USFWS: Brent Lawrence. "Diablo Lake in the Northern Cascades" Flickr, 3 November 2023, https://www.flickr.com/photos/52133016@N08/53345062751/.

Forest Carbon Modeling Component

Cedar Morton, Don Robinson, Eric Neilson, Frank Poulsen, Alex Tekatch, Clint Alexander

Friday, February 14, 2024

ESSA

Outline

- Our team (10min)
- The two carbon modeling options (15min)
- Q&A (35min)

ESSA Technologies (ESSA)

"ESSA brings together **people**, **science** and analytical **tools** to sustain **healthy ecosystems** and **human communities**. We envision a world where creativity, a focus on learning, and systems-thinking are the foundation of solutions to environmental challenges."

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ESSA Technologies (ESSA)

Columbia

Klamath

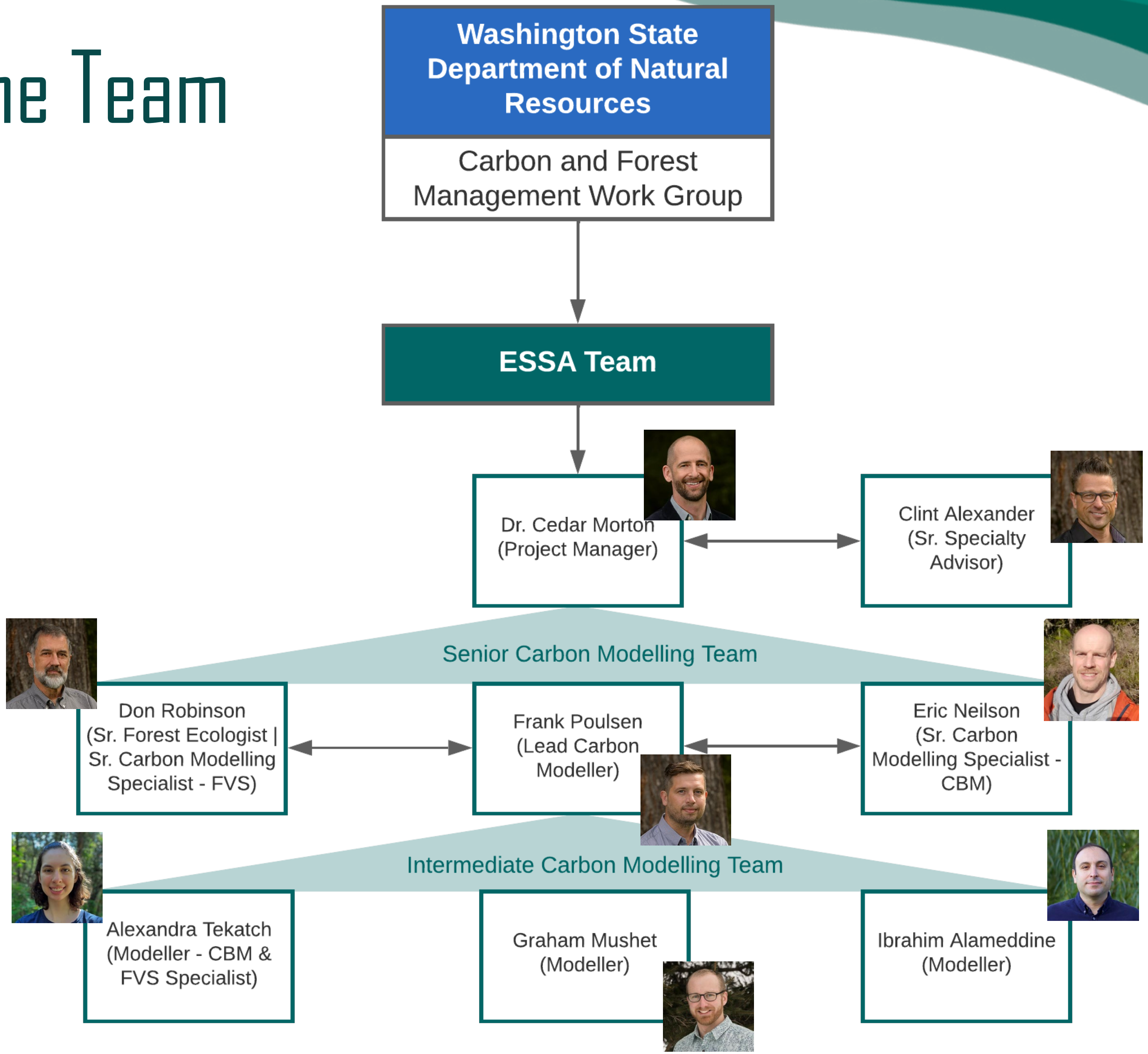
Sacramento Bay Delta

Great Lakes

Missouri

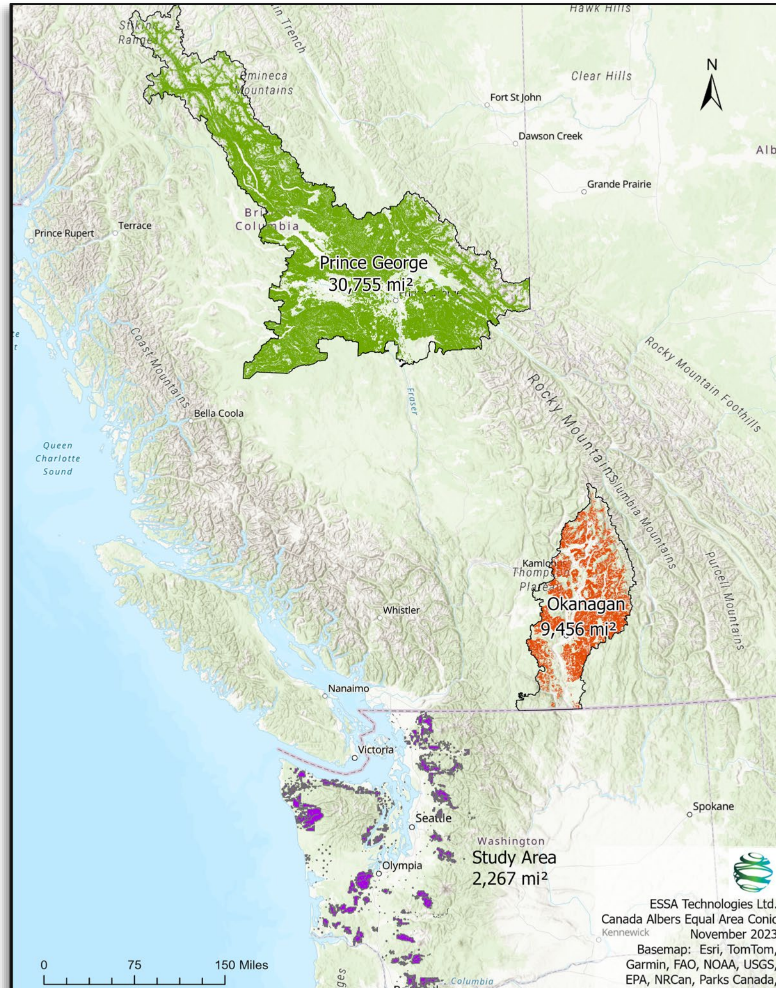
Mississippi & Gulf Coast

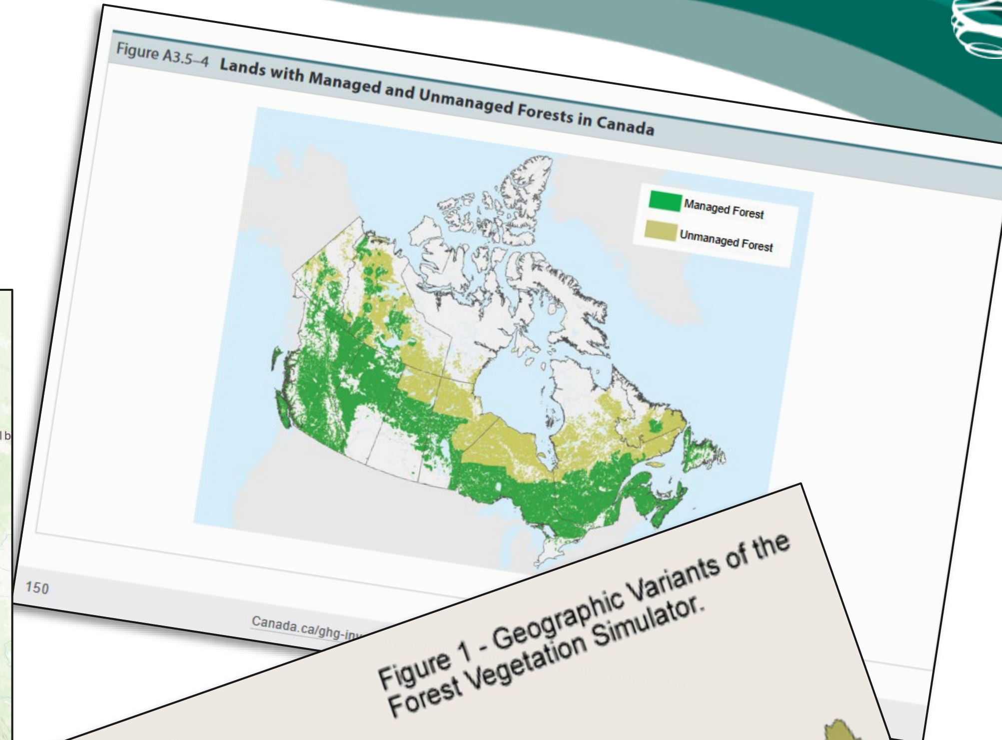
The Team

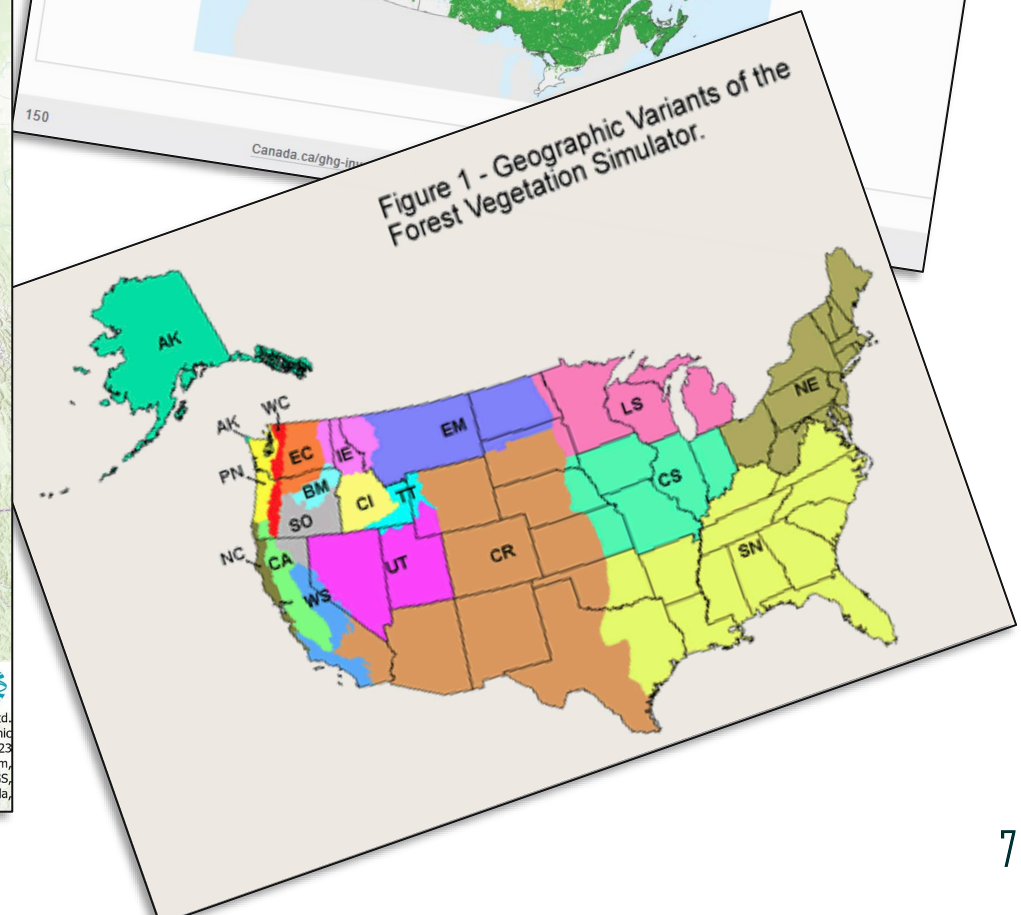

Washington State Department of Natural Resources
Carbon and Forest Management Work Group
ESSA Team
Dr. Cedar Morton (Project Manager)
Clint Alexander (Sr. Specialty Advisor)
Senior Carbon Modelling Team
Don Robinson (Sr. Forest Ecologist | Sr. Carbon Modelling Specialist - FVS)
Frank Poulsen (Lead Carbon Modeller)
Eric Neilson (Sr. Carbon Modelling Specialist - CBM)
Intermediate Carbon Modelling Team
Alexandra Tekatch (Modeller - CBM & FVS Specialist)
Graham Mushet (Modeller)
Ibrahim Alameddine (Modeller)

Team Experience

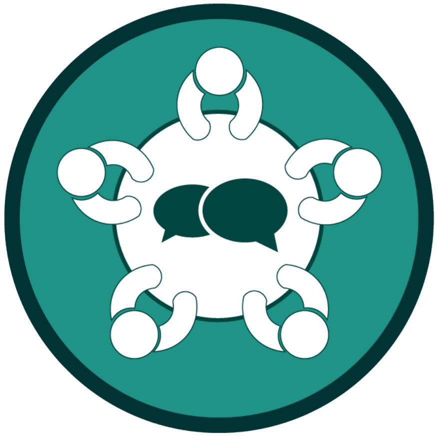
Team Experience







Modeling Tool Selection



Work Group communicates modeling needs (i.e., what forest carbon questions would you like to answer?)

ESSA evaluates models with help of Work Group input & makes recommendation to DNR

DNR selects preferred modeling tool

Example Assessment Rubric (*Might* Use)

Criteria	Importance	MODEL #1	MODEL #2	#1 Score	#2 Score
Work Group Input (WHAT WE HEARD)					
Criterion #1	?	H	H	TBD	TBD
Criterion #2	?	H	M	TBD	TBD
Criterion #3	?	H	M	TBD	TBD
Criterion #4	?	M	H	TBD	TBD
Criterion #5	?	H	H	TBD	TBD
Modelling Team Assessment					
Criterion #1	?	H	H	TBD	TBD
Criterion #2	?	H	M	TBD	TBD
Criterion #3	?	L	L	TBD	TBD
Criterion #4	?	H	L	TBD	TBD
Criterion #5	?	M	H	TBD	TBD
Criterion #6	?	L	H	TBD	TBD

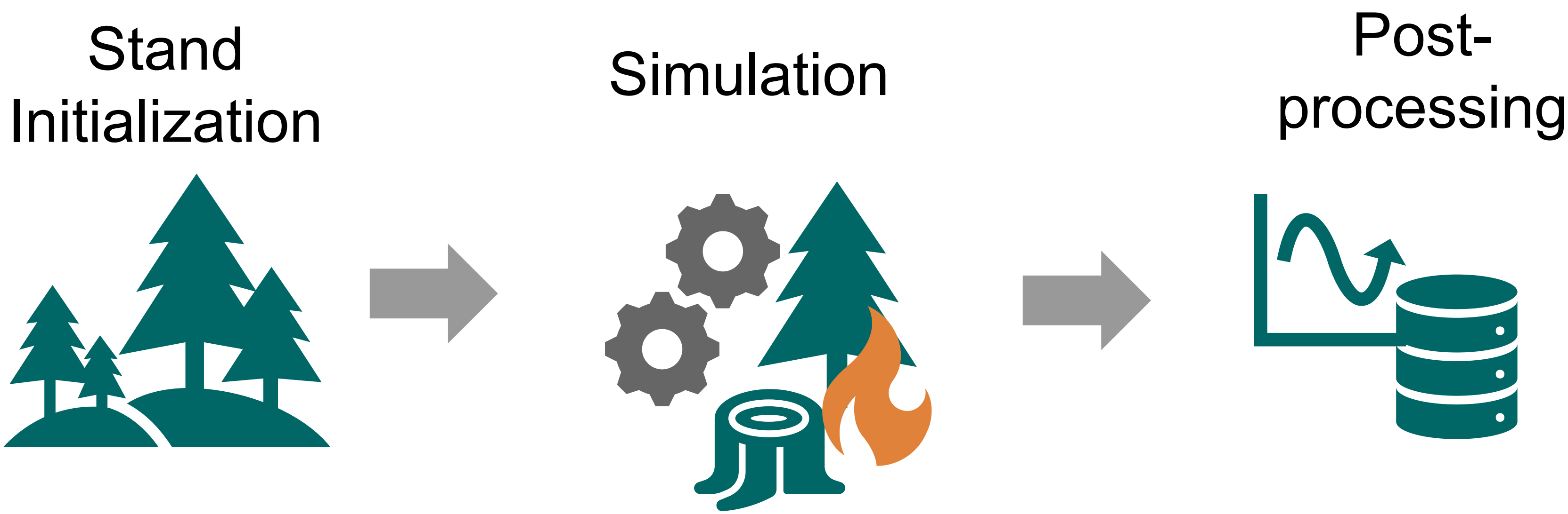
Intro to the Carbon Modeling Tools

CBM CFS3

Forest Vegetation Simulator
FVS
Forest Management Service Center

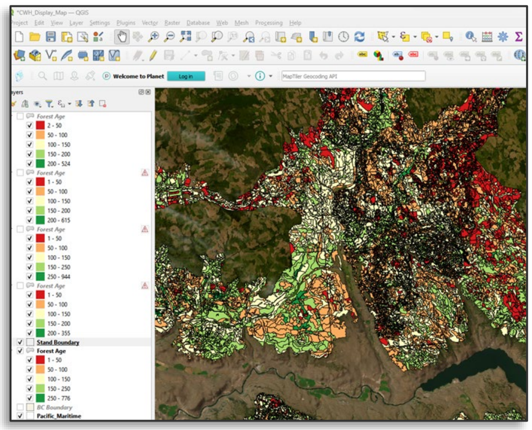
Both align with IPCC Tier 3 guidelines

Basic Model Process (Both Models)

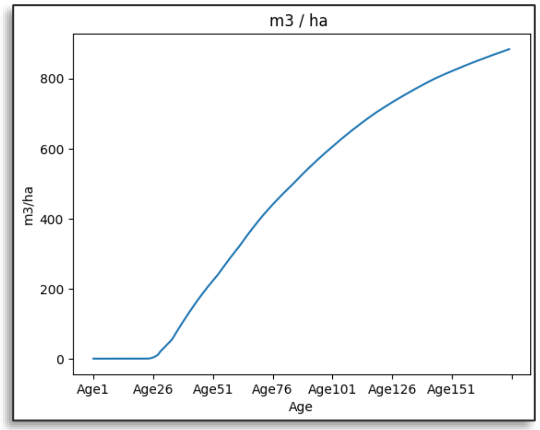


- Growth
- Carbon fluxes
- Disturbance
- Harvest

Inputs (Both Models)



Forest Inventory (e.g., FIA)

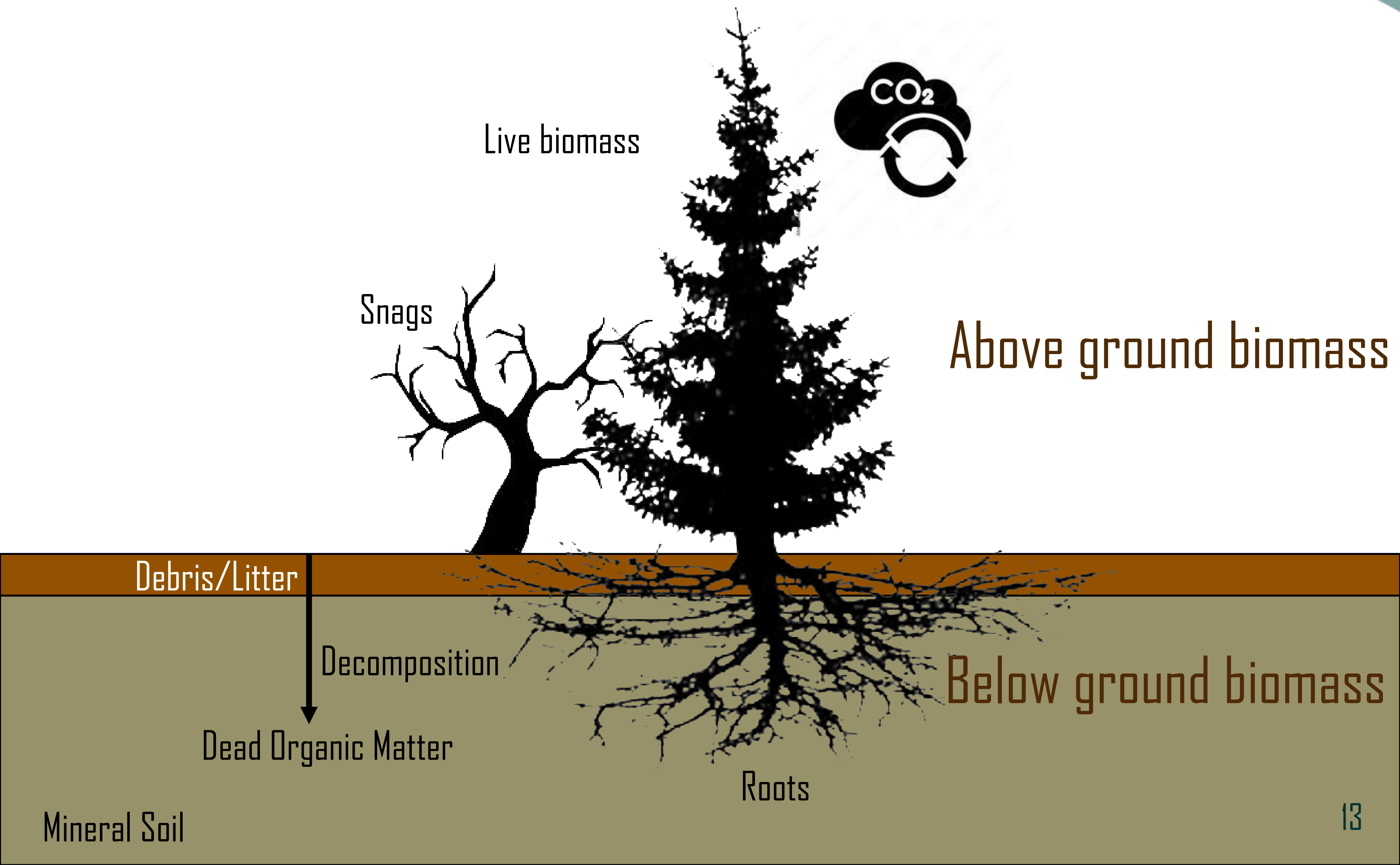


Tree Growth

Disturbance Rules

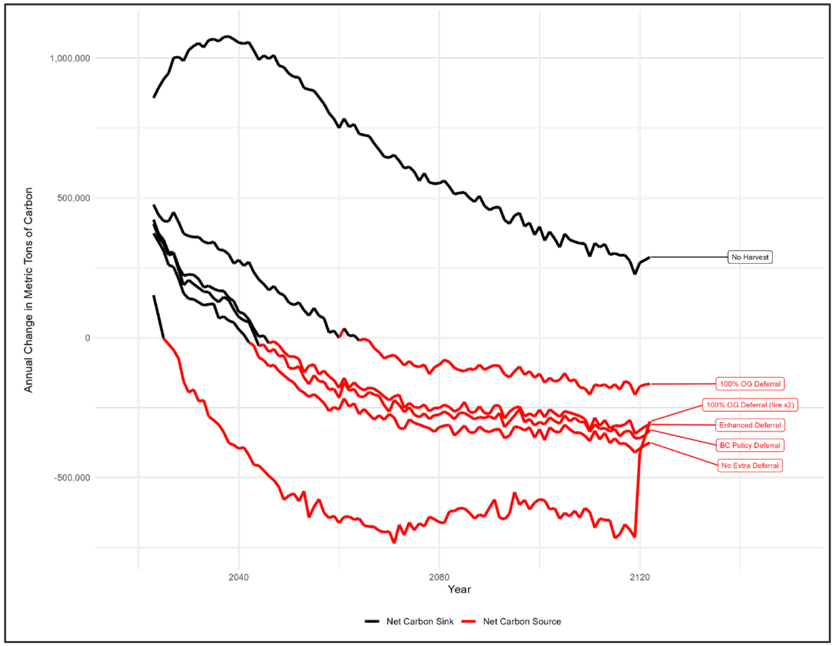
Harvest Rules

Carbon Pools (Both Models)

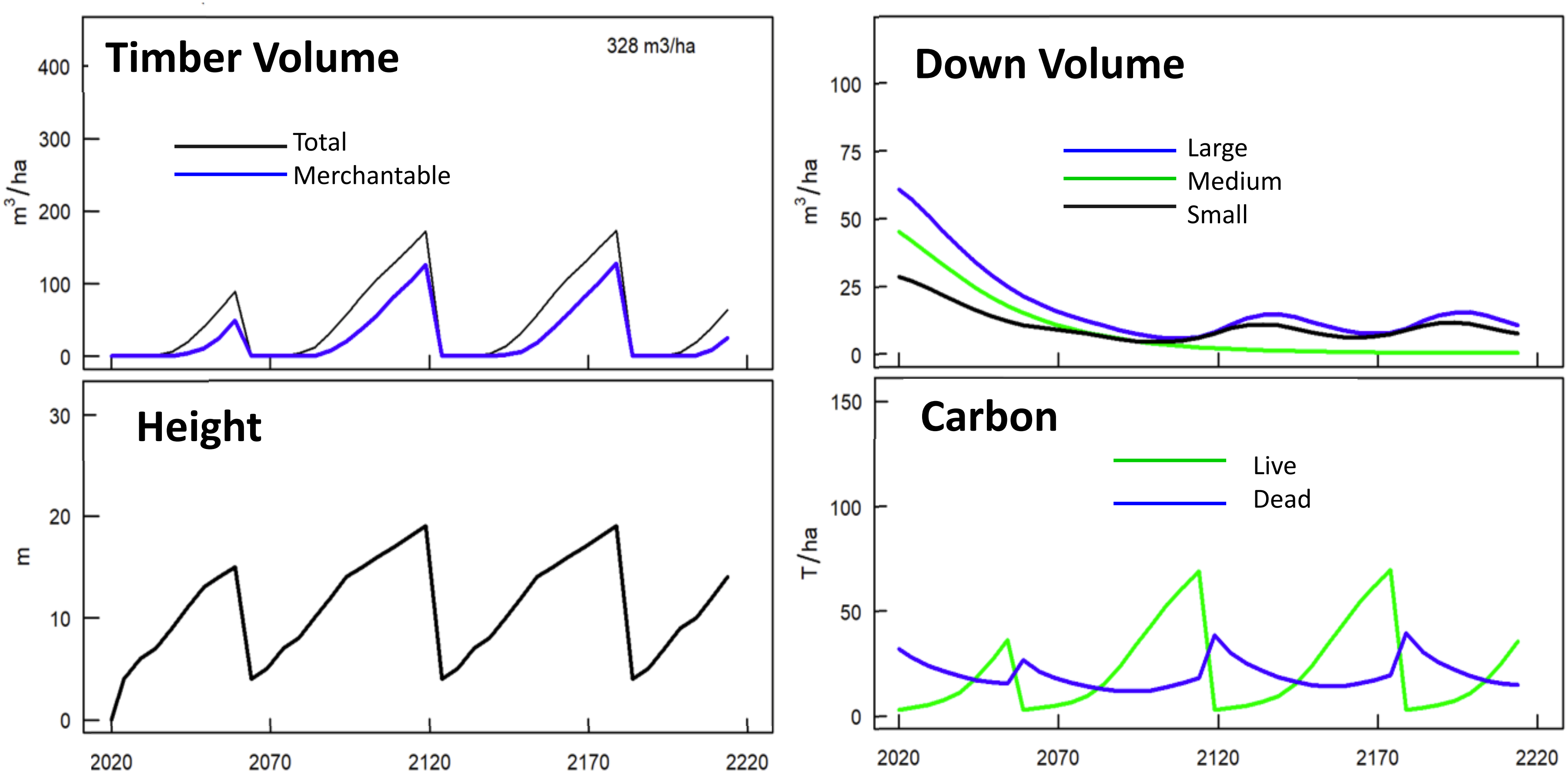


Outputs (CBM)

- tC in harvest (can be converted to tC/ac or ft^3)
  - Can be disaggregated by leading species, or other stand-level characteristics
- tC to a general wood products pool
- Custom carbon and timber volume outputs can be generated



Outputs (FVS)


Timber Volume
328 m3/ha
Total
Merchantable
m3/ha
400
300
200
100
0
Down Volume
Large
Medium
Small
100
75
50
25
0
Height
m
30
20
10
0
Carbon
Live
Dead
T/ha
150
100
50
0
2020
2070
2120
2170
2220

Key Differences

CBM CFS3	Vs. FVS
Simpler harvest (by stand, less capable of representing thinning but can be done in a rudimentary way)	More detailed harvest (tree level, e.g., can include thinning)
Simpler outputs in tC by pool, softwood/hardwood bins, leading species	More detailed live and dead biomass/carbon outputs for stem, crown, roots
Simpler climate change via fire rates, decay temperatures or adjusted growth curves	Climate change driven by GCM: changes to site productivity, carrying capacity and species tolerances
Simpler wood products representation (softwood/hardwood)	More detailed wood products representation (species, size)
Less input data needed (if available, but extra effort if not)	More input data needed
Generally faster computation per run	Generally slower computation per run (e.g., 2-5 sec/stand)
Annual time steps, no limit	5- or 10-year time steps, max 40 steps

Q&A

Your Turn!

Clarifying questions

Supplementary Slides

Attribute	FVS	CBM.CFS3
Developer/maintainer	USDA Forest Service	Canadian Forest Service
Year developed	1973	Original model: 1989; CBM-CFS3 model: 2002
Model type	Individual tree model; semi-distance independent	Stand and landscape-level model; distance independent
How are forested regions specified?	Includes 22 different model variants depending on region.	Default ecological parameters are provided, but can be modified by the user.
Time step	Default cycle length is 10 years for most variants.	Annual
Can forest management and disturbance be analyzed?	Yes	Yes
Includes climate change?	Yes, but only for Western US with Climate-FVS	No. But user can modify the default climate data (which only impacts decay), and use zero carbon impact disturbance events paired with transition rules to alter stand growth in unison with changes in climate.
Incorporates uneven-aged stands?	Yes	No. But user can modify yield curves.
How is regeneration handled?	A "full" regeneration establishment model is available for some variants in the western US. A "partial" establishment model is available for all other variants and simulates stump sprouting. User can specify information on planting and natural regeneration.	Following a stand-replacing disturbance, regeneration will occur automatically, or can be delayed or accelerated using transition rules and/or switching of growth curves. By default, there is no regeneration assumed following non-stand-replacing disturbances. However the user can implement a transition rule to switch an impacted stand to a new growth curve(s) to account for multiple growth components (although the stand can only be represented by a single age or age class).
Includes harvested wood products report?	Yes	No. But annual carcon stocks harvested and transferred to a forest products pool are tracked, and can be viewed and exported for use in HWP carbon models.
How does it incorporate carbon?	Accounts for carbon stocks and stock changes with the Fire and Fuels Extension.	Accounts for carbon stocks and stock changes in tree biomass and dead organic matter pools.

Wood Products

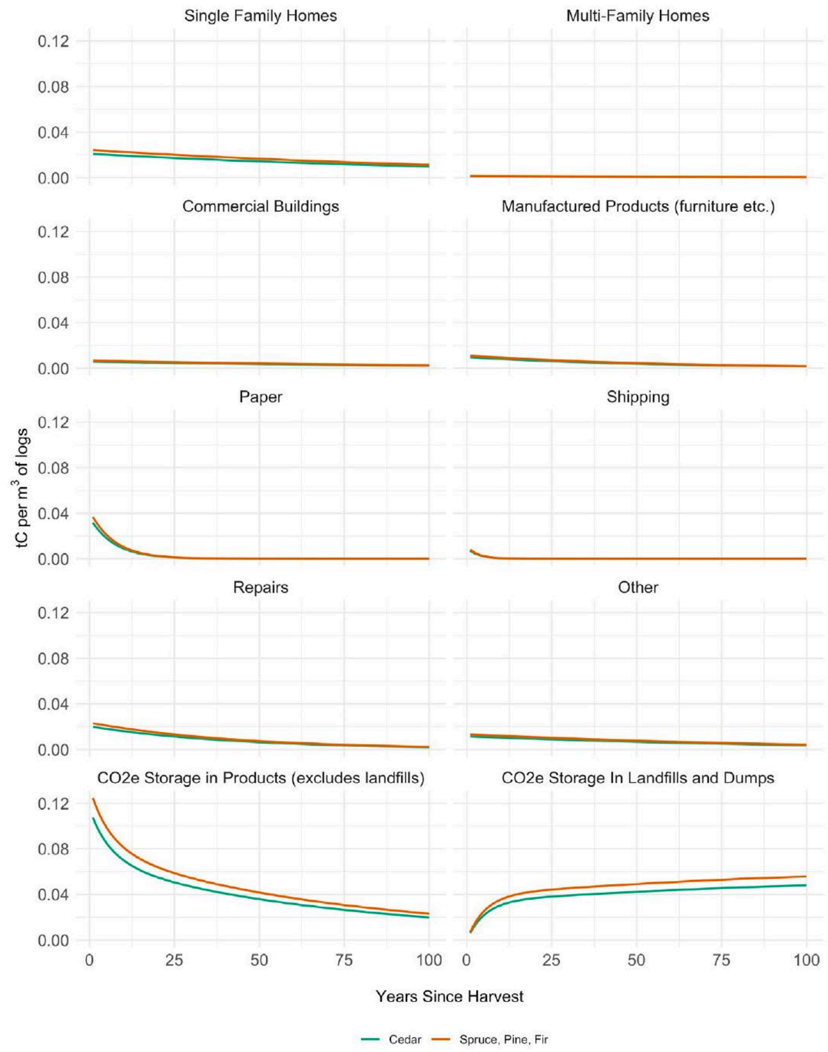
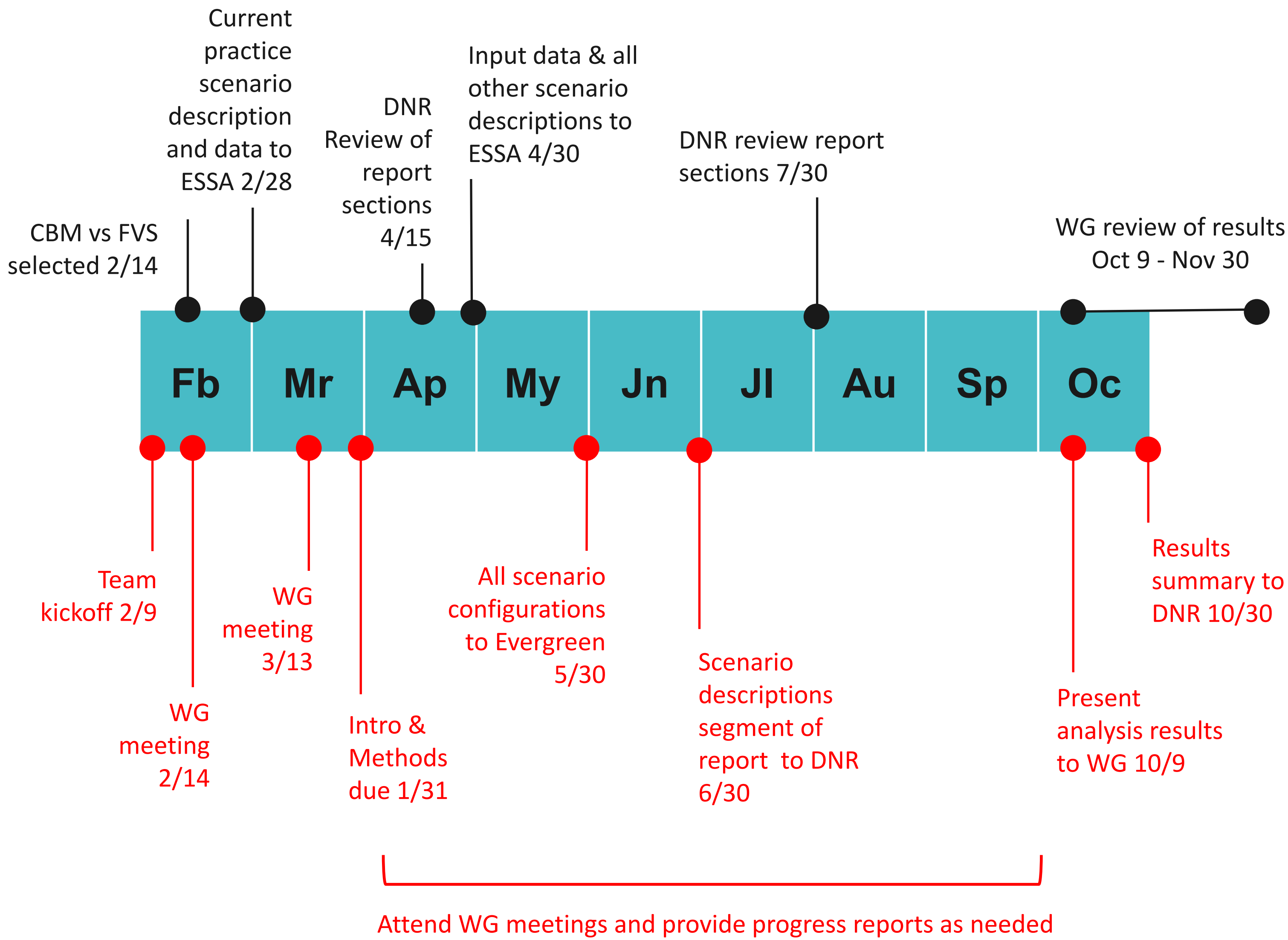
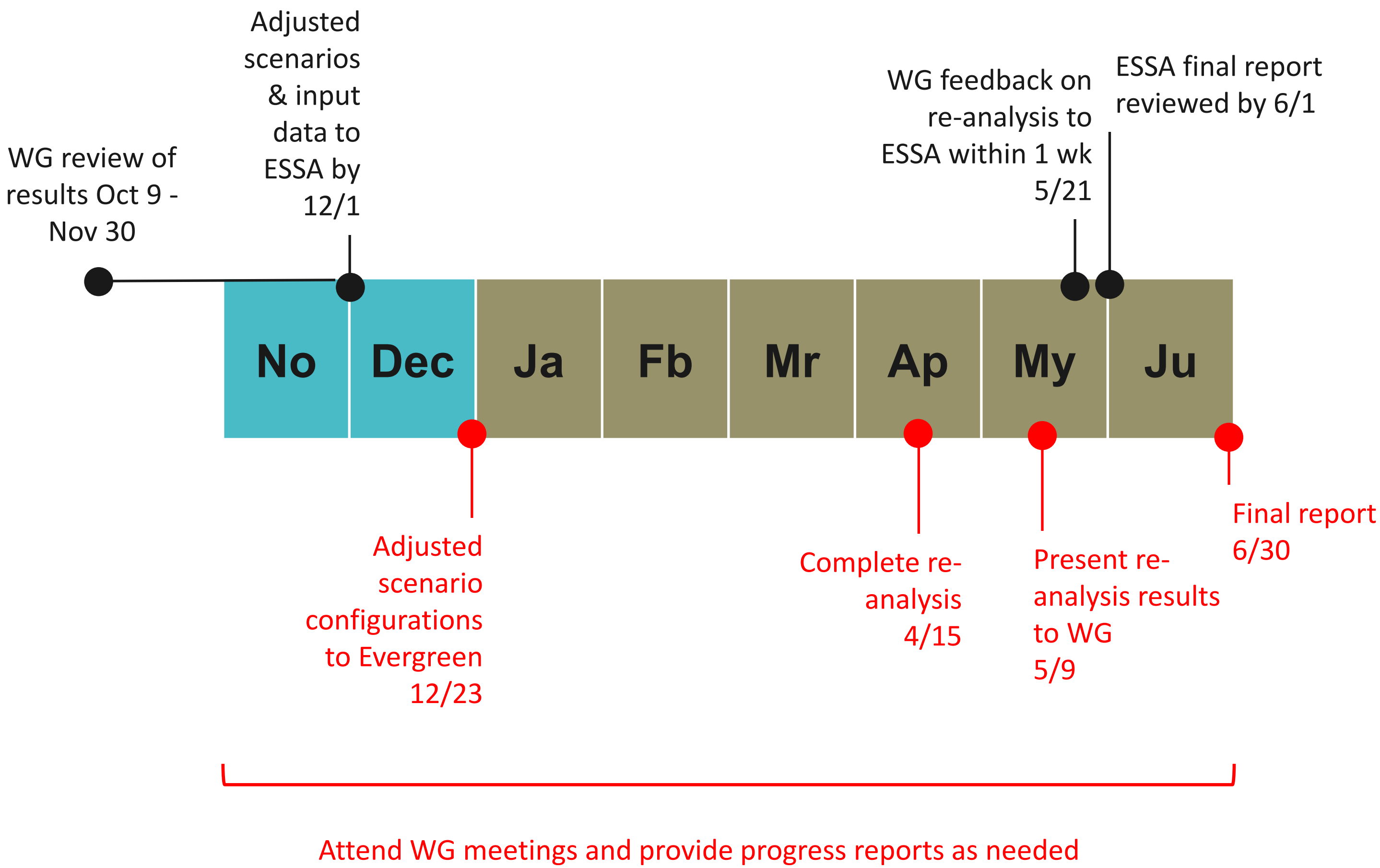


Figure 8. Carbon stored in wood or paper products for 1 m³ of harvested logs

Phase 1 - Modelling



Phase 2 - Refinement & Finalization



Answers to Big Questions

- How much timber is harvested **by species** over time?

CBM CFS3

- Hardwood
- Softwood
- Extra processing for species outputs

FVS

- Cedar
- Fir
- Balsam
- Pine
- Cottonwood
- Etc..

Answers to Big Questions

- How does **silviculture** affect results over time?

CBM CFS3

- E.g., can remove hardwood to represent thinning

FVS

- E.g., can remove species, small trees, large trees

Answers to Big Questions

- How much **carbon and timber** at end of time period?

CBM CFS3

- Tons of carbon/acre
- ft^3 of timber via conversion factor
- Hardwood / softwood

FVS

- Tons of carbon/acre
- ft^3 of timber natively
- Mbf ('000s board feet)
- By species

Answers to Big Questions

- How does **climate change** affect results?

CBM CFS3

- Adjust growth curves
- Adjust wildfire and/or pest rules
- Can't do dynamic changes in carbon decay rates
- Can represent temp but not precip in carbon decay

FVS

- Growth-yield & carrying capacity, and site quality all change
- Adjust wildfire and/or pest rules
- Can't do dynamic changes in carbon decay rates

Answers to Big Questions

- What **input data** do I need to provide?

CBM CFS3

- Forest inventory
- Volume/age per stand
- Growth-yield curves compiled from FIA data
- Fire return intervals
- Pest disturbance rules
- Harvest rules

FVS

- Forest inventory
- Individual tree (density, diameter, species)
- Growth-yield curves directly from FIA data
- Fire return intervals
- Pest disturbance rules
- More complex harvest rules

Answers to Big Questions

- What **forest products** are generated?

CBM CFS 3

- Wood products carbon pool
- Can be done with post-processing

FVS

- Wood products carbon pool (by species, size)

Modeling Phases