Forest Vegetation Simulator (FVS)
Analyzing Carbon and the Impacts of Changing Climate

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Outline

• FMSC/FVS Overview

• Carbon Accounting
  – Example of Additionality with Reforestation

• Climate Extension
  – Example of running FVS under GCM scenarios
Forest Management Service Center

- A sub-staff of the USDA Forest Service National Headquarters Forest Management Staff
- Supports timber sales contracting and forest modeling
- Provides biometric support to the Forest Service and our partners
Biometric Support Areas

Forest Products Measurement
- develops and maintains timber cruising, scaling, volume and biomass calculation, and area determination software

Forest Vegetation Modeling
- enhances, maintains and supports the Forest Vegetation Simulator (FVS), a nationally supported framework for growth and yield modeling
What is FVS?

• Individual-tree, distance-independent growth and yield model
• Responsive to site, structural differences and management actions common to forest stands found throughout the United States
Suggested Range Map

Figure 1 - Geographic Variants of the Forest Vegetation Simulator.
Input Data

<table>
<thead>
<tr>
<th>Stand /Site Conditions</th>
<th>Tree Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Species</td>
</tr>
<tr>
<td>Habitat type</td>
<td>DBH</td>
</tr>
<tr>
<td>Slope</td>
<td>Height (total)</td>
</tr>
<tr>
<td>Aspect</td>
<td>Crown ratio</td>
</tr>
<tr>
<td>Elevation</td>
<td>Past growth increment</td>
</tr>
<tr>
<td>Site index</td>
<td>Tree count (from inventory design)</td>
</tr>
<tr>
<td></td>
<td>Damage</td>
</tr>
</tbody>
</table>
Fire and Fuels Extension (FFE)

• Incorporates existing fire behavior and effect models with new snag and fuel dynamic models
• Simulate additional stand biomass dynamics over time for live and dead:
  – standing trees (boles and crowns)
  – surface fuels
• Predict or simulate the effects of fire on stand components
Carbon Model

• Converts stand biomass estimates to carbon
• Estimates carbon removed from the stand through harvest and fire activities
• Estimates the fate of harvested products
• Approved for estimating carbon stock changes in American Carbon Registry (ACR) projects.
Carbon Example

• Tahoe National Forest - Bassett Fire
• 2000 acres burned - 250 acre project area
• Post fire if no funds are available to replant, what is the prognosis for this stand in terms of carbon?
• Compare the carbon additionality if we do plant the stand.
Compare Additionality

- **Alternative A: NoAction Simulation**
  Natural Regeneration: establish 10 white fir seedlings/acre in decade 1 and 10 white fir seedlings/acre in decade 2 to simulate natural regeneration scattered throughout a Ceanothus velutinus (snowbrush) shrubfield.

- **Alternative B: PlantOnly Simulation**
  Natural Regeneration: same as Alternative A. Planted Regeneration: 300 seedlings/acre (160 Jeffrey pine, 100 Douglas-fir, and 40 sugar pine) in 2008. Ten-year survival rate was estimated at 70% for Jeffrey pine, 50% for Douglas-fir, and 60% for sugar pine.

- **Alternative C: PlantWithMgmt Simulation**
  Natural Regeneration: same as Alternative A. Planted Regeneration: same as Alternative B. PreCommercial Thinning: Thin from below at age 20 to 115 trees/acre targeting non-planted species. Commercial Thinning: Thin from below at age 90 to 75 trees/acre targeting non-planted species.
## Basal Area (ft²/acre)

<table>
<thead>
<tr>
<th>Year</th>
<th>A: NoAction</th>
<th>B: PlantOnly</th>
<th>C: PlantW/Mgmt</th>
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</thead>
<tbody>
<tr>
<td>2008</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>2018</td>
<td>10</td>
<td>12</td>
<td>7</td>
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<tr>
<td>2028</td>
<td>13</td>
<td>25</td>
<td>15</td>
</tr>
<tr>
<td>2038</td>
<td>17</td>
<td>49</td>
<td>34</td>
</tr>
<tr>
<td>2048</td>
<td>22</td>
<td>83</td>
<td>62</td>
</tr>
<tr>
<td>2058</td>
<td>30</td>
<td>124</td>
<td>97</td>
</tr>
<tr>
<td>2068</td>
<td>38</td>
<td>171</td>
<td>136</td>
</tr>
<tr>
<td>2078</td>
<td>48</td>
<td>215</td>
<td>177</td>
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<tr>
<td>2088</td>
<td>57</td>
<td>244</td>
<td>217</td>
</tr>
<tr>
<td>2098</td>
<td>66</td>
<td>271</td>
<td>206</td>
</tr>
<tr>
<td>2108</td>
<td>75</td>
<td>276</td>
<td>240</td>
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</table>
Total Stand Carbon
Additionality Alt A. vs Alt B.
Additionality Alt A. vs Alt C.
Carbon Accounting

- Carbon in FVS is just one more metric that FVS provides
- When comparing scenarios for Carbon Market it is Carbon Additionality that is used
- Differences between Federal Lands and Private Lands.
- Different types of Markets
Modeling Impacts due to Climate

Base FVS Assumes:
  Past Climate = Future Climate

Climate FVS Assumes:
  Past Climate ≠ Future Climate
General Circulation Models (GCM)

- Canadian Center of Climate Modeling and Analysis
  - CGCM3-A2
  - CGCM3-B1
  - CGCM3-A1B
- Met Office Hadley Centre –UK (HADMC3)
  - HADMC3-A2
  - HADMC3-B2
- Geophysical Fluid Dynamics Laboratory -Princeton University, NOAA Research (GFDLCM21)
  - GFDLCM21-A2
  - GFDLCM21-B1
- The Community Earth System Model
  - CCSM4_rcp60
- Geophysical Fluid Dynamics Laboratory
  - GFDLCM3_rcp60
- Hadley Center/Met Office (UK)
  - HadGEM2ES_rcp60
- Our ensemble of 17 AR5 model predictions
  - Ensemble_rcp45
  - Ensemble_rcp60
  - Ensemble_rcp85
Example of Predicted Climate Change
Predicted Species Ranges 1990-2090

- Utah juniper
- Pinyon pine
## Viability Score Example

<table>
<thead>
<tr>
<th>Codes:</th>
<th>PILA</th>
<th>PSME</th>
<th>QUKE</th>
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<tbody>
<tr>
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<td>0.910</td>
<td>0.857</td>
<td>0.633</td>
</tr>
<tr>
<td>2030</td>
<td>0.835</td>
<td>0.803</td>
<td>0.805</td>
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<tr>
<td>2060</td>
<td>0.539</td>
<td>0.640</td>
<td>0.898</td>
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<tr>
<td>2090</td>
<td>0.396</td>
<td>0.787</td>
<td>0.763</td>
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</table>

*Lat: 42.5 Long: -123.6, Elev: 2400, based on Ensemble RCP60*
Changes to Model Climate- FVS

- Carrying capacity may change
- Additional species specific mortality
- Species Establishment changes
- Growth is impacted
How To Run Climate-FVS

- Additional input file needed that contains viability scores.
- One additional keyword is mandatory (CLIMDATA), that specifies the location of the viability scores files, and specifies the GCM scenario to be used.
- Four other option keywords can me used to change the assumptions on climate change impacts on growth, mortality, and regeneration.
Example of additional input file needed

Filename: FVSClimAttrs.csv

<table>
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<tr>
<th>StandID</th>
<th>Scenario</th>
<th>Year</th>
<th>mat</th>
<th>map</th>
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<th>ABCO</th>
<th>ABGR</th>
<th>ABLA</th>
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<td>730</td>
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<td>0</td>
<td>0.044</td>
<td>0.878</td>
<td>0.262</td>
<td>0.000667</td>
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</tbody>
</table>

A source of the climate and species viability data file is at this web address: [http://forest.moscowfsl.wsu.edu/climate/customData/fvs_data.php](http://forest.moscowfsl.wsu.edu/climate/customData/fvs_data.php).
Climate Keywords

- **ClimData** Signal that the climate and species-viability data be read from an external file.
- **SetAttr** Change the values for a single attribute from those in the climate attributes file to new values.
- **AutoEstb** Signal that Climate-FVS automatic establishment logic
- **GrowMult** Specify a species-specific adjustment to the magnitude of the growth-rate multiplier
- **MortMult** Specify two species-specific mortality multipliers
- **MxDenMlt** Specify an adjustment of the maximum density multiplier
- **ClimRept** Generates the Climate-FVS output report
Compare Climate Scenarios

Carbon
Clearwater River, Idaho

Year
2020 2040 2060 2080 2100

Carbon (metric tons/ha)

1 Base
2 CGCM3_A1B
3 CGCM3_A2
4 CGCM3_B1
5 GFDL_CM21_A2
6 GFDL_CM21_B1
7 HADCM3_A2
8 HADCM3_B2

Total
Dead
Climate Extension

• Provides a tool for considering the effects of climate change on forested ecosystems
• Modifies growth, mortality, and regeneration models based on various climate scenarios
• Available in the western US, development in eastern US is ongoing
FVS Website:
www.fs.fed.us/fmsc/fvs