AB 1504 California Forest Ecosystem and Harvested Wood Product Carbon Inventory: 2018 Reporting Period

DATA UPDATE

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1 Executive summary and key findings

The state of California has enacted a variety of legislation establishing greenhouse gas (GHG) emissions reduction targets. Currently, the state has a net carbon sequestration target for the forest sector of 5 million metric tons (MMT) of carbon dioxide equivalent (CO_2e) annually until 2020, establishing a critical role for California's forests in meeting the state's targets. This data update was provided to inform several elements of the state's effort to meet GHG emissions reduction targets by compiling best-available data on GHG emissions, stock and flux from California's forest sector, identifying critical gaps in data, and suggesting strategies to reduce uncertainty in estimating the magnitude of stocks and flux within the forest sector.

This is the fourth release in a series of annual Assembly Bill (AB) 1504 Forest Ecosystem and Harvested Wood Product (HWP) Carbon Inventory reports to the California Board of Forestry and Fire Protection (also referred to as the Board). Based on the 2018 CA AB 1504 reporting period, California's forests remain net sinks, sequestering 24.9 MMT CO_2e per year. This value includes changes in forest ecosystem pools (26.2 MMT CO_2e per year), harvested wood product pools (0.7 MMT CO_2e per year), non-CO_2 emissions from wildfires (-0.6 MMT CO_2e per year), and forest land conversions (-1.5 MMT CO_2e per year). Net forest carbon sequestration in 2018 is down 3.0 MMT CO_2e when compared to the 2017 reporting period[1].

The 2018 reporting period annual rate of carbon sequestration for just the forest ecosystem pools is 26.2 MMT CO_2e per year. This value is down by approximately 3.0 MMT CO_2e per year from the 2017 reporting period. This reduction in carbon sequestration is the result of several factors including improvements in inventory methodology but is also being driven by two complementary factors; an increased rate of tree mortality and decreased gross growth rate on live trees during the most recent measurement years. Tree mortality regardless of cause, accounted for an additional 2.3 MMT of CO_2e converted to dead wood annually. Gross growth on trees measured 10-years earlier declined by 1.1 MMT CO_2e annually further reducing the net rate of sequestration. Of note, net change in the live tree pool on National Forest System lands decreased by 74% while net change in the standing dead pool increased by 16%. Changes in growth, removals, mortality and flux vary in each region, displaying different patterns amongst each category. Additional work is being completed to assess these differences in more detail.

Forest ecosystem and harvested wood product carbon stocks are approximately 3.2 billion metric tons. For just the forest ecosystem, carbon stocks are approximately 3.1 billion metric

[1] 2017 reporting period: CA net sequestration rate of 27.9 MMT 9 MMT CO_2e per year; includes changes in forest ecosystem pools (29.2 MMT CO_2e per year), harvested wood product pools (0.9 MMT CO_2e per year based on old version of HWP C model), non-CO_2 emissions from wildfires (-0.5 MMT CO_2e per year), and forest land conversions (-1.7 MMT CO_2e per year).

tons. This is a decrease of 0.2 billion metric tons of forest ecosystem carbon compared to the 2017 reporting period primarily due to the improvement of the forest soils estimation methodology. This decrease is attributed to refinements in the Digital General Soil Map of the United States (STATSGO2) dataset where soil orders may have changed in the updated data product, resulting in a structural change in the soil organic carbon estimates for mineral and organic soils across the entire time series (U.S. EPA 2020). However, when the 2017 reporting period is recalculated with the updated SOC method (see table 4.31), 2018 carbon stock represents an increase in line with previous results. Harvested wood products contribute an additional 134.8 MMT C to the forest ecosystem carbon stocks from current and historic harvests going back to 1952. The increase from the previous reporting period's HWP C estimate reflects revisions in input parameters and the model code, discussed further below in the "Improvements" section. When the original 2017 HWP C stocks (133.4 MMT C) are recalculated to reflect the revisions (134.6 MMT C), the 2018 stock represents an increase of 0.2 MMT C.

In many forest types, current stocking levels reflect over a century of fire suppression and may not represent stand densities that are resilient to disturbances common to California forests such as fire or pest outbreaks. Additionally, as the forests age in unharvested stands, growth rates slow. Older forests tend to store more carbon, but they might not accumulate new carbon as quickly as younger, fast-growing stands. Consequently, the stocks and flux represented in this report may not be sustainable into the future without forest management given the uncertainty in potential effects from climate change, the current level of forest disturbances from wildfire and pests, and aging of forests on federal lands. Compared to previous reporting periods, we continue to see drought effects on tree growth and mortality. Forests provide many other services beyond carbon sequestration and storage, so there are many other considerations beyond forest carbon dynamics when developing management actions.

This update includes several minor revisions to correct previous harvested wood product carbon stock and flux estimates. Corrections described below under "Improvements" section.

Key Findings:

<u>FOREST ECOSYSTEM CARBON</u>

Forest land area:

- As of 2018 there are approximately 32 million acres of forest land across all ownerships.
- 16.4 million acres are classified as timberland with an additional 4.2 million acres of productive forest land in reserves.
- The federal government manages 58% of California's forest lands, with the remaining areas under state and local government (3%) or private management (39%) (Figure 2.4).

- Overall there was a net loss of forest land at the rate of 25.9 ± 7.2 thousand acres per year, primarily to developed land-uses (Table 4.8/E1). The confidence interval is high compared to the estimate because it is a relatively rare event at the scale of the inventory.
- Most of the forest land loss occurred on non-productive “other forest” (54%), followed by timberland (41%), with little change occurring on reserved lands (5%).
- Western oak woodlands cover the greatest area of all forest types at approximately 8.8 ± 0.38 million acres, followed by California mixed conifer at approximately 7.9 ± 0.34 million acres (Table 4.11; Appendix 2, Table A17).

Average net annual forest carbon dioxide sequestration - overview:

- Overall California forests are exceeding the 5 MMT CO2e target rate of annual sequestration established by AB 1504, sequestering 26.9 ± 4.7 MMT CO_2e per year (excludes confidence interval for HWP C flux; Table 7.1). This value includes changes in forest ecosystem pools (26.2 MMT CO_2e per year), harvested wood product pools (0.7 MMT CO_2e per year), non-CO_2 emissions from wildfires (-0.6 MMT CO_2e per year), and forest land conversions (-1.5 MMT CO_2e per year).
- Based on plots initially measured between 2001-2008 and re-measured between 2011-2018, the average statewide rate of forest carbon sequestration is 26.2 ± 4.7 MMT CO_2e per year, excluding net CO_2e contributions from other sources such as, harvested wood products, forest land conversions and non-CO_2 GHG emissions from wildfire (Table 4.1, 4.3).
- Net flux in the soil organic carbon pool is estimated at -0.5 ± 0.6 MMT CO_2e per year (Table 4.1-4.3).
- Combined annual net emissions of non-CO_2 GHGs (methane and nitrous oxide) from wildfire is estimated to be 0.6 ± 0.1 MMT CO_2e per year (Table 4.2a, 4.7).
- Changes in land-use between forest and non-forest land condition is estimated to have a net effect of emitting 1.5 ± 0.9 MMT CO_2e per year (Table 4.2a, 4.9).
- Based on the 2018 measurement period, after accounting for these other CO_2 and greenhouse gas sources the statewide rate of carbon sequestration on all forest land is 27.2 ± 5.0 MMT CO_2e per year (Table 4.2a), down from the 2015 reporting period estimate of 32.8 ± 5.5 MMT CO_2e, the 2016 reporting period estimate of 30.7 ± 5.3 MMT CO_2e and 2017 reporting period estimate of 27.0 ± 5.5. This value excludes contributions from HWP pools.

Average net annual forest carbon dioxide sequestration – by pool:

- Growth on live trees, including foliage and live roots, makes up 71% of the annual CO_2e flux on all forest land at a net rate of about 19.0 ± 4.1 MMT CO_2e per year (Table 4.3).
- Of the estimated 13.7 MMT CO_2e per year cut within the forest (Table 4.3, 4.6a), approximately 10.0 MMT CO_2e per year in the form of commercial timber was removed from the forest to either be stored long term in durable wood products or emitted from burning (Appendix 3, Table 3.14).

Average net annual forest carbon dioxide sequestration – by owner:

- Individual noncorporate forest land owners provide the largest contribution, accounting for 40% of the statewide annual flux at a rate of 10.4 ± 1.4 MMT CO_2e per year (figure 4.1). While there is only an increase in the rate of 0.1 MMT CO_2e per year from the previous measurement period, this represents a 4% increase in the percent contribution, mainly due to a decrease in the contribution from National Forest System lands.
- The national forests account for 30% of the statewide annual flux at a rate of 7.7 ± 2.7 MMT CO_2e per year (figure 4.1). This represents a decrease of approximately 2.6 MMT CO_2e per year from the previous measurement period, dropping the percent contribution from these lands by 5%.
- Corporate forest land accounts for 19% of the statewide annual flux at a rate of 5.1 ± 3.2 MMT CO_2e per year (figure 4.1). This represents an increase of 0.3 MMT CO_2e per year from the previous measurement period, and a 3% in increase in the percent contribution.
- State and local governments contribute 8% of the statewide annual flux at a rate of 2.1 ± 0.7 MMT CO_2e per year (figure 4.1).
- Other federal lands contribute 3% of the statewide annual flux at a rate of 0.9 ± 1.3 MMT CO_2e per year (figure 4.1). This represents a decrease from the previous measurement period of 0.5 MMT CO_2e per year and a 3% decrease in the percent contribution.
- Only on reserved forest lands managed by the Forest Service is live tree growth not currently estimated to exceed carbon losses from the live tree pool due to tree mortality, as in previous measurement cycles (Figure 4.4a, Table 4.4a).
- As in previous measurement cycles, annual gross growth per acre on live trees is currently exceeding all other carbon losses from the live tree pool due to mortality or harvest on unreserved timberland for all ownerships including lands managed by the Forest Service.

- The annual net rate of carbon sequestration per acre in the live tree pool is greatest on timberland owned by state and local government at 4.1 ± 1.9 metric tons of CO_2e per acre per year (Appendix 2, Table B12).
- The next highest annual net rate of carbon sequestration per acre in the live tree pool is on timberland owned by private individuals at 2.5 ± 0.4 metric tons of CO_2e per acre per year (Figure 4.4b, Table 4.4b).
- Trees growing on all ownerships across all of California's forests are sequestering carbon at a net rate of 0.5 ± 0.1 metric tons CO_2e per acre per year (Table 4.4a).

Average net annual forest carbon dioxide sequestration – by region:

- The Sierra/Cascades region has the greatest annual growth in its forests relative to growth from other regions. This region also has the greatest amount of mortality; after accounting for harvest, live trees in the Sierra/Cascades region are still sequestering 3.1 ± 2.6 MMT CO_2e per year. It is no longer the region with the highest net live tree CO_2e flux due to decreases in the growth rate and increases in mortality (figure 4.6). This is down from the 2015 measurement period which estimated a rate of 8.7 ± 3.0 MMT CO_2e per year, the 2016 measurement period which estimated a rate of 7.8 ± 2.7 MMT CO_2e per year, and the 2017 measurement period which estimated a rate of 5.5 ± 2.7 MMT CO_2e per year.
- The North Coast region has the highest net carbon sequestration at 7.7 ± 1.8 MMT CO_2e per year.
- The Southern Coastal Mountains and Deserts region continues to be the only region where tree mortality is exceeding tree growth, resulting in a net carbon reduction of the live tree pool of 0.8 ± 0.4 MMT CO_2e per year (figure 4.6). Further analysis is being conducted to determine why this region is experiencing an annual net loss of CO_2e and will be presented in a later report.

Average net annual forest carbon dioxide sequestration – Forest Practice Districts

- Net annual sequestration from forests in the Northern Forest Practice District is 8.9 ± 2.9 MMT CO_2e (15% lower than 2017 reporting period); in the Southern Forest Practice District net annual forest sequestration is 2.9 ± 1.8 MMT CO_2e (42% lower than 2017 reporting period); and in the Coastal Forest Practice District it is 11.9 ± 2.7 MMT CO_2e (9% lower than 2017 reporting period) (Table 4.2b). These values include change from all forest ecosystem pools and non-CO_2 emissions from wildfires, but does not include change from harvested wood product pools or from forest land use conversions.
- The Southern Forest Practice District is experiencing carbon losses due to mortality primarily on forest land managed by National Forests nearly equaling gross growth on live trees leaving this district susceptible to net carbon loss if the current rate of disturbance increases (Tables 4d, 4e, 4f).

Average net annual forest carbon dioxide sequestration – County

- Mendocino (5.3 ± 1.4 MMT CO_2e per year) and Humboldt (4.9 ± 2.2 MMT CO_2e per year) counties have the highest net carbon sequestration rates for all forest pools (Table 4.6b).
- By county, notable counties estimated in 2018 to have a net loss of forest carbon based on all pools are; Monterey (-0.3 ± 0.6 MMT CO_2e per year), San Bernardino (-0.4 ± 0.3 MMT CO_2e per year), Santa Barbara (-0.2 ± 0.2 MMT CO_2e per year), and Tuolumne (-0.7 ± 1.1 MMT CO_2e per year) (Table 4.6b).

Average net annual forest carbon dioxide sequestration – National Forests

- The Shasta-Trinity National Forest has the highest net annual carbon sequestration rate for all forest pools at approximately 2.2 ± 0.9 MMT CO_2e per year (Table 4.6c).
- There are three national forests in California currently experiencing a net loss of carbon based on all pools; San Bernardino (-0.4 ± 0.3 MMT CO_2e per year), Los Padres (-0.6 ± 0.6 MMT CO_2e per year), Angeles (-0.1 ± 0.2 MMT CO_2e per year (Table 4.6c).

Carbon stocks for forest land remaining forest land (FF) by pool:

- Currently the is just under 3.1 billion metric tons of carbon stocks stored on forest land including forest soils across all ownerships in California (Table 4.12a, figure 4.9, 4.10).
- Although this number is approximately 173 million metric tons less than the number reported in the previous inventory, the main decrease was due to an improvement in the soil organic carbon pool accounting methodology. When the previous estimates are recalculated with this same improvement, it results in an approximate increase of 4.4 million metric tons of carbon stocks from the prior inventory.
- Approximately one third of this stored carbon is found above ground in the live tree pool (including foliage) (1,064 ± 27 MMT C, Table 4.12a, figure 4.9).
- Forest soils store about 45% of the carbon (1,400 ± 17 MMT C, Table 4.12a, figure 4.9).
- Approximately 7% of the stored carbon is found aboveground in dead wood pools (213 ± 7 MMT C, Table 4.12a, figure 4.9).
- Estimates of carbon on the forest floor was added in 2017 and contributed 136 ± 2 MMT C, Table 4.12a, figure 4.9).

Carbon stocks for forest land remaining forest land (FF) by owner:

- Approximately 65% of the carbon stocks in the state are found on public forest land (1,992 ± 40 MMT C), with approximately 80% of that on National Forest System lands (1,595 ± 31 MMT C) (Table 4.12a, figure 4.8).
- Private corporate forest land contains approximately 17% of the state's carbon stocks (529 ± 28 MMT C, Table 4.12a, figure 4.8).

- Private noncorporate forest land contains approximately 18% of the state's carbon stocks (562 ± 29 MMT C, Table 4.12a, figure 4.8).
- Approximately 60% of the forest carbon stores are found on unreserved timberland (1,843 MMT C, Table 4.12a, Figure 4.10).

Carbon stocks for forest land remaining forest land (FF) by region:

- Nearly half of California's carbon stocks in all carbon pools are found in a single region, the Sierra and Cascade Mountain Ranges. This region represents 47% of the forest land area and contains 1,442 ± 47 MMT C (Table 4.19, figure 4.11). The majority of the decrease from the previous reporting period is due to refinements in the SOC accounting method.
- The next largest carbon store, the Klamath Interior and Coast Ranges region has about half the carbon stocks found in the Sierra and Cascades and just over a quarter of those found in the state at 878 ± 44 MMT C (Table 4.17, figure 4.11). The majority of the decrease from the previous reporting period is due to refinements in the SOC accounting method.
- For each of these regions the dead tree and down woody material pools are each about 10% of the live tree carbon pool.

Carbon stocks for forest land remaining forest land (FF) by forest type:

- The California mixed conifer forest type contains the largest carbon stock compared to all other forest types, storing approximately 982 ± 44 MMT C (Table 4.21, Figure 4.12). The decrease from the previous year's estimate is entirely due to refinements in the SOC accounting method; all other pools increased slightly.
- Western oak forests follow with 636 ± 30 MMT C (Table 4.21, Figure 4.12). The decrease from the previous year's estimate is mainly due to refinements in the SOC accounting method; live tree, understory and forest floor pools decreased slightly while the remaining pools increased slightly.
- Notable exceptions of forest types where live tree carbon exceeds soil carbon includes the redwood, Douglas-fir, and tanoak/laurel types.
- Most carbon stocks are found on unreserved timberland for most softwood forest types (Table 4.22, figure 4.13).
- The redwood forest type has the highest carbon density per acre (figure 4.14).
- Regional data by forest type is included in Appendix 1.

Carbon stocks for forest land remaining forest land (FF) by county:

- The counties with the highest carbon stocks are Siskiyou county with 320.5 ± 28.5 MMT C, Humboldt county with 245.7 ± 31.1 MMT C and Trinity county with 224.0 ± 25.7 MMT

C (Table 4.12b). Although these numbers are less than the number reported in the previous inventory, the main decrease is likely due to an improvement in the soil organic carbon pool accounting methodology.

Carbon stocks for forest land remaining forest land (FF) by National Forest:

- The Shasta-Trinity National Forest has the highest carbon stocks at 230.7 ± 25.2 MMT C and is also the largest National Forest at approximately 1.9 ± 0.2 million acres. (Table 4.12c) Although these numbers are less than the number reported in the previous inventory, the main decrease is likely due to an improvement in the soil organic carbon pool accounting methodology.

Carbon stocks for forest land remaining forest land (FF) by Forest Practice District:

- The Northern Forest Practice District has the highest carbon stocks at 1,344.7 ± 45.4 MMT C (Table 4.12e).
- In the Northern and Southern Forest Practice Districts, carbon on public lands make up the majority of the forest carbon, while in the Coastal Forest Practice District carbon on private lands make up the majority of the forest carbon (Table 4.12d, e, f).

Comparison to the Forest Management Reference Level (FMRL):

- FIA's initial 10-year forest inventory in California installed from 2001 - 2010 is the FMRL basis (i.e., baseline) to evaluate relative changes in California forest carbon stocks between measurement periods.
- Stock-change comparisons to the FMRL cannot determine net flux until the entire 10-year re-measurement period is complete in 2020. The GRM method is used to estimate annual net flux.
- Comparison to the FMRL show that overall California's forest carbon stocks are increasing over time with minor annual variations (table 4.31).

HARVESTED WOOD PRODUCT CARBON

2018 reporting period HWP C estimates for stock and flux reflect revisions in erroneous input parameters (board foot to cubic foot conversion factor for 2013-2018 and end-use ratios for all years) and revisions in the HWP C model code to correct errors resulting in approximately 1% of the carbon disappearing from all storage and emission pools. Revisions are described further below in the "Improvements" section.

HWP C stock

- For the 2018 California AB 1504 reporting period, the average HWP C stock is approximately 78.0 MMT C for products in use (HWP-use), 56.8 MMT C for products in solid waste disposal sites (HWP-SWDS), and approximately 134.8 MMT C for both HWP pools (see Table 6.5). The majority of the increase from the previous reporting period's estimate of 133.4 MMT C is due to the revisions in the HWP C model. When the 2017 reporting period estimate is recalculated with the revised HWP C model, stocks are slightly higher in the 2018 reporting period. Monte Carlo analysis has not been completed for this data update as the model is currently being revised to correct errors in Monte Carlo analysis.

- For the 2018 California AB 1504 reporting period, carbon stored from privately owned forestland comprises 67% of the HWP C stock at 90.6 MMT C. Carbon stored from harvest originating from USFS forestland comprises 31% of the HWP C stock at 41.7MMT C, with the remainder of the HWP C stocks coming from Tribal, BLM, and State and other public land.

HWP C flux

- For the 2018 California AB 1504 reporting period, the average HWP C flux is approximately -1.3 MMT CO2e for products in use, 2.0 MMT CO2e for products in SWDS, and 0.7 MMT CO2e for all pools (see Table 6.6). The decrease in net HWP C flux from the previous reporting period estimate is due to revisions in the HWP C model. When the 2017 reporting period estimate is recalculated with the revised HWP C model, net flux is slightly higher in the 2018 reporting period.
- For the 2018 California AB 1504 reporting period, for all ownerships, net flux in the products in use pool is negative, representing a shift in HWP C from the products in use pool to the SWDS pool faster than new carbon is being added to the products in use pool.

Harvest

- The weighted average annual harvest values associated with the 2018 California AB 1504 reporting period is approximately 2.7 MMT C (1.6 million MBF). This equates to approximately 10.0 MMT CO2e per year in the form of commercial timber removed from the forest (Appendix 3, Table 3.14). Based on the forest ecosystem portion of the inventory for the same time period, approximately 13.7 MMT CO2e per year is cut within the forest (Table 4.6a).

HWP C Emissions

- HWP C emissions data for HWP burned with and without energy capture are not included in forest sector C accounting, but are used in other sectors (i.e., waste, energy). Cumulative emissions associated with these pools (HWP-energy, HWP-without energy) for individual years can be found in table 6.2. However, without a greater understanding of the reporting timeframes and data needs from these other sectors, additional calculations on HWP emissions are not provided in this report at this time.

Background:

The forest sector carbon data provided in this update comply with the Intergovernmental Panel on Climate Change Tier 3 good practice guidelines for carbon accounting (IPCC 2006, 2014) and are intended to assist the Board in evaluating and monitoring progress on meeting California's forest sector carbon sequestration target. This update can inform policy decision-making, but is not intended to be a complex policy assessment framework. Forest ecosystem carbon stocks and flux are established using direct measurements on forested plots throughout the state of California as part of the United States Department of Agriculture (USDA) Forest Service Forest Inventory and Analysis (FIA) program. Harvested wood product carbon (HWP C) stocks are based on estimates from the California variant of the harvested wood product carbon accounting model based upon the IPCC Tier 3 production accounting approach.

The forest ecosystem data presented in this report are based on the 2009-2018 FIA measurement cycle. Carbon stocks physically present in the forest are based on a 10-year average for the time-period of 2009-2018 and given in metric tons (MT) of carbon (C). The estimates of average annual carbon sequestration (i.e., net flux) is based on plots and trees initially measured between 2001 and 2008 then re-measured 10 years later between 2011 and 2018. Calculating flux based on actual growth, removals and mortality (i.e., the GRM approach) allows for annual reporting and is more statistically robust than a simple stock-change approach.

Harvested wood product carbon estimates include contributions from current and historic harvests going back to 1952, the year annual harvest data was available for all ownerships. Harvested wood product carbon stocks are reported by the HWP C model in the year following harvest, i.e. harvested wood product carbon stock associated with 2018 removals is reported in year 2019. To be consistent with FIA's forest ecosystem ten-year average reporting periods and correspond with 2009-2018 annual harvests, the 10-year average of the HWP C stock for the years 2010-2019 is reported. Harvested wood product carbon flux for the 2018 reporting period is reported as the average annual flux for the eight ten-year intervals of 2002-2012, 2003-2013, 2004-2014, 2005-2015, 2006-2016, 2007-2017, and 2008-2018 2009-2019 to match the removals associated with the 2018 FIA plot remeasurement cycle.

Forest ecosystem and harvested wood product carbon stock and flux results associated with these time periods are referred to as 2018 results, 2018 reporting period results, or 2018 measurement cycle results throughout the report. To more clearly describe the time periods covered in the stock and flux estimates in this report, please note that the title has been changed to reflect the "2018 reporting period," rather than specific ranges of years.

In this analysis results of carbon physically present in the forest or in harvested wood products in use or at solid waste disposal sites are given in metric tons (MT) of carbon (C). Results of carbon flux are given in metric tons (MT) of carbon dioxide equivalent (CO_2e). Net changes in individual carbon pools are also shown in units of CO_2e to provide insight into the components of change, even if they aren't a direct flux with the atmosphere (e.g., tree mortality, which is a conversion from live to dead wood that initially stays in the ecosystem; transition from harvested wood products in use to harvested wood products in solid waste disposal sites). Carbon can be converted to CO_2e by multiplying by 3.667 or the fraction 44/12[2]. Ranges in the text presented for forest ecosystem results (i.e., ±) represent a 95% confidence interval (CI), while values in the tables report the sampling error (SE; CI = 1.96*SE). Confidence intervals around forest ecosystem flux estimates tend to be slightly smaller than in the previous year's report because estimates are based on more plots (8/10ths of the full cycle compared to 7/10ths).

Reports released to date include:

- AB 1504 California Forest Ecosystem and Harvested Wood Product Carbon Inventory: 2006 – 2015 FINAL REPORT (Christensen et al. 2017).
- AB 1504 California Forest Ecosystem and Harvested Wood Product Carbon Inventory: 2006 – 2015 ERRATUM SHEET (Christensen et al. 2018a).
- AB 1504 California Forest Ecosystem and Harvested Wood Product Carbon Inventory: 2007 – 2016 DATA UPDATE (Christensen et al. 2018b).
- AB 1504 California Forest Ecosystem and Harvested Wood Product Carbon Inventory: 2017 Reporting Period FINAL REPORT (Christensen et al. 2019).
- AB 1504 California Forest Ecosystem and Harvested Wood Product Carbon Inventory: 2018 Reporting Period DATA UPDATE (i.e., this report)

Improvements:

Errors found after release of the initial inventory (Christensen et al. 2017) are detailed in Christensen et al. 2018a and are also corrected in subsequent reports. Please note that to compare some results to the initial 2015 report, the erratum must be referred to. Changes to this data update from previous reports include:

[2] Throughout the forest ecosystem portion of the inventory, results are converted from C to CO_2e by multiplying by 3.667. Throughout the harvested wood product portion of the inventory, results are converted from C to CO_2e by

- Revision of soil organic carbon stock and flux estimates based on refinements in the Digital General Soil Map of the United States (STATSGO2) dataset (U.S. EPA 2020).
- Minor revisions of harvested wood product carbon stock and flux estimates following the discovery of errors in input parameters:
    - The 2013 – 2018 board foot to cubic foot conversion factor was updated to 4.2857 from the value of 3.9594 applied to those years in the previous report – see updated table 5.2; based on information from the most recent 2016 timber products output report (Marcille, et al. in press).
    - Revisions made to end-use product ratios after discovery of rounding errors originating in McKeever (2011). Very small additions and subtractions were made to the "other" end-use category within each primary product category so that the ratios within each primary product category summed to one. This work was completed by Andrew Yost, Oregon Department of Forestry (A. Yost, pers. communication, April 30, 2020).
- Minor revisions of harvested wood product carbon stock and flux estimates following the discovery of errors in the HWP C model code that resulted in two issues: (1) on average, approximately 1% of the initial harvested carbon to disappear from storage pools and remain unaccounted for in emission categories (revisions complete in this update) (2) narrower confidences intervals than expected based on the parameters set for Monte Carlo Uncertainty Analysis (revisions to Monte Carlo Analysis still in progress and not completed in this update). These errors are being corrected through re-coding the model using R-script through an agreement between Oregon Department of Forestry, Oregon State University, and Groom Analytics, LLC.
    - Additionally, in order to allow for better quality assurance of calculations, lag times built into the original model were modified. The model assumes that all trees harvested in a given year are processed within that year and the carbon is distributed according to the end use product ratios of that same year. Most of the carbon is immediately burned or turned into Products in Use. A fraction (the 8% loss factor) is immediately discarded and distributed to the different discard fates using the discarded disposition ratios for the same year. The carbon fate for a given year is reported in the following year. Carbon that enters the model in a given year does not undergo a half-life decay until the following year. For example, the model uses the TPO for 1952 and all product and discard ratios for 1952 to distribute the carbon in Products in Use, products at Solid Waste Disposal Sites (SWDS), and the Burned with and without Energy Capture pools. The sum of those fates for 1952 is recorded in tables as occurring by January 1, 1953. Any carbon from

1952 that was distributed to Products in Use, Landfill, or Dumps was subject to a half-life decay or disposal in 1953 (J. Groom, pers. communication, Aug. 13, 2020). In this way, inputs from harvest into the products in use and solid waste disposal pools, as well as decay from those pools are all reported in the same year. Now, if a single harvest year is being evaluated, sums for all storage and emission pools within an inventory year will sum to the harvested carbon. In the previous iteration of the model, carbon was emitted or wound up in use (e.g., Products in Use) the year after harvest, and that carbon ended up in SWDS the year *after* it was produced as a stock (i.e., shifted two years). Half-life emissions from landfills and dumps occurred the same year as the discarded carbon enters SWDS (the emissions are not lagged a year, just the SWDS stocks). That the fate from one harvest year was recorded the following year and discard and associated decay was not accounted for until the year following that, complicated the ease of verifying the model tracking of harvested carbon through the various fates.

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