



USFWS: Brent Lawrence. "Diablo Lake in the Northern Cascades" Flickr, 3 November 2023, <https://www.flickr.com/photos/52133016@N00/33145062751/>.

# Methods for Initial Scenario Modeling

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# Outline

- Introduction (3min)
- Model Process Overview (5min)
- Prepare Inputs & Simulate Key Processes (20min)
- Post-Processing & Outputs (5min)
- Scenarios Review & Questions



# Today's Goal

- Continue building understanding about how the forest carbon modeling works to aid in informing voting decisions about management scenarios



# Selected modeling tool

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FOREST SERVICE HOME » FVS » WHAT IS FVS?

**Forest Vegetation Simulator**

- Home
- What is FVS? ▾
- Software ▾
- Documents ▾
- Training ▾
- Support

## What is FVS?

The Forest Vegetation Simulator (FVS) is a family of forest growth simulation models. It is a system of highly integrated analytical tools that is based upon a body of scientific knowledge developed from decades of natural resources research and experience. Since the development of the first model for northern Idaho in 1973, FVS has evolved into a collection of "variants" which represent different geographic areas across the country.

FVS answers questions about how forest vegetation will change in response to natural succession, disturbances, and proposed management actions. Extensions to the base model are available to assess the effects of insects, disease, and fire. The Fire & Fuels Extension (FFE) includes live tree, dead tree, down dead wood and forest floor biomass information, which can be used to estimate changes in carbon stocks over time.

A climate-sensitive version known as *Climate-FVS* is currently available for western states. Climate-FVS changes core growth, mortality, and regeneration estimates to respond to climate change, according a user-selected general circulation model (GCM), thereby allowing users to model the effects of management under changing climate conditions.

### Background

The Forest Vegetation Simulator (FVS) is an individual-tree, distance-independent, growth and yield model (Dixon 2002). It has been calibrated for specific geographic areas (variants) of the United States (Figure 1). FVS can simulate a wide range of silvicultural treatments for most major forest tree species, forest




Figure 1 - Geographic Variants of the Forest Vegetation Simulator.

Highlights

- [The Forest Vegetation Simulator - What is it and what can it do for me?](#)

<https://www.fs.usda.gov/fvs/index.shtml>





# Modeling phases

**WE ARE  
HERE**

DNR & WG  
Review



	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
Phase 1 - Modeling	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
Phase 2 - Refinement & Finalization	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█



ESSA data preparation, model setup, and modeling of scenarios



ESSA refinement of modeling and final reporting



# Basic Model Process



# Basic model process

## PREPARATION

## MODELING

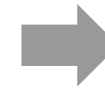
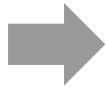
## RESULTS

Prepare  
Inputs

Stand  
Initialization

Simulation

Outputs and  
Post-processing



- Growth
- Carbon fluxes
- Disturbance
- Harvest
- Silviculture

Preparation data icon by monkik



# Basic model process

## PREPARATION

Prepare Inputs



## MODELING

Stand Initialization



Simulation



## RESULTS

Post-processing



- Growth
- Carbon fluxes
- Disturbance
- Harvest
- Silviculture

  
**WE ARE  
HERE**





# Basic model process

## PREPARATION

Prepare  
Inputs



**WHAT WE  
WANT TO  
TALK ABOUT  
TODAY**

## MODELING

Stand  
Initialization



Simulation



- Growth
- Carbon fluxes
- Disturbance
- Harvest
- Silviculture

## RESULTS

Post-  
processing





# Basic model process

## PREPARATION

## MODELING

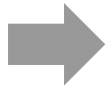
## RESULTS

Prepare  
Inputs

Stand  
Initialization

Simulation

Post-  
processing



**FOCUSING ON  
HOW?**

- Growth
- Carbon fluxes
- Disturbance
- Harvest
- Silviculture



# Basic model process

PREPARATION

MODELING

RESULTS

Prepare  
Inputs



1

Stand  
Initialization



Simulation



Post-  
processing



- Growth
- Carbon fluxes
- Disturbance
- Harvest
- Silviculture

**FOCUSING ON  
HOW?**



# Basic model process

PREPARATION

MODELING

RESULTS

Prepare  
Inputs



1

Stand  
Initialization



Simulation



Post-  
processing



FOCUSING ON  
**HOW?**

- Growth
- Carbon fluxes
- Disturbance
- Harvest
- Silviculture

2



# Prepare Inputs



# Main Inputs

## External Data

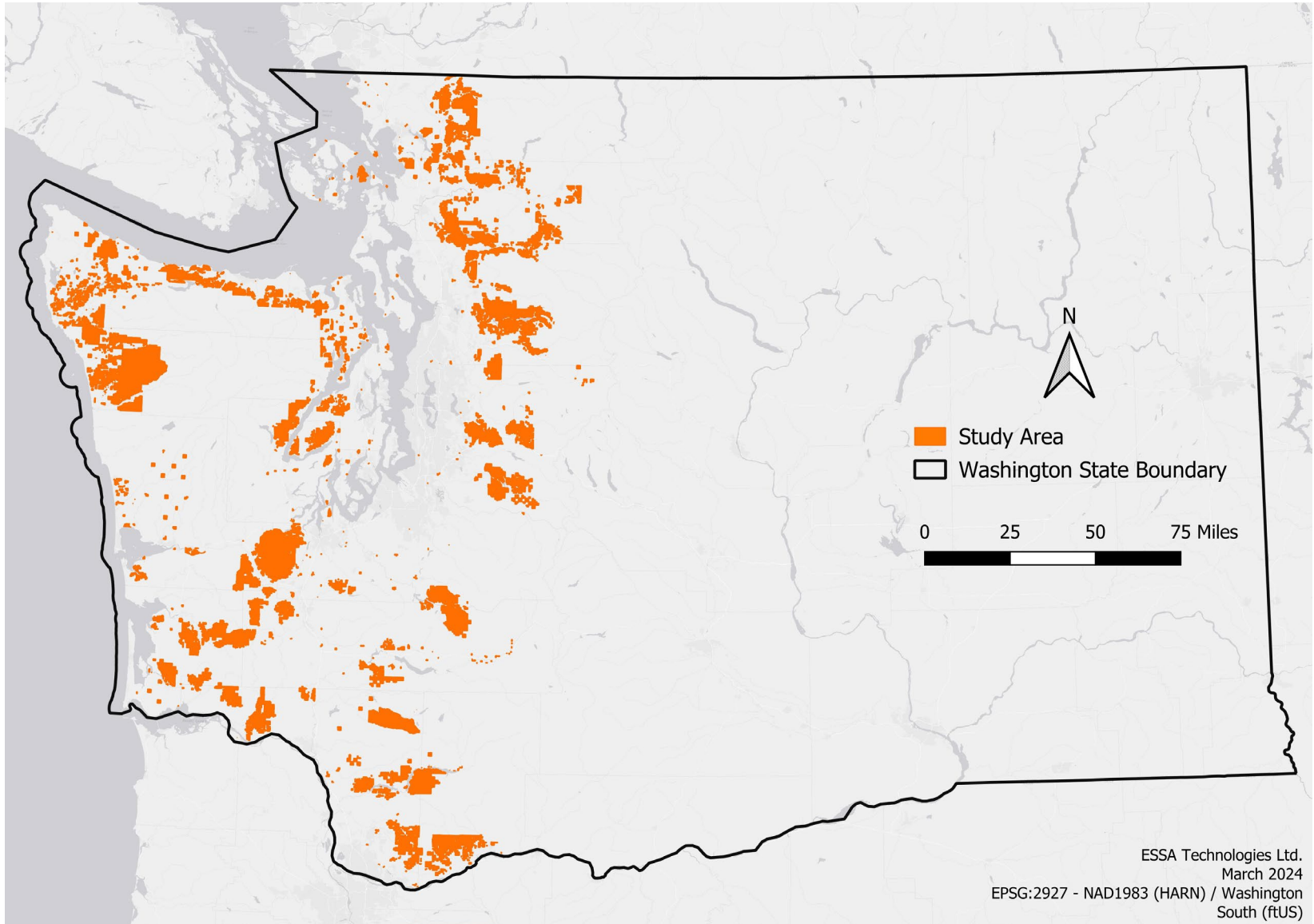
- Study area boundary
- Forest inventory
- Historical disturbance
- Land use boundaries
- Habitat mgmt. boundaries
- Deferrals
- Harvest limits

## Internal Configuration

- Tree growth
- Harvest
- Silviculture
- Natural disturbance
- Climate change



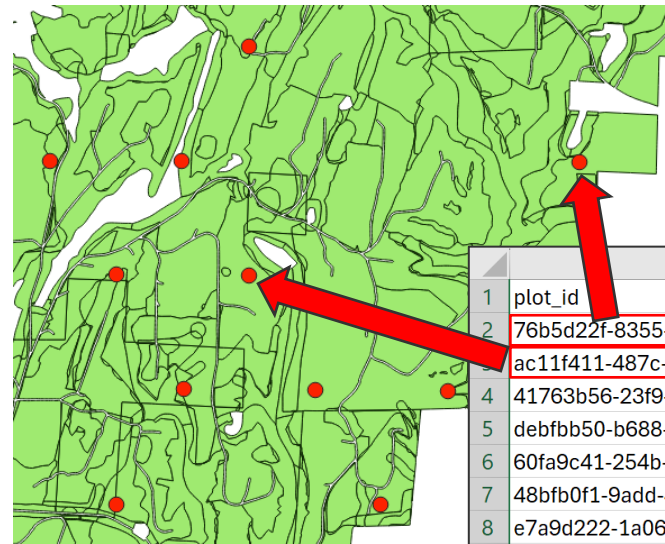
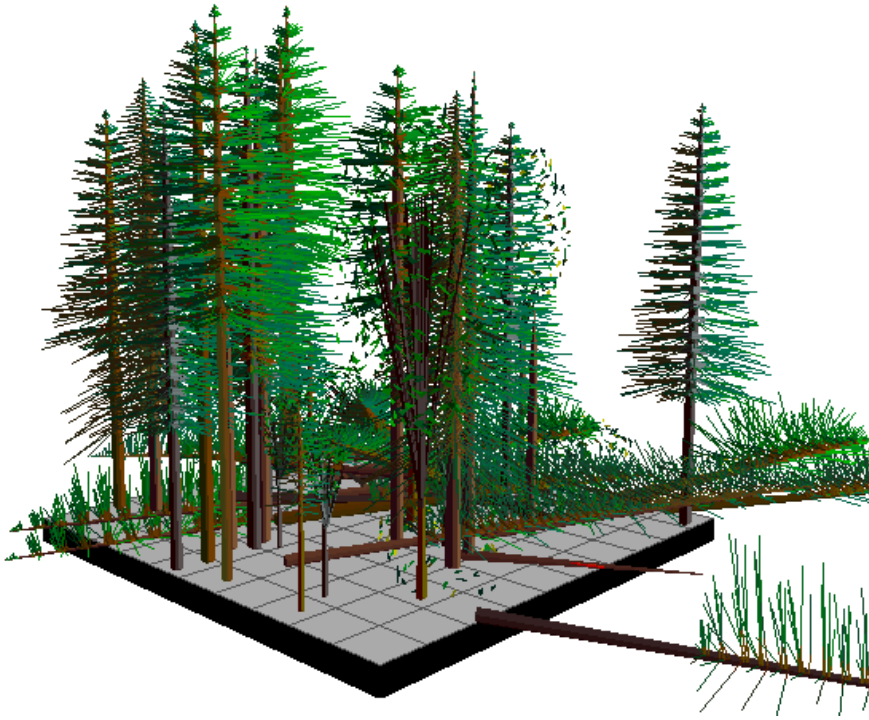
# Study Area Boundary





# Forest Inventory

- General stand and tree characteristics
- Spatial processing happens outside FVS



		H	I	J
1	plot_id	ba	ba_4	ba_4_hwd
2	76b5d22f-8355-4!	201.8	194.5	0
3	ac11f411-487c-4f	87.1	87.1	87.1
4	41763b56-23f9-4!	180.5	180.5	3.9
5	debfbb50-b688-4!	373.2	373.2	104
6	60fa9c41-254b-4!	179.1	179.1	24.1
7	48bf0f1-9add-44	173.1	173.1	28.3
8	e7a9d222-1a06-4	172.5	172.5	3.9





# Forest Inventory

Dataset	What it contains
February <b>2024 forest inventory</b> data from WA DNR	<ul style="list-style-type: none"><li>• <b>Tree-level characteristics</b> (diameter, height, species, etc.)</li><li>• <b>Plot-level characteristics</b> (tree density, basal area, leading species, snag density, etc.)</li></ul>
Resource Inventory Units in a <b>Large Data Overlay</b> (spatial polygons, updated to 2023)	<ul style="list-style-type: none"><li>• Stand boundaries</li><li>• Land use management boundaries</li><li>• Habitat management boundaries</li><li>• Additional inventory details</li></ul>
<b>10m Digital Elevation Model</b> (from USGS)	<ul style="list-style-type: none"><li>• Slope</li><li>• Aspect</li><li>• Elevation</li></ul>

# Harvest & Silviculture Rules

- Control harvesting and thinning
- Control replanting
- Stop-restart described later

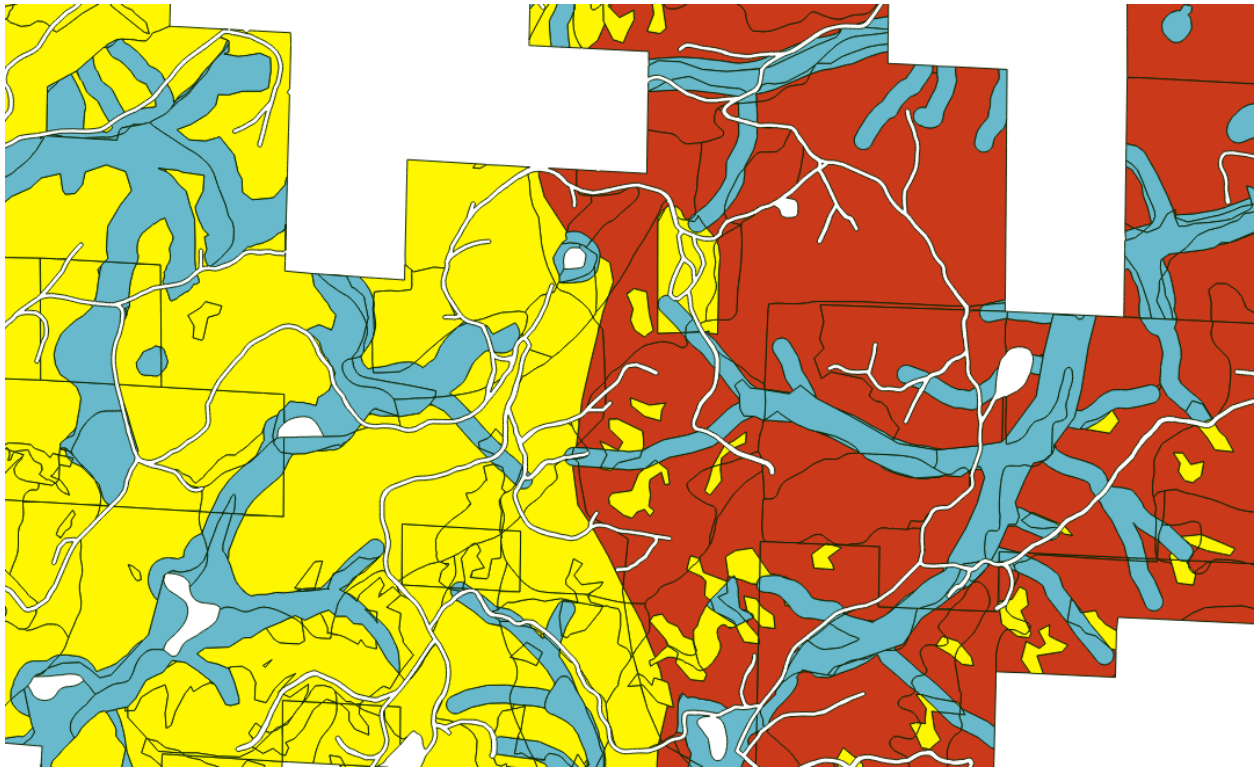
```

IF
MOD (AGE,100) EQ 0)
THEN
YARDLOSS      0      0.0      0.0      0.0
THINBBA       0      0.0
RESETAGE      0
ESTAB
PLANT          0      DF      100      100      1.00
PLANT          0      DF      200      100      2.00
PLANT          0      DF      100      100      3.00
END
FMIN
SALVAGE        0      0      20      0      0      1.0      1.0
SALVAGE        0      20     999      0      2      1.0      1.0
SALVAGE        0      20     999      0      1      1.0      0.5
END
ENDIF
  
```

EXAMPLE

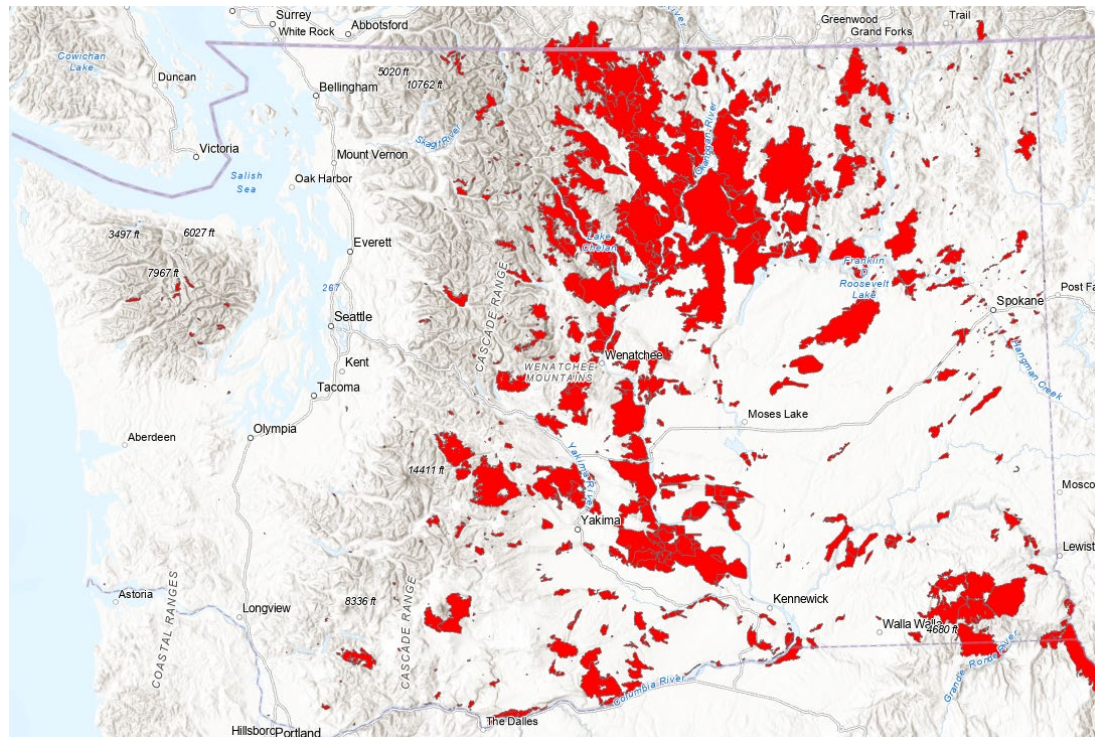
# Land Use and Habitat Management Boundaries

- Provided by DNR
- Part of the Large Data Overlay (LDO)



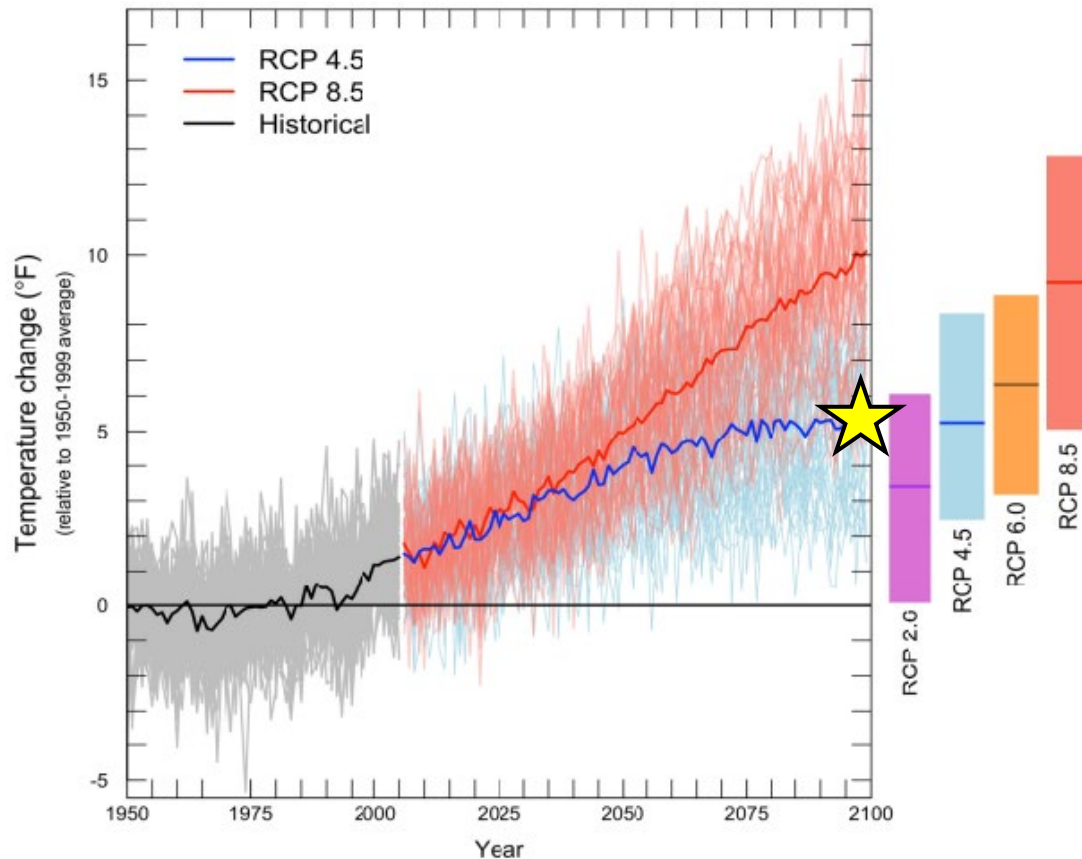
# Natural Disturbance

- Wildfire (fire return interval)\*, insect mortality (% basal area), blowdown
- Calculated from historical data and expected to change under RCP4.5
- Disaggregated by management class (GEM, upland, riparian)



# Climate Change

- Climate-FVS default data for RCP4.5
- Ensemble of 17 General Circulation Models (GCM)
- Adjusted disturbance rates TBD





# Stand Initialization



# Stand Initialization

- Generating initial forest conditions as a starting point
- Done using forest inventory data:
  - Tree diameter
  - Species
  - Density
  - Down wood





# Model Simulation

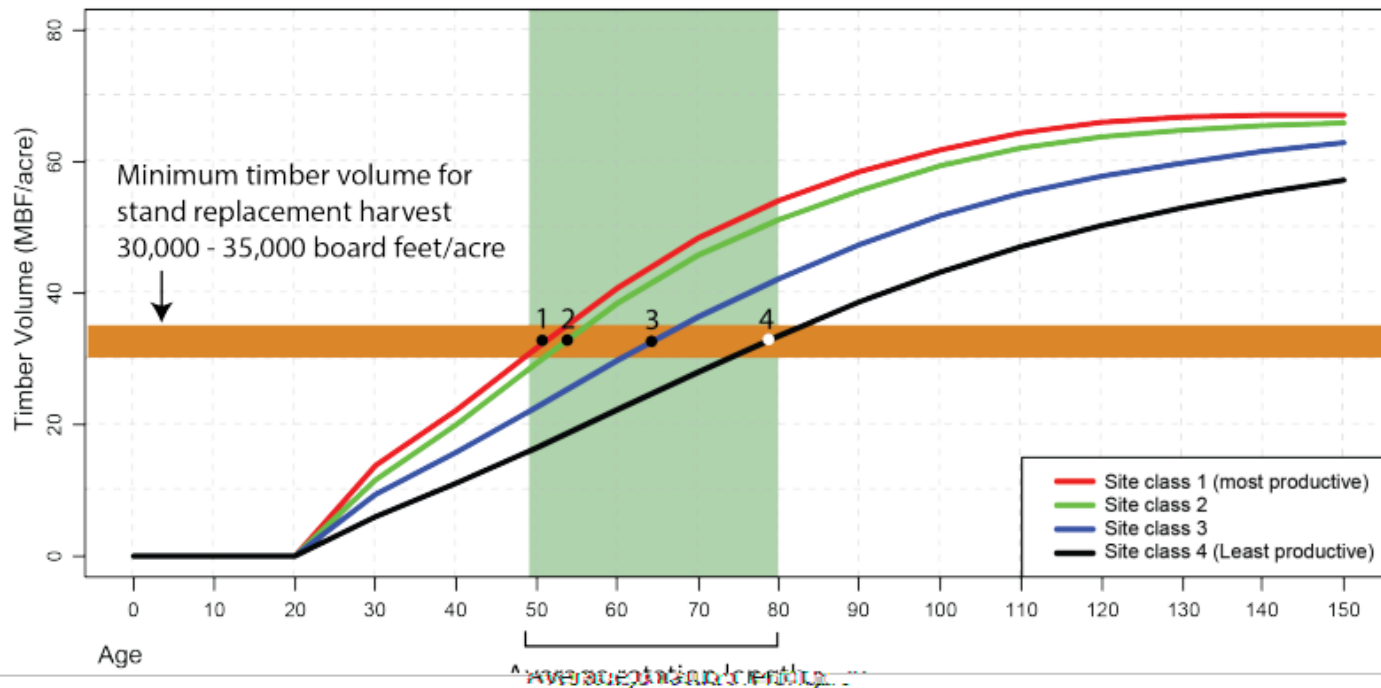




# Rotation Length

- Can be done based on volume, age or year thresholds
- We will use volume (board feet) thresholds

Sample Yield Curve for Douglas Fir in Western Washington



# Thinning

- Precommercial and commercial thinning to be implemented
- Eligibility for precommercial thinning could be by stand age, or using a volume or basal area threshold
- Eligibility for commercial thinning uses a BF threshold
- Commercial thinning is 30% removal





# Deferral

- Methods in progress
- DNR defines “structurally-complex” as:

*A forest in the ‘botanically diverse’ ‘niche diversification’ or ‘fully functional’ stage of stand development. Forests in these phases have varying sizes of trees, understory vegetation and lichen, downed wood and snags, etc.*

- Needs to be translated to FVS language



# Regeneration

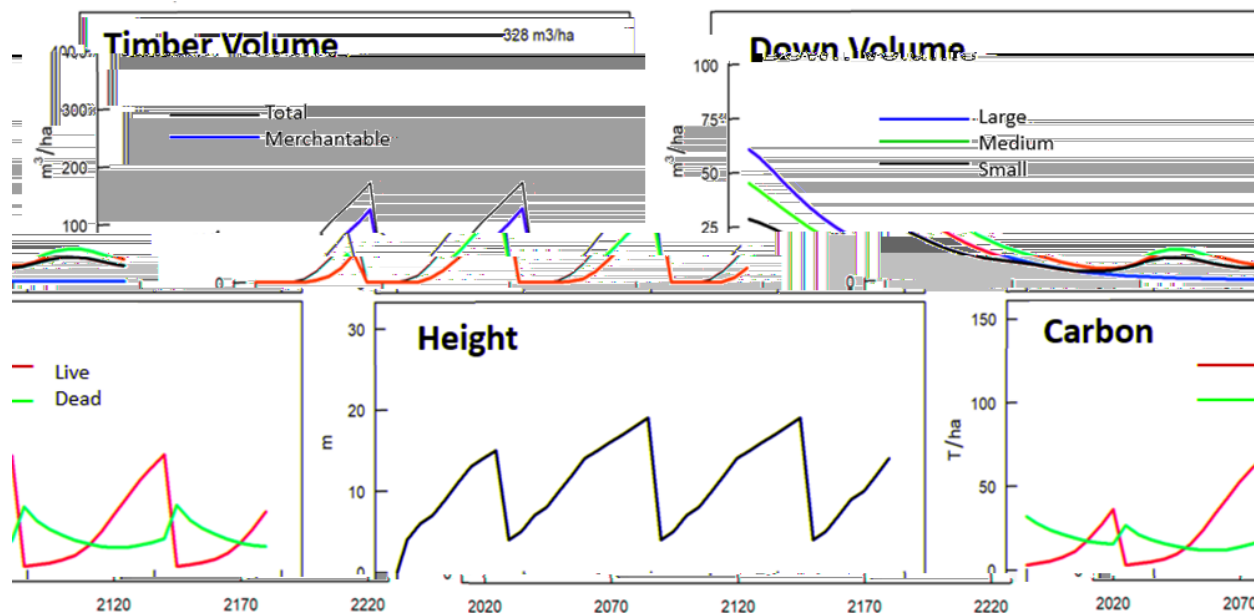
- Planting (set density)
- Natural infill (following partial harvest)

```
IF  
MOD (AGE, 40) EQ 0  
THEN  
ESTAB  
PLANT          0          PARS (3, 400, 100, 2, 0.5)  
END  
ENDIF
```



# Tree Growth

- Controlled by internal equations in FVS
  - Simulates diameter and height growth and changes in crown ratios
- Default growth parameters in FVS-PN variant
- Growth adjusted based on site conditions, disturbances and climate change





# Natural Disturbance

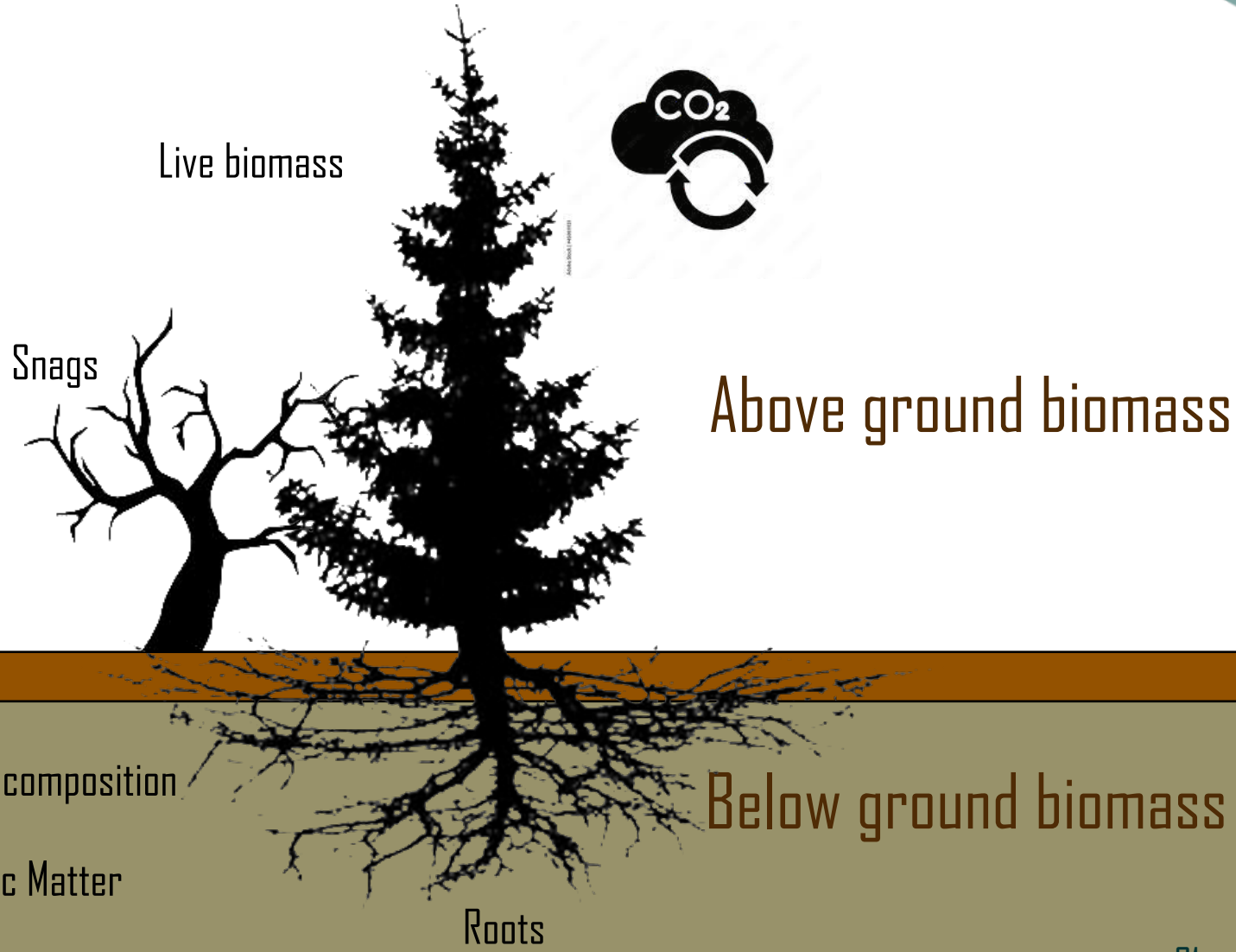
- Simulated using keywords in FVS and Fire and Fuels Extension

```
COMPUTE          0
FDBEETLE=SPMCDBH(1,3,0,12,999,0)*0.950
SNOWSNAP=SPMCDBH(1,3,0,8,999,0)*0.975
END
* Fir Beetle; all remain snags
IF
AGE GT 10 AND MOD(AGE,20) EQ 0
THEN
YARDLOSS          0          1          0
THINDBH           0          PARS(12,999,0,3,FDBEETLE,0)
ENDIF
* Windthrow/Snowsnap; 1/3 snags, 2/3 down
IF
AGE GT 15 AND MOD(AGE,20) EQ 0
THEN
YARDLOSS          0          1          .67
THINDBH           0          PARS(8,999,0,3,SNOWSNAP,0)
ENDIF
```

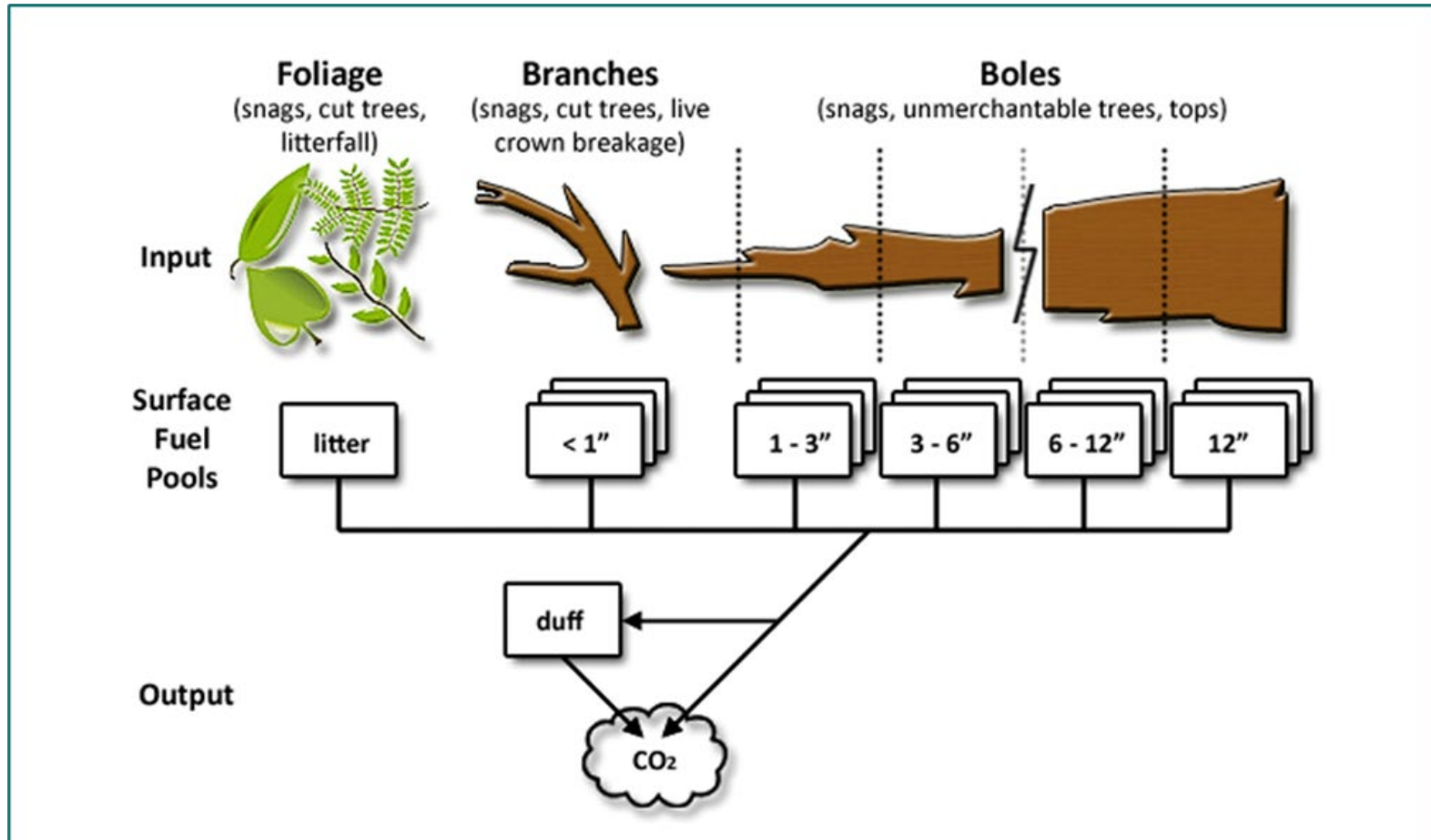
EXAMPLE



# Carbon Dynamics



# Carbon Dynamics







# Carbon Dynamics

- Simulated using the Fire and Fuels Extension of FVS
- Can produce carbon outputs for various pools

```
***** CARBON REPORT VERSION 1.0 *****
          STAND CARBON REPORT
ALL VARIABLES ARE REPORTED IN TONS/ACRE

STAND ID: 11P                      MGMT ID: NONE
```

YEAR	Aboveground Live		Belowground		Stand Dead	Forest			Total Stand Carbon	Total Removed Carbon	Carbon Released from Fire
	Total	Merch	Live	Dead		DDW	Floor	Shb/Hrb			
2005	46.8	30.0	10.4	0.7	3.3	4.6	7.1	0.3	73.3	0.0	0.0
2015	28.4	20.5	6.6	5.3	2.0	12.9	7.3	0.3	62.7	11.9	0.0
2025	30.5	21.9	7.2	3.4	0.4	6.6	6.7	0.3	55.1	0.0	0.0
2035	32.6	23.5	7.7	2.3	0.2	4.3	6.8	0.3	54.2	0.0	0.0
2045	34.9	25.3	8.3	1.5	0.2	3.2	7.0	0.3	55.4	0.0	0.0



# Incorporating Climate Change

- Each management scenario run under RCP4.5
- Climate change will be incorporated using Climate-FVS
  - Requires climate and species viability data
  - Species viability score is manipulated (incorporates impacts on carrying capacity, mortality, growth and regeneration)
- Changes in disturbance rates calculated independently of Climate-FVS

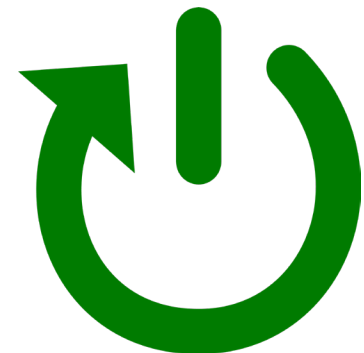
# Stop-Restart Functionality

## Problem:

- FVS will harvest all eligible stands leading to overharvesting

## Solution:

- Advanced method to stop FVS and harvest up to a set harvest target
- FVS starts up again after harvesting to continue growing the stands

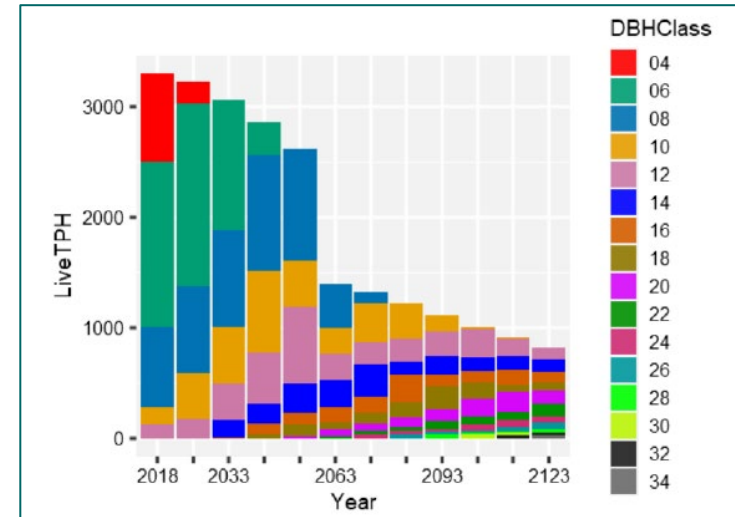
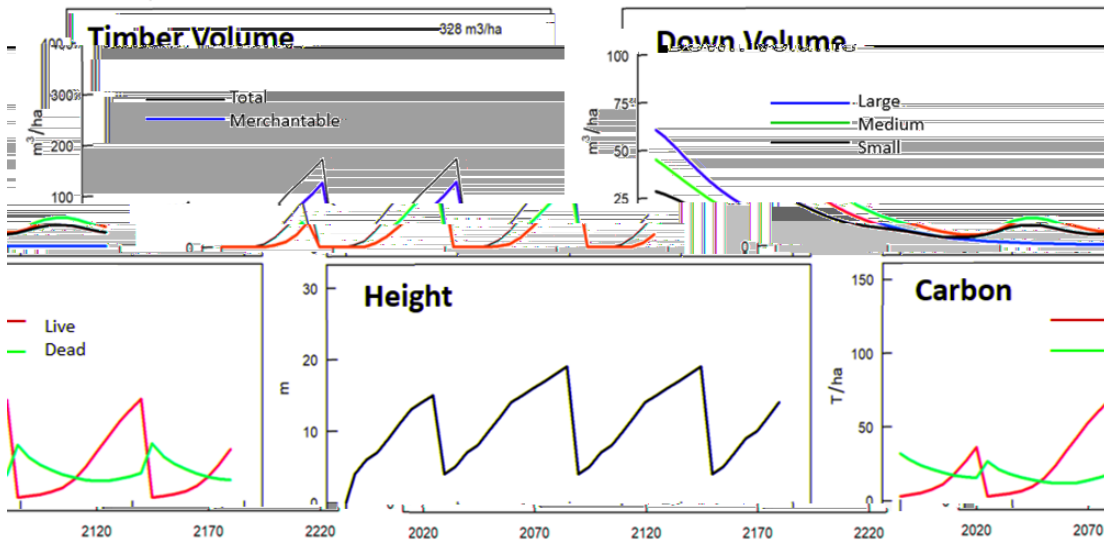




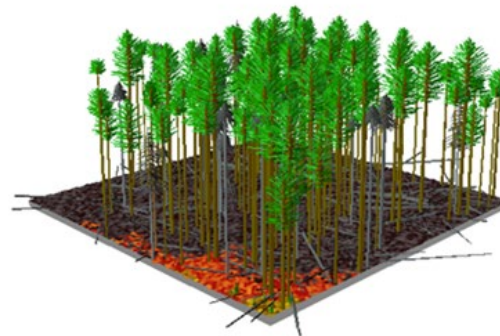
# Post-Processing and Outputs

# Where does this all lead?

- Examples of diagnostic plots:



Wildfire only

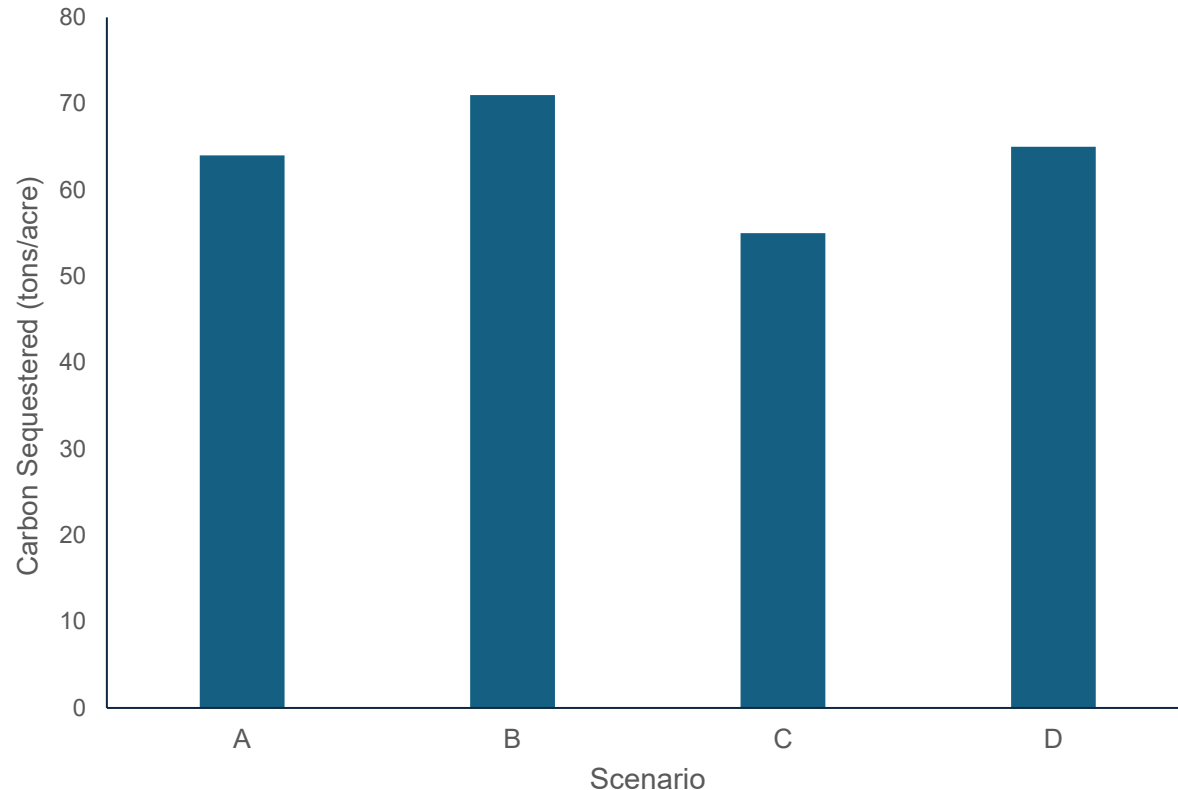


With prescribed fire



# Where does this all lead?

- Outputs for carbon will be produced and compared across all scenarios
- Example of a plot comparing scenarios:



**NOT  
ACTUAL  
RESULTS**



# Management Scenarios



# Scenarios So Far

Configuration Settings	Scenario #1: Current DNR Management Practice	Scenario #2: Lengthen Harvest Rotation	Scenario #3: Shorten Harvest Rotation	Scenario #4: Significantly Increase Thinning
Stand-replacement harvest BF/ac	30,000-35,000	50,000-55,000	20,000-25,000	30,000-35,000
Commercial thinning BF/ac	18,000-20,000			
Precommercial thinning eligibility requirement	TBD			
Stand-replacement harvest proportion (BA)	90% (minimum 8 leave trees/acre)			
Commercial thinning proportion (BA)	30%			
Harvest targets	10-year average for each harvest type	TBD	TBD	TBD
Stand-replacement harvest leave trees/acre	8			
Planting density (seedlings/acre)	360			
Fire return interval (years)	Average fire rates between 1984-2023 (*adjusted for RCP4.5)			
Insect mortality rate (% basal area loss)	Projections between 2013-2027 (*adjusted for RCP4.5)			
Blowdown rate	TBD			
Climate change	1 run no climate change, 1 run with RCP4.5 using Climate-FVS			





Questions?