem (Silberberg and Suen 2001), it can be transformed from an inseparable form to a separable and form. In addition, it also ensures additivity at both tree and group levels.

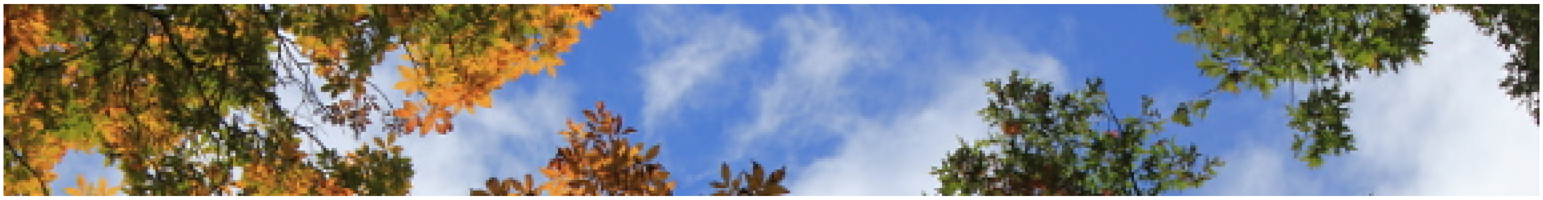


FVS Regeneration Modeling

Modeling the Impact of Overstory Density on the Regeneration Dynamics of Missouri Ozark Forests

Lance A. Vickers, David R. Larsen, John M. Kabrick, Daniel C. Dey and Benjamin O. Knapp

Foresters have long understood that overstory manipulation offers opportunities to influence regeneration dynamics due to interspecific differences in response to disturbance and resource limitation. However, predicting the effects of silvicultural choices on the composition and structure of the regeneration layer has traditionally been difficult. To improve this, we have developed a collection of models to estimate seedling establishment, allometry, and growth as a function of overstory density and other factors for several species found in the Missouri Ozarks. The covariates used in the models were predominantly based on stand development hypotheses and empirical data were used for parameterization. Although a pre-disturbance inventory is needed, an effort was made to limit the required input to attributes that are either commonly inventoried or are otherwise relatively simple to collect. The models can produce both deterministic and stochastic estimates of regeneration attributes in various time-steps for a range of residual overstory density. Though imperfect, the combination of these models provides a powerful tool for both applied and empirical objectives and provides opportunities to increase both our understanding of the regeneration process and the efficacy of our efforts to manipulate it. To date, model estimates have provided quantitative evidence of interspecific differences in both seedling establishment and growth rates, and that those differences vary with residual overstory density. These results are consistent with reports of regeneration response to various silvicultural manipulations in the Missouri Ozarks and beyond. Potential methodologies for expanding the regeneration modeling capacity of FVS for similar forest types based on the experiences of this effort will be discussed.

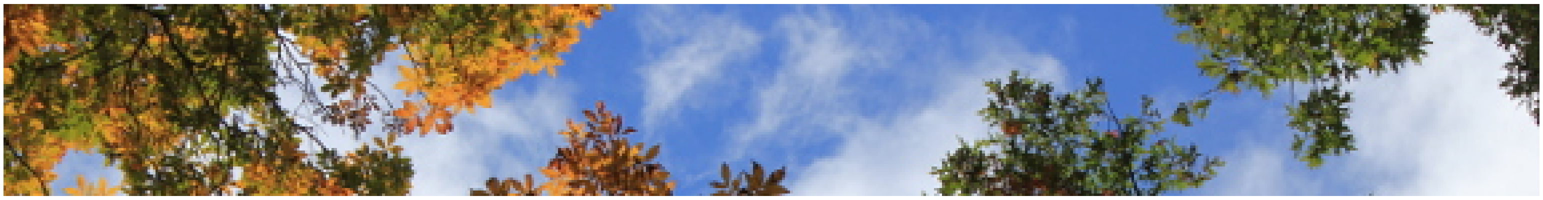


Development and Assessment of Regeneration Imputation Models for National Forests in Oregon and Washington

Leah C. Rathbun, *Andrew J. Sánchez Meador and Karin M. Kralicek*

Managers use growth models to assess the potential effects of alternative treatments and are especially useful when site-specific information regarding the potential effects of a treatment is lacking or unknown. While FVS has become the growth model of choice for many forest managers tools for automating natural regeneration remain limited or absent within the modeling process. The need exists for natural regeneration models that can be easily incorporated and automated into FVS. Ideally any models developed need to be implementable when data is restricted to the information captured in standard inventories (e.g. common stand exams) or permanent plots (e.g. Forest Inventory and Analysis, FIA) commonly collected by land managers.

While regeneration can be modeled in many ways, imputation methods are an alternative to classic regression techniques. Imputation in this context is an estimation technique where missing or non-sampled measurements from one target stand is replaced with measurements or observations from another reference stand from the same population and similar characteristics to the target stand (Rubin 1987, Ek et al. 1997, McRoberts 2001, Eskelson et al. 2009(a)). Imputation models were developed to estimate regeneration density and composition throughout Oregon and Washington. The models were based on Forest Inventory and Analysis and Pacific Northwest Regional NFS Monitoring data. Individual models were developed based on broad forest plant association groups (FPAGs) with all model development and analysis conducted in R using a most similar neighbor (MSN) imputation approach.

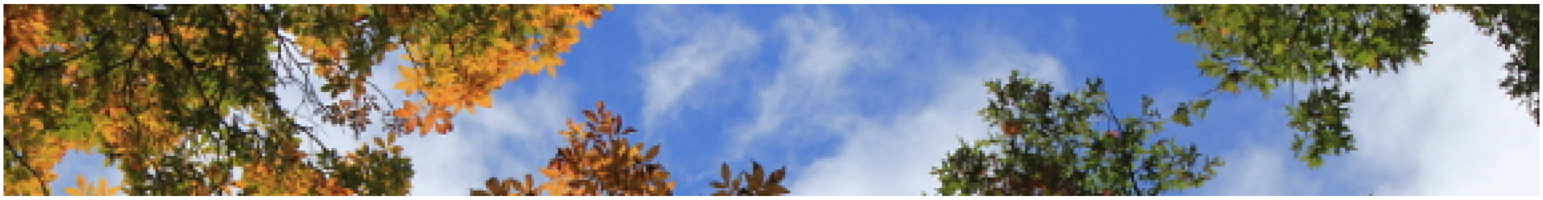


FVS Evaluation: Base Model

Performance of the Northeast (and Acadian) Variants of FVS in Relation to an Extensive Chronosequence and Remeasurement dataset for Eastern White Pine (Pinus strobus, L.) in Central Maine

David Ray and *Robert Seymour*

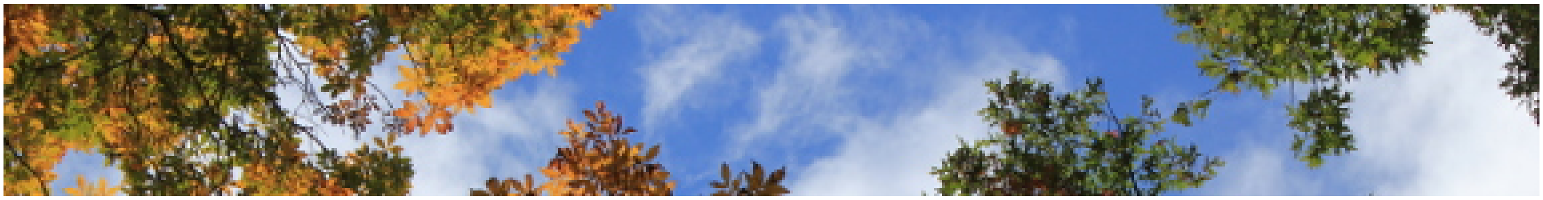
Eastern white pine has been referred to as the ‘tree that built America’, and despite steady declines in extent and stocking it remains the most important softwood timber species in the Northeastern US. At present the commercial value of EWP is derived almost exclusively from sawtimber production, which has important implications for density management, generally favoring low stocking and fast growth of individual trees. Suitable habitat for EWP is forecast to expand in response to climate change, which being a long lived (ca 450 yr) species capable of attaining surprisingly high carbon densities, makes it worthy of consideration for use in forest based carbon mitigation projects -- an objective that favors more complete utilization of growing space. This paper will explore key aspects of these divergent management scenarios using regionally appropriate variants of the FVS model, including NE and Acadian. An extensive independent dataset will be used to both calibrate and validate model predictions leading to recommendations for best practice use.



Evaluating FVS Diameter Increment in Disturbed Forests Across the US Lake States

*Mack Glasby and **Matt Russell***

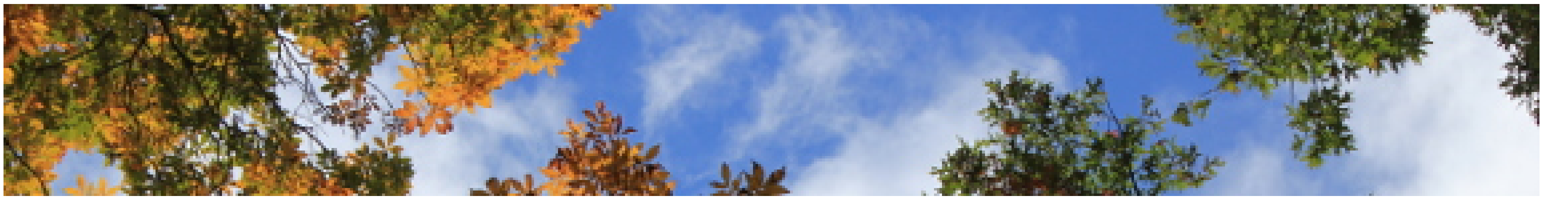
Due to the recent climatic and weather pattern changes, improving growth and yield models to better account for disturbances and stochastic events is now crucial for managers to successfully manage forests under uncertainty. Current growth equations within the Forest Vegetation Simulator-Lake States (FVS-LS) variant are not sensitive to forest disturbance which may accelerate or decelerate individual tree growth. Using 15 years of diameter increment observations from three measurements of Forest Inventory and Analysis plots, we assessed the performance of new diameter increment equations adopted in FVS-LS in 2014 in disturbed and non-disturbed forests across the US Lake States. For 22 species analyzed, FVS-LS diameter increment equations overpredicted ten-year diameter increment slightly (mean bias of 0.03 inches/10-yr) in forests that did not experience a disturbance. In disturbed forests, mean bias of ten-year diameter growth of disturbed trees was 0.12inches/10-yr, indicating that FVS-LS underpredicted diameter increment in disturbed forests. This analysis could help modelers to improve the performance of growth and yield models in the presence of disturbance and better quantify the uncertainty of forest growth following disturbance.



Evaluation of the FVScr Diameter Growth Model and Potential Modifications in Structurally-Complex Ponderosa Pine Forests

Yvette L. Dickinson*, Michael A. Battaglia and Lance A. Asherin*

Forest managers are increasingly focused on maintaining or promoting forest structural complexity; however, many of the forest models commonly used by forest managers assume that stands are homogeneous. Therefore, using these models to predict the development of structurally complex stands through time may provide inaccurate results. We investigated the accuracy and precision of stand and individual tree growth estimates from an individual tree growth model commonly used by forest managers (Forest Vegetation Simulator - Central Rockies Variant) in ponderosa pine stands over 16 years following silviculture treatments that aimed to increase forest structural complexity. Furthermore, we examined whether the addition of 28 tree vigor, semi-distance independent and spatially explicit indices of local competition to the model improved the accuracy and precision of stand development projections. We found that while the stand-scale estimates of growth from the original model were acceptably accurate, the estimates of individual tree diameter growth had a RMSE that equated to 44% of the mean individual tree diameter growth. The addition of crown ratio to the model reduced the bias and RMSE of the projected individual tree diameter growth more than the semi-distance independent and spatially explicit indices investigated, and therefore we recommend that crown ratio be added to the model to improve estimates of individual tree diameter growth in structurally complex stands.

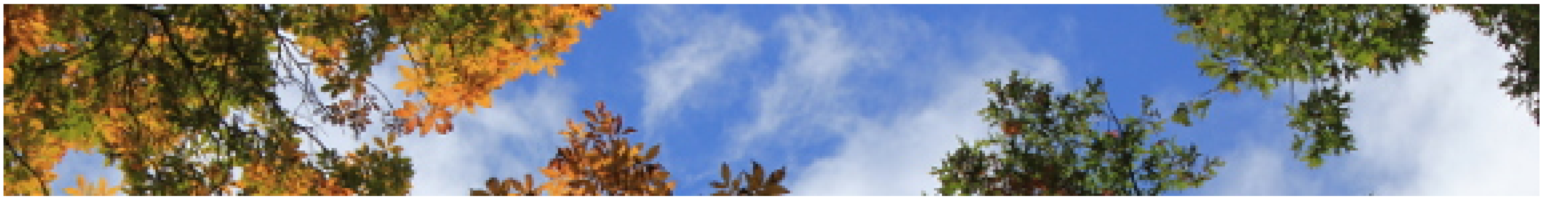


FVS Evaluation: Fire and Fuels Extension

Evaluation of the Fire and Fuels Extension (FFE) of the Forest Vegetation Simulator (FVS) within the Missouri Ozarks

Casey R. Ghilardi, Benjamin O. Knapp, Hong S. He, David R Larsen and John M Kabrick

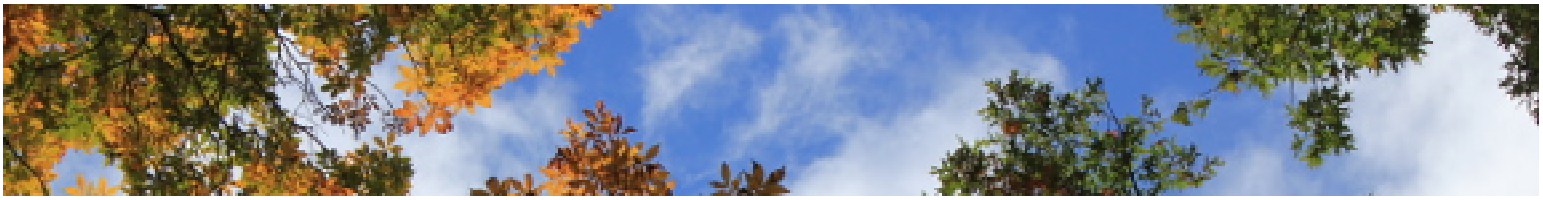
The Forest Vegetation Simulator (FVS) is a stand-based, individual tree growth and yield model designed and maintained by the USDA Forest Service. It is used by land managers on public and private ownerships to simulate and compare the effects of silvicultural treatments on forest stand dynamics including tree growth, mortality, and regeneration. The Fire and Fuels Extension (FFE) of FVS is designed to simulate changes in fuel loading through time and can incorporate user-specified fuel treatments into projections. We tested whether the default model fuel loading values from two FVS variants (Central States and Southern variants) were representative of field-based fuel loads using FIA data collected in the Ozark Highland region. We also compared fuel loads projected by FVS-FFE to empirical data collected from a 14-year study examining the impact of harvesting and burning on fuel loading in the Missouri Ozarks. Preliminary findings indicate that default values for both variants were not representative of light fuels (litter, 1, and 10 hour fuels), while larger fuel classes were represented better by the Central States variant than the Southern variant. Choice of variant did not significantly change projected fuel loading for all fuel classes at the end of the 14 year simulation. Results suggest that choice of variant has little impact on short-term projections and that using observed fuel values rather than defaults can improve projection accuracy in the short-term.



Validation of the Southern Variant Fire-Related Mortality Models for Prominent Upland Hardwood Species in the Central Hardwood Region

Tara L. Keyser, Virginia McDaniel, Robert Klein, Dan Drees, Jesse Burton and Melisa Forder

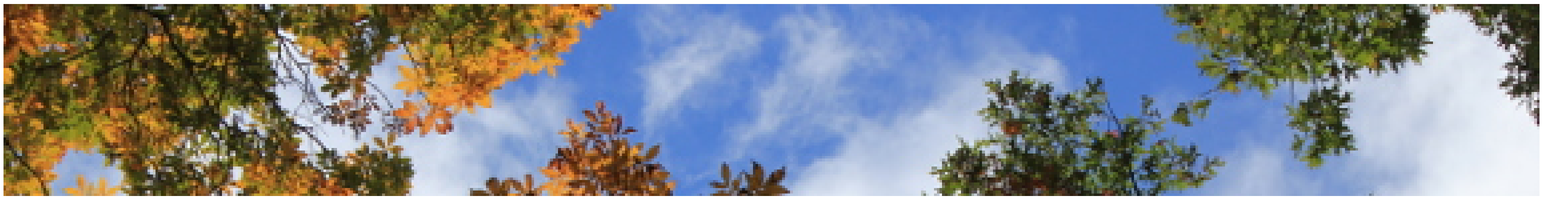
Current nationally-supported fire effects models, including FFE-FVS, are invaluable in that they allow resource managers to assess the potential effects of alternative prescribed burning prescriptions on a variety of stand-level variables including changes in structure via fire-related tree mortality. Although fire effects/behavior models are national in scope, the underlying equations driving the prediction of fire-related mortality for the vast majority of US tree species were derived from data obtained from western conifer species. For tree species in the Central Hardwood Region (CHR), quantitative models that predict mortality following prescribed fire – one of the most widespread land management activities conducted in the southern forests – are lacking. Consequently, fire planning programs must utilize empirical models developed for western conifers to predict mortality of eastern tree species. Widespread application of models built with data outside the geographic range of application, let alone across functional groups, has the potential to introduce substantial error into model forecasts and misrepresent the ecological effects of prescribed burning. In this study, we utilize a fire effects monitoring dataset to validate postfire mortality models embedded in the FFE-FVS (Sn) for some of the predominant species in the CHR, and, when necessary, develop new species- or functional-group specific mortality equations. By developing postfire mortality for the suite of species that comprise upland forests of the CHR, and incorporating those predictive models into available fire planning tools, managers will have improved ability to predict fire effects and assess the efficacy of burn efforts guided by restoration goals and objectives.



Estimating Canopy Bulk Density and Canopy Base Height for Conifer Stands in the Interior Western US using the Forest Vegetation Simulator Fire and Fuels Extension

Seth Ex, *Frederick (Skip) Smith, Tara Keyser and Stephanie Rebain*

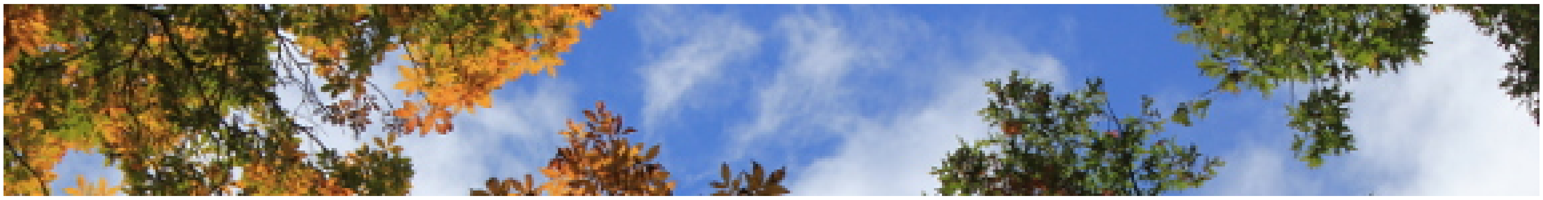
The Forest Vegetation Simulator Fire and Fuels Extension (FVS-FFE) is often used by land managers in the interior western US to evaluate crown fire hazard for conifer stands. FVS-FFE generates estimates of effective canopy bulk density (CBD) and canopy base height (CBH), which are key characteristics of the canopy fuel profile. In this work we evaluated the impact of using alternative crown fuel distribution assumptions and crown fuel biomass allometries on CBD and CBH estimation using FVS-FFE. Our approach was to estimate CBD and CBH for mostly pure, even-aged stands of seven conifer species by modifying FVS-FFE to use non-uniform instead of uniform crown fuel distributions, which allowed us to determine whether distribution effects on CBD and CBH estimates were species-specific or general. For two species, we also compared estimates derived using local versus non-local crown fuel biomass allometries to ascertain whether there was a consistent bias in CBD and CBH estimates associated with application of allometries outside their geographic area of origin. Using non-uniform distributions caused consistent increases in average CBD estimates of ~10–30% for all species compared to estimates obtained using uniform distributions, while effects on CBH varied. This caused estimates of the critical spread rate required to sustain crown fire to decrease by ~3 m min-1 on average. There was no consistent bias in CBD or CBH estimates associated with the use of non-local crown fuel biomass allometries.



Sensitivity of Crown Fire Modeling to Inventory Parameter Dubbing in FVS

Wade Tinkham, *Chad Hoffman, Seth Ex, Michael Battaglia and Alistair Smith*

A core objective of most forest restoration treatments in the western United States is the reduction of potential crown fire behavior. Growth and yield models such as the Forest Vegetation Simulator are utilized to evaluate the effects of treatment alternatives on crown fire behavior, which is controlled by forest stand attributes such as canopy base height and canopy bulk density. The accurate projection of fire potential is an important consideration in designing and comparing treatment alternatives. Typically, the individual tree characteristics (height and crown ratio) needed to estimate these stand attributes are only inventoried on a subsample of an inventory and then must be estimated (dubbed) through allometry for trees missing these measurements, introducing two possible sources of error. This study evaluates the proportion of inventoried trees within the Forest Vegetation Simulator that must have height and crown ratio measurements for outputs to accurately represent stand level attributes controlling crown fire behavior. This is evaluated by simulating four stem mapped ponderosa pine dominated 4 hectare stands with site indices of 11, 17, 23, and 29 m at a base age of 100 years. Within each stand random subsets of the inventoried trees from 0 to 100% are modeled with either total height or a combination of total height and crown ratio parameterized. The accuracy of the dubbing process is evaluated by comparing model outputs, including canopy base height, canopy bulk density, canopy fuel load, and percentage canopy cover, from the random subsets against the census inventory scenario.



FVS Application: Inventory Processing

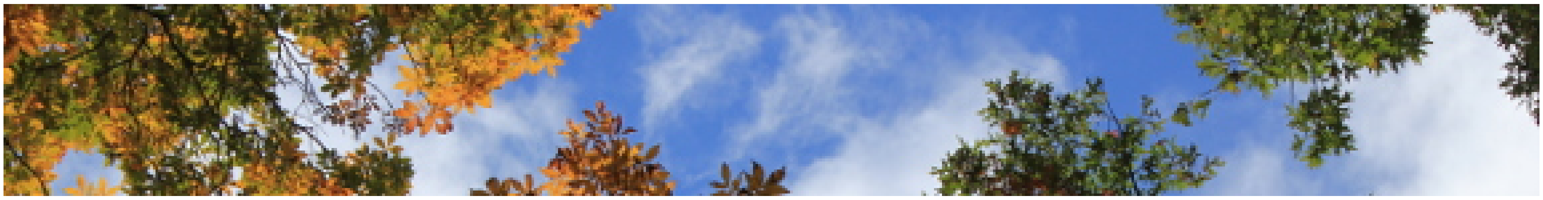
Use of FVS Simulations to Update Vegetation and Fuel Layers in the LANDFIRE Program

Donald Long and Jim Napoli

The LANDFIRE mapping process begins with acquisition, vetting, and processing a large number of datasets that provide the foundation for mapping the basic vegetation composition and structure that are used to derive a suite of fuel and fire regime products. Updated products in LANDFIRE capture areas of landscape change due primarily to federal agency management activities and natural disturbances. The FVS Simulation process was used in order to more accurately model post disturbance vegetation and fuel conditions. Two products are available resulting from this effort.

The Forest Vegetation Simulator (FVS) Ready Database (FVSRDB) contains attributes for FVS simulations. These data include plot level input data for all FVS variants nationwide. These data also include predefined input tables used for initializing stand level and plot level information for FVS. The Forest Vegetation Transitions Database (FVTDB) contains information that describe post-disturbance vegetation and fuel conditions derived from FVS simulations using the FVSRDB. Outputs cover all FVS Variants at multiple severities and time-steps. These disturbances include fire, insect and disease, wind, mechanical add, and mechanical remove. Each disturbance was simulated with three severities and results output at three different time steps: immediately after disturbance, 2-5 years post disturbance, and 6-10 years post disturbance.

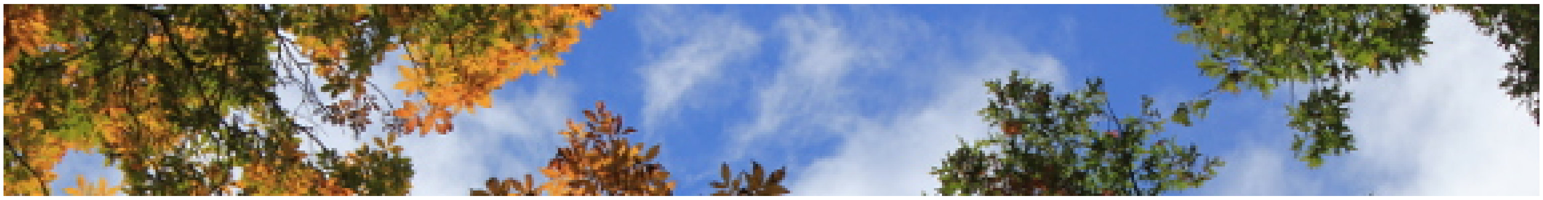
A version of the FVS Disturbance Database (FVSDDB) is available containing FVS disturbance simulation outputs. Outputs include predefined outputs used for stand and plot level analysis post disturbance using the STANDSQL keyword in FVS as well as disturbance tables and tools to summarize and sort.



Using FVS as Part of a Regional Inventory Compilation Process for Data Stored in FSVeg

Renate Bush

Region 1 uses FVS as part of its inventory compilation process. All inventory data, from stand exams to FIA data, is extracted from FSVeg, and run through FVS. Depending upon the type of inventory data various attributes are calculated; such as tree heights, tree volumes, biomass, and potential fire type; and then loaded into FSVeg. These attributes are then available for use in Region 1 analysis tools for a project area up to forest plan revision. This discussion will focus on all aspects of this compilation process.

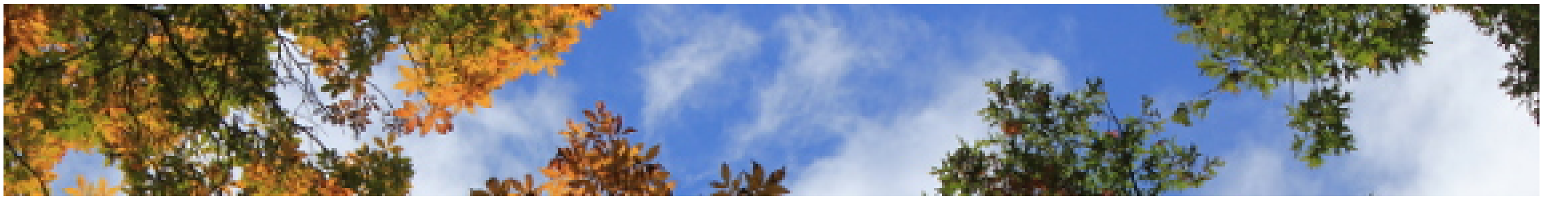


FVS Application: Fire, Carbon and Climate

Managing Carbon on Federal Public Lands: opportunities and challenges in southwestern Colorado

***Katharine C. Kelsey**, Lisa Dilling, Daniel P. Fernandez, Yin D. Huang, Jana B. Milford and Jason C. Neff*

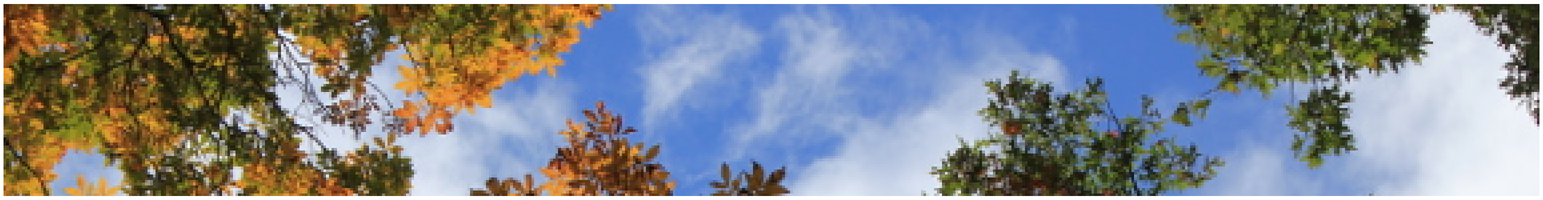
Federal lands in the United States have been identified as important areas where forests could be managed to enhance carbon storage and help mitigate climate change. However, there has been little work examining the context for decision making for carbon in a multiple-use public land environment, and how science can support decision making. This case study of the San Juan National Forest and the Bureau of Land Management Tres Rios Field Office in southwestern Colorado examines whether land managers in these offices have adequate tools, information, and management flexibility to practice effective carbon stewardship. To understand how carbon was distributed on the management landscape we added to a newly developed carbon map for the SJNF–TRFO area based on Landsat TM texture information (Kelsey and Neff in Remote Sens 6:6407–6422. doi:10.3390/rs6076407 , 2014). We estimate that only about 22% of the aboveground carbon in the SJNF–TRFO is in areas designated for active management, whereas about 38% is in areas with limited management opportunities, and 29% is in areas where natural processes should dominate. To project the effects of forest management actions on carbon storage, staff of the SJNF are expected to use the Forest Vegetation Simulator (FVS) and extensions. While identifying FVS as the best tool generally available for this purpose, the users and developers we interviewed highlighted the limitations of applying an empirically based model over long time horizons. Future research to improve information on carbon storage should focus on locations and types of vegetation where carbon management is feasible and aligns with other management priorities.



Using Climate-FVS to Inform Management Decisions: four case studies from the American Southwest

Andrew Sánchez Meador, *Alicia Azpeleta Tarancón, Michael Todd Stoddard and Sushil Nepal*

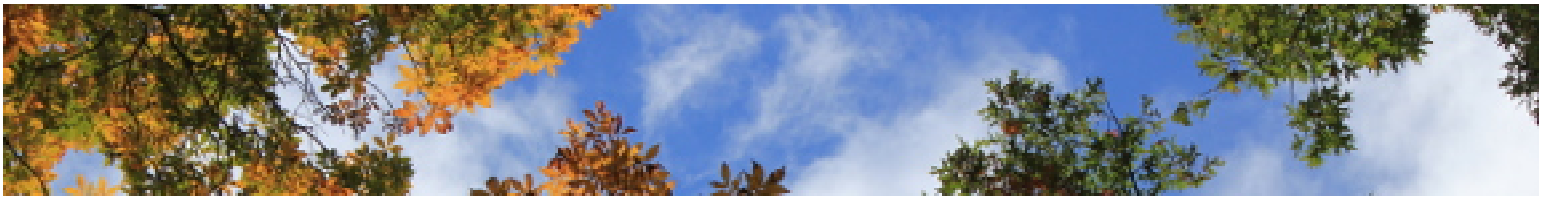
Managers are being increasingly tasked with considering how current and planned actions may affect forests' ability to adapt to a changing climate, yet the toolset for evaluating these the types of scenarios is hugely limited. Making matters more challenging is the fact that predictions and assessments of uncertainty regarding treatments-climate interactions is not well understood nor easily obtained, highlighting the need for "climate-aware" decision support tools like ClimateFVS. We present the results of three case studies where ClimateFVS was utilized to help inform important decisions focused on 1) post-fire predictions of forest recovery under future climate and management scenarios following uncharacteristic mega fires, 2) quantifying potential forest trajectories following various restoration treatments in dry mixed-conifer forests of southern Colorado, 3) parameterization of state-and-transition models used to inform economic analyses of fuels reduction and restoration treatments in frequent-fire forests of the Colorado Plateau and 4) assessing potential growth, mortality, and carbon stores following treatments within the US Forest Service's largest Collaborative Forest Landscape Restoration Program (CFLPR) landscape over the next century. We provide overviews of each study, discuss the lessons learned and emphasize future research directions that may improve the use of ClimateFVS.



Modeling the Long Term Impact of Large Wildfires and Forest Restoration Treatments on Western US National Forests

Alan Ager, Robert Seli, Rachel Houtman and Ana Barros

One of the major science gaps in US wildfire policy is the lack of studies on the long term benefits of hazardous fuel reduction and restoration programs. For instance, there is scant information to predict how current fuel management programs and wildfire activity through time will potentially lead to a stable and acceptable level of wildfire risk to social, ecological, and economic values on national forests. Similarly, we do not have models to test the efficacy of strategies concerning the increased use of fire for resource benefit in concert with restoration and fuel reduction programs. To address this gap, we expanded on several previous studies to build a forest landscape-disturbance-succession model using the FVS Parallel Processing Extension (PPE) originally developed by Nick Crookston. In the current work, we incorporated the FSim wildfire simulation model into FVS-PPE and optimized the system for simulating fuel management and restoration policies at the national forest scale (e.g. 1-2 million hectares). FSim is a widely used fire simulation model developed by Mark Finney at the Rocky Mountain Research Station, and simulates large fire events (i.e. ignition, spread, intensity) in contrast to stand fire behavior modeled in the FVS-FFE. FSim was created to simulate large number (e.g., 50,000) of hypothetical wildfire seasons to support a range of problems related to fire management policy in the US. FSim predicts daily probability of a fire based on logistic regression of historical fire occurrence and Energy Release Component (ERC), and fire containment using probability models also based on ERC. Weather data for fire simulations are derived from 20-30 year historical records obtained from remote automated weather stations. We incorporated FSim into three variants (Central Oregon, Blue Mountains, Northern Idaho) and are in the process of completing case studies at the 1.5 – 2.5 million hectare scale in all three regions. In each study area we are analyzing 6 to 12 management scenarios in which spatial treatment strategies and intensities are varied and landscape responses are measured over 50-year simulations. Response variables include burned area and severity; wildfire impacts on the wildland urban interface; and a cost-benefit analysis of fuel treatments in terms of suppression costs. In this talk we will present initial findings and discuss future application of the model.

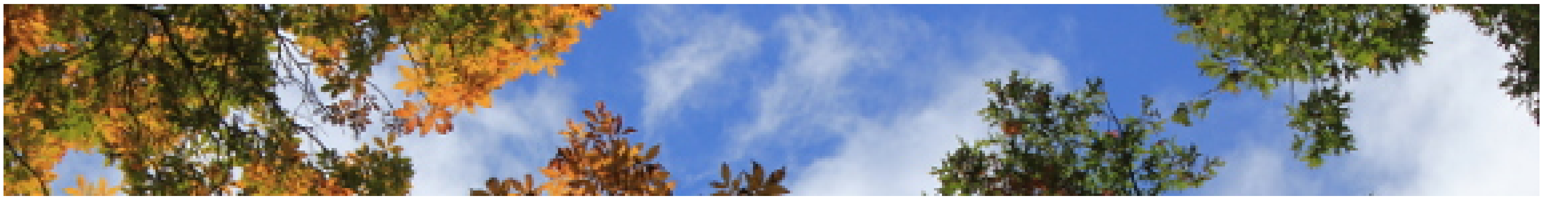


FVS Projects: Forest Health

Use of the Forest Vegetation Simulator (FVS) and the Southern Pine Beetle (SPB) Event Monitor to Identify Silvicultural Treatments for the Reduction of SPB Hazard and Enhancement of Restoration on the North Carolina Piedmont

Jason A. Rodrigue*, Chad E. Keyser and John T. Nowak*

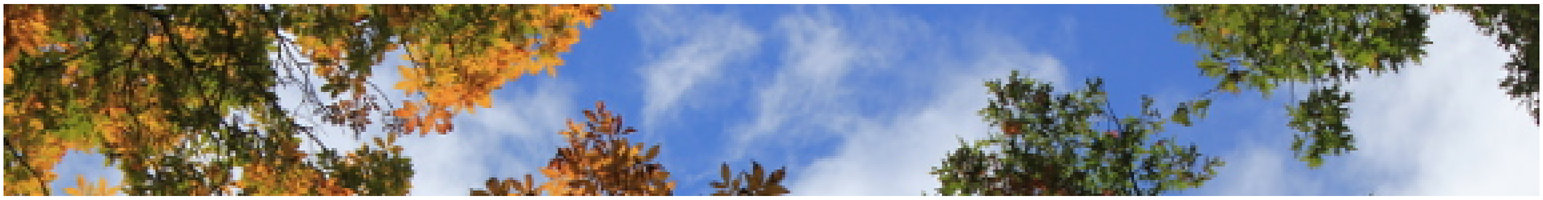
The 2012 Farm Bill included new categories of abbreviated environmental documentation under the National Environmental Policy Act when related to treatments that reduce the threat of forest insects and diseases. The use of a data driven vegetation management project examined approximately 3,000 acres of forest land on the Uwharrie National Forest in the central North Carolina piedmont for hazard to SPB (i.e. overstocked stand conditions, off-site pine trees). Up to date common stand exam inventory information was loaded into FSVeg and pulled directly into FVS (southern variant) for calculation of SPB hazard and other post processed stand-level descriptive statistics. Draft silvicultural decisions were considered based on modeled conditions. FVS was then used to model treatments, their outputs and the effect on stand-level SPB hazard. Based on results, treatments were prioritized and integrated with forest restoration opportunities outlined in the Uwharrie Forest Management Plan. A subset of highest priority treatments were then field validated and moved forward into the environmental analysis under the 2012 Farm Bill Categorical Exclusions. This process resulted in several efficiencies that led to development of a rapid decision for treatment under these new authorities.



Simulating Changes to Forest Type and Structure as a Result of Forest Pests: a case study using FVS to simulate potential effects of emerald ash borer across a broad landscape

Andrew McMahan

We simulated potential mortality to ash trees (Fraxinus spp.) resulting from emerald ash borer (EAB) activity in thousands of treelists representing locations throughout the geography of the FVS variants for the Lake States, Central States and Northeast Areas. Treelists came from LANDFIRE's FVS-ready database of FIA-sourced inventories (tens of thousands of treelists). The EAB mortality was simulated via thinning keywords, which removed approximately 90% of the ash over a 10-year simulation time frame. (The FIXMORT keyword was not used since its use precludes stump sprouting.) Mortality was simulated in treelists containing ash (about 1/3 of the nearly 14,000 treelists representing the project area) originating in counties currently experiencing EAB. We analyze landscape scale trajectories of, and changes to, forest type and other structural metrics over a circa 40-year time frame. Approximately 10% of ash-containing stands experienced a change in forest type after 40 years as a result of simulated EAB mortality. The analysis demonstrates the utility of FVS to address questions about the potential status of future forest landscapes vis-à-vis forest pests and other disturbances.

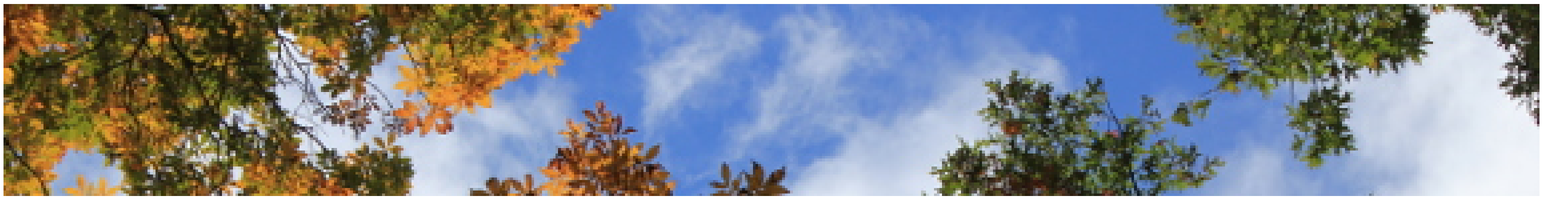


FVS Projects: FSVeg Spatial Data Analyzer

Application of Climate-Fvs Using Fsveg Spatial Data Analyzer on Large Landscapes: A 4fri Analysis

Lloyd R. Fuller and *Jonathan Marston*

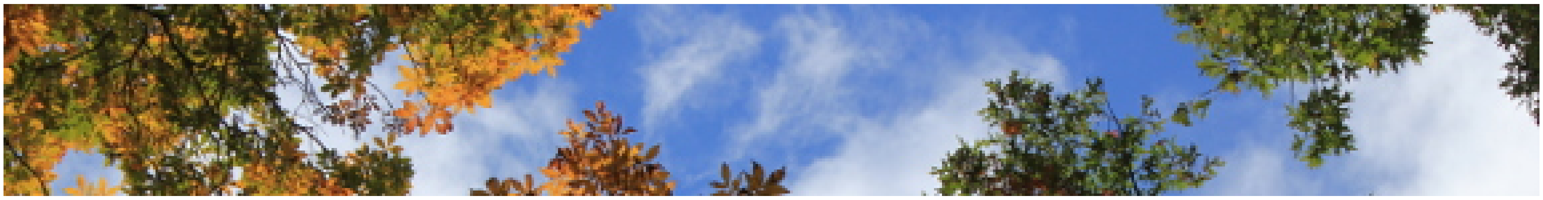
The National Resource Manager (NRM) is a national Forest Service organization responsible for supplying national database solutions for storing Forest Service resource data as well as interfaces to use that data. The FSVeg database supports storage of stand exam data, fuels data, permanent grid inventory data, and other vegetation inventory data. FSVeg Spatial stores the GIS vegetation polygons, forest Common Stand Exam plot locations, and summary vegetation attributes. FSVeg Spatial Data Analyzer (DA) is designed to assist with landscape and NEPA analysis for a project area of any size by bringing together FSVeg and FSVeg Spatial data into a program integrated with FVS. Users create alternatives and compare them through built-in visualizer tools. Users assign FVS activities via GIS to features within the project area to define their alternative scenarios. For stands that have stand exams, FVS may be used to model changes over time (i.e., growth, mortality, fire, climate change, and carbon sequestration/fluxes). Nearest Neighbor imputation methods are available to give the user a “wall-to-wall” spatial and FVS ready dataset. The FSVeg Spatial Data Analyzer integrates with Climate-FVS allowing the user to visualize and evaluate the uncertainties of climate change impacts from up to 17 different Global Circulation Models (GCM). Each alternative scenario can be evaluated for potential silviculture treatments strategies under the climate scenarios. This technique is being used on the Four Forest Restoration Initiative (4FRI) Rim Country Project Environmental Impact Assessment encompassing 1.23 million acres of ponderosa pine ecosystems in northern Arizona.



Using LANDFIRE, FSVeg Spatial DA Nearest Neighbor, FVS and FlamMap to Compare Treatment Effects across a Landscape

James Arciniega

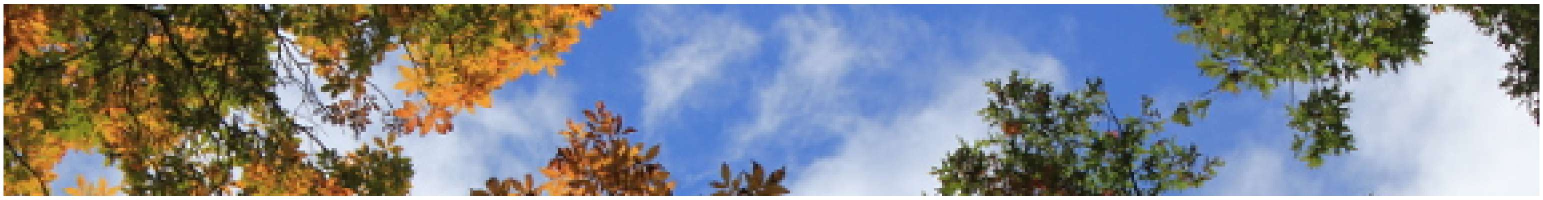
Input for fire behavior programs such as FlamMap and FARSITE is readily accessible via the LANDFIRE database. This is useful for analysis of current conditions, but proves difficult to manipulate in a defensible and repeatable manner in order to reflect changes based on silvicultural manipulation. In order to simulate alternative future conditions, forest inventory data containing individual tree characteristics are required for programs that utilize FVS. These treelist data aren't available nationally and are normally attained at a project scale. One method of overcoming the need to acquire forest inventory in every stand is imputation. The Forest Service maintains forest inventory data via Field Sampled Vegetation (FSVeg). This program includes an application known as the Data Analyzer (DA) which enables construction of a wall-to-wall dataset via a variety of nearest neighbor imputation methods e.g., most similar neighbor, gradient nearest neighbor, random forest, etc. Imputation is a process of "filling in" missing data with plausible values based on existing vegetation data from similar stands. Analysis of fire risk and fire hazard on a 160,000 acre project area was made possible in large part by imputation. The analysis was conducted in part using a combination of LANDFIRE and FSVeg Spatial DA imputed data whose canopy characteristics were derived from FVS outputs. These data were combined into a landscape file and fire behavior metrics were derived from FlamMap outputs. Proposed Action effects to vegetation were modeled via FVS to derive post-activity fire behavior metrics from FlamMap outputs.



Linking the FVS Econ Extension and FSVeg Spatial Data Analyzer to Map Timber Ecosystem Services On The Monongahela National Forest

Chris Haberland and Jonathan Marston

The FSVeg Spatial Data Analyzer (DA) environment has recently been updated to support the visualization of outputs from the FVS Econ extension. The linking of FVS Econ and DA allows users the ability to map projected costs and benefits of tree harvest using relatively fine-scale FSVeg data at the stand level. To demonstrate this, we estimate and assign regional three-year averages of stumpage prices for different tree species on the Monongahela National Forest and simulate the FVS “clearcut” management scenario across all stands. The spatially-explicit output can assist forest planners and managers in estimating the value of ecosystem services provided by timber across stands of various compositions and at different spatial scales. Maps produced from the output may serve as a resource when comparing the tradeoffs between ecosystem services resulting from management alternatives.



FVS Projects: Economics

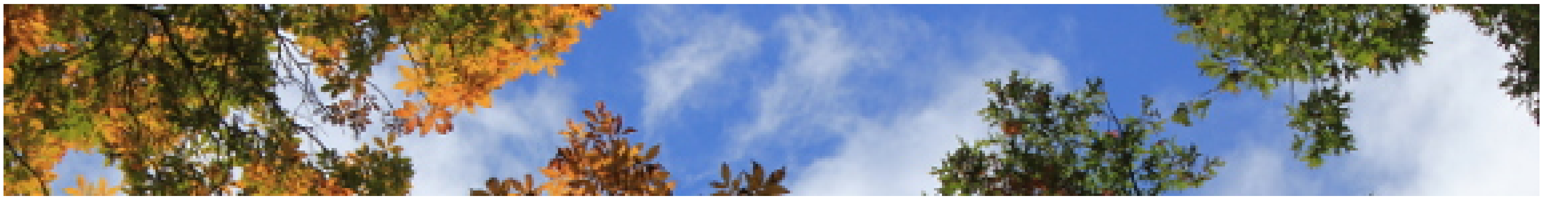
Economic Returns of White Spruce Plantation Thinning Scenarios Using Forest Vegetation Simulator (FVS)

Curtis L. VanderSchaaf*, Gordon Holley, Andrew Arends, Joshua Adams, Donald Deckard*

Out of the approximate 88,000 acres of Minnesota white spruce plantations (Picea glauca (Moench) Voss) one-fifth of the acreage is managed by the Department of Natural Resources (DNR). Many of these plantations are at or near the time for a potential first thinning, and some for a potential second thinning. Hence, the objective was to use FVS to determine the optimal number of thinnings, residual stand density following thinnings, and final harvest rotation age to maximize economic returns.

For simplicity, it was assumed that all harvested timber was white spruce. Four different thinning treatments and an unthinned scenario were examined. Thinning scenarios differed as to the timing of thinnings based on standing basal area per acre and the residual basal area per acre following the thinning. Timings of final harvests were modeled based on maximizing financial returns for the differing thinning times and intensity scenarios.

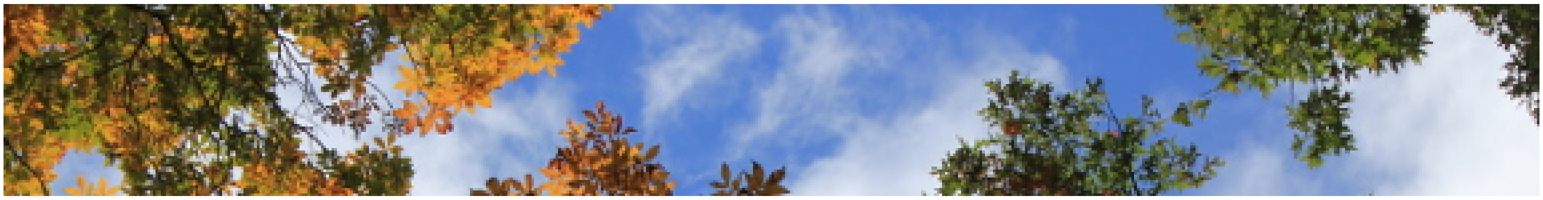
When using stumpage revenues of $12.64, 20.58, and 40.46 per cord for pulp only, pulp and bolt, and sawlog, respectively, the optimum financial regime on the lower site (SI of 59, base age 50) was too thin at 150 square feet back to 120 square feet of basal area and to conduct a final harvest at age 60, and on the higher site (SI of 70) it was optimum not to thin and conduct a final harvest at age 50. A more operationally feasible regime of thinning at 150 square feet back to 90 was nearly as financially optimum on both site qualities.



Even-and Uneven-Aged Management Scenarios for Maximizing Economic Return in the Sweetgum - Nuttall Oak - Willow Oak Forest Type of the Bottomland Hardwood Forest in the LMAV

Sunil Nepal, Brent R. Frey and James E. Henderson

The sweetgum - Nuttall oak - willow oak forest type is widely distributed and one of the important forest types in bottomland hardwood forests of the Lower Mississippi Alluvial Valley (LMAV). Currently there is little guidance available to landowners and foresters regarding possible economic tradeoffs of alternative forms of management. This study was developed to investigate financially optimal management scenarios for both even-and uneven-aged management. US Forest Service (USFS) Forest Inventory and Analysis (FIA) data were used to describe a range of initial stand conditions that were each simulated using the USFS Forest Vegetation Simulator (FVS) for both even- and uneven-aged management. Net present values (NPV) were calculated to identify financially optimal management scenarios. Scenarios for both even-and uneven-aged management were also simulated for a range of key input variables to allow for sensitivity analysis. Preliminary results indicate that even-aged management scenarios produce higher NPVs compared to uneven-aged management scenarios. However, the degree of tradeoff between even-and uneven-aged management depends on initial stand conditions such as basal area, stocking percent, species composition, model assumptions related to regeneration, and structural targets. Further, financially optimal management scenarios will be identified for both even-and uneven-aged management and the economic tradeoff between the two management approaches will be discussed. Study findings should help landowners better evaluate management options for their forestland by providing an indication of how much economic loss or gain in terms of timber revenue may be realized by favoring either even- or uneven-aged management.



Poster Session

Using Forest Vegetation Simulator (FVS) to Calculate Cover Type Transition Probabilities of Deferred/Altered Stands within the Border Lakes Subsection

Curtis L. Vanderschaaf

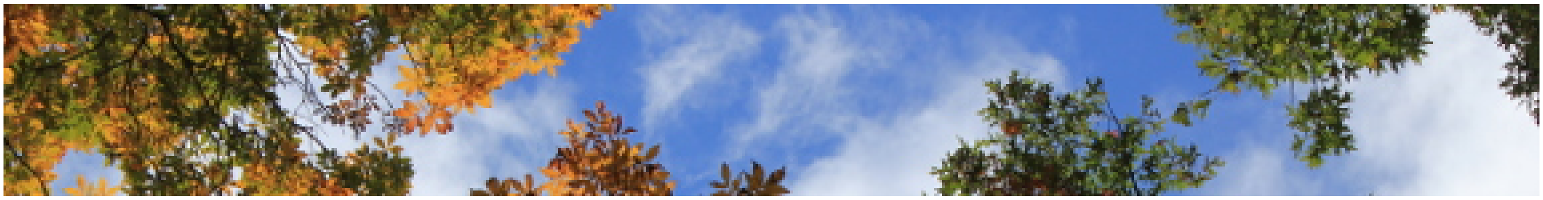
Many Minnesota Department of Natural Resources (DNR) stands selected for examination have their timber sale deferred to a future period and many stands have their cover type “Altered” since it is felt the current cover type is incorrect. To better estimate harvest amounts during DNR planning efforts, it was decided to estimate how these altered/deferred stands may transition into other cover types.

One method is the Forest Vegetation Simulator (FVS) Lake States growth and yield projection system. An Access database was downloaded from the FIA DataMart, FIADB version 5.1, website. The FIA2FVS translation tool was used to place FIA plots into a FVS format. Plots were projected for 100 years with no management to see if transitions occurred by cover type.

DNR field staff submitted “best guess” transition probabilities.

These “expert” transition probabilities can be compared to transition projections from FVS. The field guesses are likely superior because they include local knowledge and better represent local growing conditions and are probably more applicable to those conditions that actually produce a deferral or alteration.

It appears best to use probabilities provided by the DNR Areas, although FVS provides reasonable probabilities, there are some concerns, such as regeneration assumptions, inability to quantify factors that would better identify only those FIA plots with conditions similar to those stands that are likely to be deferred/altered, and substantial differences associated with the Balsam Fir cover type. If FVS transition probabilities were to be used, these problems would likely need to be more fully addressed.



Comparing Unthinned Slash Pine Plantation Yield Predictions from Time-of-Planting

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Slash pine (Pinus elliottii Engelm.) has been planted in the Western Gulf region but studied less extensively than other southern yellow pines. Several yield prediction systems have been developed to examine how different management options likely impact financial returns of these plantations, including FVS. The objectives of this study were to compare projections from FVS to two other freely available growth and yield systems in the Western Gulf region named SLAeatx and CSLASH (COMPUTE P-SLASH).

Predictions from the time-of-planting were obtained for densities of 300, 500, and 700 stems per acre for site indexes of 50, 70, and 90 feet (base age 25). CSLASH was developed based on observations of plantations in Louisiana, Mississippi, and Texas, FVS projections were modified to best represent conditions in central Louisiana, and SLAeatx is based exclusively on observations of East Texas plantations.

During common rotation ages (e.g. 15 to 30 years), projections of basal area and total merchantable cubic feet per acre are fairly consistent among the three systems in the middle ranges of the site qualities and planting densities. However, at the extremes, for example combination of 300 seedlings per acre and a site index of 50 feet, there are some substantial differences even within the ages from 15 to 30. This is particularly true for volume. CSLASH volume projections generally greatly exceed the two other systems. Generally SLAeatx predicted the presence of merchantable volume at younger ages compared to FVS. At older ages both FVS and CSLASH projections exceeded those of SLAeatx.