



Forest Service
U.S. DEPARTMENT OF AGRICULTURE

Mapping Carbon: Forest Inventory and Analysis, TreeMap, and the Forest Vegetation Simulator

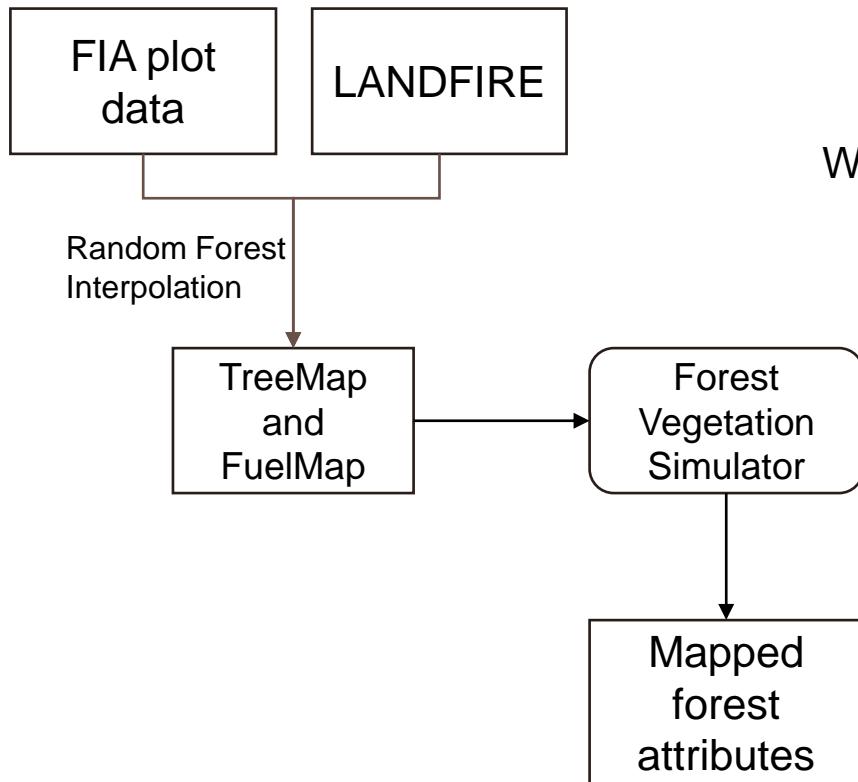
Rachel M. Houtman, Karin Riley, John Shaw (USDA Forest Service)

Rachel M. Houtman

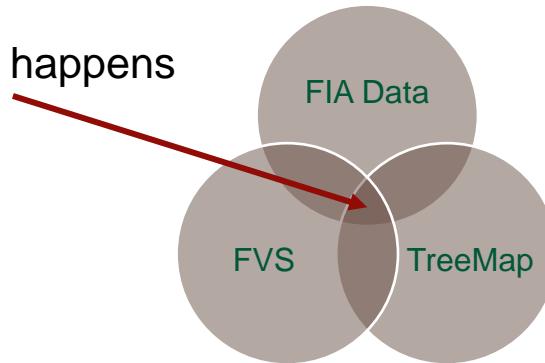
Biological Scientist, USDA Forest Service, Missoula Fire Sciences Lab

4/10/2024 Growth Model Users Group Conference

Stand data + Spatial data layer + Stand growth model



Where the magic happens



Forest Inventory and Analysis

FIA is a nation-wide assessment of forest lands that consists of multiple parts.

1 plot per 6,000 acres (approx.).

Remeasured every 5-10 years.

These are direct-measured forest plots across land ownerships (plot locations are not available to the public).

The FIA program maintains a database of all plots that are available to the public.

Fuels are measured on a subset of plots.



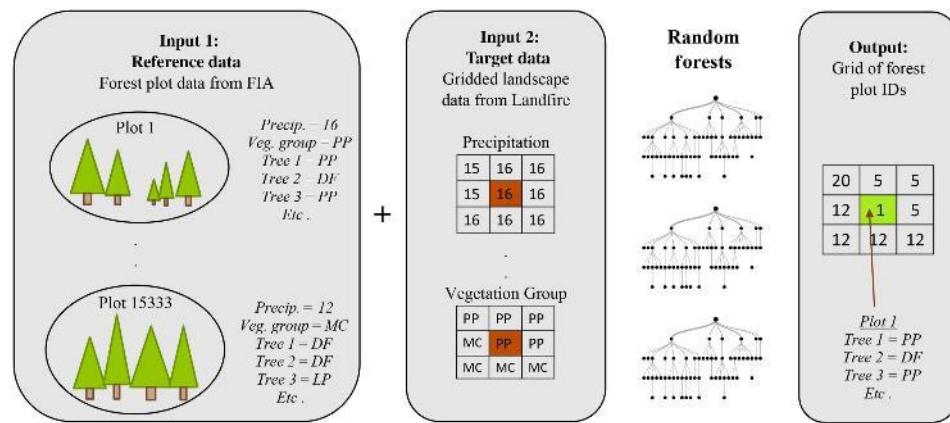
The screenshot shows the official website for the Forest Inventory and Analysis (FIA) program of the U.S. Forest Service. The header features the USDA Forest Service logo and the text "Forest Inventory and Analysis National Program". Below the header, a large banner on the right side has the text "Forest Inventory and Analysis" in large, bold, green letters, followed by "We are the Nation's Forest Census" and a "Welcome!" message. On the left, there is a sidebar with a search bar and a navigation menu. The menu includes links for "U.S. Forest Service", "Forest Inventory & Analysis", "About Us", "Program Features", "FIA Data and Tools", "FIA Library", "FIA Stakeholder Mtg", "Links", "Contact Us", and "Work With Us". The main content area contains a paragraph about the FIA program's history and purpose, followed by a section about FIA reports and a "Watch on YouTube" button.

TreeMap

CONUS-wide dataset of FIA plot data interpolated to gridded LANDFIRE data.

Current versions available were created using 2014 and 2016 LANDFIRE, 2020 and 2022 versions are in process.

Datasets are available from the Research Data Archive and 2016 TreeMap is now available on Google Earth Engine.



FuelMap

Fuels include litter, duff, fine woody debris, and coarse woody debris.

Fuels influence

Carbon

Fire behavior

Habitat

Fuel transects in FIA are collected only for a subset of plots.

FuelMap allows for direct loading of these fuel values into the FVS database, rather than the default values.



Publication Details

Title: FuelMap 2014: Imputed map of carbon stored in litter, duff, fine woody debris, and coarse woody debris for CONUS forests circa 2014 [\[DOI\]](#)

Author(s): [Riley, Karin L.](#); [Grenfell, Isaac C.](#); [Shaw, John D.](#)

Publication Year: 2023

How to Cite: These data were collected using funding from the U.S. Government and can be used without additional permissions or fees. If you use these data in a publication, presentation, or other research product please use the following citation:

Riley, Karin L.; Grenfell, Isaac C.; Shaw, John D. 2023. FuelMap 2014: Imputed map of carbon stored in litter, duff, fine woody debris, and coarse woody debris for CONUS forests circa 2014. Updated 07 February 2024. Fort Collins, CO: Forest Service Research Data Archive. <https://doi.org/10.2737/RDS-2023-0042>

Abstract: FuelMap 2014 is an imputed map of litter, duff, fine woody debris, and coarse woody debris loadings for

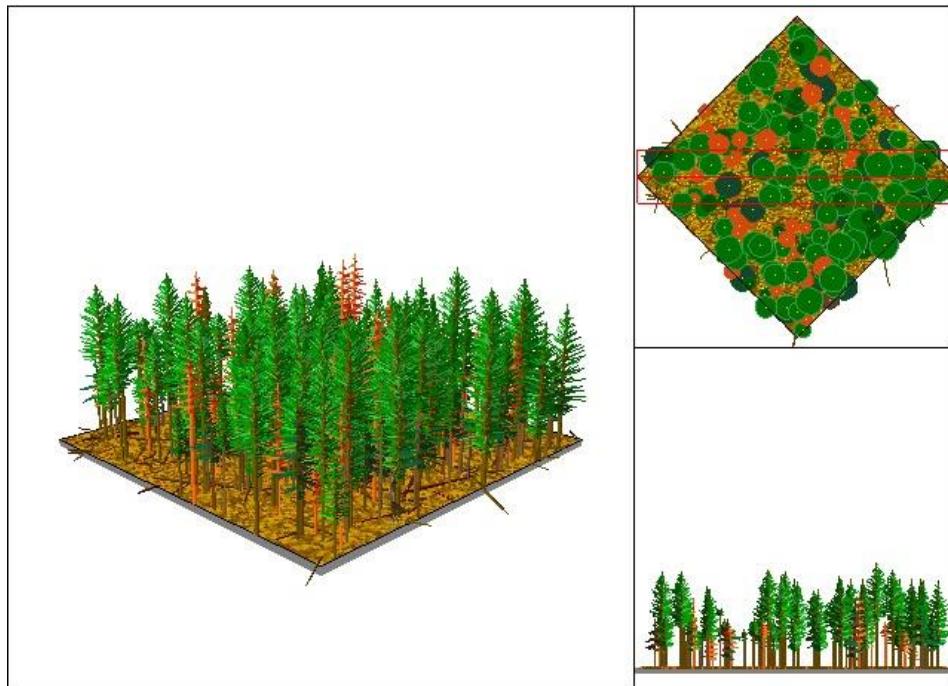
The Forest Vegetation Simulator

A Forest Service-maintained stand-based forest growth model

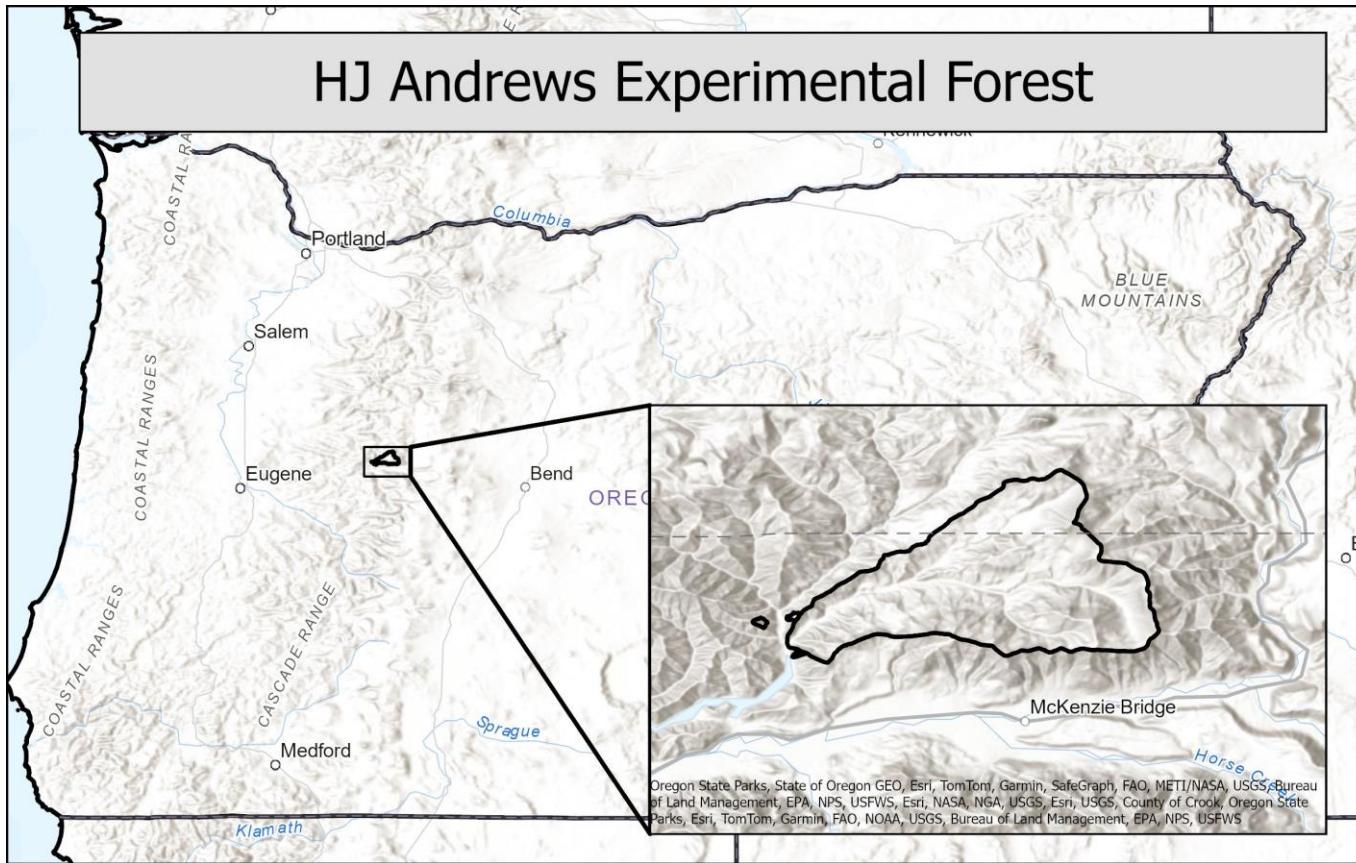
Multiple geographic variants for CONUS and Alaska.

The model can compute and report a wealth of stand-level characteristics, including volume, fire behavior, carbon, and more, as well as individual tree attributes like post-fire mortality.

Requirements include a stand table with a tree list for every stand, length of simulation (in years), and desired outputs.



Example Application on the HJ Andrews Research Forest



Identify TreeMap plots within the study area boundary

Esri, NASA, NGA, USGS, FEMA, Oregon State Parks, State of Oregon, GEO, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA, USFWS, Foley Springs

HJ Andrews TreeMap 2014

Plot ID	Value	Count	tl_id
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2293194010497	22932138010497	109	8320
34593540489998	40219331010497	109	8320
27364152020004	273641515489998	109	8320
188771531020004	216959364020004	109	8320
40390697010690	216959364020004	109	8320
37276219010690	23953181489998	109	8320
188771532020004	17476387010497	109	8320
37274634010690	22953278010497	109	8320
12366863010690	2395314010497	109	8320

Stands_HJAndrews - Note...

File Edit Format View Help

Plot ID	Value	Count	tl_id
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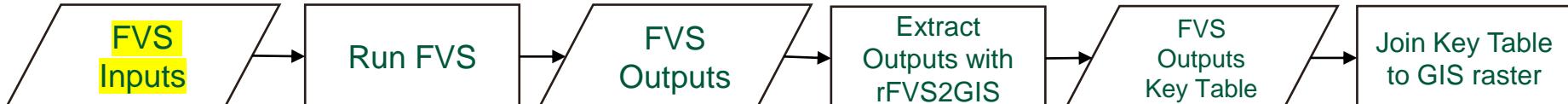
FVS Stand and Tree List Tables

Stand List Table (FVS_StandInit)

STAND_CN	STAND_ID	VARIANT	INV_DAY	INV_YEAR	INV_MONTH
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3	174763107020004	0041201302030104398559	WC	28	2014
4	174763132020004	0041201302030104375420	WC	26	2014
5	174763148020004	0041201302030103957098	WC	18	2014
6	174763159020004	0041201302030103975941	WC	14	2014
7	174763251020004	0041201302030104391155	WC	25	2014
8	174763314020004	0053201302030704173787	WC	31	2014
9	174763322020004	0041201302030201970930	WC	14	2014
10	174763382020004	0041201302030104373400	WC	28	2014
11	174763417020004	0041201302030103965792	WC	15	2014
12	174763556020004	0041201302030004784086	WC	3	2014
13	174763559020004	0041201302030104371626	WC	15	2014
14	174763586020004	0041201302030004775859	WC	18	2014
15	174763619020004	0041201302030103974756	WC	15	2014
16	174763626020004	0041201302030004783751	WC	22	2014
17	174763634020004	0041201302030103973324	WC	9	2014
18	174763636020004	0041201302030103970047	WC	2	2014

Tree List Table (FVS_TreeInit)

STAND_CN	STAND_ID	PLOT_CN	STANDPLOT_CN	STANDPLOT_ID	PLOT_ID	TREE_CN	TREE_ID	TAG_ID	A2
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2	12366863010690	0030200702050108992905	12366863010690_2	0030200702050108992905_2	2	12366876010690	2	NA	
3	12366863010690	0030200702050108992905	12366863010690_2	0030200702050108992905_2	2	12366877010690	3	NA	
4	12366863010690	0030200702050108992905	12366863010690_2	0030200702050108992905_2	2	12366878010690	4	NA	
5	12366863010690	0030200702050108992905	12366863010690_2	0030200702050108992905_2	2	12366879010690	5	NA	
6	12366863010690	0030200702050108992905	12366863010690_2	0030200702050108992905_2	2	12366880010690	6	NA	
7	12366863010690	0030200702050108992905	12366863010690_2	0030200702050108992905_2	2	12366881010690	7	NA	
8	12366863010690	0030200702050108992905	12366863010690_3	0030200702050108992905_3	3	12366882010690	1	NA	
9	12366863010690	0030200702050108992905	12366863010690_3	0030200702050108992905_3	3	12366883010690	2	NA	
10	12366863010690	0030200702050108992905	12366863010690_3	0030200702050108992905_3	3	12366884010690	3	NA	
11	12366863010690	0030200702050108992905	12366863010690_3	0030200702050108992905_3	3	12366885010690	4	NA	
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13	12366863010690	0030200702050108992905	12366863010690_4	0030200702050108992905_4	4	12366887010690	1	NA	
14	12366863010690	0030200702050108992905	12366863010690_1	0030200702050108992905_1	1	S12366890010690	1002021	NA	
15	12366863010690	0030200702050108992905	12366863010690_2	0030200702050108992905_2	2	S12366891010690	100172	NA	
16	12366863010690	0030200702050108992905	12366863010690_2	0030200702050108992905_2	2	S12366892010690	100222	NA	
17	12366863010690	0030200702050108992905	12366863010690_2	0030200702050108992905_2	2	S12366893010690	1002422	NA	



Running FVS

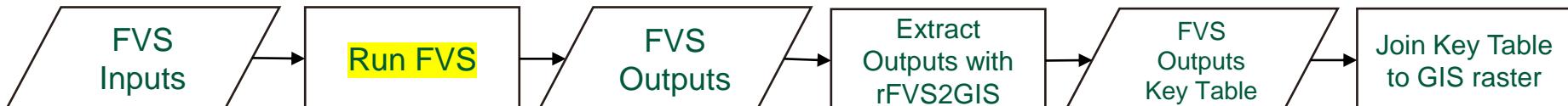
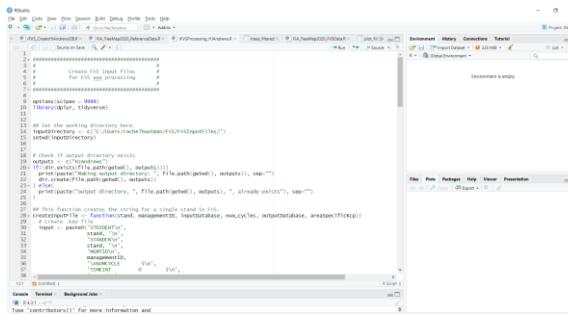
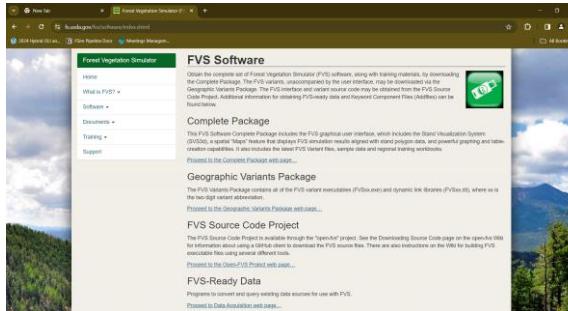
- Two options for running FVS:

- FVS Online

- Forest Service User Interface that runs FVS online.
 - Great for users who have minimal experience with FVS.

- rFVS (there are now multiple “rFVS” programs out there – this is mine)

- Simple R script that creates FVS input files to run FVS directly from executable files on a local machine.
 - Requires working knowledge of both R and FVS.



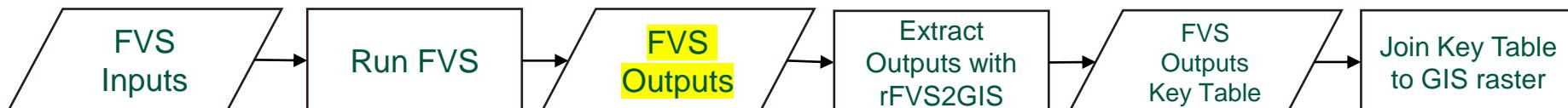
FVS Simulation Outputs

Some FVS outputs include:

- General stand characteristics: Forest type, basal area, tree volumes.
- Carbon: total carbon and by pool, total carbon emitted and by pool.
- Fire behavior: potential, fuel consumption by pool.

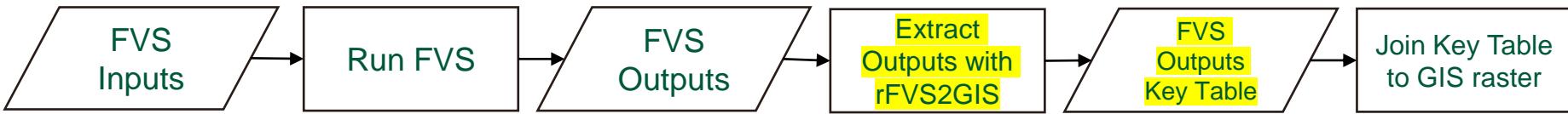
***** CARBON REPORT VERSION 1.0 ***** STAND CARBON REPORT (BASED ON STOCKABLE AREA) ALL VARIABLES ARE REPORTED IN TONS/ACRE											
STAND ID: 216958983020004				MGMT ID: 2169							
YEAR	Aboveground	Live	Belowground	Forest				Total	Total	Carbon	
	Total	Merch	Live	Stand	Dead	DDW	Floor	Shb/Hrb	Stand Carbon	Removed Carbon	Released from Fire
2020	24.5	13.5	7.4	1.3	5.2	13.6	5.7	0.2	57.8	0.0	0.0
2021	24.8	13.7	7.5	1.3	5.1	13.3	5.2	0.2	57.5	0.0	0.0
2022	25.0	13.8	7.6	1.2	5.1	13.2	5.0	0.2	57.3	0.0	0.0

Example FVS carbon report from .out file. FVS output data are compiled for each stand in a SQLite database table for easy processing.

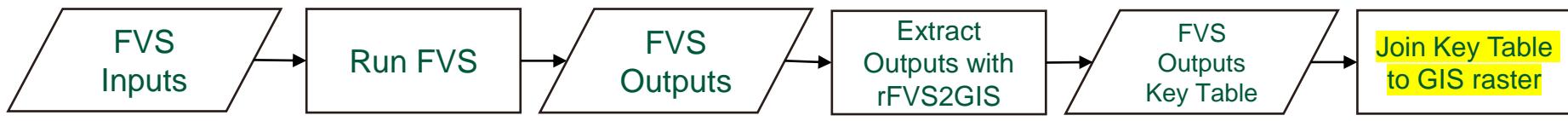
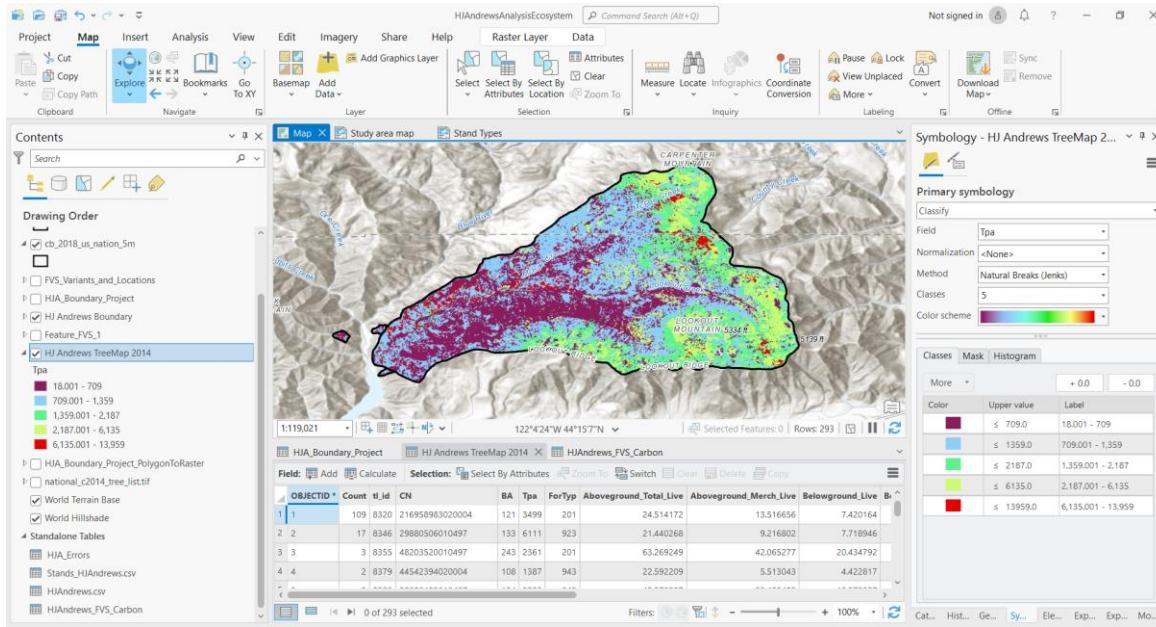


Connecting FVS back to GIS data

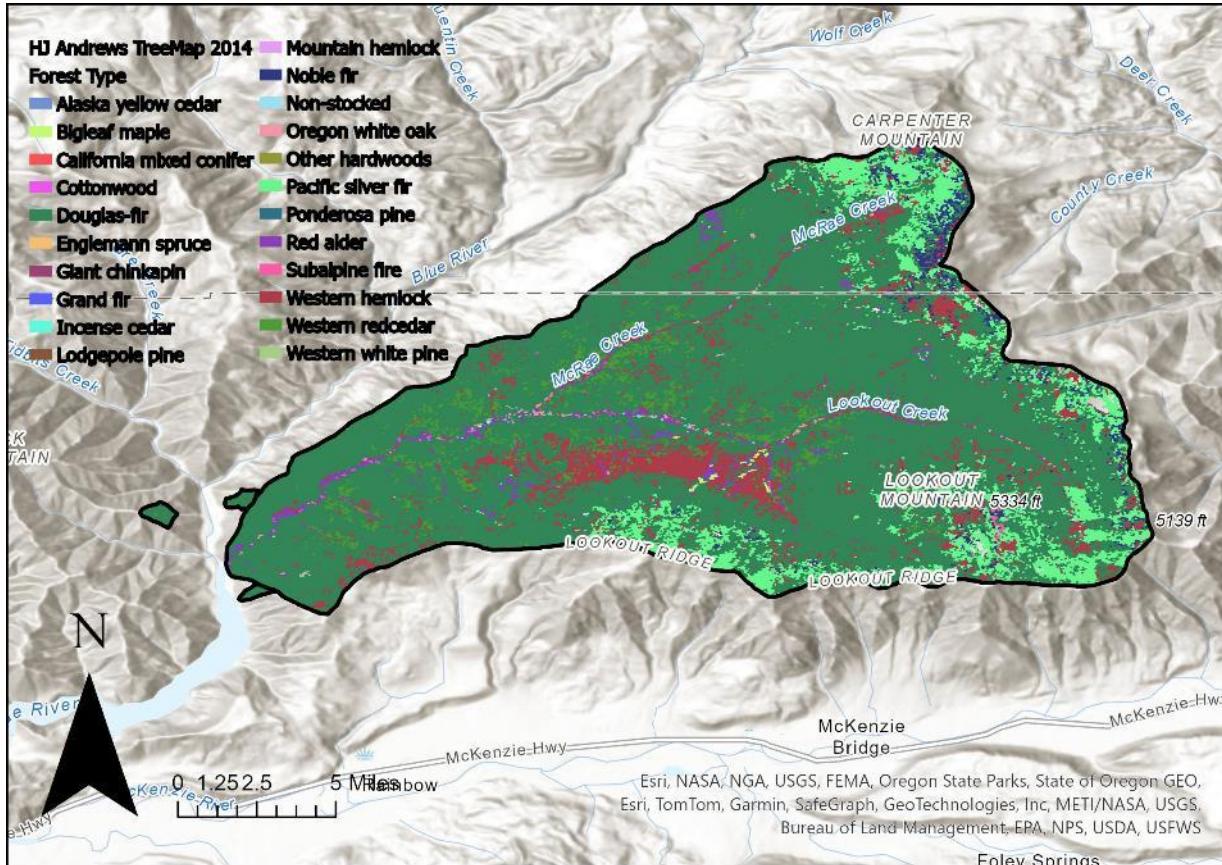
- rFVS2GIS code extracts all the data fields desired from the FVS dataset.
- Key value connects FVS outputs to GIS data. This may be the Stand ID, or some combination of Stand ID, FVS variant, and other landscape characteristics such as treatment locations.



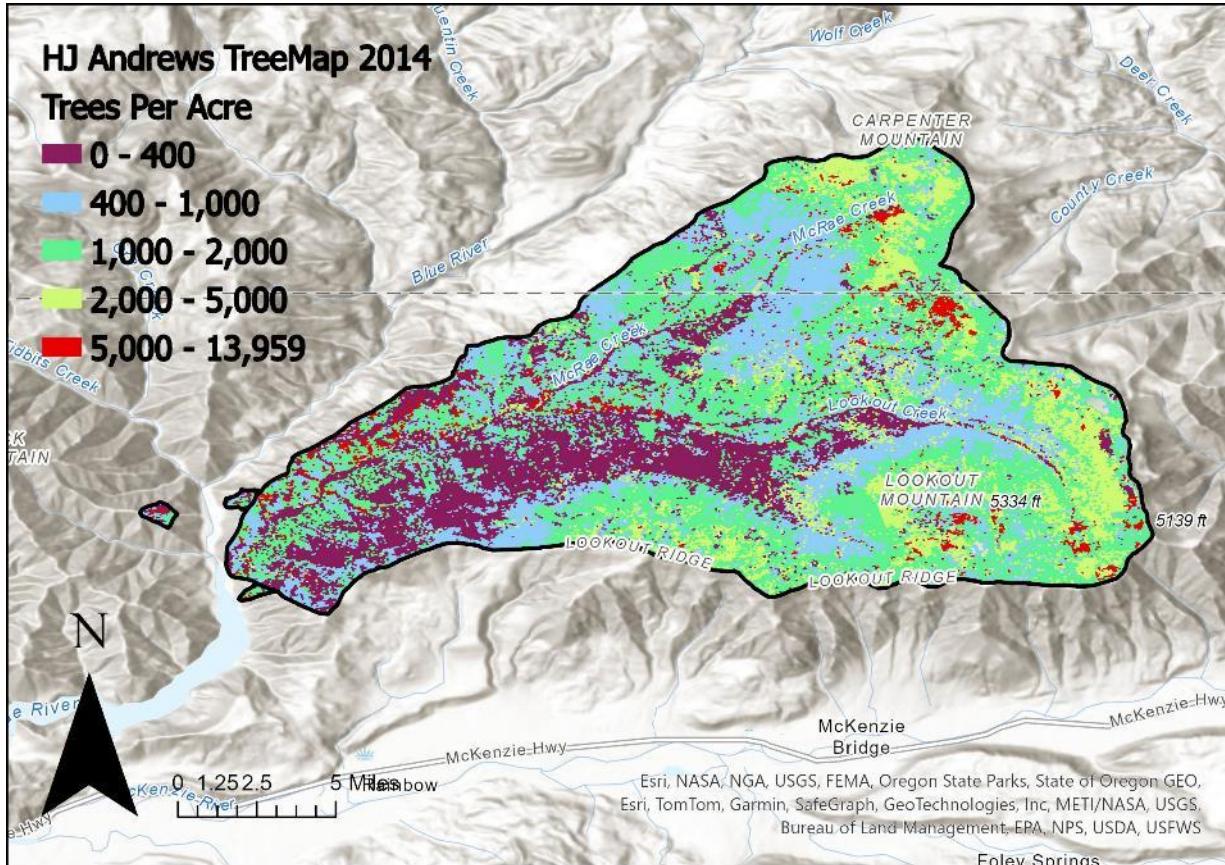
Mapping forest attributes



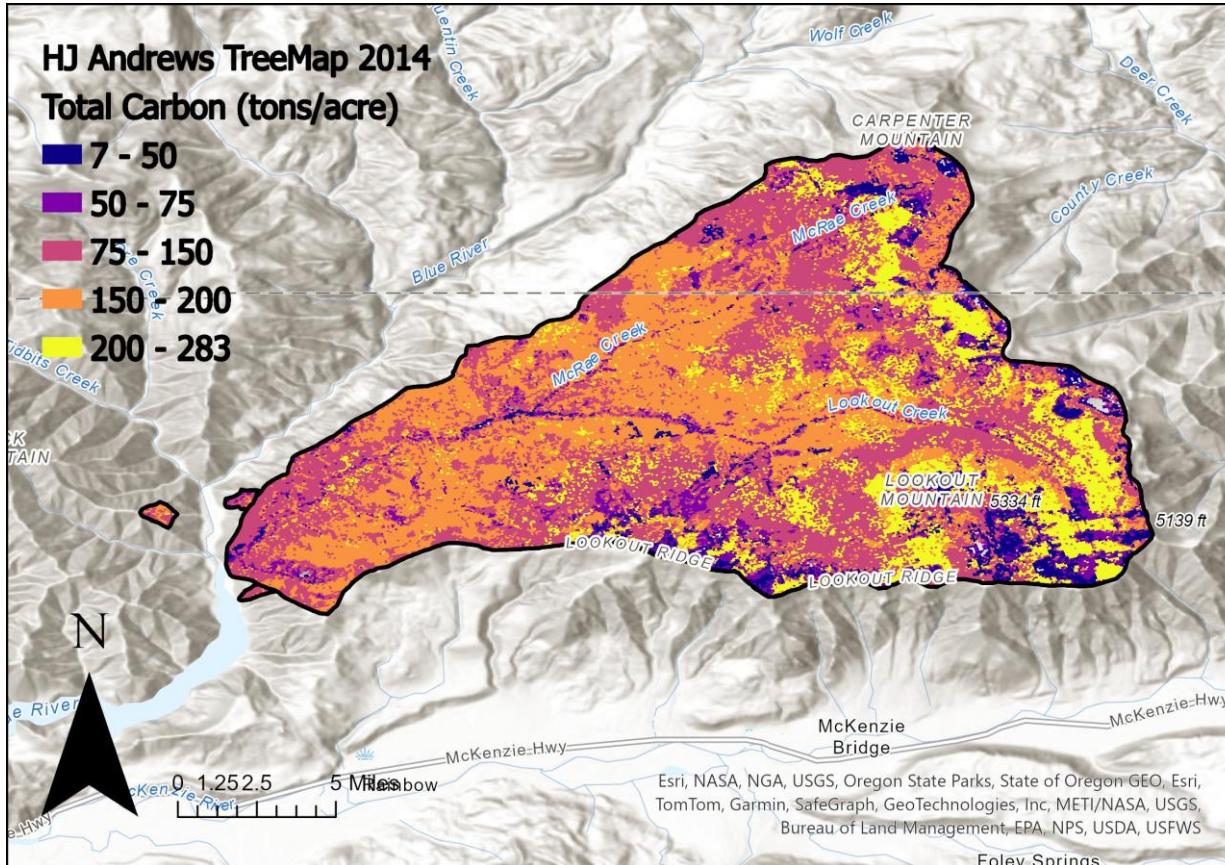
Forest type



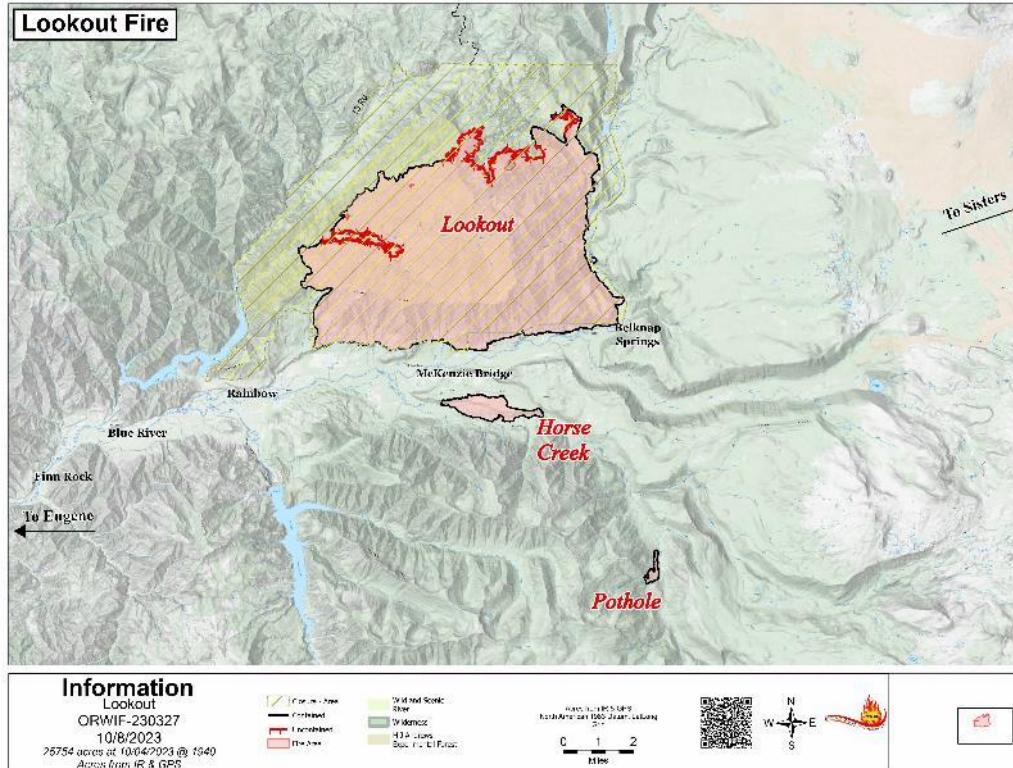
Trees per acre mapped



Total carbon mapped



Context for the area: The 2023 Lookout Fire



Questions?

How I decompress after a day of modeling



Citations

Citations

Dixon, Gary E. comp. 2002 (Revised: August 10, 2023). 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. 226p.

Rebain, Stephanie A. comp. 2010 (Revised: February 1, 2022). The Fire and Fuels Extension to the Forest Vegetation Simulator: Updated Model Documentation. Internal Rep. Fort Collins, CO: U. S. Department of Agriculture, Forest Service, Forest Management Service Center. 409p.

Riley, Karin L., Grenfell, Isaac C., Finney, Mark A., Wiener, Jason M. 2021. TreeMap, a tree-level model of conterminous US forests circa 2014 produced by imputation of FIA plot data. *Scientific Data*. 8: 11.

Riley, Karin L., Grenfell, Isaac C., Shaw, John D. 2023. FuelMap 2014: Imputed map of carbon stored in litter, duff, fine woody debris, and coarse woody debris for CONUS forests circa 2014. Fort Collins, CO: Forest Service Research Data Archive.
<https://doi.org/10.2737/RDS-2023-0042>

Scott JH, Short KC, Finney MA. 2018. FSim: the large-fire simulator guide to best practices. Available online: https://pyrologix.com/wp-content/uploads/2019/11/FSimBestPractices_0.3.1.pdf Accessed: 1/10/2024.

FVS and carbon/emissions

- Run each stand through FVS with fires at each flame length to estimate carbon emissions under each flame length.
- Extract FVS outputs, including (but not limited to):
 - Total initial carbon
 - Total carbon emitted
 - Carbon emitted by pool
 - Total carbon remaining on site
- Join these attributes back to our mapped stands for analysis

***** CARBON REPORT VERSION 1.0 ***** STAND CARBON REPORT (BASED ON STOCKABLE AREA) ALL VARIABLES ARE REPORTED IN TONS/ACRE												
STAND ID: 15148182010497			MGMT ID: 1514									
YEAR	Aboveground		Live		Belowground		Forest			Total Stand Carbon	Total Removed Carbon	Carbon Released from Fire
	Total	Merch	Live	Dead	Stand	Dead	DDW	Floor	Shb/Hrb			
2010	4.3	1.9	1.5	0.0	0.0	0.0	1.1	0.0	0.4	7.2	0.0	0.0
2011	1.8	0.9	0.6	0.9	2.5	0.4	0.4	0.1	0.4	6.6	0.0	1.3
2012	1.9	1.0	0.6	0.9	2.3	0.5	0.5	0.1	0.4	6.8	0.0	0.0

***** FIRE MODEL VERSION 1.0 ***** FUEL CONSUMPTION & PHYSICAL EFFECTS REPORT (BASED ON STOCKABLE AREA)																
STAND ID: 15148182010497			MGMT ID: 1514													
YEAR	EXPOSR	PERCENT MINERAL	FUEL CONSUMED (TONS/ACRE)									% TREES WITH (TONS/ACRE)				
			SOIL	LITR	DUFF	0-3"	3"+	3-6"	6-12"	12"+	SHRUB CRWNS CONS.					
2011	39	0.6	0.0	0.6	0.7	0.4	0.2	0.0	0.5	0.5	2.8	51	57	0	0.02	0.02

FVS carbon pool and fuel consumption outputs for a single stand