

Carbon Reporting with the Forest Vegetation Simulator (FVS)

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**Providing Environmental Services from Agriculture in a Budget-Constrained
Environment**

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Introductions

- Ecosystem ecologist
- Have been working on forests and carbon since 1999
- Work at the stand and landscape scales
- Interested in management effects
- Outreach and training

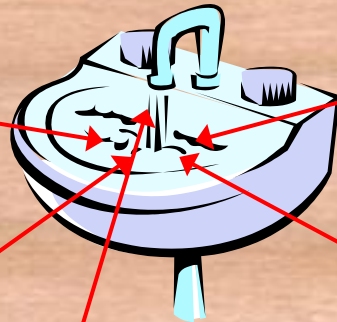


There's a lot to keep track of...



Biomass

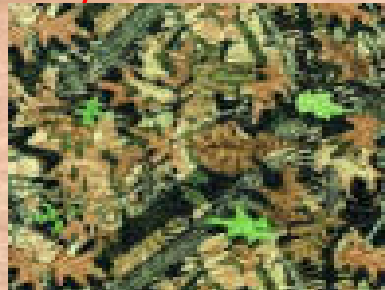
**Forest
Carbon Sink**



Products



Soils



Forest Floor



Woody debris

Carbon in Harvested Trees



- Some plans allow carbon in products to be counted if verifiable
- Categories:
 - **Products in use**
 - **Products in landfills**
 - Wood burned for energy
 - Emissions
- Challenging to track through time; changing markets and regional differences

What is the Forest Vegetation Simulator (FVS)?

Individual-tree growth and yield model

- Uses standard inventory data
- Generally run at the stand level
 - Not an ecological process model, not spatially explicit
- Can simulate nearly any type of management

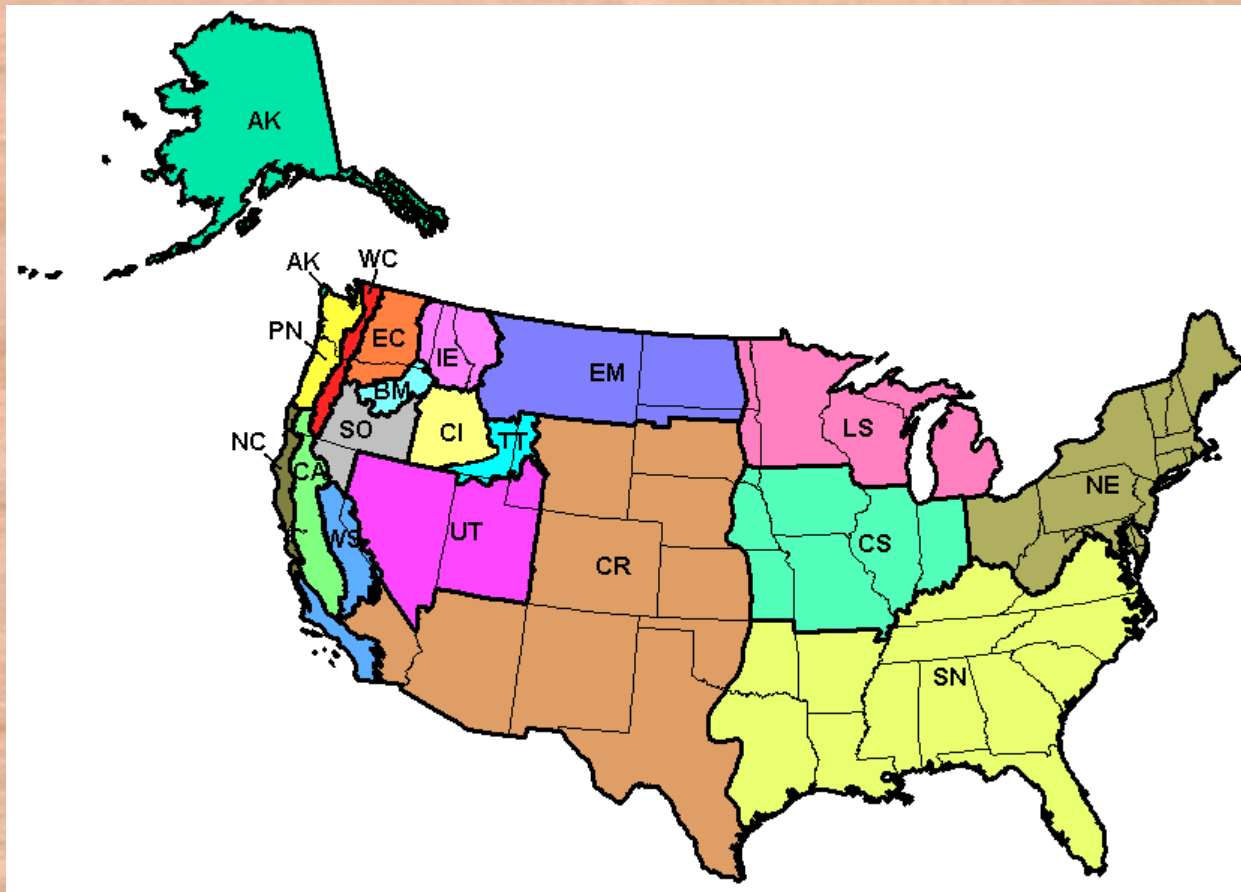


More about FVS

- Widely used by forest managers, especially in the National Forest System
- National coverage -“variants” developed for geographic regions
- Many extensions and post processors are available to look at more than timber :
 - Fire and fuels extension
 - Insect and disease extension
 - Wildlife habitat reports
 - Many more!

Geographic Variants

Each has its own set of species, growth and mortality functions, volume calculation procedures, etc.



What inputs does FVS need?

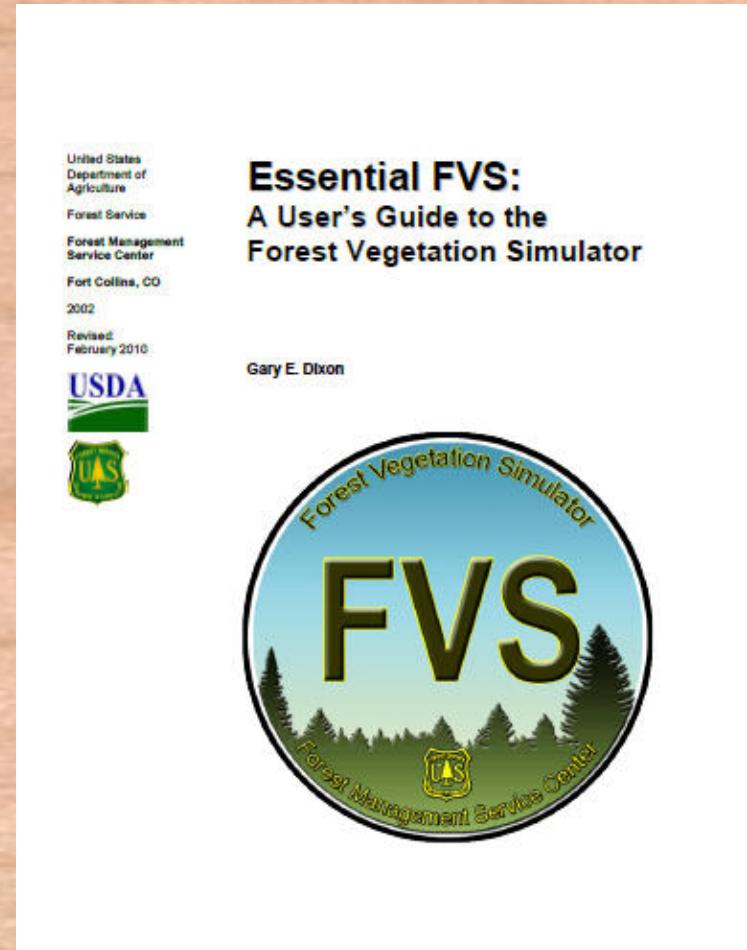
- Stand level data:
 - Slope, aspect, elevation, information related to the inventory method, site index, etc.
- Tree level data:
 - **Species, diameter**, tree history, height, etc.
- There are many tree and stand level variables that may be entered. FVS will supply regional defaults for *most* variables.

What kinds of output can I get?

- The FVS base reports provide information on the stand: trees per acre, basal area, volume, average stand diameter, etc.
- Other reports can be generated: the stand carbon report, the harvested carbon report, fuels reports, disease risk
- Reports are saved as a text file, but can be written to Excel files, or used to generate "pictures" of the stand.

More on inputs and outputs

- You **MUST** have a treelist to use FVS!
- Many types of output and reports are available
- Check the FVS documentation for details on model inputs and outputs





Simulating management actions

FVS can simulate nearly any management action:

- Thinning
- Prescribed fire
- Harvesting: single tree selection, group selection, shelterwood, clearcut
- Planting/regeneration
- Slash management

More on management

- Management actions are not “canned”
- For example, once a thinning is selected, many options are possible:
 - Thin from above, below, within all or part of a diameter range, to a specified basal area or density target, with or without species preferences, at a set time or when a specific condition is reached, and more.
- Except for a few variants, regeneration is not automatic: you must tell FVS when and how to add new seedlings

Example

The screenshot displays the 'Suppose v2.02' software interface. The main window title is 'Suppose v2.02 Simulation file: C:\Fvsdata\Regional-Training\ex2.key'. The menu bar includes 'File', 'Edit', 'Data Preparation', 'Simulation Preparation', 'After Simulation', 'Preferences', and 'Help'. The 'Main' window shows a 'Simulation Preparation' section with buttons for 'Select Stands', 'Set Time Scale', 'Select M...', 'Add Keywords', 'Insert From File', and 'Select Post...'. Below this is a tree view of 'Simulation file contents' for 'Stand: UT_BareGround', including groups like 'All_Stands' and 'Group: All'. The 'Management Actions' dialog box is open, listing various actions such as 'Planting & Natural Regeneration', 'Traditional FVS Thinning Operations' (which is highlighted), 'Tree Removal Preference', and 'Disease Management'. A list of thinning methods is shown on the right, including 'Thin from above, basal area target' and 'Thin to a residual percent canopy co...'. The dialog has a 'Close' button at the bottom. The bottom of the main window features an 'Edit Simulation' section with buttons for 'Edit Selection', 'Delete', 'Write', 'Append', 'Copy', 'Cut', 'Change Group Membership', and 'Paste', and an 'After Simulation' section with buttons for 'Read FVS Outputs', 'Generate Graphs', 'Generate Reports', and 'Exit'.

Suppose v2.02 Simulation file: C:\Fvsdata\Regional-Training\ex2.key

File Edit Data Preparation Simulation Preparation After Simulation Preferences Help

Main

Simulation Preparation

Select Stands Set Time Scale Select M...

Add Keywords Insert From File Select Post...

Simulation file contents:

- Stand: UT_BareGround
 - Group: All_Stands
 - From Database
 - Group: All
 - Plant & Natural Regeneration
 - Thin throughout a diameter range
 - Build SVS Treelist
 - Select Carbon Reports
 - Select Fire and Fuels Reports
 - Prescribed burn
 - Group(s) with no attached components:
 - Group: forest_type=999
 - Group: Variant=UT
 - Group: BareGround

Management Actions

Planting & Natural Regeneration
Regeneration Methods: Even-aged
Regeneration Methods: Uneven-aged
Thinning & Pruning Operations
Cleaning & Release Operations
Traditional FVS Thinning Operations
Tree Removal Preference
Biomass Removal and Retention
Fuel Treatments
Salvage Operations
Identify Species Groups
Fertilizer
Disease Management

Thin from above, basal area target
Thin from below, basal area target
Thin from above, trees per acre target
Thin from below, trees per acre target
Thin from a specific diameter range
Thin from a specific height range
Thin individually "marked" trees
Thin dwarf mistletoe infected trees
Thin to a residual relative density (C...
Thin to a residual stand density inde...
Thin to a residual percent canopy co...

Close

Edit Simulation

Edit Selection Delete Write Append Copy Cut

Change Group Membership Paste

After Simulation

Read FVS Outputs Generate Graphs Generate Reports Exit

Example

Suppose v2.02 Simulation file: C:\Fvsdata\Regional-Training\ex2.key

File Edit Data Preparation Simulation Preparation After Simulation Preferences Help

Main

Simulation Preparation

Select Stands Set Time Scale Select

Add Keywords Insert From File Select

Simulation file contents:

- Stand: UT_BareGround
 - Group: All_Stands
 - From Database
 - Group: All
 - Plant & Natural Regeneration
 - Thin throughout a diameter range**
 - Build SVS Treelist
 - Select Carbon Reports
 - Select Fire and Fuels Reports
 - Prescribed burn
 - Group(s) with no attached components:
 - Group: forest_type=999
 - Group: Variant=UT
 - Group: BareGround

Edit Simulation

Edit Selection Delete Write

Change Group Membership

After Simulation

Read FVS Outputs Generate Graphs

Edit - Thin throughout a diameter range

Name: Thin throughout a diameter range

Schedule by Year/Cycle Schedule by Condition

2062 Select Year 0 years after Condition is met

Density in terms of Basal area

Residual Density (within specified species size range) 50

OR

Proportion of trees to cut (within specified species size range) 1.

Species to be removed in this cut All species

Smallest DBH to be considered for removal (greater than/equal) 7

Largest DBH to be considered for removal (less than) 999.

Description:
This management action thins equally throughout the diameter range specified. Only species selected will be thinned.

Ok Use Params Reset Cancel

Caveats

- FVS is a large, flexible, complex model. It will simulate nearly any management action. It will NOT check to see if the settings chosen “make sense.”
- The user must be able to interpret the output to see if the simulation worked as intended.
- For most realistic projections, defaults should be modified to reflect local conditions.



In short....

- If you are new to FVS, taking the one week training course offered by the FVS staff is **strongly** recommended
- Trainings are held throughout the US
- A forestry or natural resources background is helpful in interpreting the basic stand reports
- For more:
<http://www.fs.fed.us/fmsc/fvs/>

Carbon Reporting Basics

- Reports are located in the Fire and Fuels Extension (FFE) to FVS
- Live aboveground biomass - 2 methods
 - Jenkins et al. (For. Sci. 2003)
 - FFE default method
- Live and dead roots from Jenkins et al.
- Forest floor, down dead wood, and snag pools by FFE default methods
- Harvested carbon from Smith and Heath (2006) - 1605b method

What is the Fire and Fuels Extension (FFE)?

- An “add-on” to FVS that tracks fire hazard, fuel loading, snag mass, and related variables over time
- FFE combines vegetation predictions of FVS with:
 - Estimates of fuel accumulation and decay
 - Estimates of snag fall down and decay
 - Fire behavior models

Why are the Carbon Reports in the FFE?

- The FFE uses information from FVS to track various kinds of fuel
- These fuels represent many of the carbon pools that are commonly reported, such as dead wood and the forest floor
- So, the biomass pools needed were already modeled in the FFE - they just needed to be translated to carbon



What data do I need to use the carbon reports?

- The same that you need to run FVS. When you request the carbon reports, FVS passes the information to the FFE
- If you don't have dead wood and forest floor data, FVS will use regional defaults
- If you simulate a harvest, that information will be used to generate the harvested carbon report

CarbCalc Keyword

Edit - Fire and Fuels Extension: CarbCalc

Name:

Biomass predictions:

Units:

Annual decay rate (proportion per year)

DBH breakpoint (in) between pulpwood and sawtimber for softwoods

DBH breakpoint (in) between pulpwood and sawtimber for hardwoods

Description:
Set the carbon accounting parameters.

Choice of methods: can also use FVS default method

English units also available

Default values are adjustable by user

What outputs do I get?

***** CARBON REPORT VERSION 1.0 *****												
STAND CARBON REPORT												
STAND ID: 2849												
MGMT ID: NONE												
YEAR	Aboveground Live		Belowground		Stand Dead T/HA	Forest			Total Stand Carbon T/HA	Total Removed Carbon T/HA	Carbon Released from Fire T/HA	
	Total	Merch	Live	Dead		DDW	Floor	Shb/Hrb				
	T/HA	T/HA	T/HA	T/HA		T/HA	T/HA	T/HA				
2006	114.4	75.2	21.4	12.5	0.0	18.1	14.9	0.7	182.1	48.5	0.0	
2011	119.6	77.8	24.3	10.1	0.1	11.4	15.7	0.7	181.9	0.0	0.0	
2016	123.2	80.4	23.5	9.1	1.2	10.2	16.2	0.7	184.1	0.0	0.0	
2021	128.2	83.4	24.2	7.6	1.1	9.7	16.6	0.7	188.1	0.0	0.0	
2026	132.7	85.8	25.0	6.5	1.6	10.2	17.1	0.7	193.7	0.0	0.0	
2031	138.2	88.6	26.0	5.5	1.8	10.8	17.4	0.7	200.4	0.0	0.0	

- All of the major pools EXCEPT soil carbon are reported, as well as merchantable live tree carbon
- Carbon removed from the stand, if harvest occurs
- Carbon released from fire, if fire is simulated
- Values are stocks - tons C/ac or tonnes C/ha

What outputs won't I get?

- Soil carbon
 - Forest soil carbon has high spatial variability
 - Reliable default estimates are not available
 - Forest soil C does not respond in a uniform way to management actions
- Emissions from management: e.g. fuel use
 - FVS is a growth and yield model, not a lifecycle analysis or greenhouse gas model
- Information on other GHGs: N_2O , CH_4

Calculating Change

***** CARBON				
STAND ID: 2849				

Aboveground Live		Belowground		
YEAR	Total	Merch	Live	Dead
	T/HA	T/HA	T/HA	T/HA

2006	114.4	75.2	21.4	12.5
2011	119.6	77.8	24.3	10.1
2016	123.2	80.4	23.5	9.1
2021	128.2	83.4	24.2	7.6
2026	132.7	85.8	25.0	6.5
2031	138.2	88.6	26.0	5.5

•Aboveground live biomass 2006 = 114.4 t/ha

•Belowground live biomass 2006 = 21.4 t/ha

•Total live biomass 2006 = 135.8 t/ha

•Total live biomass in 2026 =
132.7 + 25.0 = 157.7 t/ha

So, projected net change in live carbon stocks from 2006-2026 is : $157.7 - 135.8 = 21.9$ t/ha

Mean annual change = $(157.7 - 135.8) / 20 = 1.1$ t/ha/yr

CarbCut Keyword

User specifies reporting duration and reporting interval

Sawtimber/pulp diameter breakpoint is set in CarbCalc dialog box

Suppose 1.20 Simulation file: C:\Fvsdata\KEF\Comp6_7.key

File Edit Basics Extras Options Help

Fire and Fuels Extension: CarbCut

Name: Fire and Fuels Extension: CarbCut

Starting year for the harvested products carbon report:

Schedule by Year/Cycle Schedule by Condition

2006 Select Year 0 years after Condition is met

Reporting period duration (years) 30

Reporting interval (years) 5

Description:
Request the harvested products carbon report.

Ok Use Parm's Reset Cancel

Example of Harvested C Report

```
***** CARBON REPORT VERSION 1.0 *****
          HARVESTED PRODUCTS REPORT
          MGMT ID: NONE
STAND ID: 2849
```

YEAR	Prducts	Lndfill	Energy	Emissns	Merch Carbon	
					Stored	Removed
	T/HA	T/HA	T/HA	T/HA	T/HA	T/HA
2006	25.6	0.0	9.4	6.4	25.6	41.4
2011	18.2	3.9	11.3	8.1	22.1	41.4
2016	13.7	6.1	12.5	9.1	19.8	41.4
2021	10.9	7.4	13.2	9.9	18.4	41.4
2026	9.1	8.2	13.7	10.4	17.3	41.4
2031	7.9	8.7	14.1	10.8	16.6	41.4

- Values are stocks - user needs to compute change
- C allocation among pools changes over time
- Follows methods in GTR NE-343 (Smith et al.)

Things to remember

- Reports provide stocks at a point in time
 - User must calculate stock changes
- If harvests are simulated, add the stock value from the Stand Carbon Report to the stock value from the Harvested Carbon Report to get total
- To compute average annual change: divide the stock change for a time interval by the number of years

What about disturbances?

- Since FVS is a growth and yield model and not an ecological process model, disturbances are not explicitly included
- However, the effects of disturbances can be included
 - Wildfire can be simulated in the FFE
 - Other disturbances can be simulated by selecting a lower site index, using the insect and disease extensions, using different growth multipliers, or adjusting mortality rates

What about land use change?

- Under most circumstances, FVS requires a treelist in order run
- There is a “bare earth” option that can be used if converting from non-forest
 - Stand level data must be supplied
 - The regeneration keyword is then used
 - User supplies information on number, type, height, survival rate of seedlings
- Remember, soil C is not included

More things to remember

- FVS was developed to model stand growth and yield, not carbon or ecosystem processes
- Does not include all C fluxes; tracks major C pools (excluding soil)
- Output units are in English or metric tons of carbon, not in CO₂
 - If CO₂ is needed, multiply by 3.67

