



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

Forest Carbon Modeling Component

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

Friday, February 14, 2024





Outline

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



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Science



People



Tools



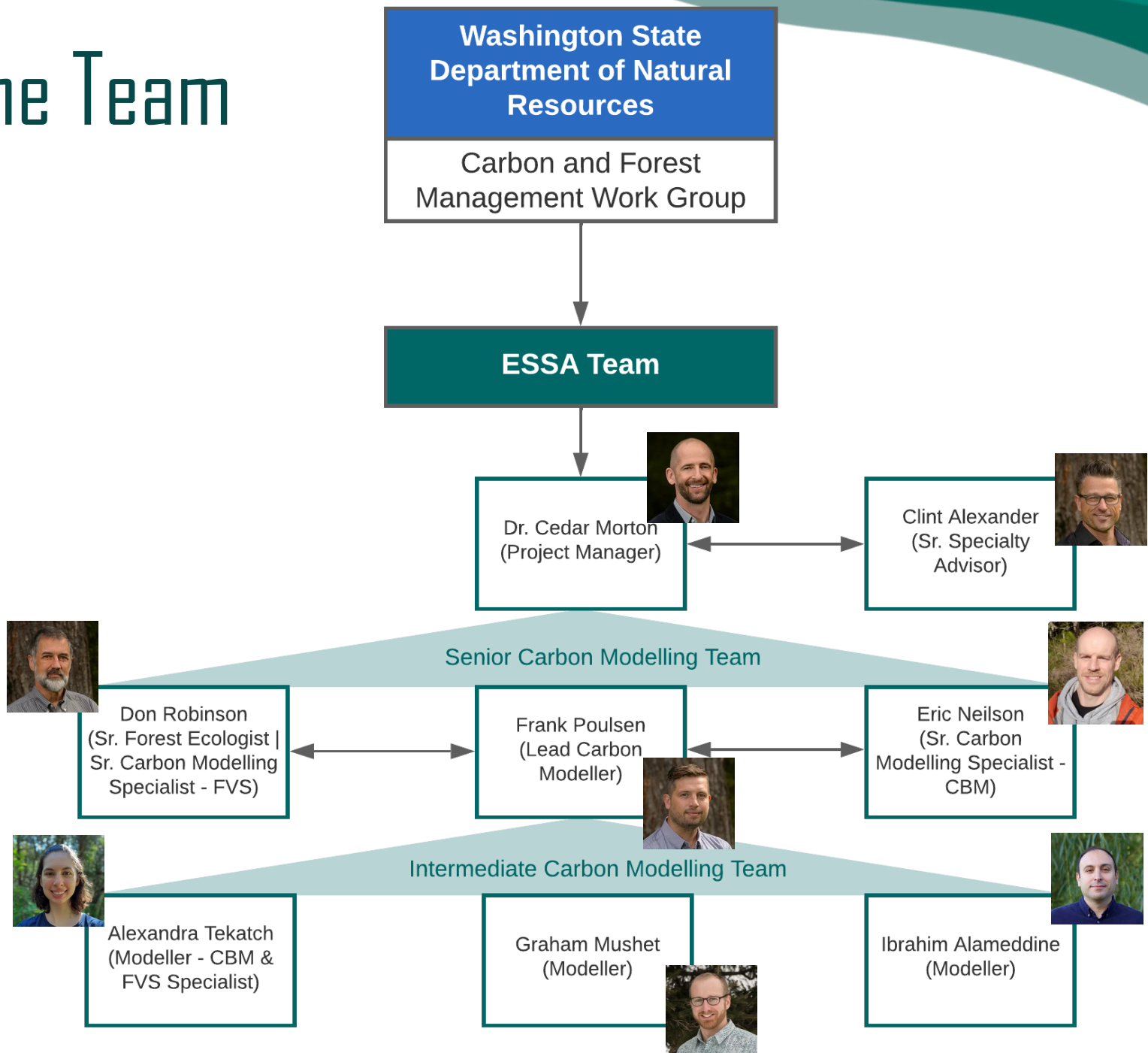
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The Team



Team Experience



The Carbon Budget of the Canadian Forest Sector: Phase I
 W.A. Kurz, T.M. Webb, P.J. McNamee
 ESSA - Environmental & Social Systems Analysts Ltd.
 Vancouver, British Columbia, Canada

and
M.J. Apps
 Forestry Canada, Northwest Region
 Northern Forestry Centre
 Edmonton, Alberta, Canada

Abstract

An assessment of the contribution of Canadian forest ecosystems and forestry activities to the carbon budget has been undertaken. The focus of this study consisted of the development of a computer modeling framework and the utilization of published information to establish the sector's role as a net source or a net sink of atmospheric carbon.

The framework includes age-dependent carbon sequestration by living forest biomass, decomposition of litter fall of carbon to the forest floor, soil

of 2007 (Environmental and Social Systems Analysts Ltd., of Vancouver, British Columbia). ENFOR (ENergy from the FOReSt) is a contract research and development program managed by Forestry Canada and aimed at generating sufficient knowledge and technology to realize a marked increase in the contribution of forest biomass to Canada's energy supply. The program was begun in 1978 as part of a federal initiative to develop renewable energy alternatives with

SCIENCE ADVANCES | RESEARCH ARTICLES

APPLIED ECOLOGY

Natural climate

C. Ronnie Draver¹ & Susan

Development of FVS^{Ontario}: A Forest Vegetation Simulator Variant and Application Software for Ontario

Murray E. Woods¹
 Donald C.E. Robinson²

Abstract—The Ontario Ministry of Natural Resources is leading a government/industry partnership to develop an Ontario version of the Forest Vegetation Simulator (FVS). Based on the FVS user interface, the Prognosis™ user-interface, the FVS^{Ontario} project is motivated by a need to assess the impacts of intensive forest management strategies and the multiple ecological and social values faced by today's resource managers. Currently, the large tree diameter model and the "Tree List Manager" has also been created to develop FVS tree-lists from the data collected through various field-cruising methods. Current efforts with the model involve the identification of model weaknesses, improvement of user control on silvicultural treatments, and development of models for populating stand species- and diameter-distributions for inventory polygons through field forest inventory attribution using high resolution digital imagery combined with LiDAR individual Tree Crown classification approaches.

Ontario's Landbase

The province of Ontario, Canada, is ranging from sparsely-treed spruce in the north to deciduous forest in the south. The province's landbase is approximately 1,076,800 km² (415,794 mi²). The province's landbase is divided into 12 major forest types, each representing a different ecological and management regime. The province's landbase is divided into 12 major forest types, each representing a different ecological and management regime.

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nature
 LETTERS

Mountain pine beetle and forest carbon feedback to climate change

W. A. Kurz¹, C. C. Dymond¹, G. Stinson¹, G. J. Rampley¹, E. T. Neilson¹, A. L. Carroll¹, T. Ebata² & L. Safranyik¹

The mountain pine beetle (*Dendroctonus ponderosae* Hopkins, Coleoptera: Curculionidae, Scolytinae) is a native insect of the pine forests of western North America, and its populations periodically erupt into large-scale outbreaks^{1–3}. During outbreaks, the

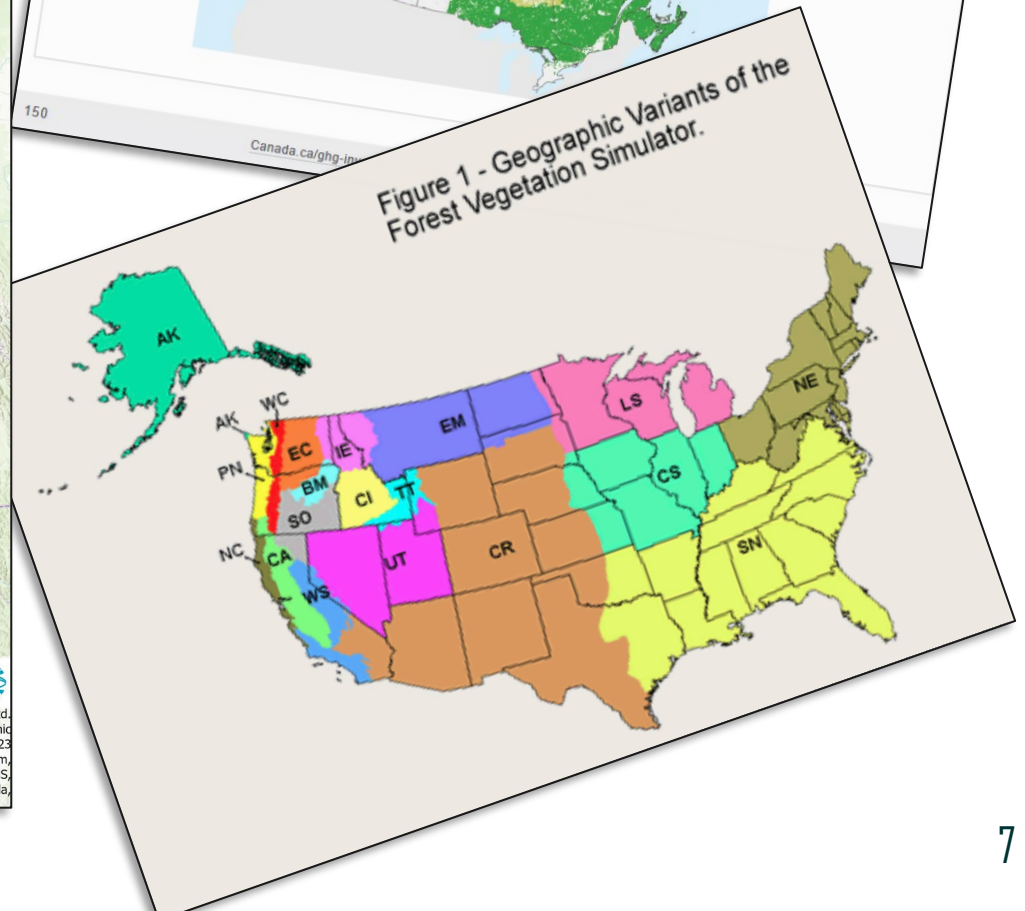
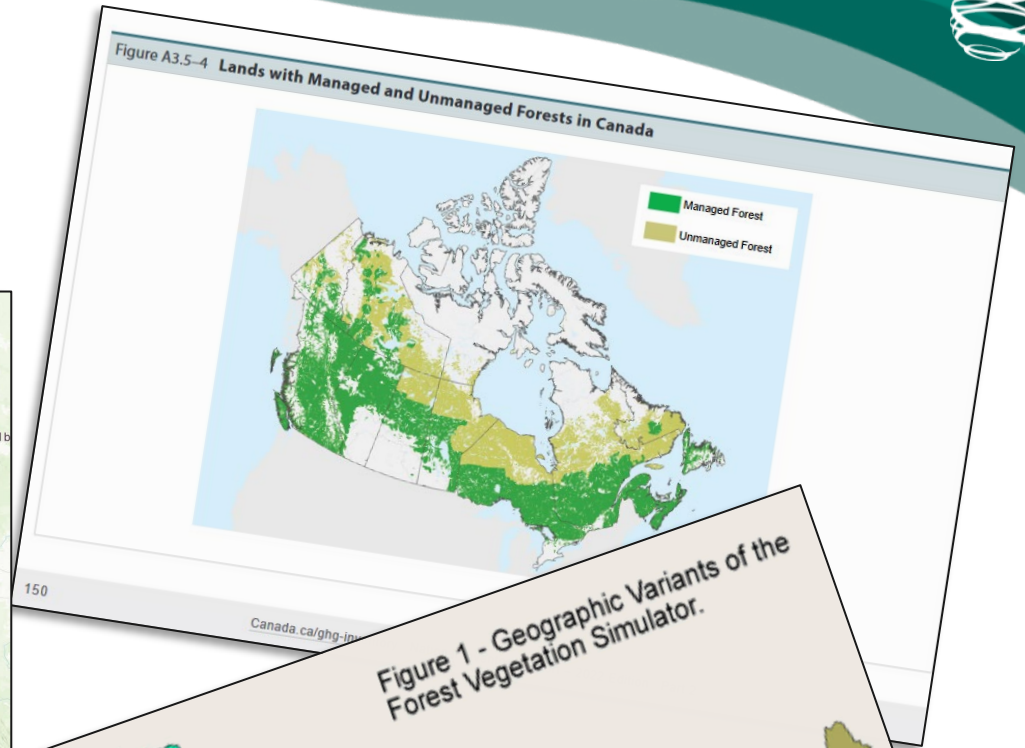
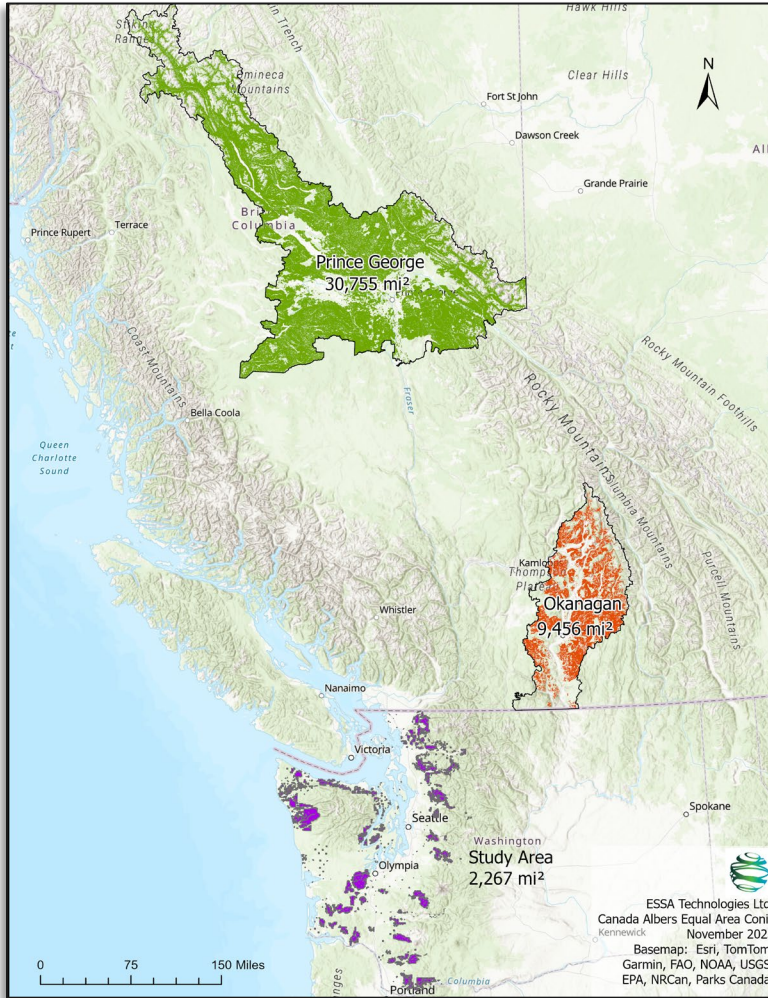
stand in a single year¹¹. Timber losses are estimated to be more than 435 million m³, with additional losses outside the commercial forest¹². The forest sector has responded by increasing harvest rates and reallocating some harvest to increase the pine portion of the stand (table 2), the management system that most closely represents species which require full light conditions to regenerate and grow to maturity, like white and red pine, poor-quality tolerant hardwood forests and mid-tolerant like oak and yellow birch are managed through the application of the uniform forest system. The shelterwood system, with its series of partial cuts, best emulates density ground fire disturbances, which along with wind, is the dominant natural disturbance method for these species. Uneven aged tolerant hardwood stands of good quality and site quality are managed with the single-tree selection silvicultural system. The single-tree selection system, with its series of partial cuts, best emulates the gap-phase regeneration dynamics that normally occur in these ecosystems.

¹ Havis, Robert N.; Crookston, Nicholas L. comp. 2008. Third Forest Vegetation Simulator Conference, 2007 February 13–16, Fort Collins, CO. Proceedings RMRS-P-54. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.
² Senior Analyst, Forested Landscapes, Ontario Ministry of Natural Resources, Bay, Ontario; e-mail: murray.woods@mnr.gov.on.ca.
³ Science Technician, ESSA Technologies Ltd., Vancouver, B.C.; E-mail: drobinson@essa.com.

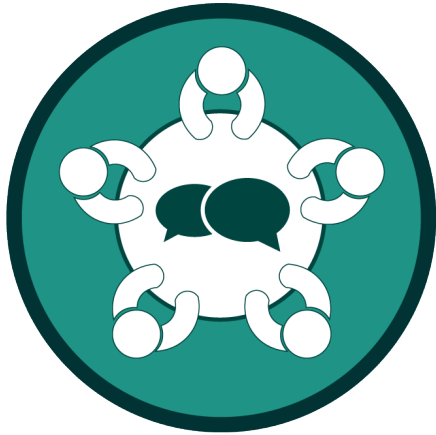
Economic Valuation of Old Growth Forests on Vancouver Island: Pilot Study
 Phase I - Preliminary Assessment and Scoping
 FINAL REPORT

ESSA Technologies Ltd.
 Vancouver, BC Canada V6H 3H4
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Team Experience



Modeling Tool Selection



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



ESSA

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
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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
CFS **3**

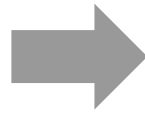


Both align with IPCC Tier 3 guidelines

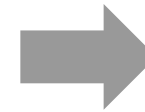


Basic Model Process (Both Models)

Stand
Initialization



Simulation

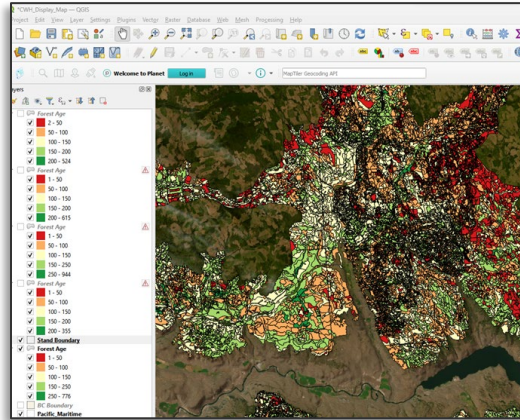


Post-
processing

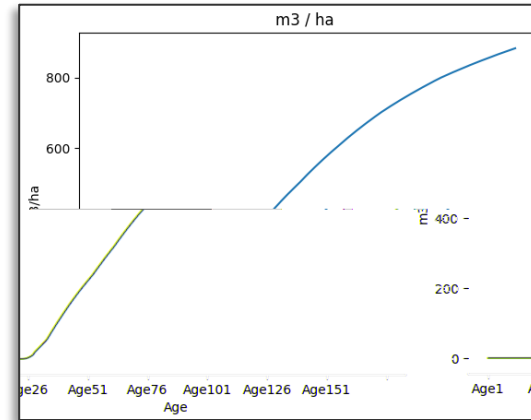


- Growth
- Carbon fluxes
- Disturbance
- Harvest

Inputs (Both Models)



Forest Inventory
(e.g., FIA)



Tree Growth



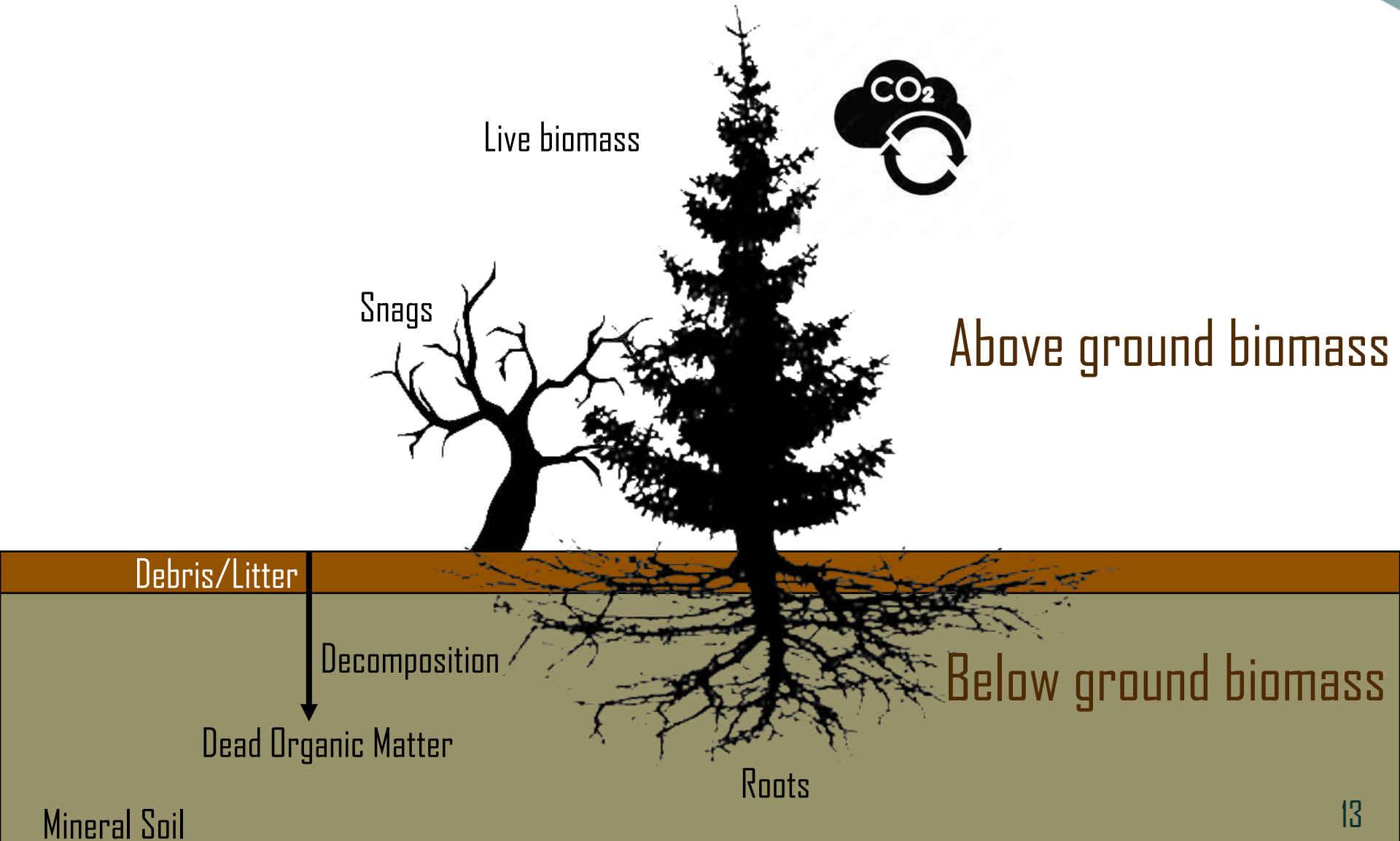
Disturbance Rules



Harvest Rules



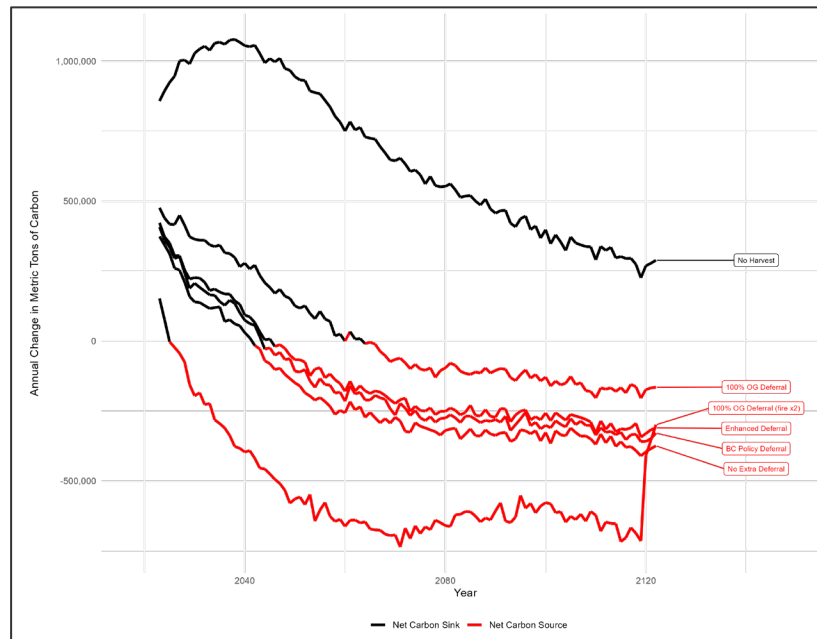
Carbon Pools (Both Models)





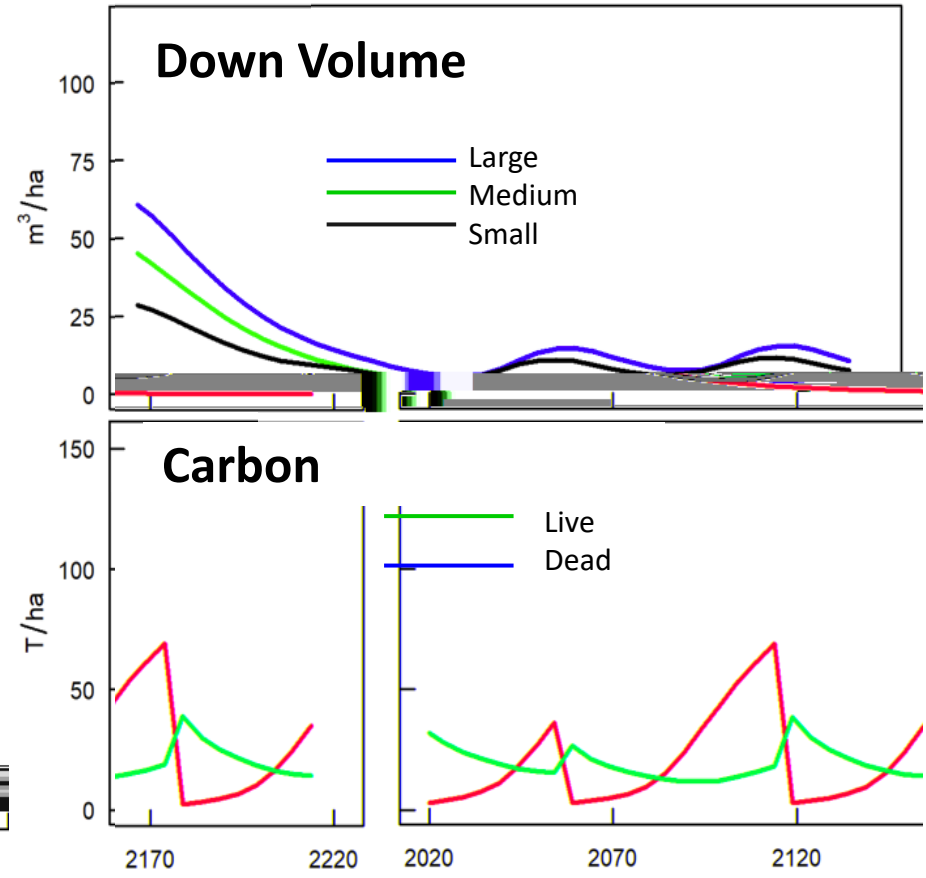
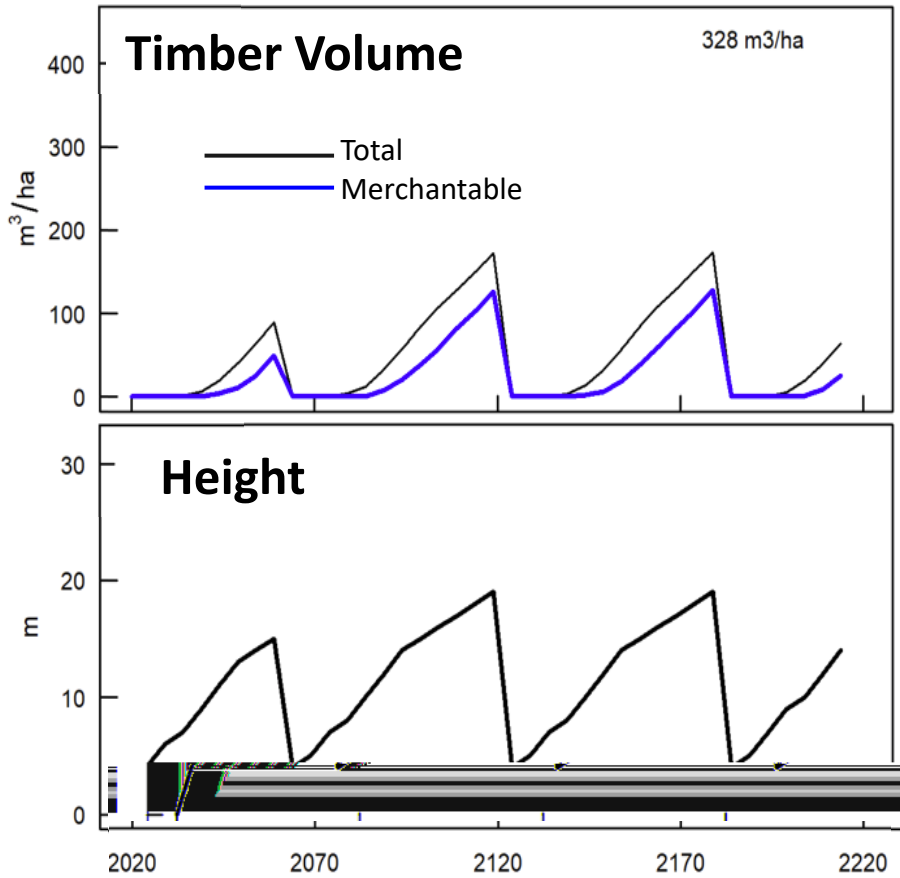
Outputs (CBM)

- tC in harvest (can be converted to tC/ac or ft³)
 - 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)



Key Differences



Vs.



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



CBM
CFS **3**



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 carbon 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

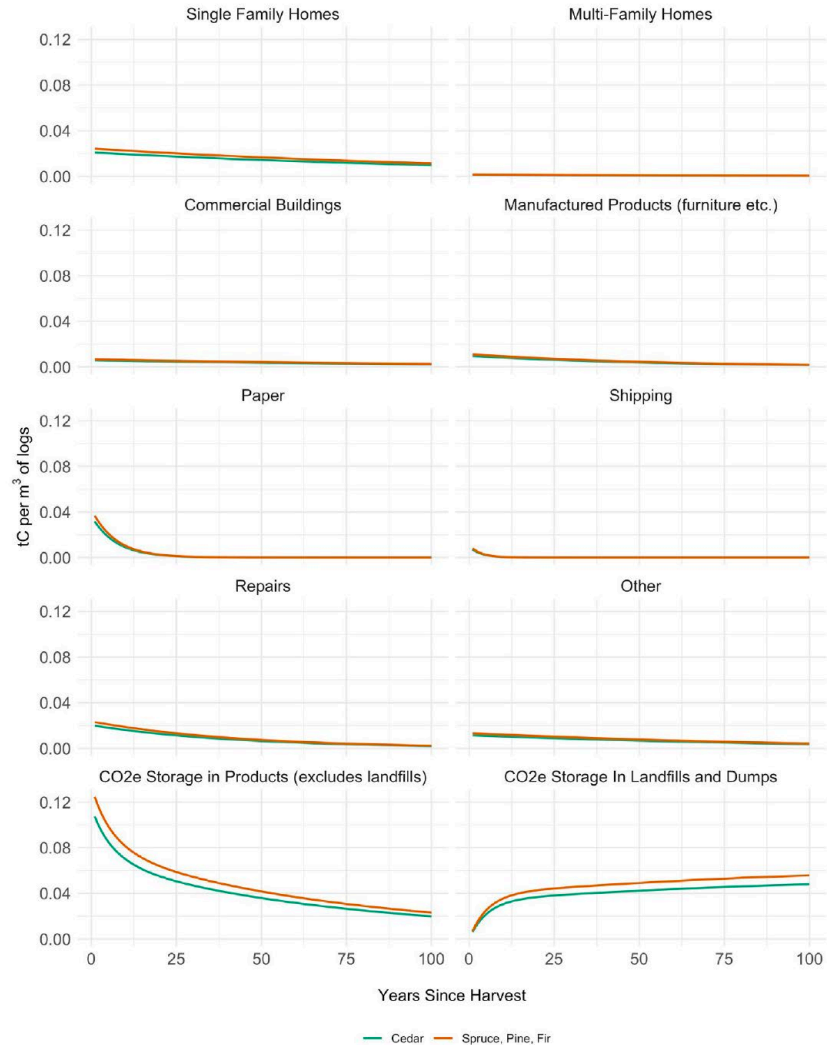
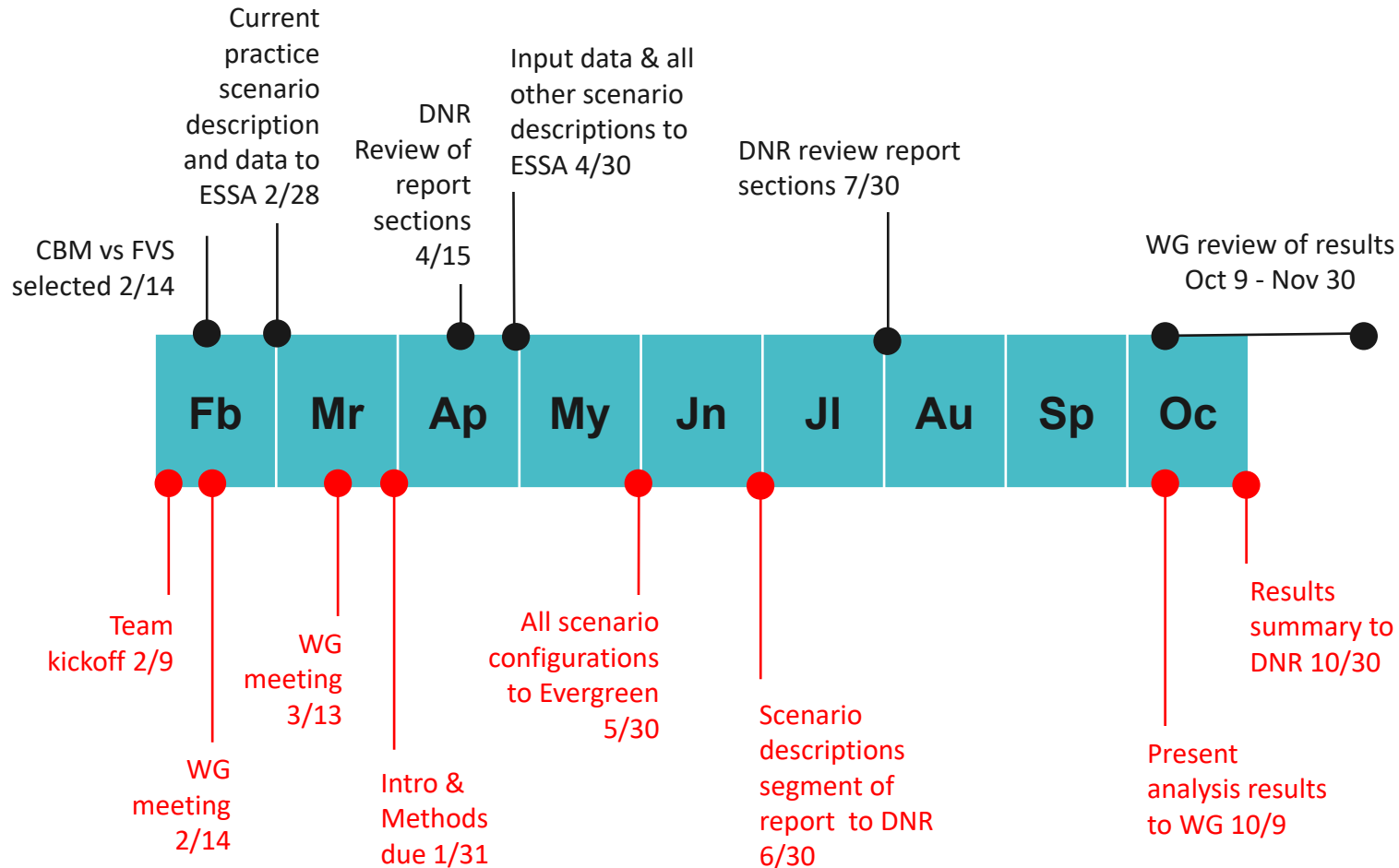


Figure 8. Carbon stored in wood or paper products for 1 m³ of harvested logs



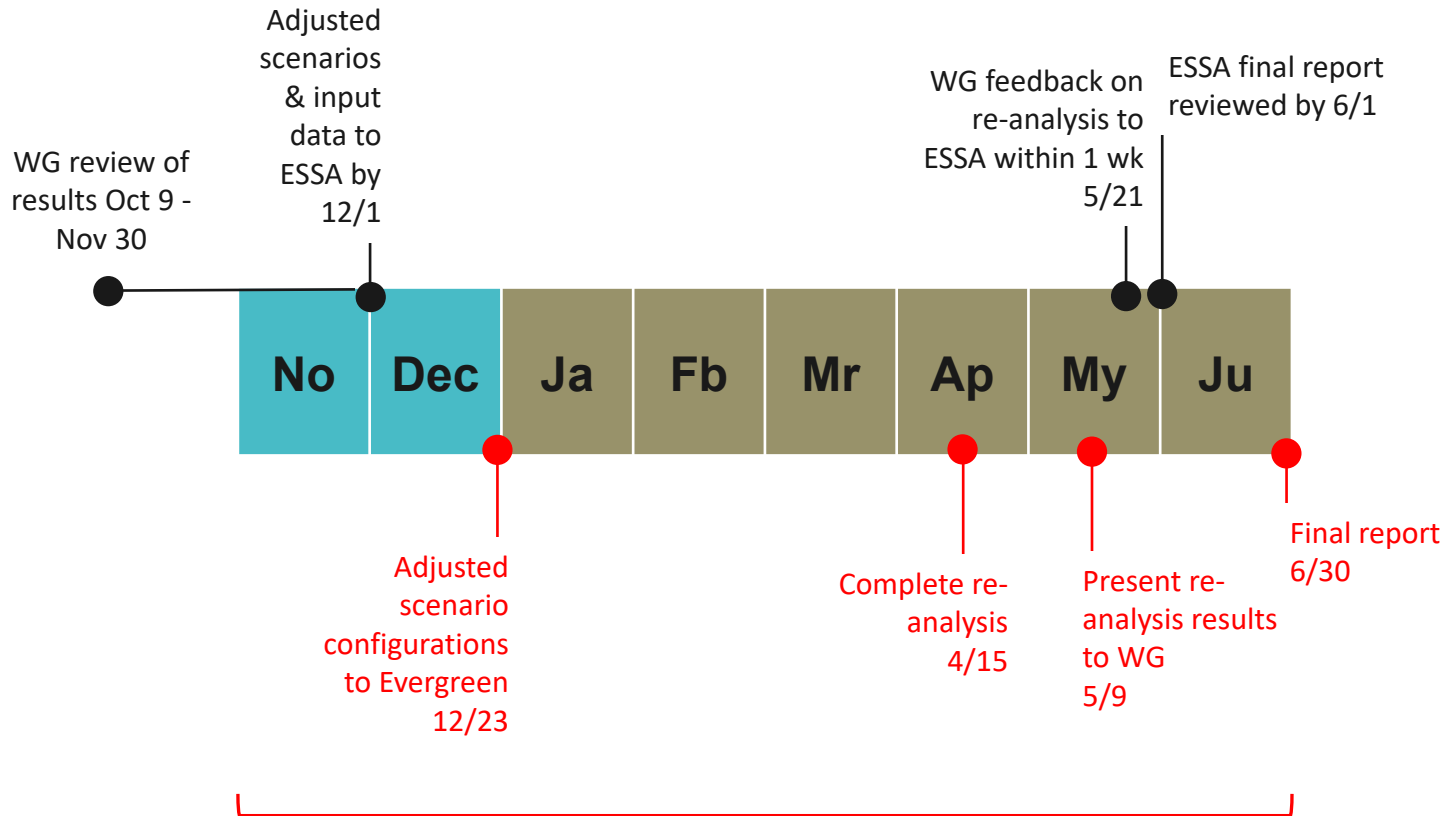
Phase 1 - Modelling



Attend WG meetings and provide progress reports as needed



Phase 2 - Refinement & Finalization



Attend WG meetings and provide progress reports as needed

Answers to Big Questions

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



- Hardwood
- Softwood
- Extra processing for species outputs



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

Answers to Big Questions

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

**CBM
CFS 3**

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



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

Answers to Big Questions

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



- Tons of carbon/acre
- ft³ of timber via conversion factor
- Hardwood / softwood



- Tons of carbon/acre
- ft³ of timber natively
- Mbf ('000s board feet)
- By species

Answers to Big Questions

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



- 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
- 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?



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

- 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?



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



- Wood products
- carbon pool (by species, size)



Modeling Phases

Work Group
Review



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



ESSA data preparation, model setup, and modeling of current practice case plus alternative management scenarios



ESSA refinement of modeling and final reporting