Using FIA Data in the Forest Vegetation Simulator

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ABSTRACT: *The Forest Vegetation Simulator (FVS) is a national system of forest growth models maintained by the USDA Forest Service. It is the official tool for stand growth projection on National Forest lands, but it is also used widely on other ownerships. Model extensions and post-processors permit FVS users to perform a broad range of functions, including silvicultural manipulations, wildlife habitat analyses, and fuel treatment evaluations. Because FIA data were made available in FVS-ready format through the FIA Mapmaker interface, an increasing number of users have been using FVS as their tool of choice for compilation of FIA data at the plot level. With the transition from Mapmaker to FIDO, users who have built analysis systems around this data availability have lost access to new data. Due to the need to update FIA-FVS data translation, there is an opportunity to re-design the system to eliminate prior limitations and take advantage of recent developments in FIA and FVS. Select capabilities of FVS, and potential modifications and enhancements to the FIA-FVS linkage are discussed.*

Keywords: Forest Vegetation Simulator, FVS, FIA Mapmaker, database, data access, ODBC

Introduction

Open access to Forest Inventory and Analysis (FIA) data has resulted in a greatly increased user base in recent years. As the number and diversity of users has increased, so has the demand for access to the data in different forms. Currently, FIA data are served through Forest Inventory Data Online (FIDO; http://fia.fs.fed.us/tools-data/), which allows users to generate reports using pre-defined and customized queries, and through the FIA datamart, which provides field-measured and computed data for inventory plots in download files (see http://fiatools.fs.fed.us/fiadb-downloads/datamart.html). Access to these data is critical to users who wish to conduct analyses that are beyond the scope of FIDO. Among these users are those who desire to project FIA plot conditions forward using forest growth simulators or other models.

The Forest Vegetation Simulator (FVS) is a national system of forest growth models maintained by the USDA Forest Service (Johnson 1997, Dixon 2002). It is the official tool for stand growth projection on National Forest lands, but can be used on land of any ownership. Model extensions and post-processors permit FVS users to perform a broad range of functions, including silvicultural

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manipulations, wildlife habitat analyses, and fuel treatment evaluations. A flexible programming environment also allows users to produce customized variables and output tables. This allows users to extract summary information from inventory data without having to manipulate the data directly.

FIA data were originally made available in FVS-ready format through the FIA Mapmaker interface until Mapmaker version 2.1. With the availability FIA data in FVS-ready format, an increasing number of users have been using FVS as their tool of choice for compilation of FIA data at the plot level. Many of these users were already familiar with FVS capabilities, and had an interest in using FIA data. The access to data in FVS-ready format facilitated their use of the data by eliminating the need to develop their own compilation methods. This accessibility led to a substantial amount of use; Miles (2008) reported that there were 2,386 downloads of FVS-ready data over a 4-year period.

In the Mapmaker release, FIA data are provided in the file formats introduced with the Suppose interface (Crookston 1997): a location file (.LOC) that contains information about the stands in an inventory location or project (i.e., those included in the Mapmaker download), a stand list file (.SLF) that contains stand-level data and refers to the files containing tree-level data, and one or more tree data files (.FVS), each of which contains the data from an individual stand (Dixon 2002). In the case of FIA data, each .FVS file contains data for all trees recorded on an individual FIA plot. In the data coding, FIA subplots may be treated as FVS plots, and the FIA plot is considered a “stand”.

With the transition from Mapmaker to FIDO, users who built analysis systems around this data availability have lost access to newer FIA data. The most recent available data are from 2005, and there have been many user requests for the most current data. Because of this demand, there is a need to update the FIA-FVS data translation process. There is also an opportunity to re-design the translation process to eliminate prior limitations and take advantage of recent developments in FIA and FVS.

One of the most important FVS developments, and one that is key to the FIA-FVS data link, is the implementation of Version 2.0 of the FVS Database Extension (Forest Vegetation Simulator Staff 2003). The new database version eliminates the need for multiple input files, replacing the SLF and FVS files with three tables that can be accessed using Open Database Connectivity (ODBC). These tables may be contained in Microsoft Access, Microsoft Excel, or SQL-based relational databases such as Oracle (Forest Vegetation Simulator Staff 2003). One important advantage of this structure is that the database can include fields that are not used by FVS, but which may be important to the user for other purposes (e.g., last treatment dates or local cover type designations).

Taking advantage of additional data and new program features can be accomplished with relative ease, but there are several issues that should be recognized by FIA developers and FVS users. Once these issues have been addressed, the necessary enhancements to the FIA-FVS linkage can be developed.

What FIA Developers Need to Know about FVS and FVS Users

FVS is the nationally supported forest growth modeling framework for the USDA Forest Service. It is maintained by the Forest Service Forest Management Service Center (http://www.fs.fed.us/fmsc/), and the program and source code is freely available. FVS is actually a collection of forest growth models, known as FVS variants, that are run under a common interface called Suppose (Johnston 1997, Crookston 1997). Many of these variants trace their lineage to the Stand Prognosis Model (Stage 1973, Wykoff and others 1982), but other models such as TWIGS and ORGANON are the growth engines of some variants. Variants typically cover specific geographic areas, with limited overlap (Figure 1). There are variants for all U.S. forests, with the exceptions of interior Alaska, Hawaii, and U.S. territories. However, not all species, or even all common species within a given geographic area may be included in the local variant. Model updates are frequent and ongoing; new variants for interior Alaska and Maine are in development, and Prognosis-based variants are being developed to replace some that are currently TWIGS-based.

FVS requires only species, diameter, and the number of trees per acre as minimum data. Unmeasured tree characteristics, such as height and crown ratio, are estimated with dubbing submodels. However, if variables such as height and crown ratio are measured, they are used in various submodels. These and other variables, such as periodic increment, may also be used to calibrate specific submodels if certain criteria, such as a minimum number of observations, are met. Internally, all variants include single-tree, distance-independent growth models. Stand density and tree rank affect growth and mortality. Although inter-tree distance is not used explicitly, diameter growth models and the mortality routines are sensitive to within-stand variability as represented by varying density among plots in the stand.

What sets FVS apart from other growth models is its capability to simulate silvicultural operations and their effect on future stand development. Through the use of keywords and custom scripts, users can implement a wide range of silvicultural operations spanning simulation periods of up to 300 years. One of the most common uses is to evaluate growth and yield implications of multiple management options through a series of “what if” simulations. In addition to modeling growth responses, model extensions for insect, disease, and fire permit users to model stand resistance and resilience in the face of anticipated disturbances.

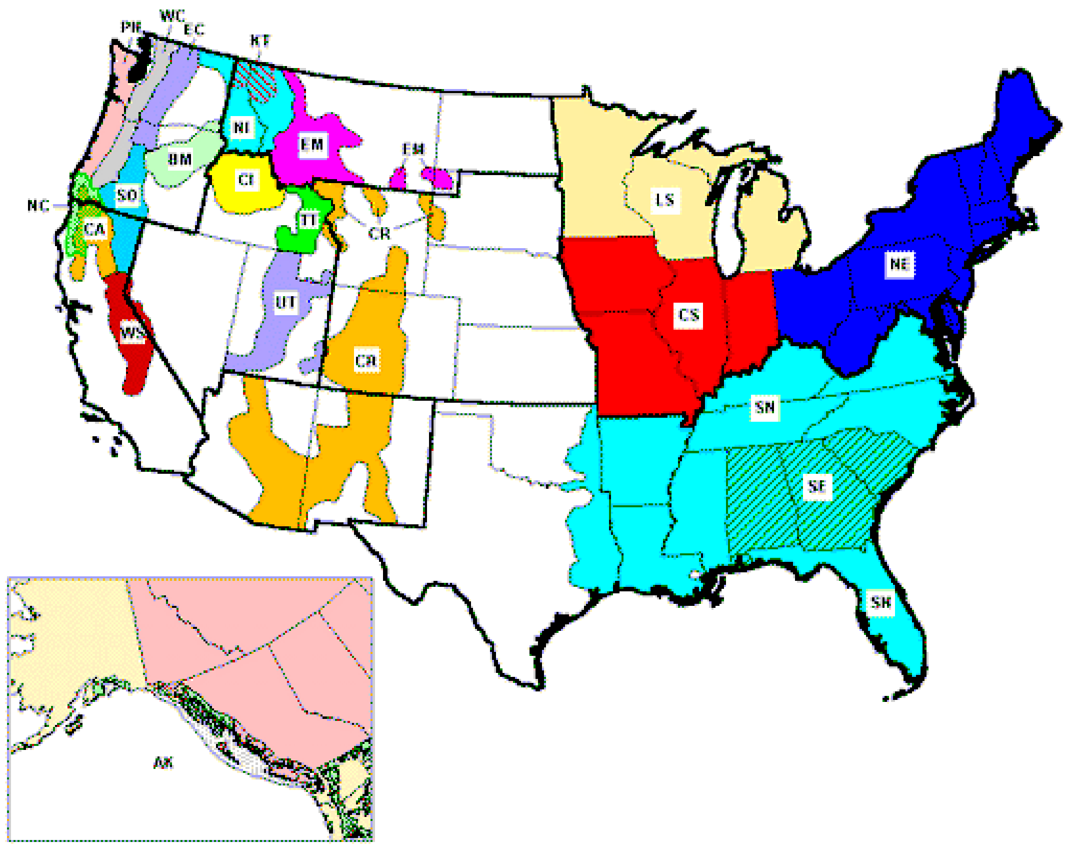

FIGURE 1: Map of FVS variant coverage in the coterminous 48 states and Alaska from the FMSC web site (http://www.fs.fed.us/fmsc). AK = Southeast Alaska/Coastal British Columbia, BM = Blue Mountain, CA = Inland California/Southern Cascades, CI = Central Idaho, CR = Central Rockies, CS = Central States, EC = East Cascades, EM = Eastern Montana, KT = Kootenai/Kaniksu/Tally Lake, LS = Lake States, NC = Klamath Mountains, NE = Northeast, NI = Northern Idaho/Inland Empire, PN = Pacific Northwest Coast, SE = Southeastern (superceded by SN), SN = Southern, SO = South Central Oregon/Northeast California, TT = Tetons, UT = Utah, WC = Westside Cascades, WS = Western Sierra Nevada.

The core FVS user base is primarily made up of silviculturists and vegetation management planners, but the user base has greatly expanded since the introduction of the Suppose interface. Suppose eliminated the need for the manual scripting and file management that was necessary in earlier versions of FVS, allowing users with little or no programming experience to run relatively complex simulations. The Fire and Fuels Extension (Reinhardt and Crookston 2003) has been used not only as a treatment evaluation tool, but also as an educational tool that managers have used to demonstrate the effects of proposed fuel treatments. Other important user groups include wildlife managers, economists, remote sensing specialists, and educators. Entry-level skills in FVS are now part of many university forestry curricula (Shaw and Long 2002).

Connections Between FIA and FVS

Currently there are no formal connections between the FIA and FVS programs, but there is ample opportunity to expand on informal connections that have been developed though various projects. As noted earlier, FVS is used as a compilation tool by some users of FIA data. Conversely, the data produced by the FIA program can be used to enhance the use and development of FVS. For example, Donnelly and others (2001) relied heavily on FIA data for development of the Southern variant of FVS. For variants that have already been developed, FIA data may be used for calibration or validation (figure 2). For example, since the initial data-gathering effort for the Southern variant, there have been as many as two full remeasurement cycles in some southern states. These data could be valuable for calibration and validation of the submodels developed for the first version of the variant. Validation applications may become extremely important for the next generation of FVS variants, which are to be climate sensitive. Certain submodels may require periodic adjustment as the effects of climate change become better known.

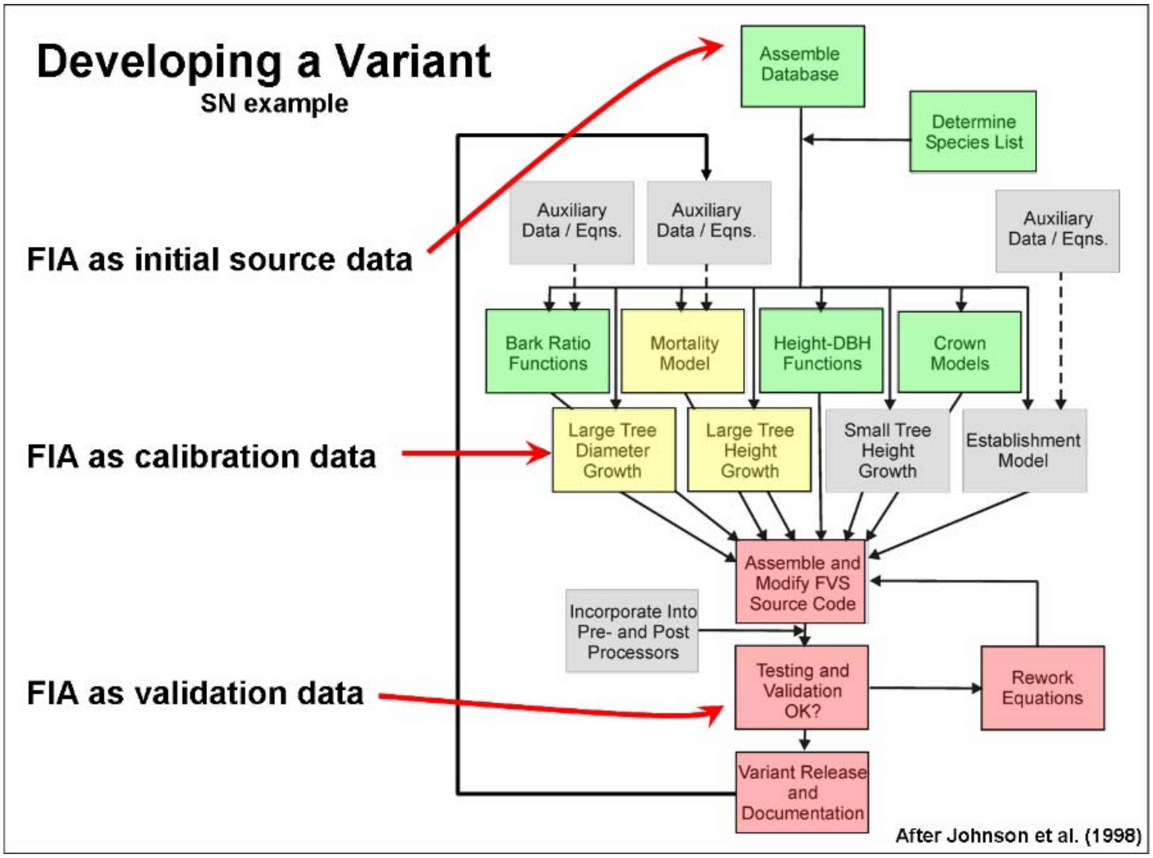

FIGURE 2: Generalized process for development of an FVS variant, and stages in the process where FIA data may be used.

FVS model validation is a current topic of interest among FVS users and researchers, so it would be beneficial to make the FIA database available to FVS users in the fullest extent possible. There are many variables in FIA data that are not usable by FVS directly, but which may be useful to users. Some of these variables may be used for data stratification, or as auxiliary variables during model testing. Because of the large number of FIA variables, it is impossible to comprehensively address all of the possibilities here. However, it is possible to discuss the variables that are used by all FVS base variants and discuss the feasibility of cross-walking them with FIA variables.

The remainder of this paper will describe the variables used in the base FVS variants, the corresponding FIA variables, and the issues and possible solutions that have been identified in cases where direct variable transfer is not possible. The list of variables includes all of those that are included in the StandInit and TreeInit tables in the database version of FVS input files (Forest Vegetation Simulator Staff 2008). Due to the large number of variables involved, they are listed in a table format with the FVS variable in the first column, the corresponding FIA variable(s) in the second column, and a description of the variable(s) and related notes in the last column. In the description column, the original FVS description appears in normal text. Additional text that describes the relationship between the FVS and FIA variables appears in bold.

TABLE 1: Variables in the predefined FVS_StandInit table structure, their corresponding FIA variables, and descriptions.

FVS variable	FIA variable	Description and notes
Stand_CN	PLOT.CN or COND.CN	Database control number. Required by Suppose 2.0 when populating stand lists. **FIA uses several control numbers as linkages between tables. Some may be usable in FVS.**
Stand_ID	Possible composite of INVYEAR, STATE, COUNTYCD, and LOC	Stand identification code. Required by Suppose 2.0 when populating stand lists. **The original translation of FIA data to FVS uses a composite stand ID that included the state, county, plot, and inventory year of the FIA plot. This variable was useful to users, because the general location of plots could be quickly identified during simulations.**
Variant	No FIA variable	The two character variant identification code. Required by Suppose 2.0 when populating stand lists. **In the original Mapmaker release, users were prompted to supply the name of the variant that would be used with the FIA data. It is possible that this step can be made transparent to the user by mapping variant coverage areas (see Discussion below).**
Inv_Year	MEASYEAR	The stand's inventory year corresponding to IY(1) in FVS. Required by Suppose 2.0 when populating stand lists. **FIA uses an inventory year variable (INVYR) in the PLOT table, but this represents the panel or subpanel to which the plot belongs. The actual year in which the data were collected is recorded in MEASYEAR. The latter is the most appropriate variable for use as FVS Inv_Year.**

TABLE 1: Variables in the predefined FVS_StandInit table structure, their corresponding FIA variables, and descriptions.

FVS variable	FIA Variable	Description and notes
Groups	Many possible	A list of Grouping codes, also separated by spaces, tabs, carriage returns, or newlines. Used by Suppose 2.0 when populating stand lists**. In the Mapmaker release, users were allowed to pick from a limited list of group codes that were populated from FIA variables. It would be possible to expand this list and increase users' flexibility (see Discussion below).**
AddFiles	n/a	A list of Addfile names (.kcp), separated by tabs, carriage returns, or newlines, which will be inserted into simulation file as one or more components. Used by Suppose 2.0 when stands are added to simulations. **Not applicable to FIA data at this time.**
FVSKeywords	n/a	A list of FVS keywords, separated by spaces, tabs, carriage returns, or newlines, which define the FVS run. Used by Suppose 2.0 when stands are added to simulations. **Some keywords may be used to override FVS default values with the values of certain variables that are stored in the FIA database.**
Latitude	LATITUDE	Latitude in degrees of the stands location. **The FIA program is prohibited by law from releasing precise plot coordinates to the public. In most cases, the coordinates in the public database are within one mile of the true location. These are referred to as "fuzzed" coordinates.**
Longitude	LONGITUDE	Longitude in degrees of the stands location. **See Latitude for treatment of FIA coordinates.**
Region	ADFORCD	USDA-FS (National Forest) Region code. **The first two places in the FIA variable ADFORCD specify the National Forest region.**
Forest	ADFORCD	USDA-FS National Forest code. **The last two places in the FIA variable ADFORCD specify the National Forest.**
District	No FIA variable	USDA-FS District code. **Not used by FIA, but mappable from FIA coordinates.**
Compartment	No FIA variable	USDA-FS Compartment code. **Not used by FIA, but mappable from FIA coordinates. Compartment size may limit accuracy when fuzzed coordinates are used.**
Location	See notes	Location Code representing the Region/Forest/District/Compartment codes and corresponds to KODFOR in FVS. When specified, Location takes precedence over Region, Forest, District, and Compartment. **See notes on component variables above.**
Ecoregion	ECOSUBCD	Bailey's Ecoregion code (not yet used by FVS). **FIA records the Bailey's Ecoregion subsection code (ECOSUBCD) according to the map update by Cleland and others (2005). These codes may be truncated to the Ecoregion level, depending on FVS needs at the time of implementation.**
PV_Code or Habitat Type	HABTYPCD1, HABTYPCD2	PV_Code identifies the potential vegetation. It is often the Habitat type or Plant association code. The two names shown are synonymous. **The FIA database includes thousands of Habitat Type and Plant Association codes, but many are represented by few or no plots in the database. These codes used by FIA are under review and may require extensive review before cross-walking.**

TABLE 1: Variables in the predefined FVS_StandInit table structure, their corresponding FIA variables, and descriptions.

FVS variable	FIA Variable	Description and notes
PV_Ref_Code	See notes	Potential vegetation reference code for the PV_Code. **See notes on PV_Code / Habitat Type above.**
Age	STDAGE, BHAGE, TOTAGE	Stand age in years. **FIA uses STDAGE to store stand age, but the methods used to populate this variable vary regionally and for periodic vs annual inventories. Age data for individual trees may be found in the BHAGE or TOTAGE variables in the TREE or SITETREE tables, depending on the species and FIA work unit.**
Aspect	ASPECT	Aspect in degrees. **FIA records ASPECT at the Condition and Subplot level.**
Slope	SLOPE	Slope in percent. **FIA records SLOPE at the Condition and Subplot level.**
Elevation	See ElevFt	Stand elevation represented in 100's of feet for all variants except AK were it is elevation in 10's of feet. (see ElevFt below)
ElevFt	ELEV	Elevation in feet. When specified, ElevFt takes precedence over Elevation. **The FIA variable ELEV is recorded in feet, and corresponds to the FVS ElevFt variable.**
Basal_Area_ Factor	DESIGNCD	Basal area factor corresponding to BAF in FVS. **FIA uses a design code (DESIGNCD) variable, located in the PLOT table, that defines fixed vs variable-radius design, diameter breakpoints, and the number of subplots in the design. For single-condition plots, FVS plot design variables can be populated directly. For multi-condition plots, translation is more complex (see Discussion).**
Inv_Plot_Size	DESIGNCD	The inverse of the fixed plot size in acres. **See notes for Basal_Area_Factor.**
Brk_DBH	DESIGNCD	Breakpoint DBH in inches. **See notes for Basal_Area_Factor.**
Num_Plots	DESIGNCD	Number of plots represented in FVS. **See notes for Basal_Area_Factor.**
NonStk_Plots	STATUSCD (SUBPLOT)	Number of non-stockable plots. **Some FIA subplots may not have tree data associated with them because they were not sampled or because they sampled non-forest conditions. Non-sampled subplots are identified with a status code (STATUSCD) in the SUBPLOT table. Depending on how users desire to treat FIA data in FVS, the FVS NonStk_Plots variable may be used.**
Sam_Wt	EXPNS or derived variables	Sampling Weight used to compute the average yield tables and other weighted averages**. For users who are interested in population estimates, FVS sampling weight could be used to store the appropriate expansion factor for an FIA plot, given the area of interest. These factors may have to be calculated on the fly and populated for each data query.**
Stk_Pcnt	STATUSCD (SUBPLOT)	Stockable percent. **See notes above for NonStk_Plots, and discussion on treatment of conditions.**
DG_Trans	No FIA variable	Diameter growth translation code. Code 0 for increment cores and code 1 for remeasurement data. **DG_Trans can be coded appropriately according to the FIA data source.**
DG_Measure	REMPER	Diameter growth measurement period. **The number of years between remeasurements of FIA plots is recorded in the REMPER variable in the PLOT table.**

TABLE 1: Variables in the predefined FVS_StandInit table structure, their corresponding FIA variables, and descriptions.

FVS variable	FIA Variable	Description and notes
HTG_Trans	No FIA variable	Height growth translation code. Code 0 for height growth and code 1 for remeasurement data. **HTG_Trans can be coded appropriately according to the FIA data source.**
HTG_Measure	REMPER	Height growth measurement period. **See description for DG_Measure.**
Mort_Measure	REMPER	Mortality measurement period. **See description for DG_Measure.**
Max_BA	No FIA variable	Maximum basal area. **Max_BA is used as part of the mortality routine in FVS, so there is no comparable variable in FIA data. FIA uses STOCKING variables in the TREE and SEEDLING tables that may be used to compute stocking on an area basis. Stand density index (SDI) is also used (see below).**
Max_SDI	SDIMAX	Maximum stand density index. **FIA uses maximum SDI values that are consistent with FIA computation methods and FIA forest types. These may or may not be the same maximum values that would be used for growth simulations or silvicultural objectives. The consistent definition and use of maximum SDI is being coordinated between FIA and the FVS staff.**
Site_Species	SISP	Site species code. **Site species codes are compatible with FIA species codes in SISP.**
Site_Index	SI	Site index. **FIA records site index in feet at a specified base age (SIBASE). These base ages are different than the base ages assumed by FVS in some variants. It may be necessary to cross-walk site index values because FVS base ages are fixed.**
Model_Type	n/a	Model type code. Only applies to CR and SE variants.
Physio_Region	n/a	Physiographic region code. Only applies to SE variant.
Forest_Type	FORTYPCD	Forest type code. **FVS forest type codes may or may not be compatible with FIA forest types. These will need to be cross-walked by variant.**
State	STATECD	FIA state code
County	COUNTYCD	FIA county code
Fuel_Model	*	Fire behavior fuel model
Fuel_0_25	*	Initial tons per acre of 0 to 0.25 inch fuel
Fuel_25_1	*	Initial tons per acre of 0.25 to 1 inch fuel
Fuel_0_1	*	Initial tons per acre of 0 to 1 inch fuel, if not using previous two fields
Fuel_1_3	*	Initial tons per acre of 1 to 3 inch fuel
Fuel_3_6	*	Initial tons per acre of 3 to 6 inch fuel
Fuel_6_12	*	Initial tons per acre of 6 to 12 inch fuel
Fuel_gt_12	*	Initial tons per acre of greater than 12 inch fuel.
Fuel_Litter	*	Initial tons per acre of litter
Fuel_Duff	*	Initial tons per acre of duff
Photo_Ref	*	Photo series reference number (1 – 32, see FFE documentation)
Photo_Code	*	Photo code (appropriate character strings depend on the photo series reference number, see FFE documentation)

* Fuel data are available only for Phase 3 FIA plots at this time. Phase 3 data were not included in the Mapmaker release, but it may be possible to include them in future translation programs.

Inclusion of these data will require a cross-walk process, based on the requirements of the FVS Fire and Fuels Extension.

Table 2. Variables in the predefined FVS_TreeInit table structure, their corresponding FIA variables, and descriptions.

FVS Variable	FIA Variable	Description and notes
Stand_CN	PLOT.CN or COND.CN	Same as Stand_CN in FVS_StandInit table. Not read by FVS, but may be used for querying purposes. **FIA uses several control numbers as linkages between tables. Some may be usable in FVS.**
Stand_ID	Possible composite of INVYEAR, STATE, COUNTYCD, and LOC	Same as Stand_ID in FVS_StandInit table. Not read by FVS, but may be used for querying purposes. **The original translation of FIA data to FVS uses a composite stand ID that included the state, county, plot, and inventory year of the FIA plot. This variable was useful to users, because the general location of plots could be quickly identified during simulations.**
Tree_ID	TREE	Unique tree identifier within FVS plot. **Because the FIA subplot is the equivalent of the FVS plot, FIA trees are uniquely identified by tree number within subplots. See Plot_ID note below.**
Plot_ID	SUBPLOT	Plot number in the FVS data. **FVS uniquely identifies plots within stands. Because the area represented by an FIA plot or condition is considered to be a "stand", the FIA subplot is the equivalent of the FVS plot.**
Tree_Count	TPA_UNADJ or 1	Number of trees represented by this data tree. **When plot data are reported on a per-acre basis (i.e., Basal_Area_Factor = -1 and Inv_Plot_Size = 1 in the FVS_StandInit table), Tree_Count is the per-acre expansion factor associated with the tree. When plot design data are supplied, Tree_Count is generally set to 1 (meaning that one tree of this species, diameter, height, etc was tallied on the plot).**
History	STATUSCD	In FVS, History Code 0-5 are live trees, 6 and 7 died during mortality observation, 8 and 9 died before mortality observation period. **The FIA variable STATUSCD distinguishes between live and dead trees, but other variables, such as MORTYR, may be used to assign the appropriate History code.**
Species	SPCD	Tree Species Code, can be the FVS alpha code, FIA numeric code or USDA plant symbol. **The FIA variable SPCD can be used without modification.**
DBH or Diameter	DIA	Diameter in inches. Diameter is an alias for DBH in the FVS tables. For woodland trees, diameter is measured at the root collar (DRC). **The FIA variable DIA can be used without modification.**
DG	No FIA variable	Diameter growth in inches (not tenths of inches). **The FVS DG variable may be calculated using the FIA variables DIA, TREE.PREV_DIA (previous diameter), and PLOT.REMPER (remeasurement period).**
Ht	HT	Height in feet. **In the case of trees with broken or missing tops, the FIA height variable includes the broken or missing portion. See HtTopK / ACTUALHT below.**

Table 2. Variables in the predefined FVS_TreeInit table structure, their corresponding FIA variables, and descriptions.

FVS Variable	FIA Variable	Description and notes
HtG	Float	Height Growth in feet. **FIA does not currently report height growth or provide both current and previous heights as national variables, partly because height measurements were not collected by some FIA work units in the past. However, height should become a national core variable in the future.**
HtTopK	ACTUALHT	Height to top kill is the height to the point of top kill of the tree in feet. **In FIA data, if ACTUALHT = HT, then the tree does not have a broken top. If ACTUALHT < HT, then the tree does have a broken or missing top.**
CrRatio	Float	If the number is 0-9 then it is considered a crown ratio code, according to the FVS documentation. **If the number is 10-99 the value is considered a percent live crown. In the past, the FIA variable for compacted crown ration (CR) has also contained a mixture of the coded and percentage crown ratios. At the time of the Mapmaker release, FVS appeared to not handle this situation correctly.**
Damage1	DAMTYP1	Damage Code, see the FVS documentation for details. **Although there are existing FIA damage variables, damage and severity codes are currently undergoing substantial revision within the FIA program. The new national coding scheme is anticipated to be implemented no sooner than 2011.**
Severity1	DAMSEV1	Severity Code corresponding to damage code 1. **See notes on Damage1**
Damage2	DAMTYP2	Second damage code. **See notes on Damage1**
Severity2	DAMSEV2	Second severity code. **See notes on Damage1**
Damage3	DAMTYP3	Third damage code. **See notes on Damage1**
Severity3	DAMSEV3	Third severity code. **See notes on Damage1**
TreeValue	Float	Tree Value Class Code 1 for desirable, 2 for acceptable, 8 for non-stockable and any other number represents a live cull. **FIA cull and growing stock variables are currently undergoing revision. It should be possible to develop a rule set for converting certain combinations of FIA cull variables into FVS codes.**
Prescription	No FIA variable.	Prescription code. **Prescription codes are used in FVS to describe trees that may be candidates for silvicultural manipulation. The FIA program does not assign similar identifiers to individual trees, so there is no corresponding variable.**
Age	BHAGE or TOTAGE	Age of the tree record. **In FIA data, individual tree ages can be found in the BHAGE or TOTAGE variables in the TREE and SITETREE tables.**
Slope	SLOPE (SUBPLOT)	Slope percentage on the plot where the tree was located. **The slope measured on the FIA subplot is comparable to plot-level slope in FVS.**

Table 2. Variables in the predefined FVS_TreeInit table structure, their corresponding FIA variables, and descriptions.

FVS Variable	FIA Variable	Description and notes
Aspect	ASPECT (SUBPLOT)	Aspect in degrees on the plot where the tree was located. **The aspect measured on the FIA subplot is comparable to plot-level aspect in FVS.**
PV_Code or Habitat Type	See PV_Code entry in Stand_Init table.	The potential vegetation code on the plot where the tree was located. **FIA habitat type and potential vegetation codes are recorded in the condition table, so they are more appropriately used in the Stand_Init table.**
PV_Ref_Code	See PV_Ref_Code in the Stand_Init table.	Potential vegetation reference code for the PV_Code
TopoCode	TOPO_POSITION_PNW	Topography Code 1=bottom, 2=lower, 3=mid slope, 4=upper slope, and 5=ridge top, on the plot where the tree was located. **Only the Pacific Northwest (PNW) FIA program uses a topographic position code that it comparable to the FVS TopoCode.**
SitePrep	TRTCD1, -2, and -3	Site Preparation code 1=none, 2=mechanical, 3=burn, and 4=road cuts/road fills/stockable road beds, on the plot where the tree was located

Tables 1 and 2 provide a general framework for translation of FIA variables into FVS-ready format. In some cases, there are several options for translation that may be user-defined or may be pre-set for ease of use, depending on users needs. However, some of these options are not yet common knowledge to users, so they will be introduced briefly here.

Choice of Plot and Tree Data Formats

FIA mapped (annual) design plots have four 1/24-acre subplots design for a total surface area of approximately 1/6 acre, resulting in an expansion factor of 6.02 trees per acres for tally trees $\geq$ 5.0 inches in diameter. Seedlings and saplings are measured on 1/300-acre microplots that are nested within each subplot, resulting in a per-acre expansion factor of 74.97. There are two ways to code this information in FVS:

A) Basal_Area_Factor = -24, Inv_Plot_Size = 300, Brk_DBH = 5.0, and Tree_Count = 1

B) Basal_Area_Factor = -1, Inv_Plot_Size = 1, Brk_DBH = null, and Tree_Count = 6.02 (trees $\geq$5.0 inches) or Tree_Count = 74.97 (trees <5.0 inches)

In example (A), the FVS-formatted data utilize the FIA plot design information and expansion factors are computed by FVS. The negative sign in front of the Basal_Area_Factor value indicates that the value is for a fixed-plot area, and not a basal area factor. In example (B), all trees are represented by their per-acre expansion factors and the FIA plot design specifics are ignored.

In terms of the computation of stand structure, volume, and other characteristics in FVS, both approaches produce identical results. However, in terms of growth, mortality, and other submodel functions, there may be differences between the two. The reason for this is that FVS uses both stand-level and plot-level variables in some submodels. In other words, a 10-inch tree that was recorded on a dense subplot may be grown slower than a 10-inch tree recorded on a sparse subplot. Although the magnitude of difference is unknown and will vary on every plot, preserving the information from intra-plot (subplot) variability may be desirable to some users. In addition, FVS preserves the subplot-level tally and passes that information to the Stand Visualization System (SVS; McGaughey 1997), allowing users to compare compositional and structural differences among subplots.

It is possible to make data available in either format (A) or format (B), depending on user needs. On single-condition, mapped-design plots, the preference for one format or the other makes little difference, except for the possible growth and mortality differences mentioned above. However, there are certain circumstances under which one format or the other may be preferable, or even necessary. The most important of these involves the treatment of multiple conditions that might occur on a single FIA plot.

Treatment of Multiple Conditions

Briefly described, conditions are delineated on FIA plots when part of the plot is occupied by forest and another part is occupied by nonforest land, water, or some situation exists that precludes sampling part of the plot (figure 3). Forested conditions are further divisible by reserved status, owner group, forest type, stand size class, regeneration status, or tree density. In some cases, these divisions equate to what would typically be called separate stands, but in other cases they are not.

Depending on user needs, the division of a plot by condition may or may not be important. If the objective of a simulation is to evaluate silvicultural options on a landscape, it may be important to exclude reserved lands from treatment options. The consideration of multiple-condition plots as a single condition that includes mixtures of forest and nonforest or different types of forest may misrepresent composition, structure, or growth potential at the plot level.

Other Considerations

It is not possible to anticipate all user needs, or even to consider all of the possibilities, given the complexity of the FIA database, the FVS base system, and all of the FVS extensions. Undoubtedly, users who are intimately familiar with one of more of the programs will be able to identify issues not covered here.

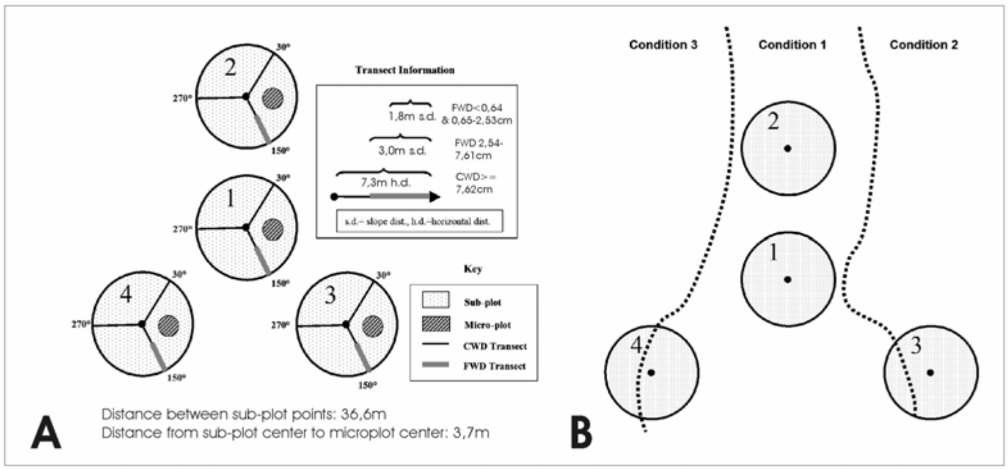

FIGURE 3: The FIA annual plot design (A) and example of mapping multiple conditions on the plot footprint (B).

Conclusion

In summary, the work that needs to be done on the next generation of FIA to FVS data translation can be described in three groups: opportunities, data needs, and open questions. Issues belonging each of these groups have been described, to some degree, in this paper, but the list is not exhaustive. The opportunities may be taken advantage of in one step, or may be implemented gradually. The data needs are relatively easily identified, and can be satisfied through further investigation. It is possible for FIA developers to begin to address these issues right away. The open questions will require solicitation of user input and priority ranking, because some answers may have important implications for data delivery and use. Once the open questions have been answered and addressed, the result should be a greatly enhanced outlet for FIA data.

Opportunities

- Export FIA data to FVS input files as a database
- Utilize the existing FVS map to assign default geographic variant

Data Needs

- Site index species and site index values must conform with FVS variant
- Stockable area should be computed consistently
- Damage and severity codes should be translated to FVS specifications where possible
- FIA habitat and community types need to be cross-walked to FVS types
- Diameter and height growth data should be provided when available

- Work toward allowing NFS volume equation computation for tree records
- Include tree defect data where available
- Include stem count for woodland species
- Include access to older periodic data
- Export seedling data when available
- Export dwarf mistletoe data when available
- Include fuel loading data from Phase 3 plots

Open Questions

- How to deal with multiple conditions?
- When to incorporate plot design codes?

Miles (2008) noted that "FVS users of FIA data make up a small but extremely important part of the overall FIA user community. It is important to maintain the delivery of FIA data to this user group." This paper is a first step toward restoring access to the most current FIA data for this user group. As this effort proceeds, input from all interested parties is welcome.

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References Cited

Cleland, D.T.; Freeouf, J.A.; Keys, J.E., Jr.; Nowacki, G.J.; Carpenter, C.A.; McNab, W.H. 2004. Subregions of the conterminous United States. A.M. Sloan, tech. ed. Washington, DC: U.S. Department of Agriculture, Forest Service, presentation scale 1:3,500,000; colored. Also available on CD-ROM consisting of GIS coverage in ArcINFO format.

Crookston, N.L. 1997. Suppose: An Interface to the Forest Vegetation Simulator. In: Teck, Richard; Moeur, Melinda; Adams, Judy. 1997. Proceeding: Forest vegetation simulator conference. 3-7 February 1997, Fort Collins, CO. Gen. Tech. Rep. INT-GTR-373. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station.

Dixon, G.E., comp. 2002. Essential FVS: A user's guide to the Forest Vegetation Simulator. Internal Rep. Fort Collins, CO: U. S. Department of Agriculture, Forest Service, Forest Management Service Center. 219p. (Last Revised: April 7, 2008)

Donnelly, D.; Lilly, B.; Smith, E. 2001. The southern variant of the Forest Vegetation Simulator. [available online: http://www.fs.fed.us/fmsc/ftp/fvs/docs/overviews/snvar.pdf]

Forest Inventory and Analysis Program. 2008. The forest inventory and analysis database: database description and users manual version 3.0 for Phase 2, revision 1. U.S. Department of Agriculture, Forest Service, Washington Office. [available online: http://www.fia.fs.fed.us/library/database-documentation/FIADB_user_manual_v3-0.pdf]

Forest Vegetation Simulator Staff. 2003. Users Guide to the Database Extension of the Forest Vegetation Simulator Version 2.0. Fort Collins, CO: U. S. Department of Agriculture, Forest Service, Forest Management Service Center. 219p. (Last Revised: May 2008)

Johnson, R.R. 1997. A historical perspective of the Forest Vegetation Simulator. In: Teck, Richard, Moeur, Melinda; Adams, Judy, comps. Proceedings: Forest Vegetation Simulator Conference, February 3–7, 1997; Fort Collins, CO. Gen. Tech. Rep. INT–GTR–373. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station.

McGaughey, R.J. 1997. Visualizing forest stand dynamics using the stand visualization system. In: Proceedings of the 1997 ACSM/ASPRS Annual Convention and Exposition; April 7-10, 1997; Seattle, WA. Bethesda, MD: American Society of Photogrammetry and Remote Sensing. 4:248-257.

Miles, P.D. 2008. Forest inventory and analysis data for FVS modelers. Pp. 125-129 in: Havis, Robert N.; Crookston, Nicholas L., comps. 2008. Third Forest Vegetation Simulator Conference; 2007 February 13–15; Fort Collins, CO. Proceedings RMRS-P-54. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. p. 125-129.

Reinhardt, E.; Crookston, N.L., tech. eds. 2003. The Fire and Fuels Extension to the Forest Vegetation Simulator. Gen. Tech. Rep. RMRS-GTR-116. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 209 p.

Shaw, J.D.; Long, J.N. 2002. FVS Lessons on the web: A resource for users and instructors. Pp. 2-5 in Crookston, Nicholas L.; Havis, Robert N., comps. 2002. Second Forest Vegetation Simulator Conference; 2002 February 12–14; Fort Collins, CO. Proc. RMRS-P-25. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Stage, A.R. 1973. Prognosis model for stand development. USDA Forest Service, Intermountain Forest & Range Experiment Station. General Technical Report INT-137. Ogden, UT.

Wykoff, W. R.; Crookston, N.L.; Stage, A.R. 1982. User’s guide to the Stand Prognosis Model. Gen. Tech. Rep. INT-133. Ogden, UT: U. S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 112 p.