

User Guide for VERSION 1.0 Excel Workbook to Support “Level 1” Quantification Approaches for the Managed Forest Systems Chapter Within the 2024 Update to the USDA Publication Quantifying Greenhouse Gas Fluxes in Agriculture and Forestry: Methods for Entity-Scale Inventory

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1 Introduction

This user guide provides supplementary guidance on how to use the Excel workbook (Lister et al., 2024) that accompanies chapter 5 Quantifying Greenhouse Gas Sources and Sinks in Managed Forest Systems (Murray et al., 2024) in the *2024 USDA Entity Scale Guidelines for GHG Flux in Agriculture and Forestry*. The Excel workbook facilitates “Level 1” quantification approaches for silvicultural practices and improved forest management (section 5.2.1), harvested wood products (HWPs) (section 5.2.2), and wildfire and prescribed fire activities (section 5.2.3).

2 Purpose and Function

The Excel workbook combines user selections and inputs with pre-processed (default) data and coefficients to automatically render a variety of greenhouse gas (GHG) emissions/removals estimates (i.e., flux and/or stocks) associated with the included selection of forest management activities inclusive of wildfires, harvested wood products, and substitution (i.e., carbon displacement). More detail on each of the included forest management activities is offered in the step-by-step guidance sections below.

The forest management activities included are:

- **Basic projections of forest carbon:** Generalized projection of carbon stocks at 5-year intervals for user-selected combination of U.S. region, forest type, age class, stand origin, and rotation length (where applicable). A basic projection could be the baseline (or status quo, or business as usual [BAU]) of the entity. Two basic projection options are offered:
 - a. Basic projection under forest management. Carbon sequestered up to 50 years into the future is quantified and reported as total change in included¹ living and dead carbon pools (t CO₂eq) over that period.
 - b. Basic projection under forest management, with harvest. Carbon sequestered until the specified planned harvest time. Projected carbon stock accumulation from forest maintenance is combined with estimates of carbon flux from harvest to offer total forest biogenic (AFOLU sector)² carbon stock change (flux) (CO₂eq). Users may enter custom harvest volumes/mass or apply default data on growing stock volumes (i.e., regional averages as derived from U.S. Department of Agriculture, Forest Service Forest Inventory and Analysis [FIA] program data) to estimate postharvest carbon flux.

Life cycle analysis (LCA)-quantified substitution potential associated with harvest, transport, and processing is also offered separately as a non-AFOLU sector estimate of the potential impact of this forest management activity.

- **Impact of changing management practices on carbon outcomes:** Carbon stocks are projected at 5-year intervals for a BAU scenario and a planned activity scenario based on a user-selected combination of U.S. region, forest type, age class, stand origin, and rotation length (where applicable). Net impacts reflect the difference between the two scenarios. The Excel workbook offers three scenario-based comparisons of the following generalized types of forest management treatments:

¹ See “Carbon Pools” in section 5.3 for more information on what carbon pools are captured in the projections.

² Biogenic carbon stock change estimates include the growth or decay of living organisms and fall within the IPCC agriculture, forestry, and other land use (AFOLU) sector. They do not include emissions from other sectors such as energy or waste (e.g., emissions from equipment usage and transportation).

- a. **Extended rotation:** Carbon benefit from deferring harvest in even-aged stands³, including estimates of carbon flux from harvest, to estimate total biogenic carbon stock change (flux) (t CO₂eq). The results reflect the difference between projected carbon stocks under the BAU planned harvest date and the extended rotation harvest date. The analysis applies default data on growing stock volumes (i.e., regional averages as derived from USDA, Forest Service Forest Inventory and Analysis program data) to estimate postharvest carbon flux. LCA-quantified substitution potential associated with harvest, transport, and processing is also calculated separately as a non-AFOLU sector estimate of the potential impact of this forest management activity.
 - b. **Reforestation:** Two reforestation options are offered: (1) natural; and (2) planted. Results show the projected total amount of carbon sequestered over 50 years. The BAU scenario assumes zero carbon flux (i.e., without the reforestation effort, the area would have neutral carbon stocks).
 - c. **Avoided Deforestation:** Ecosystem carbon that remains stored is estimated because of avoiding deforestation as well as projected flux over 50 years. The BAU scenario is forest clearing at year 0 and assumes forest carbon stocks are emitted as a result. Under the BAU scenario, the forest is cleared immediately following time 0 and future carbon the forest might have sequestered is foregone. In the avoided deforestation scenario, the immediate loss of biomass carbon stocks is prevented, and carbon may be allowed to continue to accumulate over time in the living biomass.
- **Other quantifications:**
 - a. **Harvest:** This option does not compare silvicultural treatments. Rather, it quantifies GHG flux from harvest at time 0. Additionally, the LCA-quantified substitution potential associated with harvest, transport, and processing is calculated separately as a non-AFOLU sector estimate of the potential impact of this forest management activity.
 - b. **Fire (prescribed or natural):** Greenhouse gasses emitted along three fire severity scenarios are quantified, reflecting immediate combustion emissions. Emissions magnitude for carbon dioxide (CO₂), nitrous oxide (N₂O), and methane (CH₄) are quantified (CO₂eq).

3 Key Specifications and Caveats

A full listing of assumptions and caveats associated with the quantification methodologies is offered in Chapter 5, but the following summarizes some important context and considerations for users.

3.1 Scope

The methods and data applied for generating estimates of GHG flux are limited to biogenic AFOLU sector emissions (i.e., no emissions resulting from waste, energy, industrial sectors are included), with the exception of the estimates provided for potential product and bioenergy substitution from harvested wood products.

3.2 Carbon Pools

The forest **carbon stock** estimates applied for the forest management and harvest calculations include all carbon pools except soil carbon.

³ Even-aged forests typically consist of trees that are in a limited number of age classes (one or two, e.g., 0 to 20 and 21 to 40 years old).

The **carbon flux (emissions or sequestration) estimates** include all carbon pools except soil carbon and standing dead tree carbon. In the case of soil carbon, changes in soil carbon stocks are assumed to be *de minimis* over the timelines in question as there is a lack of available data on the impact specific forest management practices have on soil carbon stocks at the entity scale. In the case of standing dead tree carbon, the FIA program measures standing dead trees but does not track individuals after their transition to fallen dead wood; therefore, closed system accounting for change methods for that pool requires further research.

Forest carbon stock and flux are otherwise referred to as “ecosystem carbon.” The “ecosystem” side of carbon accounting covers carbon accumulation in living and dead biomass, as well as living and dead biogenic carbon flux because of harvest, such as that occurring from decomposition of logging residues. For activities that involve harvest, additional estimates are computed representing carbon flux associated with the harvested wood that reaches the mill and is converted to wood products and mill residues (products in use), some of which decompose or ultimately end up in solid waste disposal sites (SWDS).

3.3 Uncertainty

The sources of uncertainty associated with the data sourced, the quantification approaches presented, and the user data inputs are varied and, in some cases, unquantified (e.g., model selection error). Although the FIA program quantifies sampling error such uncertainty is expected to be compounded by measurement and model errors. This version of the guidance and Excel workbook does not include estimates of uncertainty. Users should interpret results as those generally representative of the activities included within U.S. ecosystem types. Projections of emissions or carbon sequestration (i.e., flux) should be carefully considered within the context of site-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.

3.4 Stratification

Results are presented for individual strata such as a particular stand age class within a particular forest type of one region of the U.S. Where the forest being assessed is highly heterogenous (e.g., mixed densities, topography, or management history), attaining more accurate results may require that users first stratify the land into more homogenous units and then run the analysis for each individual stratum. See section 5.1.5.1 in chapter 5 for more guidance on stratification.

4 Structure of the Excel Workbook Tool

Table 1. Structure of the Excel Workbook

Excel Workbook Component	Tab Identifying Color	Excel Tab	Description
Guidance and Context	Yellow	Instruction and Context	Provides an overview of the purpose of the Excel workbook and user instructions.
		U.S. Regions	U.S. regional delineations as applied in the guidance.
		Acronyms, Tabs, Citations	Lists abbreviations used in the Excel workbook, tabs and their contents, and citations. Also contains text that offers possible explanations where calculator outputs render estimated emissions.

Excel Workbook Component	Tab Identifying Color	Excel Tab	Description
User Data Entry	Red	User Data Entry	Users choose the management activity to quantify GHG flux for, then enter data and/or select from dropdown menus to define the quantification scenario(s) (e.g., baseline or management).
			Immediate detailed results for projected carbon stocks and flux for some management activities are dynamically shown.
Main Results	Dark Orange	Forest Management & HWP Results	For clarity, summarized results are presented as separate categories: “Ecosystem Carbon Impacts Forest Growth”: Change in living and dead carbon pools from the growth, mortality, and decay of forest biomass on site. “Ecosystem Carbon Impacts from Harvest”: Proportion of total ecosystem carbon stocks transferred to HWPs or emitted as a result of harvest. “Postharvest Carbon Impacts”: Harvested wood products in use, harvested wood products in Solid Waste Disposal Sites (SWDS), HWP emissions. This results in an estimate of carbon sequestered as a result of forest management activity. If the activity includes a harvest, the summary tables reflect the complete accounting approach, reflecting the magnitude of ecosystem carbon left on site, as well as in wood products and ultimately emitted or stored in products or SWDS.
			“Total AFOLU Biogenic Carbon Stock Change from Management Action”: A final result is also shown, which reflects the estimated stock change (flux) in AFOLU sector carbon. Negative values confer sequestration; positive values reflect either emissions (emissions at harvest, HWP emissions from decay) or decreased stocks/stock change (storage in harvested sawlogs etc.).
			The “LCA Quantified Substitution Potential Associated with Harvest, Transport and Processing” area gives additional context, but is not presented as part of the total impact because some emissions fall outside the AFOLU sector.
Detailed Results for Reference	Light Orange	Fire Results	Estimates of emissions for three fire activity scenarios.
		Harvest Carbon Calculator	Offers detailed annualized estimates of emissions and storage of HWPs under different decay functions across the full 100-year accounting timeline.
		Growing Stock Calculator	Offers detailed estimates of the harvest volumes by roundwood product types

Excel Workbook Component	Tab Identifying Color	Excel Tab	Description
		Potential Substitution	Quantified potential substitution benefits occur outside the AFOLU sector and are intentionally presented separately and not combined with the AFOLU totals, in accordance with IPCC reporting.
		Various	Several other tabs with detailed outputs to calculations.
Lookup and reference values	Gray	Various	Back-end lookup tables are view-only. Additional gray-shaded tabs are included for transparency. Some include the values applied to calculations to render results.

5 Instructions

5.1 Overview

The only worksheet users can enter data into is the red “User Data Entry” tab (figure 1). Detailed projections of ecosystem carbon stocks and flux will immediately appear in the “Detailed Ecosystem Carbon Scenario Projection” section (columns G-R) of the “User Data Entry” tab. Data entry fields automatically appear as white boxes. The main results are displayed in the orange “Forest Mgmt & HWP Results” tab, including a complete breakdown of emissions and storage associated with forest harvest activities and potential substitution benefits. Emissions from the “Fire (prescribed and natural)” forest management activity are only displayed in the “Fire Results” tab.

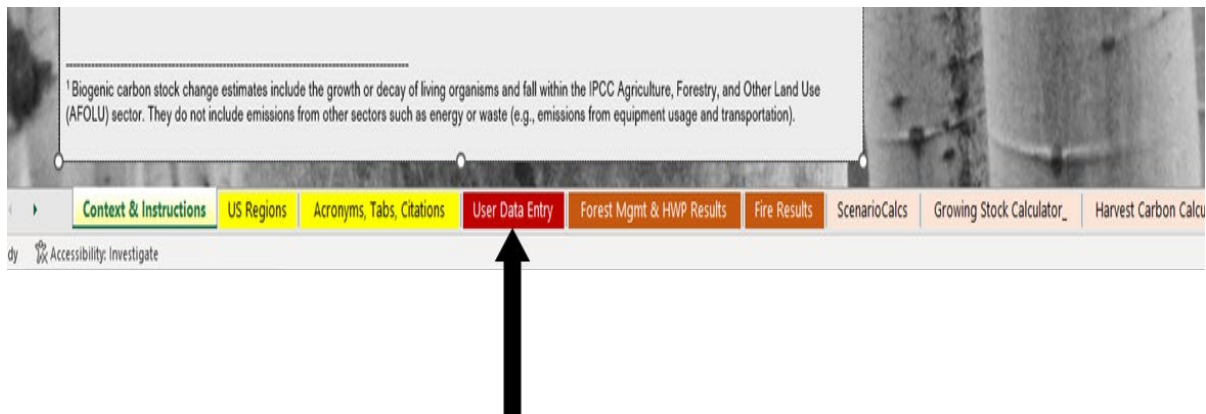


Figure 1. Tabs in the Excel workbook. The User Data Entry tab is the fourth tab in and indicated in red (pointed at with a black arrow).

There are two fields of data entry (figure 2):

- Step 1: BASIC USER INPUTS
- Step 2: SILVICULTURE AND HARVESTING INPUTS

	A	B	C	D	E
	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)	50		Acres	Users may select acres or hectares from the dropdown menu and results will automatically adjust.
	U.S. Region		Great Plains	See 'US Regions' tab for geographic delineations applied.	
	Forest Type Group (if reforestation, planned forest type group)		Oak / pine 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 stocks and stock change to apply in the calculator.	
	Descriptions of each forest type group are listed in Appendix D of Burrill, et al. 2022.				
	Planted or Natural forest origin		Unknown	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?	10			
	Do you know what your harvest volume is? If Yes, enter the details below. If no, default values of growing stock will 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)	Please select the units for harvest calculations.	Please select the units for harvest calculations.	
	What is the MAIN wood type of the eventual products?	Softwood	Please select a primary wood type.	Please select a primary wood type.	
	What is the MAIN log type that will be produced from the trees removed?	Sawlog	Please select a primary log type	Please select a primary log type	
	Should the tool apply default fuelwood values that are generated from sawlog and pulpwood production? (if you don't know, assume 'yes')	Yes			

Figure 2. Data entry fields: Step 1: Basic Inputs and Step 2: Silviculture and Harvesting Inputs

While some user-supplied data or dropdown menu selections are required for all management activities, some fields are only relevant to specific management activities. The Excel workbook will automatically present or hide relevant fields where user-supplied information is needed (white cells) based on the type of management treatment selected (cell C2). Data requirements are delineated in table 2 below.

Table 2. Basic User Inputs Data Fields

Data Input	Description
Type of forest management treatment to be applied	<u>Required for all forest management activities.</u>
Area subject to management activity of stratum	<p><u>Required for all forest management activities.</u></p> <p>The area in which the entity anticipates undertaking the silvicultural activity. The Excel workbook assumes that entries are associated with a single stratum (such as a stand or group of stands). To generate results for multiple strata (such as forest stands with different stand origins), aggregate results from various strata with multiple runs of the tool.</p> <p>The Excel workbook allows users to choose the units—acres or hectares. See section 5.2.1.2 in chapter 5 for more information on how these area data values can be determined.</p>
U.S. Region	<p><u>Required for all forest management activities.</u></p> <p>The broad geographic region in which the silvicultural activity will take place. A map is offered in the “US Regions” tab of the Excel workbook.</p>
Forest type group ^a	<p><u>Required for all forest management activities.</u></p> <p>Select the forest type group that best matches the forest stand that will be subject to the forest management activity. If the forest type group is unknown, select “predominantly hardwood species,” “predominantly softwood species,” or “unknown.”</p> <p>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 apply average values for a broader range of regional forest type groups.</p>
Planted or Natural forest origin	<p><u>Required for all forest management activities except the “Fire (prescribed or natural)” forest management activity.</u></p> <p>Users select whether the stand was planted or grew naturally. Choose “unknown” if the stand origin is not known.</p>
Age class	<p><u>Required for all forest management activities except the “Reforestation” and “Fire (prescribed or natural)” forest management activity.</u></p> <p>Users select the age range of the forest stand. Forests accumulate carbon at different rates, so knowing stand age class renders a more accurate estimate of annual and total carbon accrual from the anticipated activity.</p> <p>Choose “unknown” if the stand age class is not known.</p>
Length of rotation/harvest	<p><u>Required for “Basic projection under fm, with harvest” or “Extended rotation” forest management activities.</u></p> <p>If “Basic projection under fm, with harvest” or “Extended rotation” options are selected, users must enter the rotation date (5-year increments). For extended rotation, two rotation dates are needed: (1) harvest under the baseline scenario; and (2) harvest under the extended rotation scenario.</p>

^a The forest types correspond to the “forest type groups” described in the FIA database phase 2 user guide (Burrill et al., 2021, appendix D). These forest types are also listed explicitly in table 5B-11.

The “Forest Mgmt & HWP Results” tab provides a breakdown of estimates as follows:

- **ECOSYSTEM CARBON IMPACTS from Forest Growth:** This reflects the change (i.e., carbon removals or emissions) in living and dead carbon pools associated with silvicultural practices over the selected timeframe or 50 years.
- **ECOSYSTEM CARBON IMPACTS FROM HARVEST (Brown and Tan fields).** These results only appear if a forest management activity involving harvest is selected. The summary tables reflect the complete accounting approach, reflecting the magnitude of ecosystem carbon left on site, as well as in wood products and ultimately emitted or stored in products or solid waste disposal sites (SWDS). These are broken down into green and brown fields, separating carbon storage or emissions assumed to occur on site and those associated once the HWPs enter the products in use or products in SWDS. Estimates are provided at year 0 postharvest and year 100 postharvest of carbon stocks in HWPs in use, SWDS, emissions with and without energy capture.
- **The TOTAL AFOLU (Forest) BIOGENIC CARBON STOCK CHANGE (FLUX) from Management Action and Harvest (t CO₂eq)** reflects the sum of ecosystem stock change (flux) in AFOLU sector carbon and equals net ecosystem change plus bark and logging residues emitted, plus harvested sawlogs, pulpwood and fuelwood minus annual stock change in harvested wood products in use and SWDS at year 0. A total carbon balance estimate at 100 years postharvest was intentionally not provided because ecosystem side projections for up to 100 years postharvest are not provided in the calculator due to the high uncertainties associated with projecting postharvest site carbon flux that far into the future.
- **LCA Quantified Substitution Potential Associated with Harvest, Transport and Processing** estimates are presented separately as estimation procedures include sources or sinks of GHGs outside the AFOLU sector but support a more holistic understanding of the GHG

Box 1. Interpreting Results

ECOSYSTEM CARBON STOCKS are presented as positive numbers.

ECOSYSTEM CARBON FLUX is shown as either positive or negative numbers. Positive (+) numbers are emissions, and negative (-) carbon flux numbers demonstrate carbon removals (i.e., sequestration). In other words, negative numbers convey the amount of CO₂ removed from the atmosphere resulting from the forest management activity.

Where emissions (positive numbers) are rendered, users should consider the following reasons:

- Carbon stock values applied in the Excel workbook represent the average values of observations and measurements collected from FIA plots. In some cases, these values showed the forests are a source of emissions, rather than a carbon sink. This may be a true reflection of carbon dynamics playing out across many Western landscapes where the severity and frequency of disturbances in recent years is causing forests to lose more carbon than they sequester each year (Domke et al., 2023; Hoover and Smith, 2021).
- Another possibility is that too few plots matched the particular combination of region/forest type group/stand age class/stand origin used to group carbon stock and stock change estimates for the Level 1 approach. Where this is suspected, users can instead select broader grouping of forest type groups, stand age, or stand origin in the Basic Inputs part of the “User Data Entry” tab (e.g., select the “unknown” option which will apply average values for a broader range of forest type groups within the selected region).

See section 5-A.2.6 Background for Lookup Tables in chapter 5 for more on this topic.

impact of wood products. Potential Substitution Benefits reflect the CO₂ equivalent emissions avoided when wood substitutes for nonwood fossil-based alternatives.

Results for the “Fire (prescribed or natural)” management treatment are shown in the Fire Results tab separately.

More detailed results for estimates of carbon flux from harvested wood products, as well as substitution effects, are also available in the light orange Harvest Carbon Calculator, Growing Stock Calculator, and in Potential Substitution tabs. Gray tabs are for reference only.

5.2 Step-by-Step Guidance for Data Entry and Results Interpretation

5.2.1 Basic Projection Under Forest Maintenance

This forest management activity reflects carbon sequestered up to 50 years into the future and is quantified and reported as total change in living and dead carbon pools (not soil) (CO₂eq) over that period.

1. In the “User Data Entry” tab, enter data into the blue Step 1: BASIC INPUTS section:
 - a. Select the management activity “Basic projection under forest maintenance (fm)” from the dropdown in cell C2 (figure 3).

	QUESTIONS	RESPONSES
Step 1: BASIC INPUTS <i>If you stratified your forest/management area, you need to run separate calculations for each stratum.</i>	Type of forest management treatment to be applied.	Basic projection under forest maintenance (fm)
	Area subject to management activity or area of stratum (you may specify hectares or acres)	Select a management treatment
	U.S. Region	Basic projection under forest maintenance (fm)
	Forest Type Group (if reforestation, planned forest type group)	Basic projection under fm, with harvest
	Descriptions of each forest type group are listed in Appendix D of Burrill, et al. 2022.	Extended rotation
	Planted or Natural forest origin	Reforestation (natural)
		Reforestation (planted)
		Avoided deforestation
		Harvest
		Fire (prescribed or natural)
	Age Class	Select an Age Class

Figure 3. Step 1 of the Basic Inputs section in the User Data Entry tab. “Basic projection under forest maintenance (fm)” is selected (indicated by the red box) in the response to the question “Type of forest management treatment to be applied.”

- b. Input the area of land the management activity will take place on in cell C3 and adjust units to either acres or hectares in cell D3.
- c. Select the “U.S. Region” in which the forest management activity will take place from the dropdown menu in cell C4. Refer to the “US Regions” tab to confirm the region.
- d. Select the rest of the variables from dropdown menus in cells C5–C7 including Forest Type Group, Planted or Natural Forest origin, and Age class. If the forest type group is not known, broader groupings may be selected such as “predominantly hardwood species,” “predominantly softwood species,” or “unknown” which will apply average values for a broader range of regional forest type groups.

- e. Detailed projections of carbon stocks and carbon flux will immediately appear in the “Detailed Ecosystem Carbon Scenario Projection” section (columns G-R) (figure 4). See box 1 in this document for guidance on interpreting results.
2. The “Forest Mgmt & HWP Results” tab will show the cumulative projected carbon flux 50 years into the future.

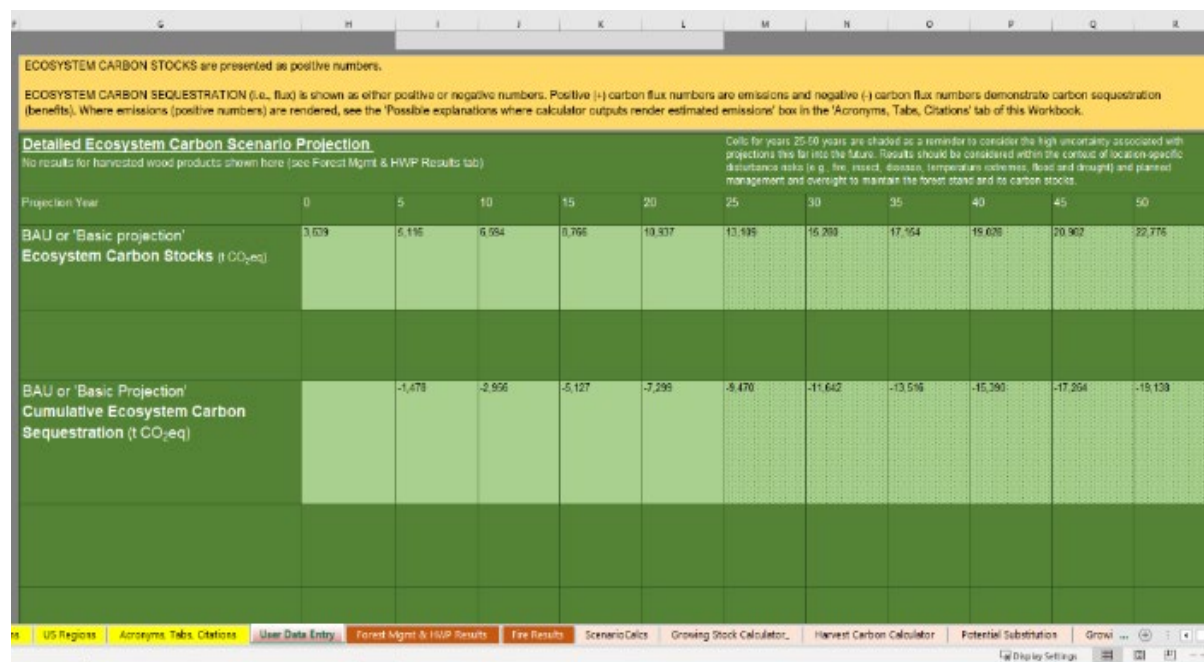


Figure 4. Carbon projections for the given scenario, found in the User Data Entry tab.

5.2.2 Basic Projection Under Forest Maintenance with Harvest

This forest management activity quantifies carbon sequestered until the specified planned harvest time. Projected carbon stock accumulation from forest maintenance is combined with estimates of carbon flux from harvest to offer total forest biogenic (AFOLU sector) carbon stock change (flux) (CO₂eq). This includes biogenic carbon flux at harvest (logging residues and bark) as well as postharvest carbon flux (carbon emissions from processing end use products, burning and wood decay from discarded products stored in solid waste disposal sites) at year 0 postharvest and up to 100 years after harvest. Users may enter custom harvest volumes/mass or apply default data on growing stock volumes to estimate postharvest carbon flux. Users may also indicate what percentage of total area is harvested.

Life cycle analysis (LCA)-quantified substitution potential associated with harvest, transport, and processing is also offered separately as a non-AFOLU sector estimate of the potential impact of this forest management activity.

1. In the “User Data Entry” tab, enter data into the blue Step 1: BASIC INPUTS section:
 - a. Select the management activity “Basic projection under fm with harvest” from the dropdown in cell C2 (figure 5).
 - b. Select the U.S. Region in which the forest management activity will take place from the dropdown menu in cell C4. Refer to the “US Regions” tab to confirm the region.

	A	B	C	D	E
1		QUESTIONS	RESPONSES		
2	Step 1: BASIC INPUTS <i>If you stratified your forest/management area, you need to run separate calculations for each stratum.</i>	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.	
3		Area subject to management activity or area of stratum (you may specify hectares or acres)	Basic projection under forest maintenance fm Basic projection under fm with harvest	Users may select acres or hectares from the dropdown menu and results will automatically adjust.	
4		U.S. Region	Reforestation (natural) Reforestation (planted) Avoided deforestation Harvest Fire (prescribed or natural)	US Regions' tab for geographic delineations applied. 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	
5		Forest Type Group (if reforestation, planned forest type group)		Select whether the forest was planted or of natural origin. Where this is not known, users may select 'unknown' from the dropdown menu options	
6		Planted or Natural forest origin	Planted	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.	
7		Age Class	0-20 years		

Figure 5. Step 1 of the Basic Inputs section in the User Data Entry tab. “Basic projection under fm, with harvest” is selected (indicated by the red box) in the response to the question “Type of forest management treatment to be applied.”

- c. Select the rest of the variables from dropdown menus in cells C5-C7 including Forest Type Group, Planted or Natural Forest origin, and Age class. If forest type group is not known, broader groupings may be selected such as “predominantly hardwood species,” “predominantly softwood species,” or “unknown” which will apply average values for a broader range of forest type groups within the selected region.
2. Enter data into the brown Step 2: SILVICULTURE AND HARVESTING INPUTS:
 - a. Select the number of years from now until the harvest is planned (cell C8). Note that the projection will only include estimates for the number of years from now that is selected (e.g., if 15 is selected, the projected values will go through 15 years from now)
 - b. Select whether estimated harvest volume is known or not (cell C10). Selecting “NO” will apply default data on growing stock volume.⁴
 - i. If “NO” is selected, continue to step 2.c.
 - ii. If “YES” is selected, enter data on up to three product types for the anticipated amount of wood harvested (cells C13-E13) and the corresponding units (cells C14-E14) offered in the dropdown menus (figure 6).

⁴ Applying default data for highly productive timber stands may render results reflecting that the wood harvested exceeds the estimated total site carbon stocks the calculator produces. In these instances, ecosystem carbon stocks should be interpreted as an underestimate.

Step 2: SILVICULTURE AND HARVESTING INPUTS
Required data entry fields will automatically appear based on the forest management treatment selected.

Do you know what your harvest volume is? If Yes, enter the details below. If no, default values of growing stock will be applied based on your selections in the 'Basic Inputs' section.	YES	<p>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.</p> <p>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 so it is an even-aged forest management routine.</p>			<p>No results for harvested wood products shown here</p> <p>Projection Year</p> <p>BAU or 'Basic projection' Ecosystem Carbon STOCKS (tCO₂e/yr)</p> <p>Includes all carbon pools except soil carbon. Carbon stocks are presented as positive numbers.</p>
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	<p>Product type 1</p> <p>7.5</p> <p>Thousand board feet per acre (MBF/acre)</p>	<p>Product type 2 (if applicable)</p> <p>Cords</p>	<p>Product type 3 (if applicable)</p> <p>Thousand board feet (MBF)</p>	<p>BAU or 'Basic Projection' Cumulative Ecosystem Carbon FLUX (tCO₂e/yr)</p> <p>Includes all carbon pools except soil carbon and tree carbon. Negative numbers represent sequestration. Positive numbers represent emissions.</p>
What is the amount you harvested or plan to harvest?					
And what units are that amount in?					
What is the MAIN wood type of the eventual products?		<p>Please select the units for harvest calculations.</p> <p>Thousand board feet (MBF)</p> <p>Thousand board feet per acre (MBF/acre)</p> <p>Hundred Cubic Feet (CCF)</p> <p>Hundred Cubic Feet per acre (CCF/acre)</p> <p>Green Tons</p> <p>Green Tons/acre</p> <p>Dry Tons</p> <p>Dry Tons/acre</p> <p>Cords</p> <p>Cords/acre</p>			<p>Softwood</p> <p>Pulpwood</p>
What is the MAIN log type that will be produced from the trees removed?					
Should the tool apply default fuelwood values that are generated from sawlog and pulpwood production? (if you don't know, assume 'yes')					

Context & Instructions US Regions Act Forest Mgmt & HWP Results Fire Results ScenarioCalcs

Figure 6. Cells where amount and type of products to be harvested can be entered. Note that at least one product and amount must be entered, but up to three can be entered.

- c. Enter in cell C11 what percent of the area subject to management activity reported in cell C3 will be harvested.
 - d. Select the main wood type of the eventual products from the dropdowns in row 15 for the up to 3 product types entered (only one product type is available if "NO" was selected under step 2.b.).
 - e. Select the main log type that will be produced from the trees removed in row 16 for the up to 3 product types entered (only one product type is available if "NO" was selected under step 2.b.).
 - f. Indicate in cell C17 if default fuelwood values should be applied.
 - g. Detailed projections of carbon stocks and carbon flux will immediately appear in the "Detailed Ecosystem Carbon Scenario Projection" section (columns G-R) (figure 7). See box 1 in this guidance on interpreting results.
3. A full breakdown of results is displayed in the "Forest Mgmt & HWP Results" tab. Refer to section 5.5 of this guidance for information on interpreting results.

(Percent), where emissions (positive numbers) are rendered, see the Possible Explanations where calculator outputs render estimated emissions box in the Acronym, 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 ₂ eq)	3,639	5,116	6,594	8,766	10,937	13,109	15,280	17,154	19,028	20,902	22,776
BAU or 'Basic Projection' Cumulative Ecosystem Carbon Sequestration (t CO ₂ eq)		-1,478	-2,956	-5,127	-7,299	-9,470	-11,642	-13,516	-15,390	-17,264	-19,138

User Data Entry | Forest Mgmt & HWP Results | Fire Results | ScenarioCalcs | Growing Stock Calculator_ | Harvest Carbon Calculator | Potential Substitution | Growing Stock Calculator_ (BAU) | Harvest Car ...

Figure 7. Carbon projections, found in the User Data Entry tab

5.2.3 Extended Rotation

This forest management activity estimates the impact from deferring harvest in even-aged stands, which is quantified as the difference between projected carbon stocks under the BAU scenario harvest length and the extended rotation harvest length. It is assumed stands are replanted or regenerated postharvest otherwise this would be considered land-use change (i.e., conversion) and not forest management, so the net impact also considers postharvest carbon accrual for the period between the BAU harvest length and extended rotation length. The carbon sequestered under the extended rotation harvest length and BAU lengths are combined with estimates of carbon flux from harvest to offer total biogenic carbon stock change (flux) (t CO₂eq). The difference between the extended rotation carbon flux including harvest and the BAU carbon flux including harvest represents the total impact.

The extended rotation projection assumes 100 percent of the area subject to management activity is harvested. This activity is limited to default data on growing stock volumes to estimate postharvest carbon flux.

Life cycle analysis (LCA)-quantified substitution potential associated with harvest, transport, and processing is also offered separately as a non-AFOLU sector estimate of the potential impact of this forest management activity.

1. In the “User Data Entry” tab enter data into the blue Step 1: BASIC INPUTS section:
 - a. Select the management activity “Extended rotation” from the dropdown menu in cell C2.
 - b. Input the area of land the management activity will take place on in cell C3 and adjust units to either acres or hectares in cell D3.
 - c. Select the U.S. Region in which the forest management activity will take place from the dropdown menu in cell C4. Refer to the “US Regions” tab to confirm the region.

- d. Select the rest of the variables from dropdown menus in cells C5–C7 including Forest Type Group, Planted or Natural Forest origin, and Age class. If the forest type group is unknown, broader groupings may be selected such as “predominantly hardwood species,” “predominantly softwood species,” or “unknown” which will apply average values for a broader range of forest type groups within the selected region.
2. Enter data into the brown Step 2: SILVICULTURE AND HARVESTING INPUTS:
 - a. Select the number of years from now the harvest is planned under the BAU scenario (i.e., no extension of rotation) (cell C8) using the dropdown menu. Note that the projection will only include estimates for the number of years from now that is selected (e.g., if 15 is selected, the projected values will go through 15 years from now).
 - b. Select the number of years from now the harvest is planned under the extended rotation scenario (cell C9) using the dropdown menu.
 - c. Indicate in cell C17 if default fuelwood values should be applied.
 - d. Detailed projections of carbon stocks and carbon flux under the BAU and extended rotation scenarios will immediately appear in the “Detailed Ecosystem Carbon Scenario Projection” section (columns G–R) (figure 8). See box 1 in this guidance on interpreting results.
3. A full side-by-side breakdown of results under the BAU and extended rotation scenarios is displayed in the “Forest Mgmt & HWP Results” tab. Refer to section 5.5 of this guidance for information on interpreting results.

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 ecosystem-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 ₂ eq)	3,635	5,115	6,594	8,106	1,130	3,092	4,350	5,120			
Planned Activity Scenario Ecosystem Carbon Stocks (t CO ₂ eq)	3,635	5,115	6,594	8,106	10,302	13,326	15,780	17,168			
BAU or 'Basic Projection' Cumulative Ecosystem Carbon Sequestration (t CO ₂ eq)		-1,478	-2,965	-4,322	-5,557	-6,582	-7,312	-7,767			
Planned Activity Cumulative Ecosystem Carbon Sequestration (t CO ₂ eq)		-1,478	-2,965	-4,322	-5,558	-6,673	-7,549	-8,156			
NET Ecosystem Carbon Sequestration from adopting the planned activity (cumulative) (t CO ₂ eq) (additional sequestration as compared to the BAU scenario)					-441	-1,203	-1,524	-2,260			

Excel Workbook User Guide

Figure 8. Carbon projections for the given scenario, found in the User Data Entry tab

Notes on interpreting results:

For extended rotation, under the BAU scenario, the land is assumed to be replanted postharvest, so carbon continues to accumulate postharvest. Depending on the scale of the operation and rate at which carbon accumulates for the selected forest type group, it is possible that the BAU carbon

balance exceeds that of the extended rotation scenario. Users may therefore explore how adjusting the rotation lengths or Forest Type Groups could improve carbon outcomes.

Harvest lengths under conventional silviculture are often based on a careful balancing of biological (i.e., mean annual increment) and economic criteria (i.e., net present value) to maximize yield and investment. The time for which a rotation is extended beyond its typical length determines the relative benefit of an extended rotation activity: the longer a harvest is deferred, the greater the potential carbon accumulation. However, the relationship between time and carbon accrual is not constant. There may be a point of diminishing returns when considering extended rotation lengths. Entities should anticipate when peak sequestration/growth will occur to maximize benefits from extending rotation lengths. See *section 5-A.2.2 Extended Rotation* in chapter 5 for more on this topic.

5.2.4 Reforestation

This forest management activity estimates the impact of silvicultural treatments to reestablish forest cover on lands with few or no mature trees. This can be done by preparing the land for natural regeneration and seeding, or by actively planting and protecting seedlings to accelerate the return to forest cover and function. Accordingly, two reforestation options are offered: (1) natural and (2) planted. Results show the projected total amount of carbon sequestered over 50 years. The BAU scenario is assumed to have no significant carbon accrual.

1. In the “User Data Entry” tab enter data into the blue Step 1: BASIC INPUTS section:
 - a. Select the management activity “Reforestation (natural)” or “Reforestation (planted)” from the dropdown menu in cell C2 (figure 9).

	A	B	C	D	E	F
	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.	Reforestation (natural)	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)	Basic projection under forest maintenance (lm)	Users may select acres or hectares from the dropdown menu and results will automatically adjust.		
		U.S. Region	Extended rotation	US Regions' tab for geographic delineations applied.		
		Forest Type Group (if reforesting, planned forest type group)	Reforestation (natural)	US 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		
		Descriptions of each forest type group are listed in Appendix D of Burill, et al. 2022.	Reforestation (planted)	Select whether the forest was planted or of natural origin. Where this is not known, users may select 'unknown' from the dropdown menu options		
			Harvest	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.		
			Fire (prescribed or natural)			

Figure 9. Step 1 of the Basic Inputs section in the User Data Entry tab. “Reforestation (natural)” is selected (indicated by the red box) in the response to the question “Type of forest management treatment to be applied.”

- b. Input the area of land the management activity will take place on in cell C3 and adjust units to either acres or hectares in cell D3.
- c. Select the U.S. Region in which the forest management activity will take place from the dropdown menu in cell C4. Refer to the “US Regions” tab to confirm the region.
- d. Select the Forest Type Group from the dropdown menu in cell C5. If the forest type group is unknown, broader groupings may be selected such as “predominantly hardwood species,” “predominantly softwood species,” or “unknown” which will apply average values for a broader range of forest type groups within the selected region.

- e. Detailed projections of carbon stocks and carbon flux will immediately appear in the “Detailed Ecosystem Carbon Scenario Projection” section (columns G-R). See box 1 for guidance on interpreting results.
2. The “Forest Mgmt & HWP Results” tab will show the cumulative projected flux 50 years into the future under the reforestation scenario.

5.2.5 Avoided Deforestation

1. In the “User Data Entry” tab enter data into the blue Step 1: BASIC INPUTS section:
 - a. Select the management activity “Avoided deforestation” from the dropdown menu in cell C2 (figure 10).

	A	B	C	D	E
		QUESTIONS	RESPONSES		
1	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.	Avoided deforestation	See 'Context & Instructions' tab for a description of dropdown menu options.	
2		Area subject to management activity or area of stratum (you may specify hectares or acres)	Basic projection under forest maintenance (lm) Basic projection under lm, with harvest Extended rotation Reforestation (natural) Reforestation (planted) Avoided deforestation.	res	Users may select acres or hectares from the dropdown menu and results will automatically adjust.
3		U.S. Region	Harvest		US Regions' tab for geographic delineations applied.
4		Forest Type Group (if reforesting, planned forest type group)	Fire (prescribed or natural)		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
5		Descriptions of each forest type group are listed in Appendix D of Bunnell, et al. 2022.			Select whether the forest was planted or of natural origin. Where this is not known, users may select 'unknown' from the dropdown menu options.
6		Planted or Natural forest origin	Planted		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.
7		Age Class	0-20 years		

Figure 10. Step 1 of the Basic Inputs section in the User Data Entry tab. “Avoided deforestation” is selected (indicated by the red box) in the response to the question “Type of forest management treatment to be applied.”

- b. Input the area of land the management activity will take place on in cell C3 and adjust units to either acres or hectares in cell D3.
- c. Select the U.S. Region in which the forest management activity will take place from the dropdown menu in cell C4. Refer to the “US Regions” tab to confirm the region.
- d. Select the rest of the variables from dropdown menus in cells C5–C7 including Forest Type Group, Planted or Natural Forest origin, and Age class. If the forest type group is unknown, broader groupings may be selected such as “predominantly hardwood species,” “predominantly softwood species,” or “unknown” which will apply average values for a broader range of forest type groups within the selected region.
- e. Detailed projections of ecosystem carbon stocks and carbon flux under the BAU (i.e., deforestation) and avoided deforestation scenarios will immediately appear in the “Detailed Ecosystem Carbon Scenario Projection” section (columns G-R). See box 1 in this guidance on interpreting results.
2. The “Forest Mgmt & HWP Results” tab will show the cumulative projected flux 50 years into the future under the avoided deforestation scenario.

5.2.6 Harvest

No results are quantified for the forest management practices. Users may indicate what percentage of total area is harvested. See “Basic projection with harvest” for more details on what that includes.

1. In the “User Data Entry” tab, enter data into the blue Step 1: BASIC INPUTS section:

- a. Select the management activity “Harvest” from the dropdown menu in cell C2.
 - b. Input the area of land the management activity will take place on in cell C3 and adjust units to either acres or hectares in cell D3.
 - c. Select the U.S. Region in which the forest management activity will take place from the dropdown menu in cell C4. Refer to the “US Regions” tab to confirm the region.
 - d. Select the rest of the variables from dropdown menus in cells C5-C7 including Forest Type Group, Planted or Natural Forest origin, and Age class. If the forest type group is unknown, broader groupings may be selected such as “predominantly hardwoods,” “predominantly softwoods,” or “unknown” which will apply average values for a broader range of forest type groups within the selected region.
2. Enter data into the brown Step 2: SILVICULTURE AND HARVESTING INPUTS (figure 6):
 - a. Select whether the estimated harvest volume is known (cell C10).
 - i. If “NO” is selected, continue to step 2.c. Selecting “NO” will apply default data on growing stock volume (i.e., regional averages as derived from USDA Forest Service FIA program data).⁵
 - ii. If “YES” is selected, enter data on up to three product types for the anticipated amount of wood harvested (cells C13-E13) and the corresponding units (cells C14-E14) offered in the dropdown menus.
 - b. Enter in cell C11 what percent of the area subject to management activity reported in cell C3 will be harvested.
 - c. Select the main wood type of the eventual products from the dropdowns in row 15 for the up to 3 product types entered (only one product type is available if “NO” was selected under step 2.b.).
 - d. Select the main log type that will be produced from the trees removed in row 16 for the up to three product types entered (only one product type is available if “NO” was selected under step 2.b.).
 - e. Indicate in cell C17 if default fuelwood values should be applied.
 - f. In the same “User Data Entry” tab, projected Ecosystem Carbon Stocks and Cumulative Ecosystem Carbon Flux for this activity will be displayed in columns G–R.
3. A full breakdown of results is displayed in the “Forest Mgmt & HWP Results” tab. Refer to the section 5.5 of this guidance for information on interpreting results.

5.2.7 Fire

This forest management activity shows an estimate of GHG emissions along three fire severity scenarios:

- High-severity fire emissions (>90 percent mortality);
- Moderate-severity fire (40–60 percent mortality); and
- Low-severity fire/prescribed burning (<20 percent mortality).

⁵ Applying default data for highly productive timber stands may render results reflecting that the wood harvested exceeds the estimated total site carbon stocks the calculator produces. In these instances, ecosystem carbon stocks should be interpreted as an underestimate.

Estimates for all three scenarios are provided, reflecting immediate combustion emissions. Emissions magnitude for CO₂, N₂O, and CH₄ are quantified separately and presented as CO₂eq.

1. In the “User Data Entry” tab, enter data into the blue Step 1: BASIC INPUTS section:
 - a. Select the management activity “Fire (prescribed or natural)” from the dropdown menu in cell C2.
 - b. Input the area of land the management activity will take place on in cell C3 and adjust units to either acres or hectares in cell D3.
 - c. Select the U.S. Region in which the forest management activity will take place from the dropdown menu in cell C4. Refer to the “US Regions” tab to confirm the region.
 - d. Select the Forest Type Group from the dropdown menu in cell C5. If the forest type group is not known, broader groupings may be selected such as “predominantly hardwood species,” “predominantly softwood species,” or “unknown” which will apply average values for a broader range of forest type groups within the selected region.
 - e. Navigate to the “Fire Results” tab to view estimates of emissions for high, moderate, and low severity fires (figure 11).

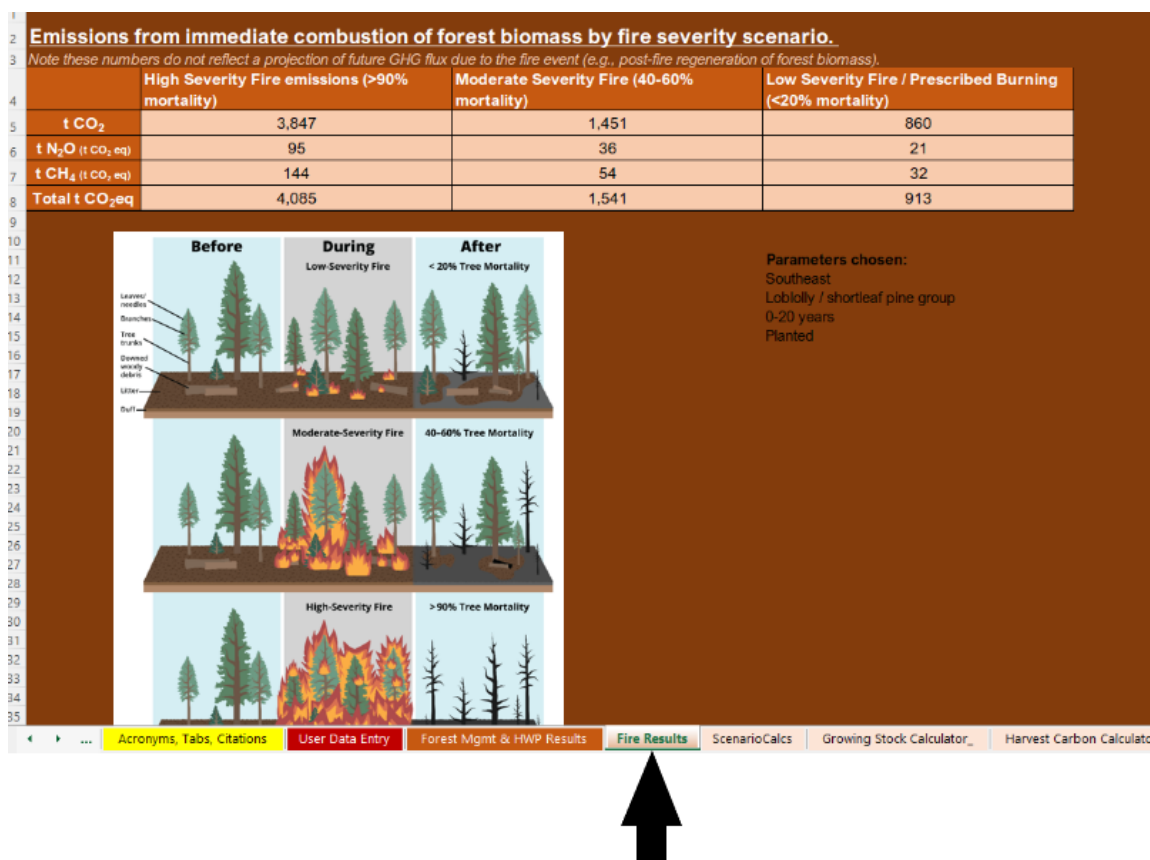


Figure 11. Projections of emissions from different levels of fire severity. Note that these results are in the “Fire Results” tab (indicated by the black arrow)