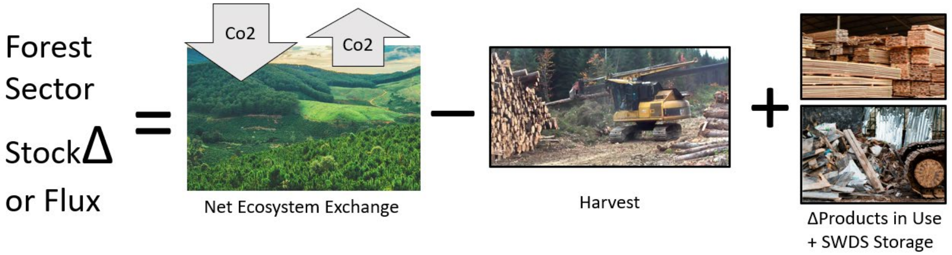
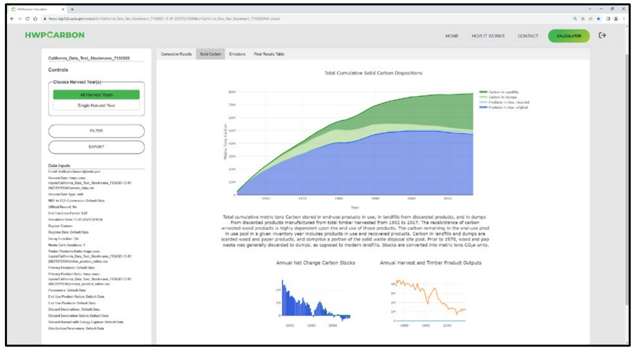
New USDA and Updated USFS Harvested Wood Product Carbon Stocks and Flux Estimation Tools

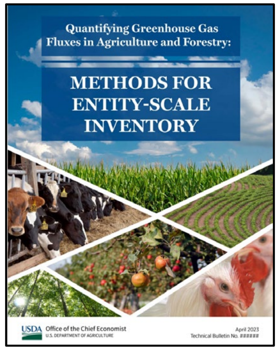
Western Forest Economists 2023

September 29, 2023, 0940 PT, Portland, Oregon



Keith Stockmann, Prakash Nepal, Richard Bergman, Dan Loeffler, Christopher Woodall, Lara Murray, Andrew Lister, Hongmei Gu, Poonam Khatri, Indoneil Ganguly, Eric and Gregg Marland





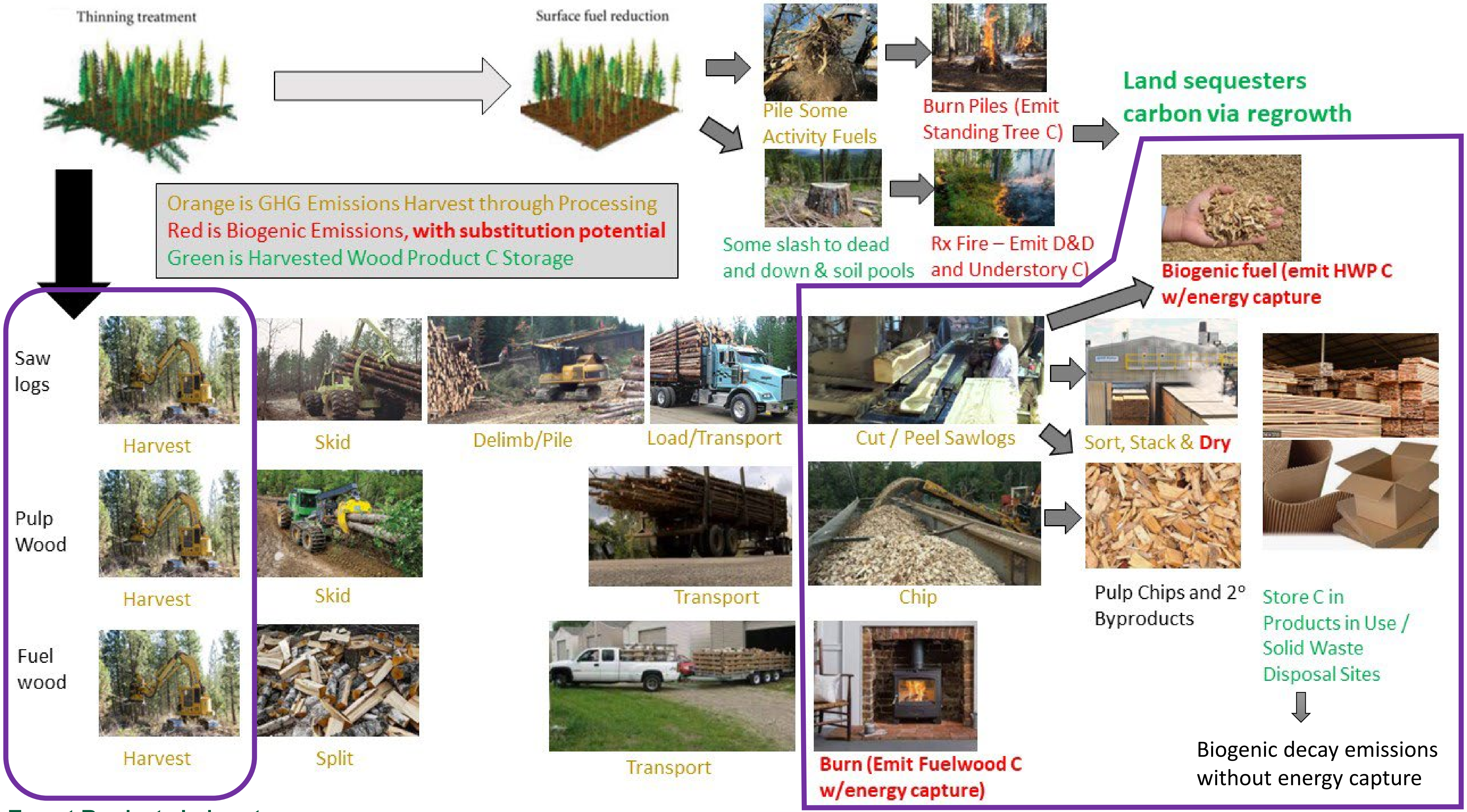
Forest Products Laboratory

Why care about HWP?

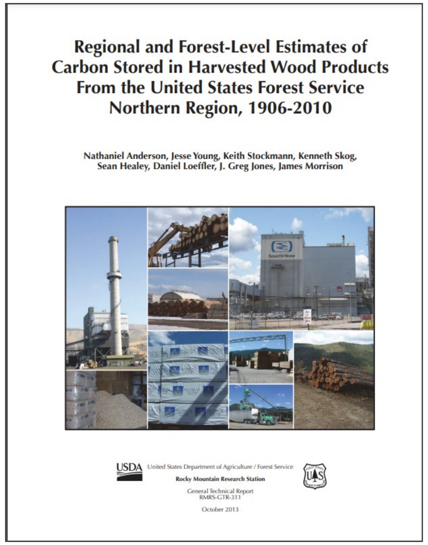
- Is all the carbon stored in our forest “sink” emitted immediately when we cut trees?
- How long does it take for HWP emissions to occur? Are there ways to extend the storage?
- Is any carbon stored permanently in wood products?
- What about the trees and parts of trees cut for wood products but left on-site? Are those included in HWP accounting?
- How can I contribute to carbon management to relieve the negative climate change impacts I see in my community, or in the news?
- What potential financial (carbon markets, incentives, etc.) opportunities are associated with forest and HWP carbon management options?
- RPA Projections suggest that harvested wood carbon annual stock change rates in 2070 will be greater than net forest ecosystem annual stock change rates under moderate and high growth future scenarios.

Presentation Outline

- The **USDA is releasing two public facing tools this year** that will help landowners and agencies estimate the carbon storage in their forests and harvested wood products.
- The USFS Forest Products Lab and Office of Sustainability and Climate are also recoding and improving **a new version of the USFS *HWP Carbon Calculator***. This tool, accompanied by a pending how-to manual, **will accommodate harvest time series data** and **offers a graphic interface** for users to provide inputs and then view and export results. This tool **will be used by the National Forests for reporting their HWP carbon pools**.
- The second tool is **part of the USDA *Quantifying Greenhouse Gas Fluxes in Agriculture and Forestry: Methods for Entity-Scale Inventory*** revision package. Working with the Office of the Chief Economist, we developed a **very flexible tool that uses either USFS Forest Inventory and Analysis data to estimate growing stock and harvest or user inputs** e.g., timber sale volumes by species. This tool **connects the two sides of the forest sector carbon, ecosystem and HWP pools and adds a new product and energy substitution calculator** to quantify potential avoided carbon emissions by using HWPs in place of functionally equivalent non-wood products.
- This presentation will compare use cases, overlap and limitations, as well as tentative plans moving forward. Both model outcomes help forest landowners and managers understand carbon implications.

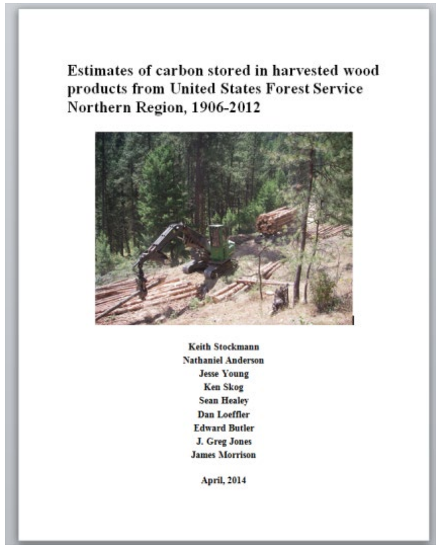


Thinning treatment
Surface fuel reduction
Pile Some Activity Fuels
Burn Piles (Emit Standing Tree C)
Land sequesters carbon via regrowth
Some slash to dead and down & soil pools
Rx Fire – Emit D&D and Understory C)
Orange is GHG Emissions Harvest through Processing
Red is Biogenic Emissions, with substitution potential
Green is Harvested Wood Product C Storage
Biogenic fuel (emit HWP C w/energy capture
Saw logs
Harvest
Skid
Delimb/Pile
Load/Transport
Cut / Peel Sawlogs
Sort, Stack & Dry
Pulp Wood
Harvest
Skid
Transport
Chip
Pulp Chips and 2° Byproducts
Store C in Products in Use / Solid Waste Disposal Sites
Fuel wood
Harvest
Split
Transport
Burn (Emit Fuelwood C w/energy capture)
Biogenic decay emissions without energy capture


Regional and Forest-Level Estimates of Carbon Stored in Harvested Wood Products From the United States Forest Service Northern Region, 1906-2010

Nathaniel Anderson, Jesse Young, Keith Stockmann, Kenneth Skog, Sean Healey, Daniel Loeffler, J. Greg Jones, James Morrison

USDA United States Department of Agriculture / Forest Service
Rocky Mountain Research Station
General Technical Report RMRS-GTR-311
October 2013


Estimates of carbon stored in harvested wood products from United States Forest Service Northern Region, 1906-2012

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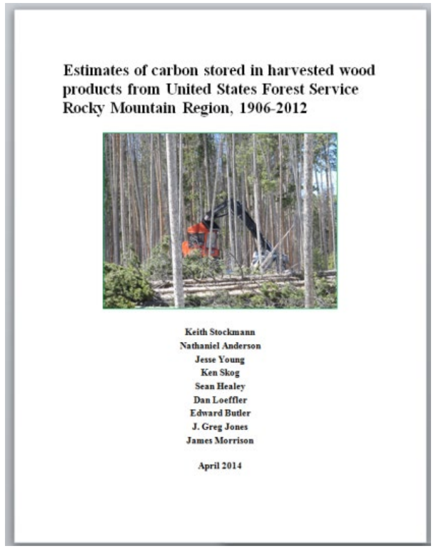
April, 2014


Estimates of carbon stored in harvested wood products from United States Forest Service Rocky Mountain Region, 1906-2012

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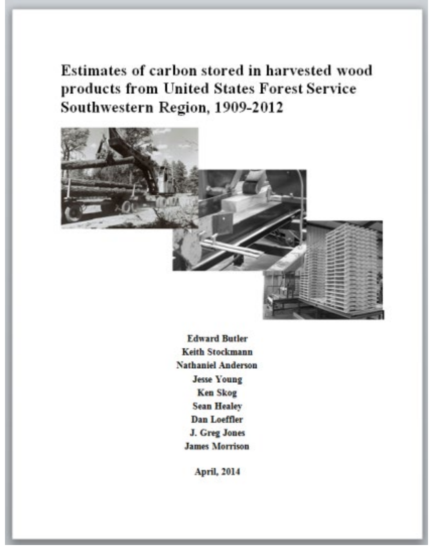
Estimates of carbon stored in harvested wood products from United States Forest Service Southwestern Region, 1909-2012

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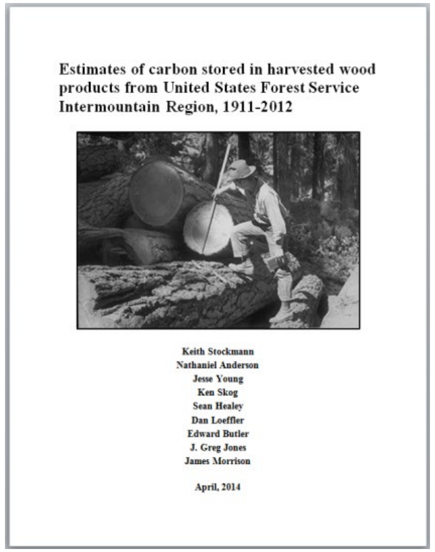
Estimates of carbon stored in harvested wood products from United States Forest Service Intermountain Region, 1911-2012

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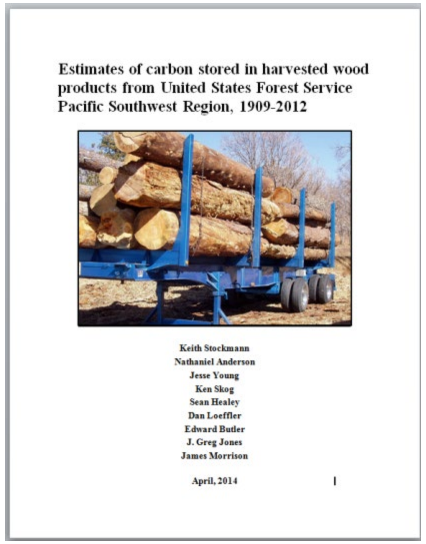
NFS Regional HWP reports available on TreeSearch, search for: carbon in harvested wood products


Estimates of carbon stored in harvested wood products from United States Forest Service Pacific Southwest Region, 1909-2012

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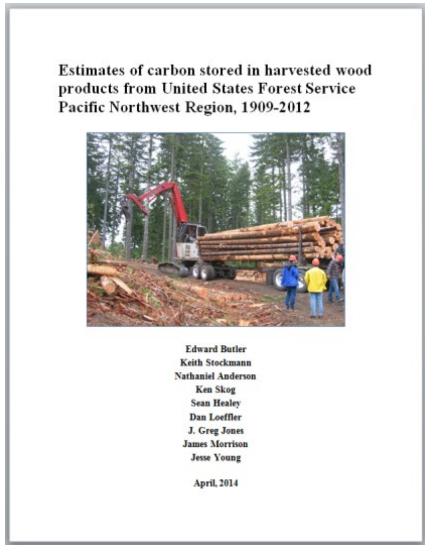
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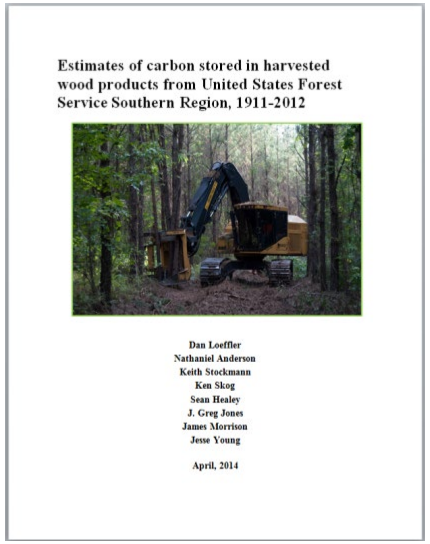
Estimates of carbon stored in harvested wood products from United States Forest Service Southern Region, 1911-2012

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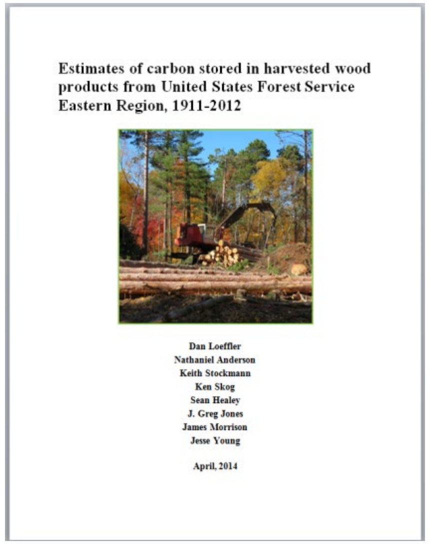
Estimates of carbon stored in harvested wood products from United States Forest Service Eastern Region, 1911-2012

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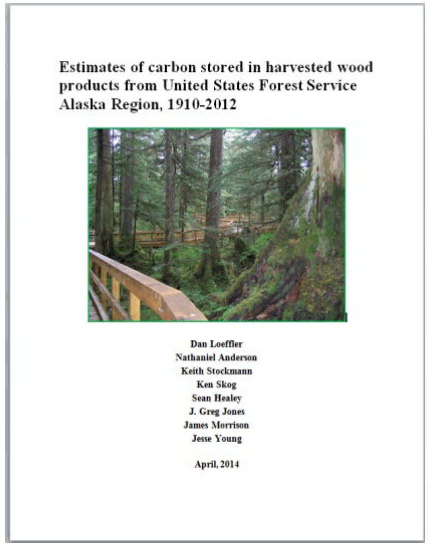
Estimates of carbon stored in harvested wood products from United States Forest Service Alaska Region, 1910-2012

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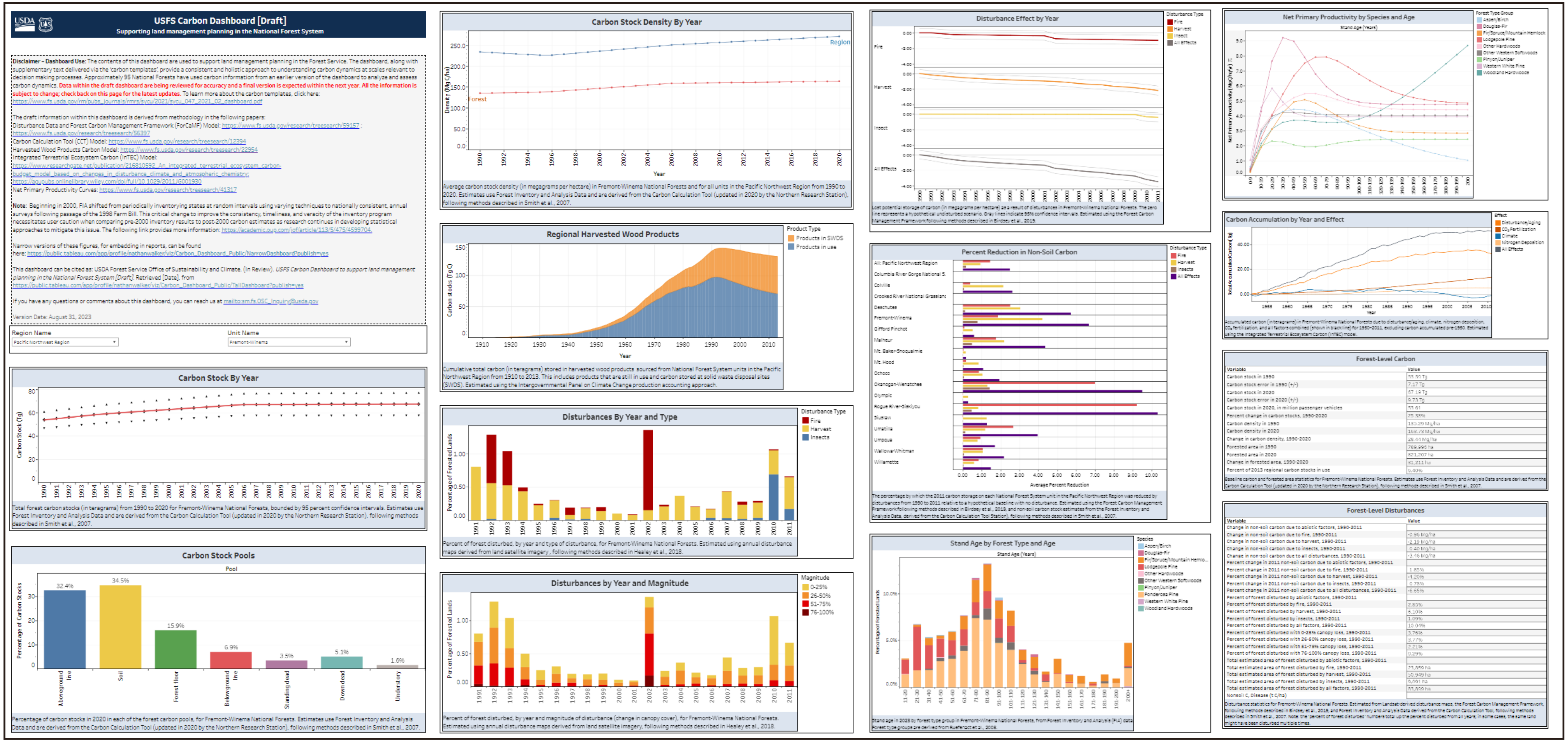
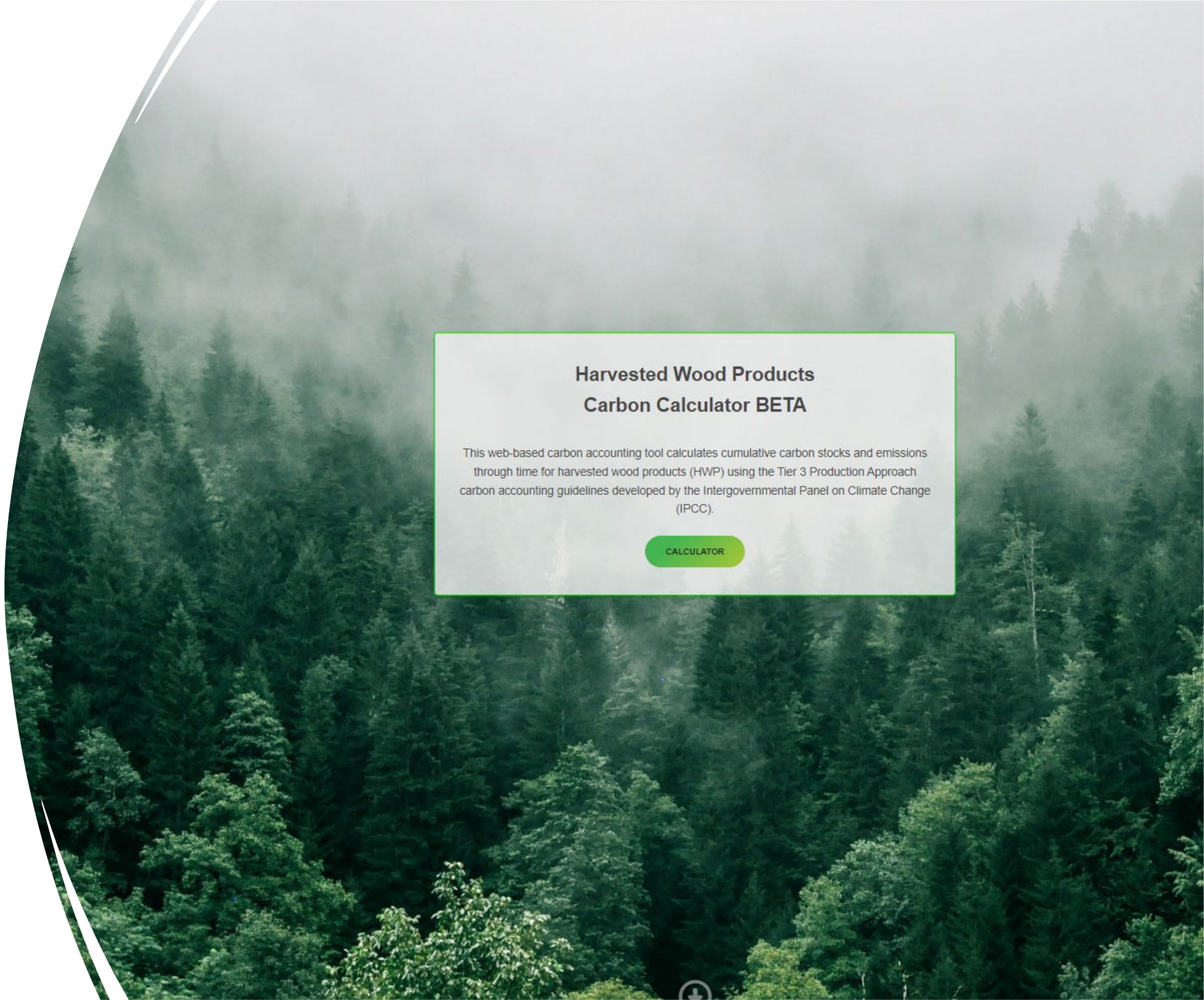
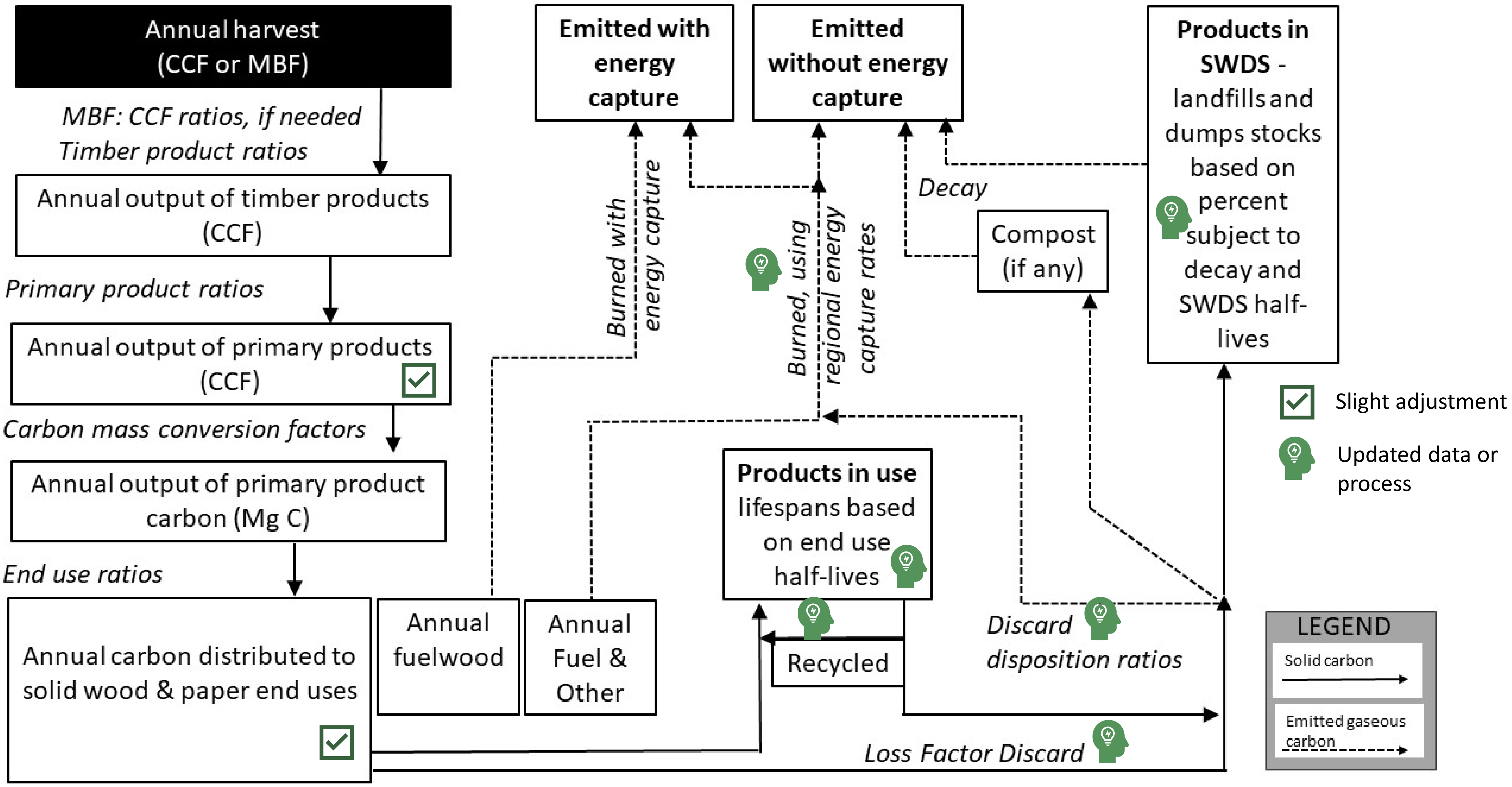
Draft USFS Carbon Dashboard – Under Revision



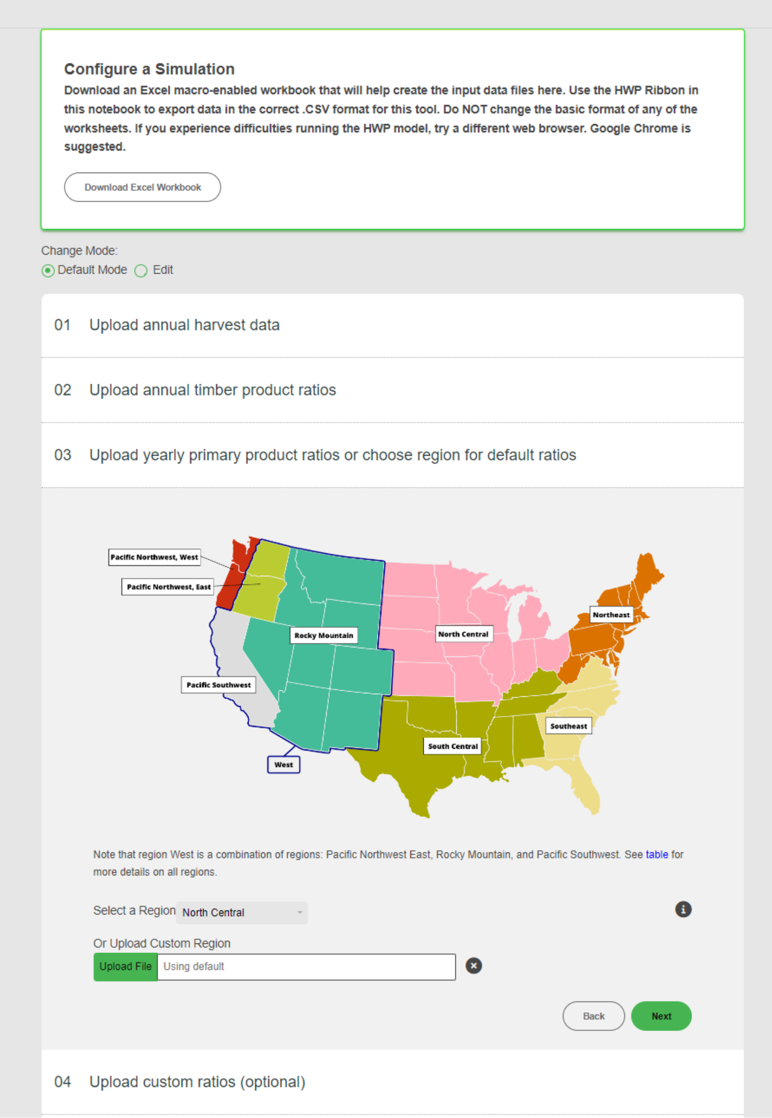
Revised USFS HWP C and NFS Reports / Whitepapers Status

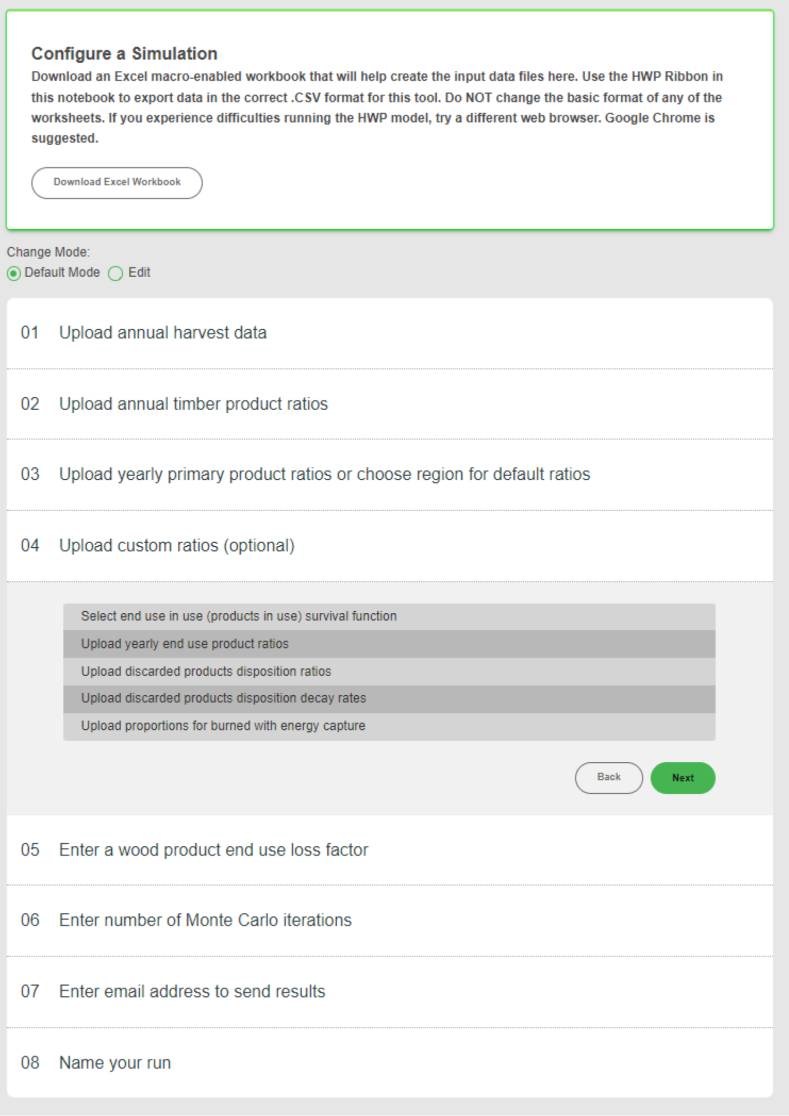
- Harvest data is all compiled and formatted for National Forest System reports
- Draft reports are awaiting model outputs
- Product owner (Keith) expanding and grooming extensive issue backlog into three parts:
  - Minimum viable product (minimum needed for NFS reports)
  - Public version
  - Future versions
- Contract solicitation alost out for more code work w/ USFS CIO addressing backlog issues in the interim
- Drafting user manual for FPL-GTR
- Updated model will be available by 2024




Annual harvest (CCF or MBF)
MBF: CCF ratios, if needed
Timber product ratios
Annual output of timber products (CCF)
Primary product ratios
Annual output of primary products (CCF)
Carbon mass conversion factors
Annual output of primary product carbon (Mg C)
End use ratios
Annual carbon distributed to solid wood & paper end uses
Annual fuelwood
Annual Fuel & Other
Products in use lifespans based on end use half-lives
Recycled
Discard disposition ratios
Loss Factor Discard
Emitted with energy capture
Emitted without energy capture
Burned with energy capture
Burned, using regional energy capture rates
Decay
Compost (if any)
Products in SWDS - landfills and dumps stocks based on percent subject to decay and SWDS half-lives
Slight adjustment
Updated data or process
LEGEND
Solid carbon
Emitted gaseous carbon

USFS HWP C Calculator User Input Screen





Modeling Harvest Time Series

California_Data_Test_Stockmann_7132023

Controls

Choose Harvest Year(s)

All Harvest Years

Single Harvest Year

FILTER

EXPORT

Data Inputs

Email: keith.stockmann@usda.gov

Harvest Data: hwpc-user-inputs/California_Data_Test_Stockmann_7132023-13-07-2023T215534/harvest_data.csv

Harvest Data Type: mbf

MBF to CCF Conversion: Default Data

Official Record: No

End Use Loss Factor: 0.05

Simulation Date: 13-07-2023T215534

Region: Custom

Regions Data: Default Data

Decay Function: Chi

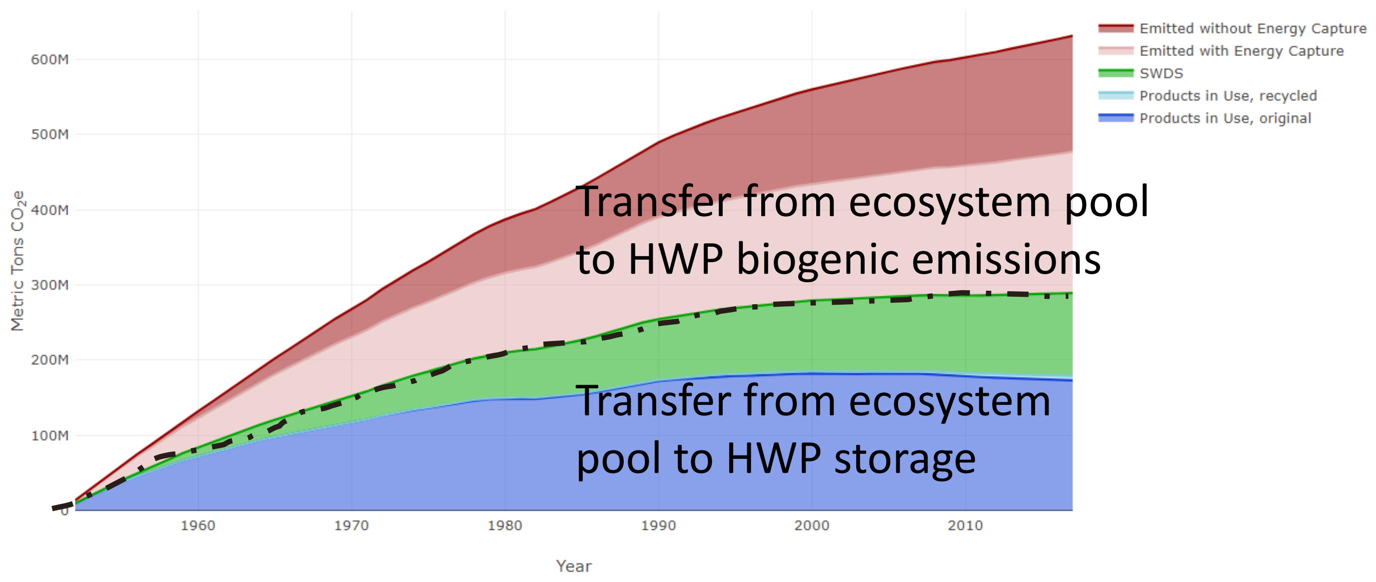
Monte Carlo Iterations: 1

Timber Products Ratio: hwpc-user-inputs/California_Data_Test_Stockmann_7132023-13-07-2023T215534/timber_product_ratios.csv

Primary Products: Default Data

Cumulative Results | Solid Carbon | Emissions | Final Results Table

Final Results



Total cumulative metric tons of carbon stocks in harvested wood products (HWP) manufactured from total timber harvested from 1952 to 2017 using the IPCC Tier 3 Production Approach and Total cumulative metric tons carbon
mitted with and without energy capture. Carbon in HWP includes both products that are still in use and carbon stored at soli
emitted from discarded wood and paper products from landfills is emitted without energy capture. Storage is converted into
isplayed in units of carbon dioxide equivalent (t CO_2e) and do not include other carbon-based greenhouse gases such as me

Modeling Single Year Harvest (1952 only)

Controls

Choose Harvest Year(s)

All Harvest Years

Single Harvest Year

Single Year: 1952

FILTER

EXPORT

Data Inputs

Email: keith.stockmann@usda.gov

Harvest Data: hwpc-user-inputs/California_Data_Test_Stockmann_7132023-13-07-2023T215534/harvest_data.csv

Harvest Data Type: mbf

MBF to CCF Conversion: Default Data

Official Record: No

End Use Loss Factor: 0.05

Simulation Date: 13-07-2023T215534

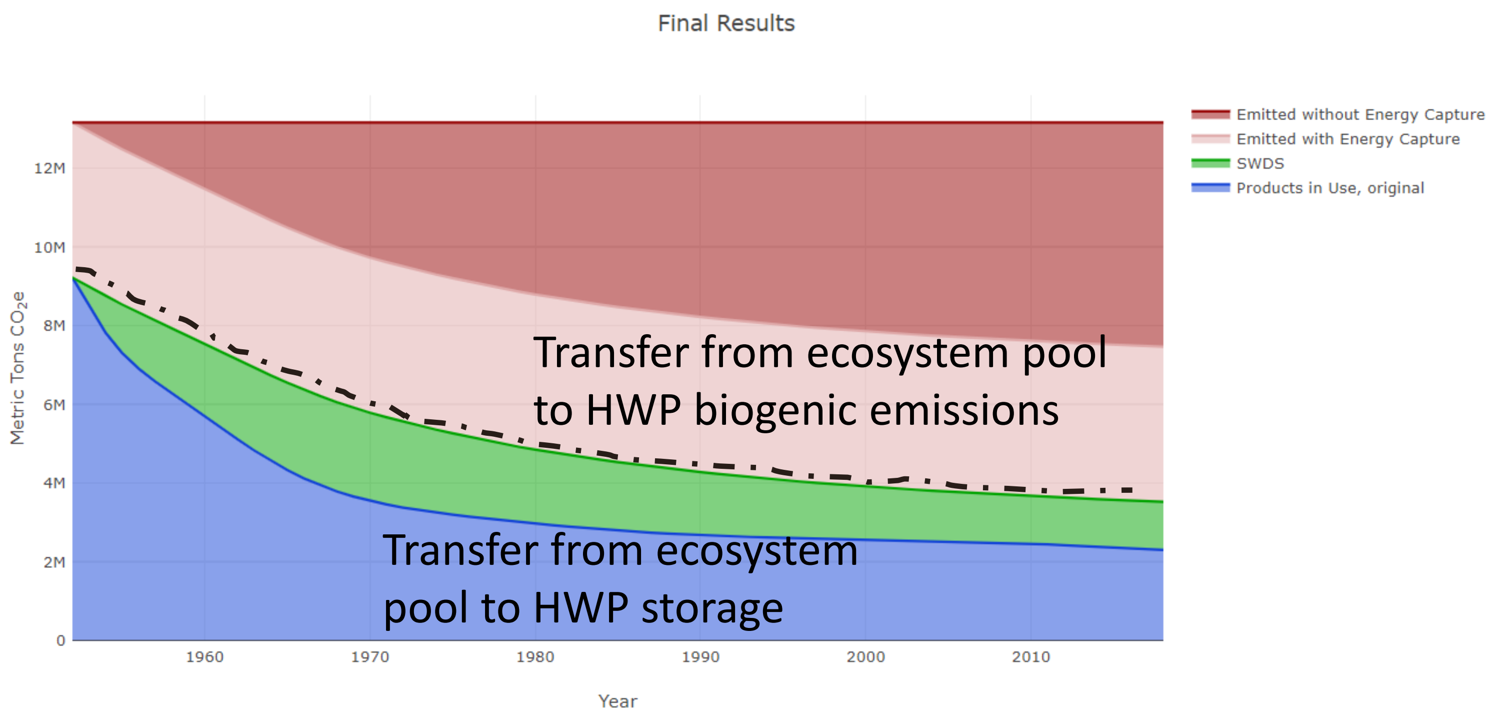
Region: Custom

Regions Data: Default Data

Decay Function: Chi

Monte Carlo Iterations: 1

Timber Products Ratio: hwpc-user-inputs/California_Data_Test_Stockmann_7132023-13-07-



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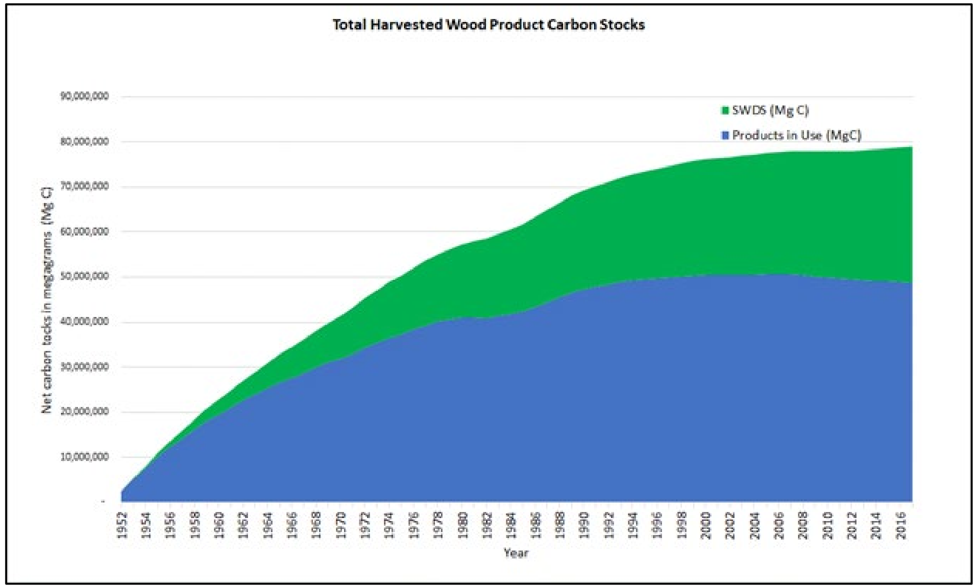
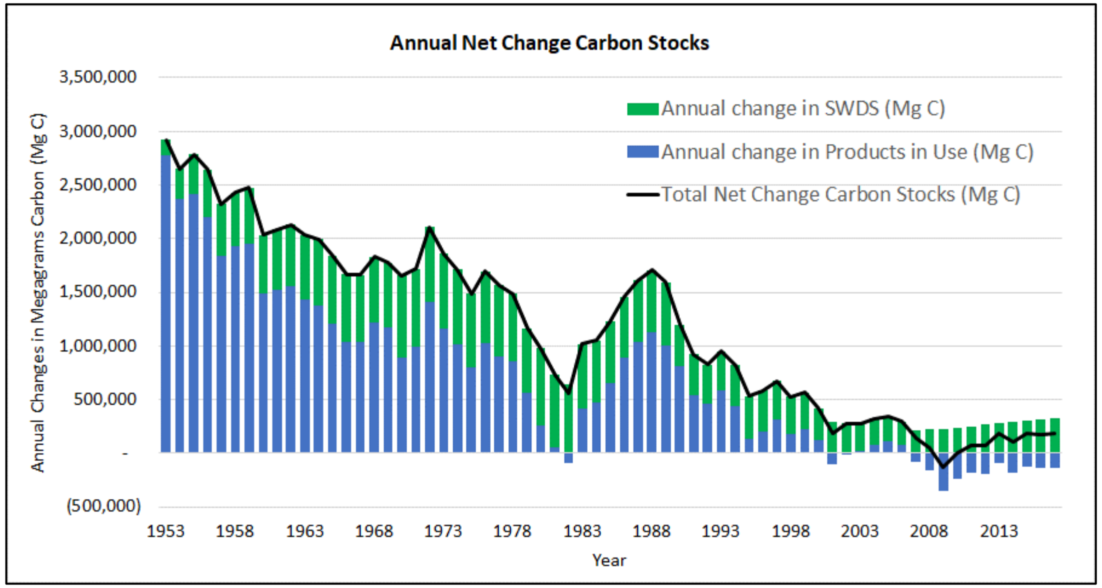
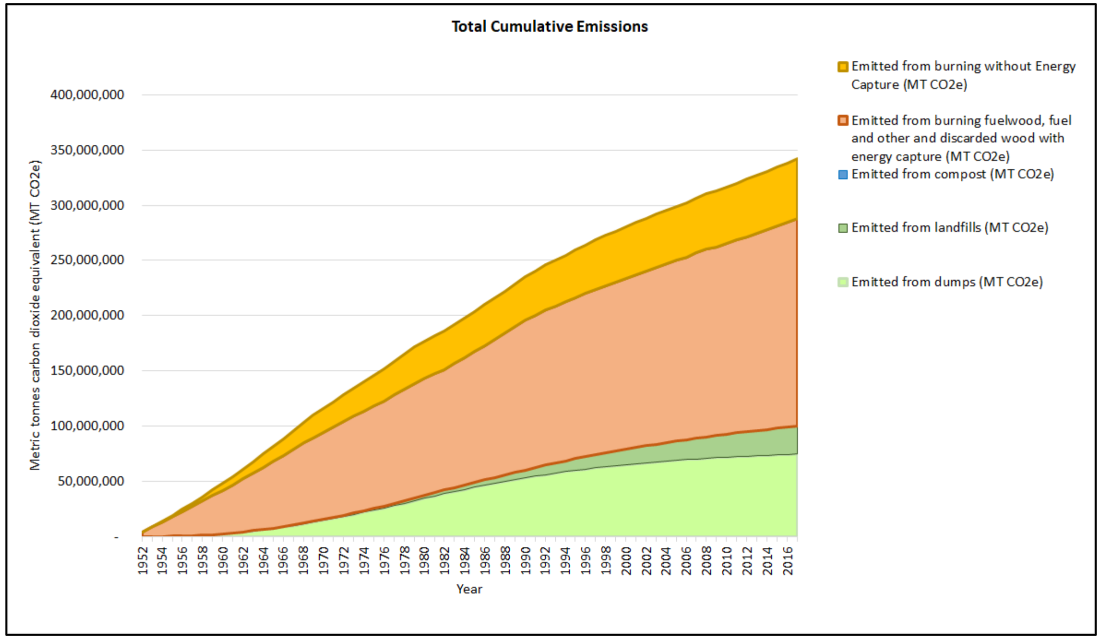
Other USFS HWP C Outputs (GUI with 39-file export folder)





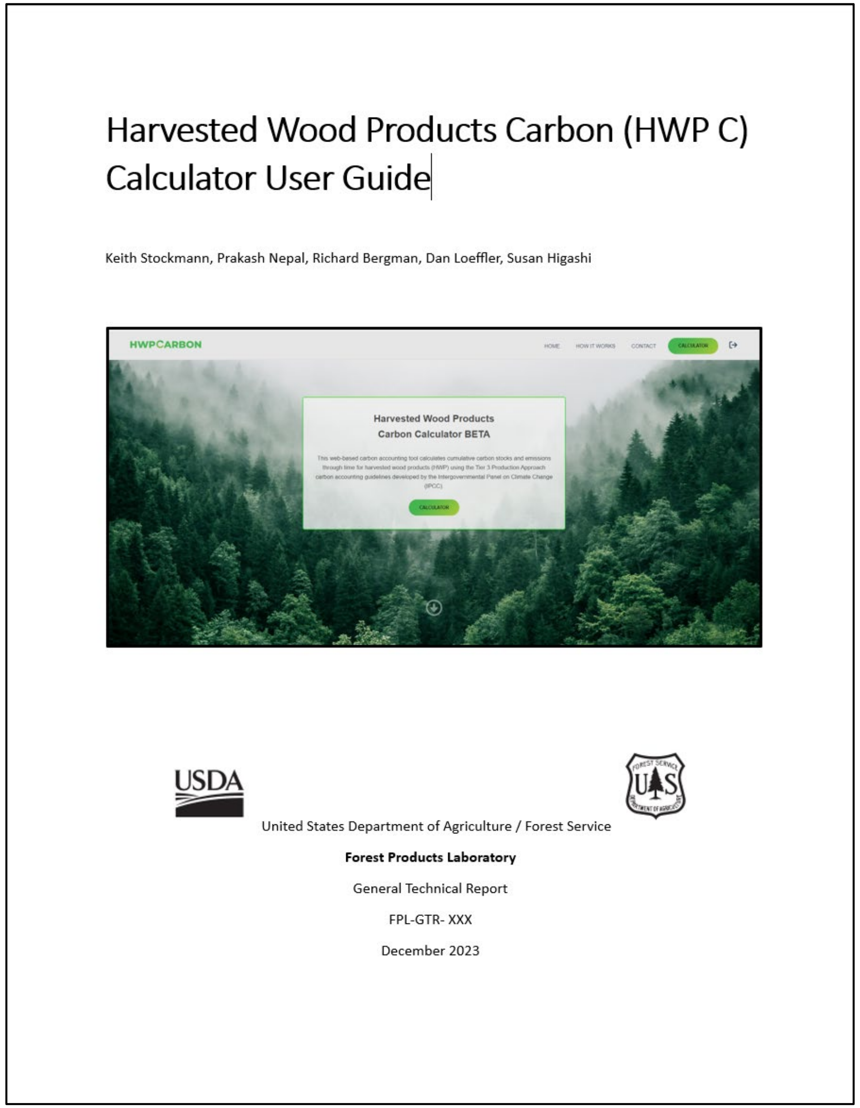
Harvested Wood Product Stocks, Emissions and Annual Net Changes (MT CO2e)

Year	Product in use	Annual change in product in use	SWDS	Annual change in SWDS	Emitted with energy capture	Annual change in emitted with energy capture	Emitted without energy capture	Annual change in emitted without energy capture	Sum of all HWP pools	Annual change in sum of all HWP pools
1952	9,217,749	9,217,749	-	-	3,940,980	3,940,980	-	-	13,158,730	13,158,730
1953	19,415,864	10,198,114	503,849	503,849	8,609,059	4,668,078	215,935	215,935	28,744,706	15,585,977
1954	28,094,682	8,678,818	1,536,548	1,032,699	12,973,206	4,364,147	712,397	496,461	43,316,832	14,572,125
1955	36,944,973	8,850,292	2,902,140	1,365,592	17,660,767	4,687,561	1,460,895	748,499	58,968,775	15,651,943
1956	45,019,931	8,074,958	4,515,648	1,613,509	22,229,093	4,568,326	2,458,146	997,251	74,222,819	15,254,044
1957	51,767,484	6,747,552	6,285,831	1,770,182	26,396,074	4,166,981	3,687,720	1,229,574	88,137,108	13,914,289
1958	58,847,213	7,079,730	8,118,370	1,832,540	30,818,669	4,422,595	5,120,611	1,432,892	102,904,864	14,767,756
1959	66,008,011	7,160,798	10,038,804	1,920,433	35,405,699	4,587,030	6,767,569	1,646,957	118,220,082	15,315,218
1960	71,461,317	5,453,306	12,035,793	1,996,990	39,409,024	4,003,325	8,680,778	1,913,209	131,586,913	13,366,830
1961	77,056,067	5,594,750	14,078,875	2,043,082	43,572,109	4,163,084	10,780,559	2,099,781	145,487,609	13,900,697
1962	82,755,090	5,699,023	16,186,648	2,107,773	47,888,717	4,316,609	13,070,403	2,289,844	159,900,858	14,413,249
1963	88,026,454	5,271,364	18,382,650	2,196,002	52,144,540	4,255,822	15,558,089	2,487,686	174,111,733	14,210,875
1964	93,065,651	5,039,197	20,647,443	2,264,793	56,412,052	4,267,512	18,235,066	2,676,976	188,360,212	14,248,478
1965	97,504,548	4,438,898	22,960,331	2,312,888	60,519,805	4,107,753	21,091,173	2,856,108	202,075,858	13,715,646
1966	101,302,233	3,797,684	25,277,252	2,316,920	64,422,599	3,902,794	24,104,940	3,013,767	215,107,023	13,031,166
1967	105,108,525	3,806,293	27,551,839	2,274,587	68,367,476	3,944,877	27,250,794	3,145,854	228,278,634	13,171,611
1968	109,588,090	4,479,565	29,779,219	2,227,380	72,631,871	4,264,395	30,518,503	3,267,709	242,517,684	14,239,050
1969	113,876,285	4,288,195	31,996,540	2,217,321	75,764,905	3,133,034	33,917,540	3,399,037	255,555,271	13,037,587
1970	117,126,074	3,249,788	34,822,802	2,826,261	78,625,420	2,860,515	36,884,105	2,966,565	267,458,400	11,903,129
1971	120,744,836	3,618,762	37,501,139	2,678,337	81,626,266	3,000,846	39,957,812	3,073,707	279,830,053	12,371,653
1972	125,918,030	5,173,194	40,050,643	2,549,504	85,107,624	3,481,358	43,129,815	3,172,004	294,206,112	14,376,059
1973	130,172,104	4,254,074	42,602,968	2,552,326	87,746,866	2,639,242	46,421,505	3,291,690	306,943,444	12,737,331
1974	133,905,740	3,733,636	45,149,403	2,546,435	90,268,701	2,521,835	49,821,601	3,400,096	319,145,446	12,202,002
1975	136,836,984	2,931,244	47,665,675	2,516,271	92,592,178	2,323,477	53,315,999	3,494,397	330,410,834	11,265,389
1976	140,611,456	3,774,472	50,110,291	2,444,616	95,128,488	2,536,310	56,885,527	3,569,528	342,735,761	12,324,926
1977	143,922,269	3,310,813	52,530,742	2,420,451	98,179,210	3,050,723	60,538,799	3,653,272	355,171,020	12,435,259
1978	147,058,951	3,136,682	54,848,116	2,317,375	101,151,546	2,972,336	64,248,370	3,709,571	367,306,984	12,135,964



Model User Guide GTR Chapter Outline

- ✓Introduction and model background
- ✓Comparison to other carbon models
  - ✓Decision tree for selecting best model
- ✓Quick Start Guide
- ✓Using the Excel data templates
- Integrating HWP results with other forest sector carbon results
- ✓Detailed modeling considerations
- Detailed output interpretation
- ✓Glossary
- References



Harvested Wood Products Carbon (HWP C) Calculator User Guide

Keith Stockmann, Prakash Nepal, Richard Bergman, Dan Loeffler, Susan Higashi

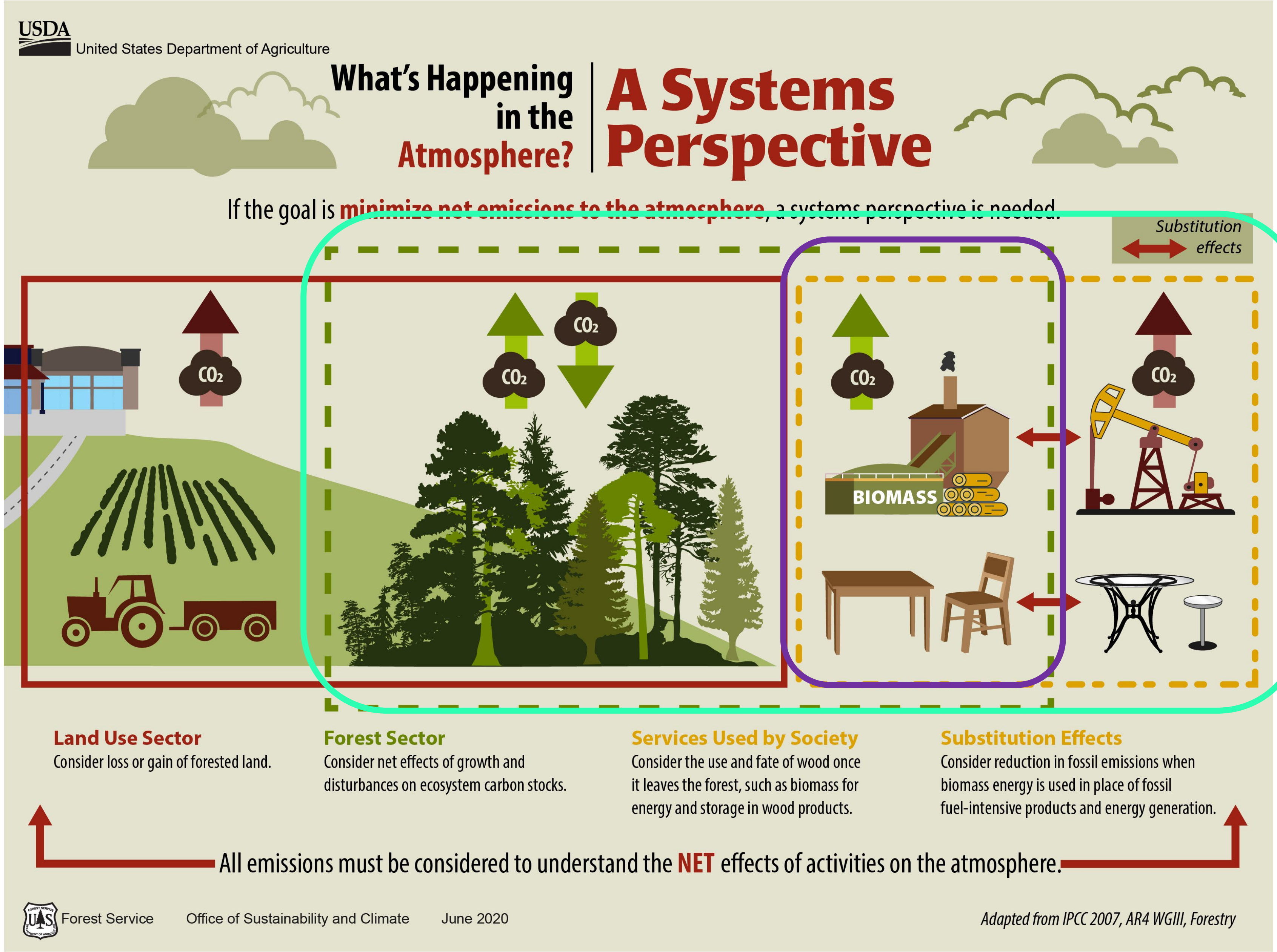
United States Department of Agriculture / Forest Service

Forest Products Laboratory

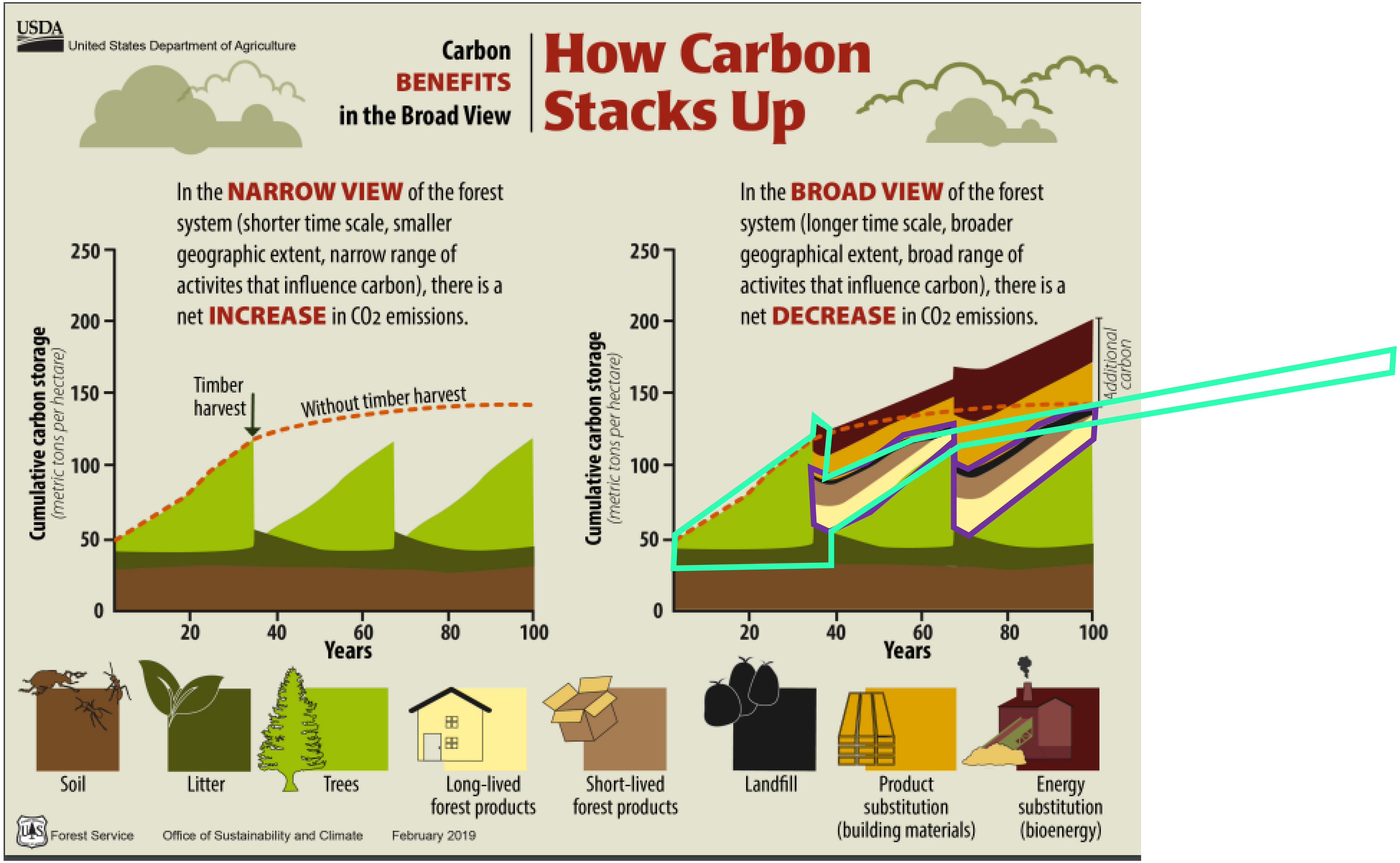
General Technical Report

FPL-GTR- XXX

December 2023



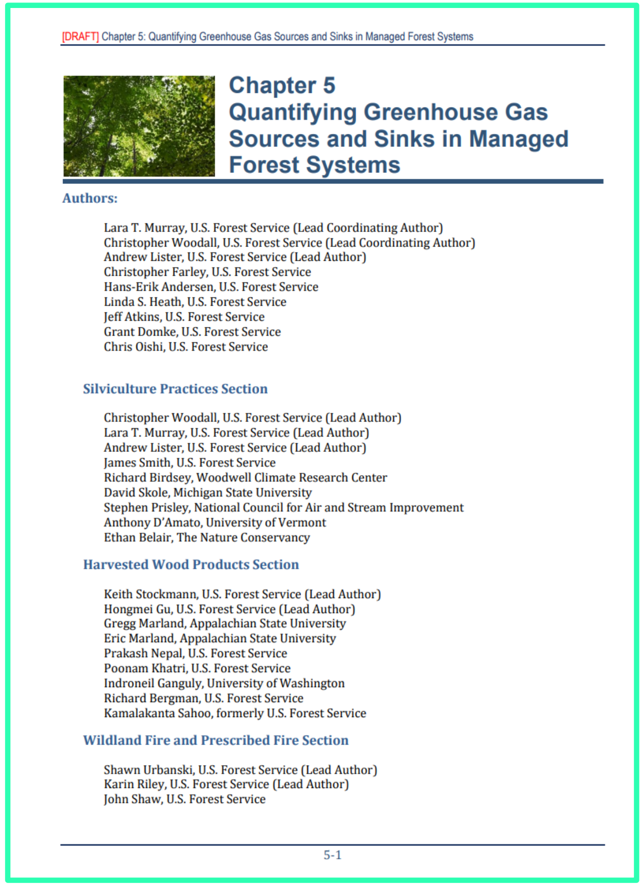
Single Harvest Scenario



USDA
United States Department of Agriculture
Carbon
BENEFITS
in the Broad View
How Carbon
Stacks Up
In the NARROW VIEW of the forest system (shorter time scale, smaller geographic extent, narrow range of activites that influence carbon), there is a net INCREASE in CO2 emissions.
In the BROAD VIEW of the forest system (longer time scale, broader geographical extent, broad range of activites that influence carbon), there is a net DECREASE in CO2 emissions.
Cumulative carbon storage
(metric tons per hectare)
250
200
150
100
50
0
Timber harvest
Without timber harvest
20
40
60
80
100
Years
Additional carbon
Soil
Litter
Trees
Long-lived forest products
Short-lived forest products
Landfill
Product substitution (building materials)
Energy substitution (bioenergy)
Forest Service
Office of Sustainability and Climate
February 2019

USDA OCE GHG Content and Status

- **Work Started December 2021** with Chris Woodall, Lara Murray, Andy Lister, Prakash Nepal, Hongmei Gu, Poonam Khatri, Indroneil Ganguly, Eric Marland, Gregg Marland and others **to revise HWP section of the Managed Forest Systems chapter in the report and build calculators**
  - Text (main body, appendices with Excel tool and demo)
  - Excel has 8 forest management options
  - FIA-based growth and yield estimates, used for harvest if you don't have data
  - Flexible user inputs units (MBF, CCF, Green or Dry Tons, Cords)
  - Blends ecosystem removals, transfer and emissions with HWP transfer and emissions
  - Adds an energy and product potential substitution calculator
  - Includes fire emissions estimates for three severity classes
- Completed Federal Register Review of "Highly Influential Publication" (an OMB designation)
- Reviewed comments and edited September '23
- Publishing expected very soon!



[DRAFT] Chapter 5: Quantifying Greenhouse Gas Sources and Sinks in Managed Forest Systems

Chapter 5
Quantifying Greenhouse Gas Sources and Sinks in Managed Forest Systems

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5-1

GHG Guidelines Level-1 Data Entry for Mgmt. Actions that Involve a Harvest

Harvest Area
Acres or Hectares

US Region
C, GP, NE, NLS, PNW E, PNW W, PS, RMN, RMS, SC, SE

Forest Type
(pick list by region, or unknown)

Do you know your harvest volume?

YES

Volume Units
Total or Per Acre

Volume Data
CCF, MBF, Dry Tons, Green Tons or Cords

Wood Type
Softwood, Hardwood, Unknown

Log Type
Sawlog, Pulpwood, Fuelwood, Unknown

Or

NO

History
Planted, Natural or Unknown

Age Class
0-20, 21-40, 41-60, 61-80, 81-100, 100+, Unknown

X

FIA Commercial Volume per Area in CCF

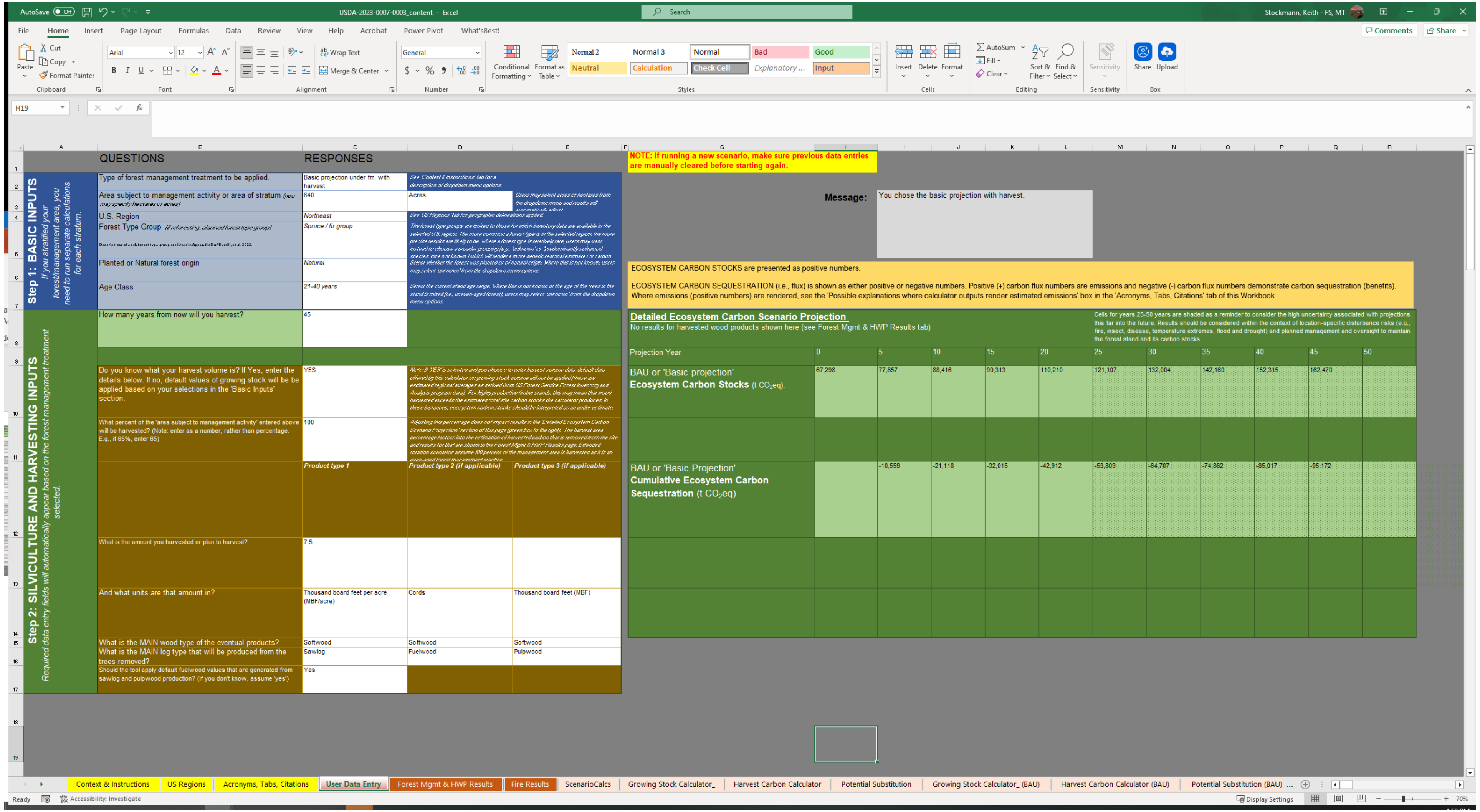
X

Percent of Harvest Area Trees you will cut

Add Fuelwood Volume
Yes (default) or No

Harvest Volume Data (CCF of MBF) by Timber Product Categories
(e.g., Softwood sawlog, Fuelwood, Rail ties, etc.

USDA GHG Calculators



USDA
GHG Calculators

Basic projection under fm, with harvest

- Select a management treatment
- Basic projection under forest maintenance (fm)
- Basic projection under fm, with harvest
- Extended rotation
- Reforestation (natural)
- Reforestation (planted)
- Avoided deforestation
- Harvest
- Fire (prescribed or natural)

	QUESTIONS	RESPONSES		
Step 1: BASIC INPUTS *If you stratified your forest/management area, you need to run separate calculations for each stratum.*	Type of forest management treatment to be applied.	Basic projection under fm, with harvest	*See 'Context & Instructions' tab for a description of dropdown menu options.*	
	Area subject to management activity or area of stratum *(you may specify hectares or acres)*	640	Acres	*Users may select acres or hectares from the dropdown menu and results will automatically adjust.*
	U.S. Region	*Northeast*	*See 'US Regions' tab for geographic delineations applied.*	
	Forest Type Group *(if reforesting, planned forest type group)* Descriptions of each forest type group are listed in Appendix D of Burrill, et al. 2022.	*Spruce / fir group*	*The forest type groups are limited to those for which inventory data are available in the selected U.S. region. The more common a forest type is in the selected region, the more precise results are likely to be. Where a forest type is relatively rare, users may want instead to choose a broader grouping (e.g., 'unknown' or "predominantly softwood species, type not known') which will render a more generic regional estimate for carbon*	
	Planted or Natural forest origin	*Natural*	*Select whether the forest was planted or of natural origin. Where this is not known, users may select 'unknown' from the dropdown menu options*	
	Age Class	*21-40 years*	*Select the current stand age range. Where this is not known or the age of the trees in the stand is mixed (i.e., uneven-aged forest), users may select 'unknown' from the dropdown menu options.*	
Step 2: SILVICULTURE AND HARVESTING INPUTS *Required data entry fields will automatically appear based on the forest management treatment selected.*	How many years from now will you harvest?	45		
	Do you know what your harvest volume is? If Yes, enter the details below. If no, default values of growing stock will be be applied based on your selections in the 'Basic Inputs' section.	YES	*Note: If 'YES' is selected and you choose to enter harvest volume data, default data offered by this calculator on growing stock volume will not be applied (these are estimated regional averages as derived from US Forest Service Forest Inventory and Analysis program data). For highly productive timber stands, this may mean that wood harvested exceeds the estimated total site carbon stocks the calculator produces. In these instances, ecosystem carbon stocks should be interpreted as an under-estimate.*	
	What percent of the 'area subject to management activity' entered above will be harvested? (Note: enter as a number, rather than percentage. E.g., if 65%, enter 65)	100	*Adjusting this percentage does not impact results in the 'Detailed Ecosystem Carbon Scenario Projection' section of this page (green box to the right). The harvest area percentage factors into the estimation of harvested carbon that is removed from the site and results for that are shown in the Forest Mgmt & HWP Results page. Extended rotation scenarios assume 100 percent of the management area is harvested as it is an even-aged forest management practice.*	
		Product type 1	***Product type 2 (if applicable)***	***Product type 3 (if applicable)***
	What is the amount you harvested or plan to harvest?	7.5		
	And what units are that amount in?	Thousand board feet per acre (MBF/acre)	Cords	Thousand board feet (MBF)
	What is the MAIN wood type of the eventual products?	Softwood	Softwood	Softwood
	What is the MAIN log type that will be produced from the trees removed?	Sawlog	Fuelwood	Pulpwood
	Should the tool apply default fuelwood values that are generated from sawlog and pulpwood production? (if you don't know, assume 'yes')	Yes		

USDA GHG Calculators

ECOSYSTEM CARBON STOCKS are presented as positive numbers.

ECOSYSTEM CARBON SEQUESTRATION (i.e., flux) is shown as either positive or negative numbers. Positive (+) carbon flux numbers are emissions and negative (-) carbon flux numbers demonstrate carbon sequestration (benefits). Where emissions (positive numbers) are rendered, see the 'Possible explanations where calculator outputs render estimated emissions' box in the 'Acronyms, Tabs, Citations' tab of this Workbook.

Detailed Ecosystem Carbon Scenario Projection

No results for harvested wood products shown here (see Forest Mgmt & HWP Results tab)

Cells for years 25-50 years are shaded as a reminder to consider the high uncertainty associated with projections this far into the future. Results should be considered within the context of location-specific disturbance risks (e.g., fire, insect, disease, temperature extremes, flood and drought) and planned management and oversight to maintain the forest stand and its carbon stocks.

Projection Year	0	5	10	15	20	25	30	35	40	45	50
BAU or 'Basic projection' **Ecosystem Carbon Stocks** (t CO_2eq).	67,298	77,857	88,416	99,313	110,210	121,107	132,004	142,160	152,315	162,470	
BAU or 'Basic Projection' **Cumulative Ecosystem Carbon Sequestration** (t CO_2eq)		-10,559	-21,118	-32,015	-42,912	-53,809	-64,707	-74,862	-85,017	-95,172	

USDA
GHG Results

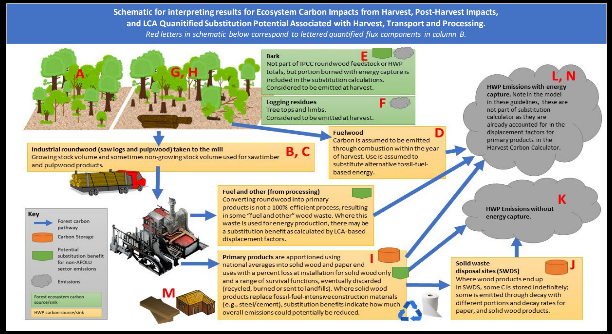
CARBON STOCKS are presented as positive numbers.

CARBON FLUX is shown as either positive or negative numbers. Positive (+) carbon flux numbers are emissions and negative (-) carbon flux numbers demonstrate

Explanation of results

ECOSYSTEM CARBON IMPACTS From Management/Silviculture Practices		
Carbon sequestration in living and dead carbon pools (not soil) (t CO_2eq)	-95,172	Basic projection under fm, with harvest at 45 years; (t CO2eq)

ECOSYSTEM CARBON IMPACTS From Harvest		
A. Total Site pre-harvest CARBON STOCKS (not including soil) (t CO_2eq)	162,470	Includes growing stock and non-growing stock live and dead carbon pools, including soil and belowground C
B. CARBON STOCKS in saw logs harvested (t CO_2eq)	17,709	If harvest volumes were provided in 'User Data Entry' tab, this number is the carbon content in the wood volumes entered. If harvest volumes are not known, this number is derived from calculations with a starting point of the default FIA-derived growing stock volume. See growing stock calculator for details.
C. CARBON STOCKS in pulpwood harvested (t CO_2eq)	0	If harvest volumes were provided in 'User Data Entry' tab, the number was converted to carbon content from volumes entered. If harvest volumes are not known, this number is derived from the default FIA-derived growing stock volume, combined with Johnson 2001 tables to account for potential pulpwood volume not included in growing stock volume estimates. See growing stock calculator for details.
D. CARBON STOCKS in fuelwood harvested (t CO_2eq)	2,428	If fuelwood harvest volumes were provided in 'User Data Entry' tab, the number was converted to carbon content from volumes entered. If fuelwood harvest volumes were not entered, but the user selects to add fuelwood, this number is derived from regional averages (softwood and hardwood) for fuelwood relative to industrial roundwood (salogs and pulpwood). Assumed to be emitted year of harvest.
E. Emissions from bark (t CO_2eq)	3,667	Estimated using regional estimates for bark carbon relative to wood carbn. Assumed to be used for energy, offering a potential substitution benefit.
F. Emissions from logging resuides left on site (t CO_2eq - stumps, branches needles, defect and non-growing stock trees cut to access growing stock, left on site)	5,289	Stumps, branches needles, defect and non-growing stock trees cut to access growing stock, left on site. Assumed to be emitted year of harvest.
G. CARBON STOCKS in medium and large growing stock remaining in forest (t CO_2eq)	0	Carbon stocks are left on site post-harvest. Extended rotation activities are assumed to be a clear cut.
H. CARBON STOCKS in other above ground carbon in the ecosystem (t CO_2eq)	133,377	Total site carbon pre-harvest minus the total carbon in wood removed, fuelwood, bark, logging residues, and medium and large growing stock trees left on site.



POST HARVEST CARBON IMPACTS		
ChiSquare Decay Function	Year 0 post-harvest	By Year 100 Post-Harvest
I. CARBON STOCKS in HWP in Use (t CO_2eq)	10,084	848
J. CARBON STOCKS in HWP in SWDS (t CO_2eq)	0	4,977
K. AFOLU HWP emissions (t CO_2eq) (cumulative burned without energy capture, emissions shown as positive)	0	2,017
L. AFOLU HWP emissions (t CO_2eq) (cumulative burned with energy capture, emissions shown as positive)	10,053	12,295
TOTAL HWP Biogenic Carbon Stored from Harvest (t CO_2eq)	10,084	5,824

TOTAL AFOLU (Forest) BIOGENIC CARBON STOCK CHANGE (FLUX) from Management Action and Harvest (t CO_2eq).	**-76,163**	This is the estmiated stock change (flux) in AFOLU sector carbon and equals net ecosystem exchange (negative sequesration or zero sequestration) plus bark and logging residues emitted, plus harvested sawlogs, pulpwood and fuelwood minus annual stock change in harvested wood products in use and SWDS year zero. The difference between total harvest and change in HWP equals HWP emissions with and without energy capture combined. A total carbon balance estimate at 100 years post-harvest was intentionally not provided because ecosystem side projections for up to 100 years post harvest are not provided in the calculator due to the high uncertainties associated with projecting post-harvest site carbon flux that far into the future.

Quantified substitution benefits occur outside of the AFOLU sector and are intentionally presented separately and not combined with the AFOLU total above.

LCA Quanitified Substitution Potential Associated with Harvest, Transport and Processing

Potential Substitution Benefits (CO_2 equivalent emissions avoided when wood substitutes non-wood fossil-based alternatives, a unitless factor estimated for cradle-to-gate life stages covering resource extraction, transportation and manufacturing).

These are estimated by comparing the LCA-quantified cradle-to-gate GHG emissions for wood products (and bark) against their functionally equivalent non-wood alternatives. GHG emissions per life stage of wood products are provided in the 'Potential Substitution' Tab of the workbook. We show electricity here, as it is the most conservative esitmate compared to three thermal energy substitution options (coal, gas, or heating oil).

	Cradle to Gate, Year 0
M. Products (t CO_2eq)	-11,384
N. Bioenergy (t CO_2eq) from fuelwood (electricity)	-1,247

USDA GHG Results

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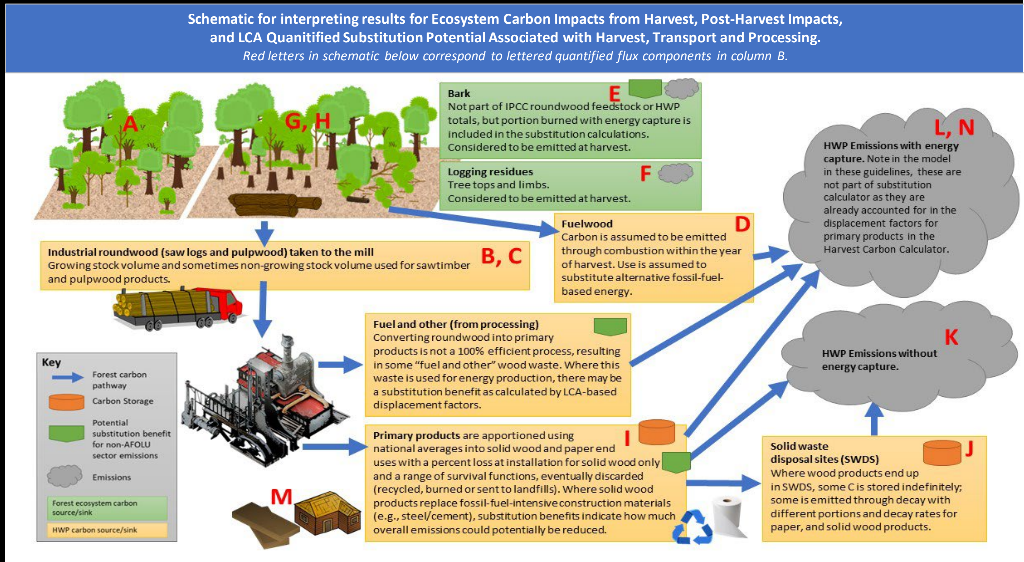

USDA
GHG Results

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Potential Substitution Benefits (CO_2 equivalent emissions avoided when wood substitutes non-wood fossil-based alternatives, a unitless factor estimated for cradle-to-gate life stages covering resource extraction, transportation and manufacturing).

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Potential Substitution Calculator

Products Produced from Harvest Calculato	Softwood Lumber Carbon (Mg)	Hardwood Lumber (Mg)	Softwood Plywood (Mg)	Hardwood Plywood (Mg)	OSB (Mg)	Non-structural panels (Mg)	Other industrial products (Mg)	Wood Pulp (Mg)	Total Processed Storage (Mg)	Fuelwood Emissions by this year (Mg)	Percent of HWP Emitted by this year	Bark biogenic emissions year of harvest with energy capture (Co2E)	Bark biogenic emissions year of harvest without energy capture (CO2E)	Percent of Bark emitted by this year
Amounts (Mg = Metric Tons)	1,886.500	-	19.299	-	-	96.496	400.459	347.386	2,750.140	662	50%	2,243	1,424	100%
	Results - Potential Cradle to Gate Substitution Factors and Effects (C02E)											**Results Potential Bark Substitution**		
	Displacement Factors													
Alternative Products Produced	Alternative Product: Steel Studs	Alternative Product: Doors	Alternative Product: Stutural Elements	Alternative Product: Stutural Elements	Alternative Product: Stutural Elements	Alternative Product: Non-Stuctural Elements	Alternative Product: Non-Stuctural Elements	Alternative Product: Non-Construction Uses	Total	Electricity		Electricity		
Substitution factors (CO2e emissions avoided from wood substitution of non-wood fossil-based alternatives, estimated for cradle-to-gate life stages (Here negative implies reduced emissions potential)	-0.99	-2.29	-1.3	-1.3	-1.3	-1.6	-1.6	-1.2		-0.267		-0.267		
Displacement Benefits (Here negative implies reduced emissions potential; this differs from how positive and negative are typically shown in LCA results, but it is consistent with our use of negative and positive elsewhere in our results.)	(6,848)	-	(92)	-	-	(566)	(2,349)	(1,528)	**(11,384)**	**(648)**		**(599)**		
										Anthrocite Coal		Anthrocite Coal		
										-0.68		-0.68		
										(1,651)		(1,525)		
										Heating Oil		Heating Oil		
										-0.57		-0.57		
										(1,384)		(1,279)		
										Natural Gas		Natural Gas		
										-0.45		-0.45		
										(1,093)		(1,010)		

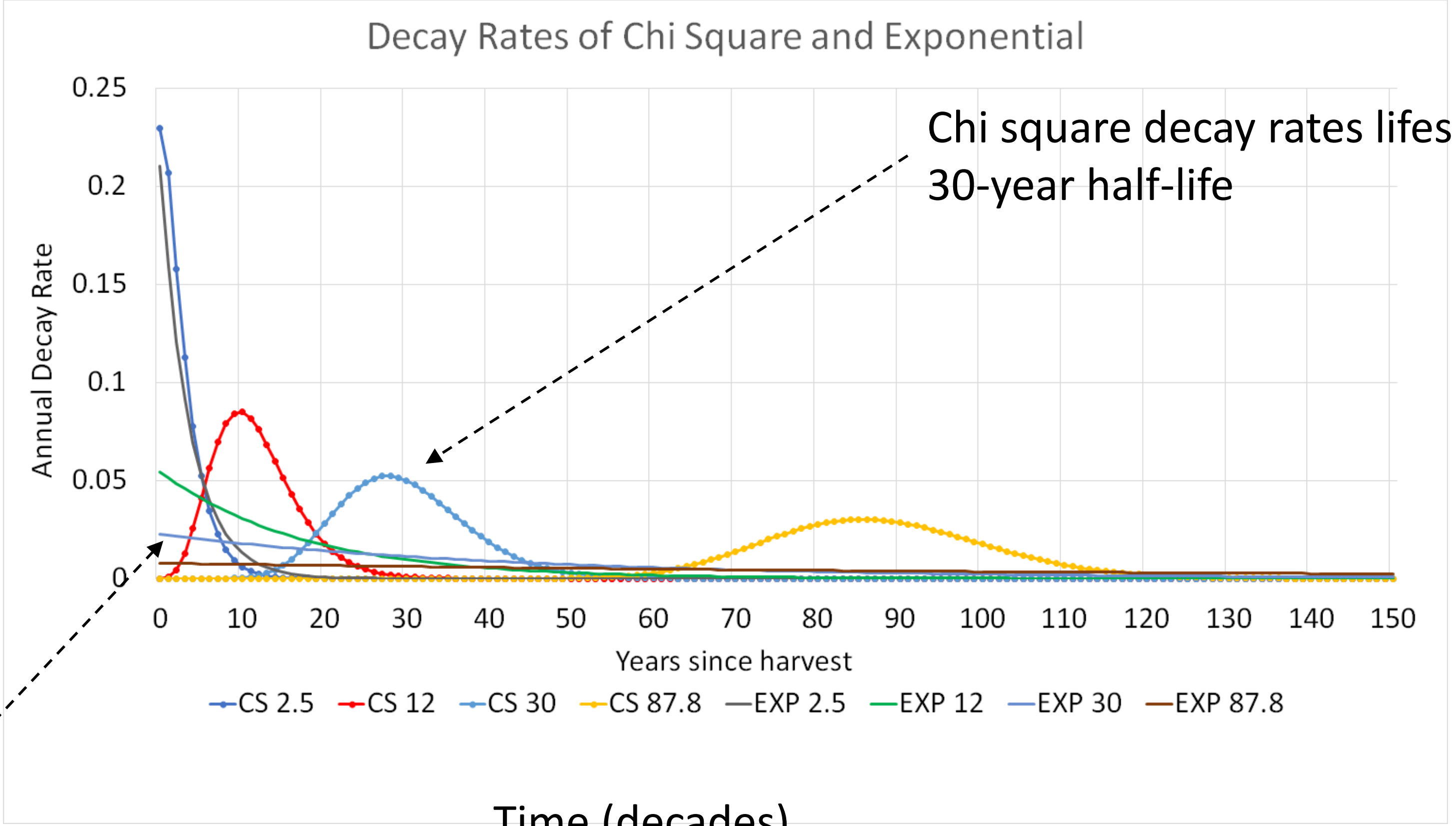
	Results - Emissions Outside the Biogenic HWP Carbon Storage or Flux								
Products Produced from Harvest Calculato	Softwood Lumber Carbon (Mg)	Hardwood Lumber (Mg)	Softwood Plywood (Mg)	Hardwood Plywood (Mg)	OSB (Mg)	Non-structural panels (Mg)	Other industrial products (Mg)	Wood Pulp (Mg)	Total Processed Emissions without Wood Pulp
Metric Tons of Products Produced (t)	1,886.500	-	19.299	-	-	96.496	400.459	347.386	
Metric Tons CO2e of Products Produced (t	6,917.166	-	70.764	-	-	353.819	1,468.350	1,273.749	
LCA Quantified GHG Emissions from Cultivation and Harvest (t CO2eq)	0.015	0.024	0.077	0.077	0.071	0.205	0.055	No Data	
Results	104	-	5	-	-	73	81		262
LCA Quantified GHG Emissions from Transportation to the Mill (t CO2eq)	0.012	0.028	0.012	0.012	0.006	0.006	0.037	No Data	
Results	83	-	1	-	-	2	54		140
LCA Quantified GHG Emissions from Wood Processing (t CO2eq)	0.061	0.096	0.173	0.173	0.136	0.241	0.056	No Data	
Results	422	-	12	-	-	85	82		602
Total LCA Quantified GHG Emissions from Wood Cultivation, Harvest, Transportation and Processing (t CO2eq)	0.09	0.15	0.26	0.26	0.21	0.45	0.15	No Data	
Results	**609**	**-**	**19**	**-**	**-**	**160**	**217**		**1,004**

New Hybrid Smith et al (2006) Skog (2008) Half-lives

				Smith et al (2006)	Smith et al 2006 and Skog 2008 with 20 year increases						
End Use ID	Timber Product	Primary Product	End Use Product	End Use Half Life	Pre 1920	1921-39	1940-59	1960-79	1980-99	2000-19	2020-39
1	hardwood, sawtimber	fuelwood and other	fuelwood and other	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	hardwood, sawtimber	lumber	manufacturing, other manufacturing	12	12.0	12.0	12.0	12.0	12.0	12.0	12.0
3	hardwood, sawtimber	lumber	rail and railcar, n/a	12	12.0	12.0	12.0	12.0	12.0	12.0	12.0
4	hardwood, sawtimber	lumber	packaging and shipping, n/a	6	6.0	6.0	6.0	6.0	6.0	6.0	6.0
5	hardwood, sawtimber	lumber	manufacturing, furniture	30	30.0	30.0	30.0	30.0	30.0	30.0	30.0
6	hardwood, sawtimber	lumber	other, n/a	12	12.0	12.0	12.0	12.0	12.0	12.0	12.0
7	hardwood, sawtimber	lumber	new nonresidential, other	67	67.0	67.0	67.0	67.0	67.0	67.0	67.0
8	hardwood, sawtimber	lumber	new nonresidential, new nonres buildings	67	67.0	67.0	67.0	67.0	67.0	67.0	67.0
9	hardwood, sawtimber	lumber	residential r and r, n/a	30	23.1	23.1	23.7	24.3	24.9	25.5	26.1
10	hardwood, sawtimber	lumber	new housing, manufactured housing	12	12.0	12.0	12.0	12.0	12.0	12.0	12.0
11	hardwood, sawtimber	lumber	new housing, single family	100	78.0	78.0	80.0	81.9	83.9	85.9	87.8
12	hardwood, sawtimber	lumber	new housing, multifamily	70	47.7	47.7	48.9	50.1	51.3	52.5	53.7
13	hardwood, sawtimber	non-structural panels	manufacturing, other manufacturing	12	12.0	12.0	12.0	12.0	12.0	12.0	12.0
14	hardwood, sawtimber	non-structural panels	new housing, multifamily	70	47.7	47.7	48.9	50.1	51.3	52.5	53.7
15	hardwood, sawtimber	non-structural panels	new housing, single family	100	78.0	78.0	80.0	81.9	83.9	85.9	87.8
16	hardwood, sawtimber	non-structural panels	residential r and r, n/a	30	23.1	23.1	23.7	24.3	24.9	25.5	26.1
17	hardwood, sawtimber	non-structural panels	new nonresidential, new nonres buildings	67	67.0	67.0	67.0	67.0	67.0	67.0	67.0
18	hardwood, sawtimber	non-structural panels	new nonresidential, other	67	67.0	67.0	67.0	67.0	67.0	67.0	67.0
19	hardwood, sawtimber	non-structural panels	rail and railcar, n/a	12	12.0	12.0	12.0	12.0	12.0	12.0	12.0
20	hardwood, sawtimber	non-structural panels	manufacturing, furniture	30	30.0	30.0	30.0	30.0	30.0	30.0	30.0
21	hardwood, sawtimber	non-structural panels	new housing, manufactured housing	12	12.0	12.0	12.0	12.0	12.0	12.0	12.0
22	hardwood, sawtimber	non-structural panels	packaging and shipping, n/a	6	6.0	6.0	6.0	6.0	6.0	6.0	6.0
23	hardwood, sawtimber	non-structural panels	other, n/a	12	12.0	12.0	12.0	12.0	12.0	12.0	12.0
24	hardwood, sawtimber	oriented strandboard (OSB)	new housing, multifamily	70	47.7	47.7	48.9	50.1	51.3	52.5	53.7
25	hardwood, sawtimber	oriented strandboard (OSB)	rail and railcar, n/a	12	12.0	12.0	12.0	12.0	12.0	12.0	12.0
26	hardwood, sawtimber	oriented strandboard (OSB)	new housing, single family	100	78.0	78.0	80.0	81.9	83.9	85.9	87.8

Exponential <u>and</u> chi square lifespans for wood products

Amount remaining each year

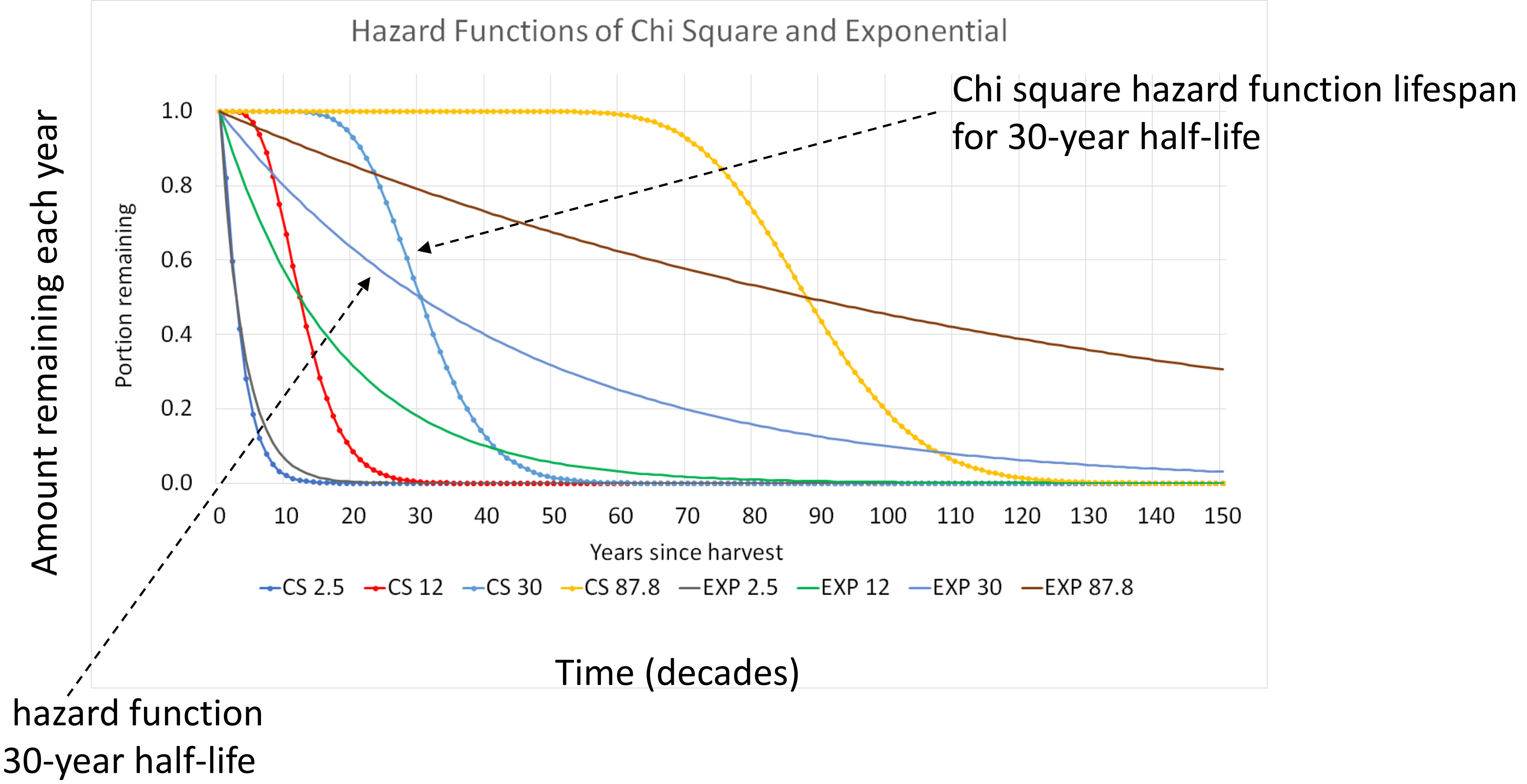


Chi square decay rates lifespan for 30-year half-life

Time (decades)

Exponential decay rates lifespan for 30-year half-life

Exponential and chi square lifespans for wood products



Impacts of National Scale Volume and Biomass (NSVB) on Forest Sector Carbon Modeling

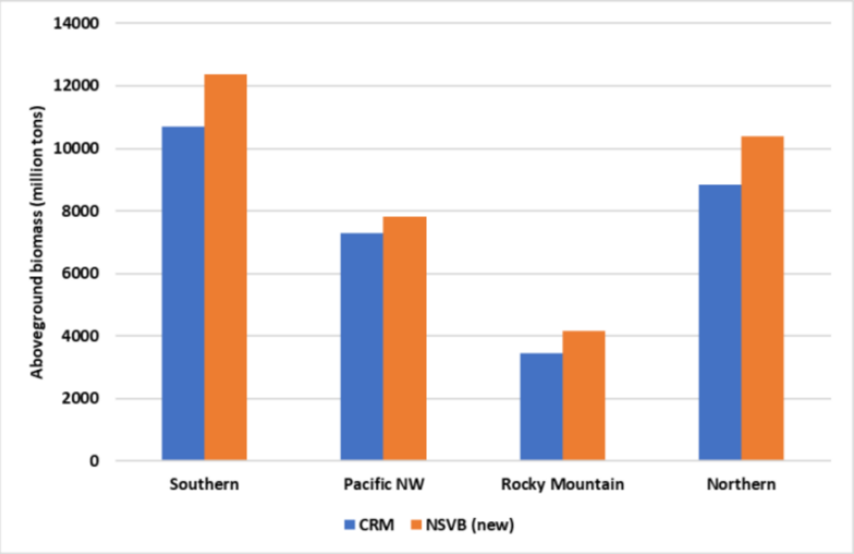


Figure 1. Total above ground biomass estimates based on current and new modeling systems by regional FIA unit. The blue 'CRM' bars refer to the legacy Component Ratio Method (CRM) and the orange 'NSVB (new)' bars refer to the updated National Scale Volume and Biomass (NSVB) estimators.

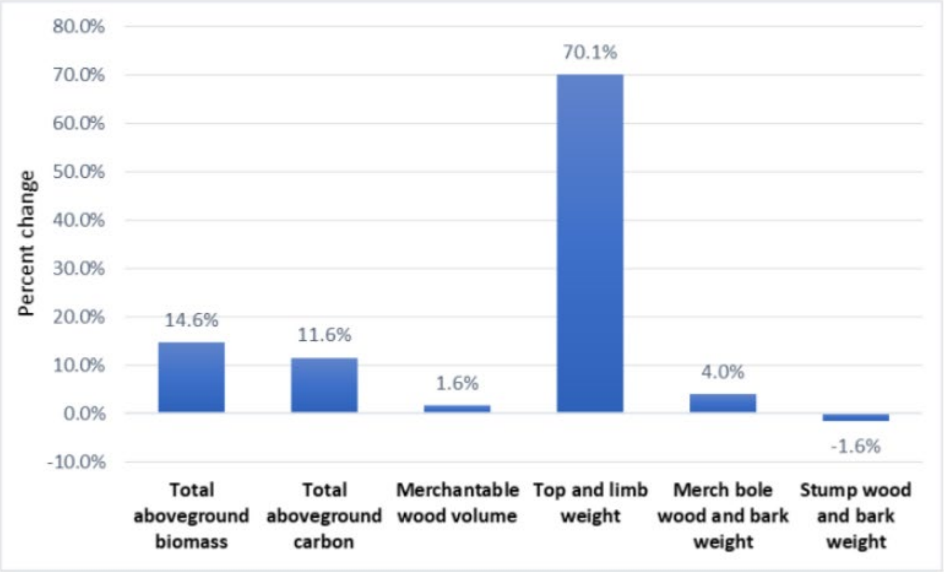


Figure 2. Percent increase in wood volume and biomass by component due to updated NSVB estimators.

Bottom line: more carbon in this modeling system, with large percentage increases focused in top and limb -ecosystem /logging residue emissions

Notable Efforts - Updating Important HWP Datasets

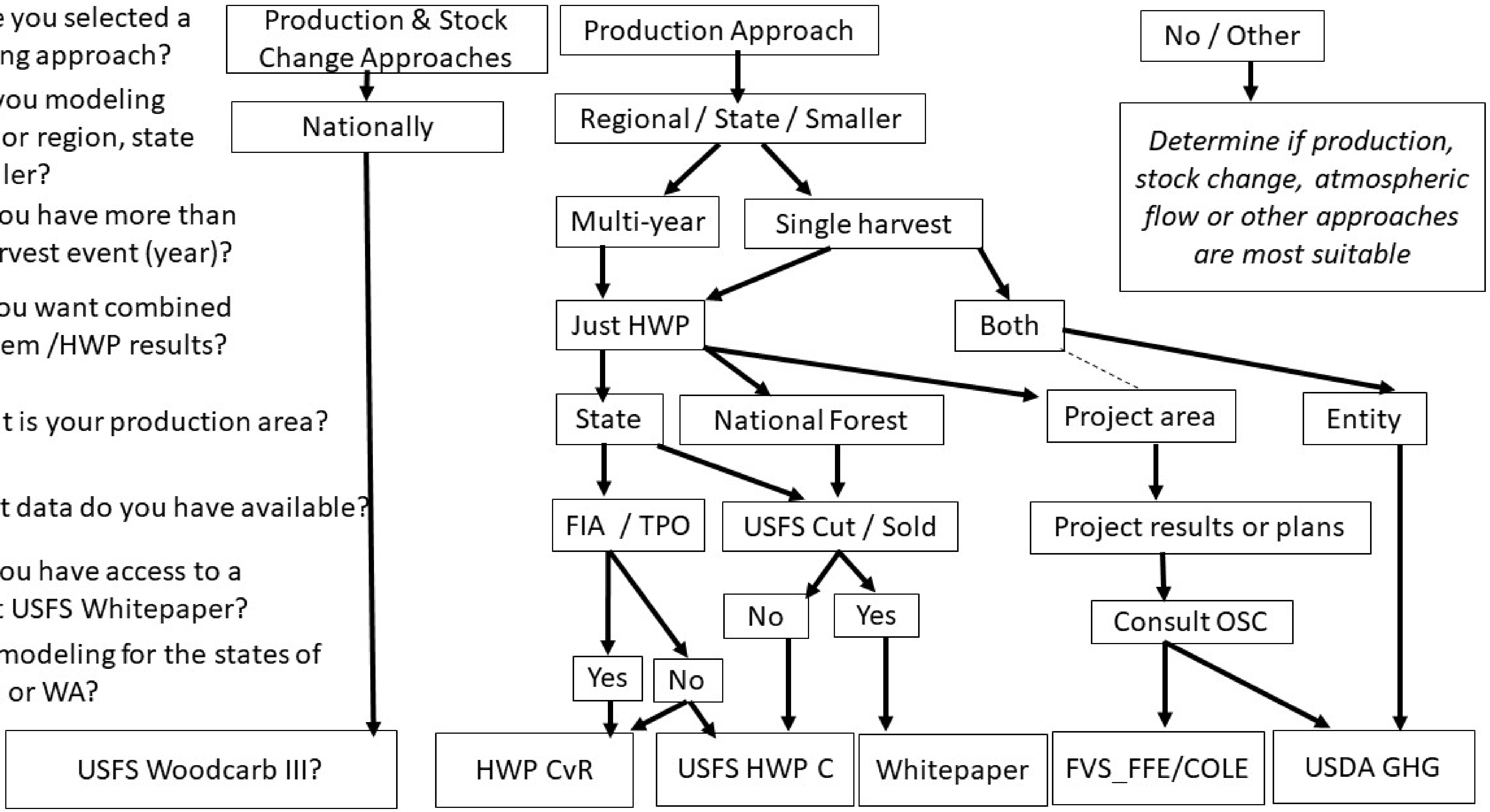
- Harvest data – Comprehensive NFS, working towards automatic cut/ sold updates to keep reporting current
- Timber product classes – Developing TPO HWP C crosswalk
- Primary products (2006) – No current activity, maybe look at timber processing areas?
- Primary product volume to carbon Mass - Carbon quantity by species? New FIA NSVB?
- Primary product end uses (2011) – Some efforts starting up by CALFIRE/ FPL
- Lifespan modeling – GHG developed chi square survival functions, but need more specific and updated half-lives (cite actual dates for estimates) Prakash Nepal at Forest Products Lab maybe tackling this soon
- Discard modeling (2018 EPA)
- Recycling (2018 EPA) - Into what end uses? How many rounds? Need slimmer code to improve model run times
- Burning with Energy Capture (2006) – no current activity, needs an update to include
- Landfill permanent storage and emissions – Should update Smith et al (2006) and 2018 EPA) – understanding other gasses
- Logging residues – need a better understand logging residue disposal and transfer to other ecosystem pools. Better understanding of bark
- Need displacement factors for more wood products and their functionally equivalent products

Comparing Carbon Models – Looking for Help!

DRAFT		HWP Cabon Modeling System				
		USFS HWP C	**HWP C vR**	**USDA GHG Entity**	**Woodcarb II**	**FVS or FVS_FFE**
Attributes	**Access**	Public website then, PIV Card or Login.gov	Public webpage	Public webpage?	No	Free Download
	Scale	National (aggegated regions or states) NFS Region, Forest, US State or Entity	National (aggegated regions or states) NFS Region, Forest, US State or Entity	**Enity (land owner)**	Country	Project or Subproject
	Harvest Events (years)	Multiple	Multiple	Single	Single	Single
	Design data source	**USFS Cut/ Sold (CCF) or TPO (MBF)**	MBF (TPO)	**FIA, or data user (CCF, MBF, Green tons, dry tons, cords (any combo of three for single harvest**	US Consumption Data	FIA or cut tree list
	Multiple Harvest Jurisdictions	No, In the future	**Yes**	No	No	N/A
	Recycling Approach	**Two rounds, same end use half-lives**	Paper five rounds, Solid wood two rounds. 2 recycling half-lives	**Unlimited rounds. 2 recycling half-lives**	Paper five rounds, Solid wood two rounds. 2 recycling half-lives	N/A
	Discard Ratios	Annual Rates, EPA WARM 2020 (though 2018)	Annual Rates, EPA WARM 2020 (though 2018)	Single rates from 2018 (EPA WARM)	Single rates from Skog 2008 (1982-2005)	Single rates from Skog 2008 (1982-2005)
	Solid Wood Lifespan Functions	**Chi square (default) or exponential**	Exponential	**Chi square (default) and exponential**	Exponential	N/A
	Half-life source	**Smith 2006 / Skog 2008**	Smith 2006	**Smith 2006 / Skog 2008**	Smith 2006 / Skog 2008	Smith 2006 / Skog 2008
	Pulpwood (paper)Lifespan Functions	Exponential	Exponential	Exponential	Exponential	Exponential
	Permanent landfill storage	**Smith 2006 / Adapted Skog 2008**	Smith 2006	**Smith 2006 / Adapted Skog 2008**	Freed and Mintz 2003	Smith 2006
	SWDS decay functions	Exponential	Exponential	Exponential	Exponential	Exponential
	Results timestep	Annual or Total	Annual or Total	Annual or summarized	5 year (for 25 years) in tons per acre	100 - year average
	Ecosystem Carbon Estimates	No	No	**Yes**	No	Yes
	Graphic User Interface	Interactive input and results	Interactive input and results	Excel Software	Excel Software	Interactive input , static results
	Exportable Custom Graphics	Yes	Yes	No	No	No
	Exportable Results Folder	Yes	Yes	No	No	No
	User manual / documentation	Yes- this GTR	Yes - Model website	Yes - Guidelines Report	Skog (2008)	Yes - https://www.nrs.fs.usda.gov/pubs/gtr/gtr_nrs77.pdf and https://www.fs.usda.gov/fmsc/ftp/fvs/docs/gtr/FFEguide.pdf
	Records Management Options	**Yes**	No	No	No	No
	Support staff	Contact group email	Contacts available	No, but contacts available	No, but contacts available	Yes

DRAFT HWP Model Decision Tree (2023) – Need Help!

1. Have you selected a modeling approach?
2. Are you modeling Nation or region, state or smaller?
3. Do you have more than one harvest event (year)?
4. Do you want combined ecosystem /HWP results?
5. What is your production area?
6. What data do you have available?
7. Do you have access to a current USFS Whitepaper?
8. Are modeling for the states of CA, OR or WA?



Tool Use Case Summary

- USFS HWP C Calculator
    - IPCC HWP Tier 3 (National Datasets)
    - Multiple Years Harvest, CCF or MBF
    - Built for National Forest System modeling

- USDA GHG Entity Guidelines
    - Expands beyond just HWP to Ecosystem for full IPCC Forest Sector results
    - Add displacement/substitution information
    - Single harvest event (flexible inputs)
    - Built for various entities (land owners)

- Both
    - Coming out soon, future versioning expected
    - Nearly identical base data for HWP calculations
    - Will have supporting documentation

Near Future for these Tools

- USFS HWP C Calculator
  - MVP modeling for NFS reporting, early adopters
  - User Guide General Technical Report publication
  - Issues Backlog > Enhanced future versions
- USDA GHG Entity Guidelines
  - Inclusion of new FIA National Scale Volume and Biomass approach
  - Publication
  - Commence Version 3 revision very soon
    - Add forest management options, such as wildfire management treatments
    - Attempt to extend ecosystem beyond harvest year, to line up with existing HWP estimates and show total forest carbon storage / emissions trajectory
- Partner Platforms?
  - US Endowment
  - Others (e.g., USDA COMET?)

Thank you for your interest!

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Enjoy the rest of this year's meeting!