Wood Carbon Seminars - Master List of Questions and Answers

This document is a product of the Wood Carbon Seminars, which was an 8-week webinar series organized by the Carbon Leadership Forum that ran from April 23 - June 11, 2020. For more information about the webinar series, including a list of speakers, presentation slides, and video recordings, go to: http://carbonleadershipforum.org/projects/wood-carbon-seminars/

#	Session	Presen-tation	Question	Answer	Author of answer
1	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	How do different approaches to forest management affect the forest carbon balance differently?	The major drivers of forest carbon balance are related to how quickly carbon is taken up (related to leaf area), how much carbon is stored in the woods (related to how many live trees, dead trees, downed wood, understory vegetation, etc.) are kept, and how quickly carbon leaves the forest (due to decay, combustion or harvest). Some of the harvested material will wind up in wood products and remain stored. Different forest management approaches affect all of these variables differently. "Lighter touch" foresty may leave more carbon in the woods, but less in products. Conversely, more intensive forestry often transfers more carbon into the products pool. The overall net effect is highly dependent on forest type, management history, and type of products that are generated.	David Diaz
2	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	What is the difference between "sustainable" and "carbon-smart" forest management?	Refer to David Diaz's presentation http://carbonleadershipforum.org/news-and-events/wood-carbon-seminars-course-page/	Monica Huang
3	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	What are the incentives for forest managers to maximize carbon storage?	The closest example we have right now is carbon offset crediting. There is a program called Environmental Quality Incentives Program which is administered by the USDA Natural Resources Conservation Service with funding from the US Farm Bill to encourage carbon sequestration through forest management, but this program has not yet seen much investment or enrollment.	David Diaz

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4	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	How do certain types of forest management activities fit within carbon offset programs?	Carbon offset programs typically recognize three main types of forest carbon projects: A/R - Afforestation/Reforestation, which involves planting trees in areas that are currently non-forest and unlikely to naturally revert to forest cover; IFM - Improved Forest Management, which involves forest practices that increase carbon stocking in the forest over time; and Avoided Conversion (also known as REDD or Reducing Emissions from Deforestation and Degradation), which involves preventing the conversion of forest to non-forest or preventing the loss of carbon stocks due to extractive management.	David Diaz
5	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	How much would the terrestrial carbon cycle change if there were significant changes in land management (good and bad) in comparison to the scale of fossil carbon emissions?	Great question. Scientists with The Nature Conservancy and others looked into the global natural climate solution mitigation opportunities and published this article in 2017, https://www.pnas.org/content/114/44/11645. They found that natural climate solutions could provide 30% of the mitigation needed to keep under a 2 degree C warming between now and 2030. Forests provide the highest opportunity with the most potential in reforestation, followed by avoided conversion. They also examined agriculture, grasslands, and wetland mitigation opportunities.	Edie Sonne Hall

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6	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	What are the challenges related to taking the carbon cycle and flows happening at the forest landscape level and attributing / addressing them along the value chain/life cycle of harvested wood products including the end-of-life treatment of the wood?	Many, many, many….. We scientists call it job security. :) Start with the idea that wood used in construction, as produced in North America, is a commodity product. It can go anywhere in the world and be used for any application - both short term and long term. Once it leaves the forest, the landowner no longer has control over how it is merchandized or where it goes. Once it leaves the mill the same applies. The AEC community has a huge role to play in designing buildings for longevity, and perhaps even for disassembly, but once they are done they no longer have control over the fate of that wood product. Choices on land use, urban growth and maybe even a natural disaster then determine the lifespan of that building. The eventual owner that decides to tear it down decides if the material is reused, recycled, landfilled or burned, perhaps in conjunction with government regulatory authorities. Tracking a single piece of wood through this system is impossible with current technology though we are talking about QR codes and what that might look like. That said, combining the detailed per m3 data found in LCA and EPD with models on global trade, wood production and distribution, urban growth, infrastructure longevity, and advances in waste recovery are all needed to really understand where we are now in developing a circularity in the carbon flows and how to improve on it to fully implement circular economy principles.	Elaine Oneil

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7	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	What is the difference between working forests and reserved forests? And between public forests and private forests?	Working forests are managed for wood products, reserved forests are reserved from harvest (no harvesting and sometimes other limitations (like no access, no fire control) are in place. Public forests are owned by federal, state, provincial, or local government authorities. Management objectives may include timber harvest to provide income for schools (e.g. - WA State lands are for that purpose), or recreation, or a myriad of other public goods. The public has an expectation and a right to have input on management choices. Private forests are owned by industrial or small private landowners. - If industrial, the focus is primarily on growing timber for sale. - If small private, the management intent is all over the map - from complete protection to managing similarly to industrial landowners. In the PNW, private lands are subject to forest practices rules developed in consultation with natural resource agencies, tribes, and interested public entities. Tribal forests are sometimes lumped in with private and sometimes with public, but they really belong in their own class as the management is driven by tribal goals and objectives for their lands.	Elaine Oneil

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8	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	What are the top 5 carbon-sequestering forestry practices?	The answer depends on which forest type of forest you're in, what the current forest conditions are, whether you account for carbon stored in wood products, and what benchmark you use to compare your performance against. - When timber harvesting is not a major driver of management, then planting trees and protecting existing forests from disturbance are common strategies. - In managed forests, if you think only about the carbon stored in the forest, leaving the forest unmanaged will typically accumulate the most carbon over time compared to any active management interventions (assuming there is not a major natural disturbance that would occur due to your departure). - If you consider "business as usual" forestry oriented towards generating revenue from timber sales as a benchmark, the most commonly proposed practices to increase carbon stocking in forests involve extending the time between harvests (extended rotations), increasing the retention of trees during harvests (partial harvest or thinning rather than clearcutting), expanding set-aside areas (reserves or buffers around sensitive locations on the landscape). - If you consider carbon stocks in products, and the potential to avoid emissions through the substitution of wood instead of more carbon-intensive materials, then practices that increase the recovery of solid wood (extended rotations to produce larger trees with higher recovery rates), and investments in milling efficiency and mass timber uses in buildings will also likely rise on the list.	David Diaz
9	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	What attributes would a timber producer need to measure and report to allow reasonable estimation of the embodied carbon associated with carbon stock stock change in their managed forests?	Two main things: 1) How much has the timber or carbon inventory changed over some specific timeframe across their ownership; and 2) How much timber have they sold to market.	David Diaz

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10	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	Could timber producers easily quantify how much they have increased or decreased the carbon stocks (or timber volume) on lands they manage over the past 5- or 10-year period? Why don't they?	David Diaz: Yes. Timber inventory stocking and change over time are usually well-known and can be translated into carbon stocking with some basic assumptions. However, information related to timber stocking and yield is closely related to the business strategies and competitive advantage that some timber producers and forest product suppliers consider to be important proprietary knowledge. In order to justify disclosure of information like this, private owners would need to believe the value of disclosing that information outweighs the costs of doing so. Unless there is a clear value proposition to disclose more information, suppliers to a market are unlikely to voluntarily disclose this type of information publicly. Edie Sonne Hall: Additionally, as a practical matter, the individual landowner level won't tell a consumer the information they want- it is the landscape level that will determin whether or not carbon stocks are increasing or descreasing. A landscape is made up of thousands of different landowners, owning forest land from 20 acres (or less) to 100,000 acres.	David Diaz, Edie Sonne Hall
11	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	What are the impacts on net carbon emissions, sequestration and storage, biodiversity conservation and ecological resilience of protecting more previously-logged forests and allowing them to recover ("pro forestation") instead of logging them?	The answer depends primarily on two assumptions: 1) if this was a forest that previously produced timber, what kind of market-mediated response will there by to meet demand by increasing timber utilization in other areas, and are those areas more or less carbon-dense than the area being protected; and 2) how much carbon emission can be avoided by using forest products in lieu of other building materials. Both of these are critical components to any serious answer of a question like this regarding sweeping forest carbon policies. Because market leakage and product substitution are indirect and market-mediated effects, they are very hard to quantify empirically, there are no standard accounting rules for doing so, and the basic methods are subject to significant and ongoing scientific debate.	David Diaz

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12	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	How do different forest types store carbon in the soil?	Soil carbon is complex and will be impacted by soil flora and fauna as well as regeneration of plants as soon as light hits the soil. From ESA.org: "Through the process of photosynthesis, plants assimilate carbon and return some of it to the atmosphere through respiration. The carbon that remains as plant tissue is then consumed by animals or added to the soil as litter when plants die and decompose. The primary way that carbon is stored in the soil is as soil organic matter (SOM). SOM is a complex mixture of carbon compounds, consisting of decomposing plant and animal tissue, microbes (protozoa, nematodes, fungi, and bacteria), and carbon associated with soil minerals. Carbon can remain stored in soils for millennia, or be quickly released back into the atmosphere. Climatic conditions, natural vegetation, soil texture, and drainage all affect the amount and length of time carbon is stored."	Pat Layton
13	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	How well do areas replanted after fire perform in terms of carbon sequestration. Is there data on how quickly a regenerate area burned by fire offsets the loss of carbon caused by the fire? What is the carbon profile if the area is salvaged for wood products and replanted?	Cynthia West: We do have a carbon profile for salvage after fire and if the primary ecosystem service is carbon salvage and conversion to long-lived forest products, the carbon benefit is greater than no salvage. However, if we are looking for wildlife benefits we want to leave some standing dead trees. It becomes a tradeoff of ecosystem service benefits. Elaine Oneil: Forests aren't always replanted after fire, especially on public lands as there simply aren't the funds to do so, and the expectation is that natural regeneration will fill the void. On private forest lands they are typically reforested after salvage harvest, sometimes by planting, sometimes by natural regeneration where its success is assured. In all cases results are mixed depending on the severity of the impacts on the forest soil which also burns during very hot fires, releasing its carbon content and reducing the forest productivity for future forests. (i.e. it can sustain less carbon sequestration).	Cynthia West, Elaine Oneil

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14	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	Are all types of wood available everywhere or are there pockets where purpose specific wood is available? For ex. softwood for CLT?	All types of wood do not *grow* everywhere, but could be *available* depending on logistics and shipping costs. Each type of wood has different properties, even within the same species depending on growing conditions, age, etc. Some species are better for certain applications than others considering. Fast-growing plantation species typically do not have much strength and are better for pulp & paper, bioenergy, or composite panels. Even within the same species, some pieces are stronger than others. Machine Stress Rated (MSR) lumber has been sorted based on strength and is better for load bearing applications. Engineered wood products such as glulam and cross laminated timber (CLT) can be made with different species of softwoods and hardwoods but should be certified based on careful testing. There are reliable organizations such as the APA: The Engineered Wood Association who test and certify wood for structural applications.	Cynthia West
15	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	Rephrased question: Aren't old growth (OG) forests just not the same as "scraggly" (young) forests?	While OG forests store a lot of carbon, their uptake is often static. It also depends on the rate of growth that is POSSIBLE on the land base. On Vancouver Island, where I worked, there is an 800 year old forest with a volume of 3600 cubic metres per hectare. Many of the trees were 10-ft or more in diameter. That is an annual growth rate of about 4.5 m3/ha/year. Another 320-year old stand had close to 2700 m3/ha. (9 m3/ha/year) But it is impossible to calculate how many trees started growing and then died and returned to CO2. The first stand had about 170 trees per hectare, with several hemlock and cedar undergrowth in that number. The second had 300 m3/ha. But in an adjacent fire-generated (natural) 60-year-old forest (5 miles away in the same valley) there is a stand with 1800 cubic metres per hectare (30 m3/ha/yr). 800 trees per hectare. We need to capture the capacity of the land base to mitigate climate change. That includes retention of OG and management for harvesting.	Peter Moonen
16	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	Is there a good resource to check out which species of softwood (and in cases hardwood) are suitable for CLT production and the physical properties of these species?	PRG 320 and affiliated standards mentioned therein. https://www.apawood.org/ansi-apa-prg-320	Pat Layton

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17	Background and basics	1.2 Trees, Forestry, and Carbon 101	How do timber harvest cycles affect forest carbon storage over the next 10, 20 and 30 years, how much is lost and stored in each of those time frames?	The major underlying question is "compared to what"? If a harvest scenario (e.g., harvest in 10 years) for a particular forest area is compared to a no-harvest scenario, ecosystem carbon stocks are likely to increase (despite losses that might be expected due to pests, fire, and other natural disturbances), while carbon stocks in wood products would decrease and any emissions avoided by substituting wood for non-wood alternatives would be delayed. Scientific research has typically found that the total carbon stocking across forests and products pools occurs if forests are left unmanaged--if wood products substitution impacts are not considered. However, if wood product substitution is considered, the net effect of alternative forest management strategies are challenging to estimate, and are very sensitive to assumptions about what would've happened (but can't ever be observed). The time-value of carbon, or the value of sequestering or emitting carbon now versus later into the future has also not traditionally been considered in answers to these types of questions either, but should illustrate how challenging and subjective many of these attempts can be at providing a simple or straightforward answer to such a complex question. It is also important to recognize that forest management and conservation decisions do not occur in policy or market vacuums, and will inevitably involve social, economic, and environmental tradeoffs beyond carbon impacts alone.	David Diaz

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18	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	All these models look forward to long scale. What should we do today to make a meaningful carbon difference in the next 30 years?	The easiest way to make a meaningful carbon difference in forests is to get more carbon in forests without reducing harvest (otherwise you have to deal with complications of accounting for leakage- either to other forests or to other materials that have higher embodied carbon). The following four strategies can enhance forest carbon without impacting harvest levels and prevent land conversion to a non-forest: 1. Plant new forests 2. Manage forests for productivity 3. Reduce risk of fire, insects, mortality. Advice for architects, engineers, owners, and other builders: - Use wood products more to encourage landowners to keep forests as forests and to manage those forests. - Do a better job of using the wood you get. CORRIM recently held a circular economy workshop (https://corrim.org/circular-economy-workshop/) where a presenter (Alan Organschi of Gray Organschi Architects) spoke to this need. While I thought the whole event was spectacular if you have only limited time please listen to his talk for some amazing inspirations on using wood as a climate mitigation solution. https://corrim.org/designing-a-global-carbon-sink/ - Ask for certification. Ask for any disclosures about the carbon and other environmental impacts that the supplier can provide about the forest or company that produced the logs. - Ask for SFI, PEFC, FSC sources. - Think local. - Question that a specifier can ask: Where was this wood sourced? Are the wood suppliers certified, and/or are they operating in a well regulated environment where rule of law prevails? Are forest resources in the supplying region increasing or declining?	Elaine Oneil/ Pat Layton / Edie Sonne Hall
19	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	How does soil carbon carbon get into the soil, how it is stored in the soil and how it is released from the soil?	(Organic) carbon gets into the soil primarily from the death and decomposition of plant tissues, both above- and belowground. It is stored in several forms which may include complex chemical bonds with mineral surfaces and in microbial biomass. Some soil carbon turns over quickly, while other "recalcitrant" soil carbon may persist for centuries. Organic carbon is released from soil by natural decomposing processes (where oxygen is available) which can be accelerated by disturbances.	David Diaz

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20	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	How variable is soil carbon? How can we quantify and verify changes in soil carbon due to human activity?	Soil carbon is very site-dependent so that is why it's hard for scientists to point-blank make a statement. However the general difference is that there is MORE carbon in a forest soil than other soil- so you get a loss of soil carbon with land-use change and vice versa. Re the impact of forest management, there are a LOT of studies that are looking at this. The Long-Term Soil Productivity sites across north America are a good place to look at studies. You will get some soil carbon emissions after harvest but that is built back over the course of the rotation. Also, Nave et al (2010) has done a meta-analysis on forest management impact on soil carbon and found there is either no or minimal change. Nave et al (2019) notes that soil carbon variability is very site specific and cannot be connected to a particular management practice.	Edie Sonne Hall
21	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	I would like to better understand what defines a 'forest.' I can appreciate the point that the best method to maintain carbon pools in forests is to 'keep forests, forests.' However, I think what some consider a forest others may consider a mono-culture tree crop that requires intensive inputs to stay healthy and in the end provides very little ecosystem service, biodiversity or natural forest characteristics. So, I think its important for this discussion to understand what you are calling a forest when you say like the best method to maintain carbon pools in forests is to 'keep forests, forests.'	There are several definitions by different organizations. Most follow something similar to the UN FAO which defines forests as places with at least 10% canopy cover by trees at least 0.5 hectares in size and for which there are not other predominating land-uses. The distinction in this question is more commonly captured in distinguishing between "natural" or "native" forests with "plantations" or "tree farms".	David Diaz

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22	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	Should old-growth forests be used for timber harvesting given that the original carbon stock may be recovered, if at all, at a very long timescale (e.g. McKinley study reference in slide 6)?	Forests with High or Exceptional Conservation Value are underrepresented on the landscape and should generally be protected. In general, the liquidation of an old growth forest for timber use now will involve a carbon debt that is unlikely to be repaid for a century or more. The loss of other ecosystem services is more dramatic. Most forest management certifications in use in North America include explicit guidance around the protection and conservation of forests, but each standard enforces these guidelines and criteria differently.	David Diaz
23	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	Are there statistics regarding timber harvesting from old-forest growth?	There isn't much harvest of old-growth in the US - we are already on the 2nd, 3rd or 4th rotation of plantations in most places - with some of them being replanted after the forest was completely cleared for agriculture (most common in SE US). Most remaining old-growth is reserved from harvest. In the BC interior they predominantly harvest old-growth as most of those forests have never been harvested before. Their massive mountain pine beetle outbreak (starting in the 1990's) which killed many old growth pine across about 17 million ha (35 million acres) has led them to accelerate harvest to try to capture that mortality before it rots and burns.	Elaine Oneil
24	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	Please explain how old-growth forests “collapse”	The old growth forests have their structure as a result of mortality. By definition, a huge number of trees die, which opens up the canopy for that complex development of understory. The total carrying capacity of that land area is thus concentrated on fewer large old trees, and some understory trees. So yes - you get a few old large trees, with other smaller trees in between. In surveys of old forests there can be more dead wood that is decaying on the ground than is standing in the trees. There are iconic old growth forests (think redwoods and giant sequoias and remnant Douglas-fir) - which aren't harvested by the way so don't contribute to the wood product system	Elaine Oneil

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25	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	In Canada, most logging is old growth boreal, as I understand it.	Yes, Canada harvests primary forests. From personal experience working in those forests, they are not growing, they are holding steady, and since I was there, millions of hectares have died from insects that hit old trees. It is not a stable system. It is dynamic as is all of nature, and even in a plantation.	Elaine Oneil
26	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	Can Cynthia provide me with a clear definition of what the USDA considers a 'forest?' 28-40 year industrial monoculture plants or an even aged forest with a mix of ages and species? Or something between?	Simple definition “trees and their affiliated plants and shrubs on a tract land” from dictionary: Forest includes natural forests and forest plantations. It is used to refer to land with a tree canopy cover of more than 10 percent and area of more than 0.5 ha. Forests are determined both by the presence of trees and the absence of other predominant land uses.	Pat Layton

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27	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	I don't see how one can attribute the regrowth of NE forests to forestry/logging - it happened mainly because of the decline of small-scale farming	Cynthia West: You are correct that most of the forests in the east are the result of farm abandonment. But growth of professional forestry over the last 60 years and state forestry program landowner assistance contributed to forest improvement Pat Layton: Most original forested land in the US will come back to forests if left alone, but that growth is slow to some extent. We are lucky in the US. In the US, many forested acres that were cleared for agriculture, returned to trees naturally, but in many cases such as under CCC, the Bankhead Jones Farm Tenet Act, the Soil Bank (1954-1960), and the CRP farmers were paid to remove agricultural crops and restore forests or grasslands. The USDA NRCS still have programs to do that in many states. Elaine Oneil: There is more natural mortality in unmanaged 'natural forests' than in planted forests. That is a national statistic that holds true in all regions. There is more growth (and sequestration) in planted forests than in unmanaged planted forests by a factor of about 30 if you look at the latest forest inventory statistics (Oswalt et al 2019, see below for citation)	Cynthia West, Pat Layton, Elaine Oneil
28	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	Can you provide the source for that citation? (Oswald 2019) Recent assessments have found gaps in the way that emissions are accounted (https://sierraclub.bc.ca/wp-content/uploads/2019-Clearcut-Carbon-report.pdf, https://loggingscars.ca). In Canada, 'sustainably' managed forests have been found lacking	Oswalt, Sonja N.; Smith, W. Brad; Miles, Patrick D.; Pugh, Scott A., coords. 2019. Forest Resources of the United States, 2017: a technical document supporting the Forest Service 2020 RPA Assessment. Gen. Tech. Rep. WO-97. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office. 223 p. https://doi.org/10.2737/WO-GTR-97.	Elaine Oneil

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29	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	If we increase demand will we harvest too much?	This is a great question and empirical evidence shows that forest landowners respond to increasing demand of wood products by planting more trees. At a global level, the countries with the highest industrial roundwood (the term used to describe wood the is manufactured into a commercial product) have the most stable or increasing carbon stocks and lowest rates of deforestation (land-use change). The converse is true as well (countries with little harvest experience the highest rates of deforestation). In the US, for example, prior to the Great Recession, harvest levels increased 35% from 1952 and forest volume increased by 50% in that same time period (USFS 2014. Forest Resources Facts and Historical Trends). In Sweden, both harvests and forest volume have doubled in the past 60 years (Royal Academy of Agriculture and Forestry. 2009. The Swedish Forestry Model). Some findings from the USFS Resource Planning Act assessment report (2010): “If future technology development and wood demands provide enhanced timber revenues, then historic experience suggests that forests and forest management with thrive. If the value of timber declines, however, through low-value use, limited demand, or insufficient forest product technology development, the future sustainability of forests will be compromised”. The IPCC also summarized: “Rather than leading to wide-scale loss of forest lands, growing markets for tree products can provide incentives for maintaining or increasing forest stocks and land cover, and improving forest health through management (IPCC 2014).	Edie Sonne Hall

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30	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	Architects and Engineers have focused on certification and promoting stronger certification - FSC vs SFI - having smaller clear cuts, bigger stream buffers, etc. What I am hearing is another large focus needs to be managing unmanaged forests, that are losing sequestered carbon through fire and insects, which sounds like supporting economic models that would allow the Forest Service to do this. Grossly oversimplified, but how can we do this?	David Diaz: Transitioning unmanaged forest landscapes to active management for timber production will involve numerous tradeoffs beyond carbon that are generally higher on the list of concerns (water quality, habitat for fish and wildlife, aesthetics, recreation) for the forest owners and managers who currently own and manage these lands. Edie Sonne Hall: As with all forest answers, this one is a mix. There are certainly many ecosystem benefits of unmanaged forests and efforts should (and are) made to preserve those that are identified as high conservation value forests or are otherwise healthy. The places where unmanaged forests are vulnerable to disturbances or have been degraded and not restored present an opportunity for improving forest health, resiliency, and productivity. These do not have to be managed primarily for timber production, but often activities such as thinning, can help improve resiliency of these forests.	David Diaz, Edie Sonne Hall

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31	Backgro und and basics	1.2 Trees, Forestry, and Carbon 101	Getting certified to FSC would require industrial forest landowners to evolve their models from a reliance on large-scale clearcutting / replanting of monocultures to a model that is less intensive, stores more carbon, retains more ecological resiliency and resistance, etc. — if certification doesn't result in improving forest practices, what's the point? It would be like 'certifying' and marketing industrial agriculture as equivalent to organics.	Certification is intended to provide a third-party verification that a landowner is meeting a certain set of agreed-upon standards related to water quality, biodiversity, wildlife, and forests with exceptional conservation value. The goal is to provide assurance that the land is being managed sustainably. US states use best management practices (BMPs) to promote good practices, but these are not required in all states. In many states, certification moves practices well beyond the minimum legal requirements. Assuming that one has to change practices in order to be certified to a standard assumes that the current practices are unsustainable, which may or may not be true- you can still maintain carbon, wildlife, water quality etc.. with intensive management but there may be different or more benefits with less intensive management. Finally, there are trade-offs between extensive (lighter touch) and intensive forestry in the number of acres needed to provide wood products.	Edie Sonne Hall/ Lauren Cooper
32	Backgro und and basics	1.3 Manufactu ring and the Forest Products Industry	What are the distribution mechanisms for various wood products?	Wood products are commonly moved by truck, rail, and ship (breakbulk and containers). Because wood products tend to be heavy and costly to move (relative to value), air transport is rare. Likewise, distance is often a limiting factor to market access, and/or weight is reduced through partial manufacturing before shipping long distances (e.g. wood is processed into pulp near the resource, then shipped around the world to paper mills).	Kent Wheiler

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33	Backgro und and basics	1.3 Manufactu ring and the Forest Products Industry	Where are timber mill locations?	This is a broad question. There are thousands of mills of various types throughout the world. If we limit this to U.S. locations, go to https://usaforests.org, click on BENEFITS and then FOREST PRODUCTS AND SERVICES, then scroll through the visuals; there are maps showing locations of sawmills, pulp mills, OSB mills, chip mills, pellet mills, biomass thermal plants, biomass power plants, cellulosic biofuel plants, and biomass-fueled combined heating and power (CHP) plants. RISI's (https://www.risiinfo.com) Random Lengths publishes an annual "Big Book" with details on all sawmills, shingle & shake mills, wood treating plants, plywood & veneer mills, OSB mills, non-structural composite panel mills, and secondary manufacturing operations throughout the U.S. and Canada. RISI publishes similar details on all pulp & paper mills in the U.S. and Canada. The EIA publishes details on all densified biomass fuel plants in the U.S. (https://www.eia.gov/biofuels/biomass/). There is similar data from multiple sources for all kinds of wood product operations throughout North America, Europe, Australia, New Zealand, Russia, etc. Many industry publications publish annual lists of manufacturing facilities throughout the world depending on the wood product and type of mill you are interested in.	Kent Wheiler
34	Backgro und and basics	1.3 Manufactu ring and the Forest Products Industry	Mill energy consumption -- which processes consume energy?	Lumber mills consume energy in the three main processes that occur at those facilities - sawing, kiln drying, and planing.	James Salazar
35	Backgro und and basics	1.3 Manufactu ring and the Forest Products Industry	Mill energy consumption -- what are the energy consumption ranges of mills?	Lumber mill energy consumption is documented in the various US regional LCA reports that are available on https://corrim.org/lcas-on-wood-products-library/.	James Salazar

#	Session	Presen-tation	Question	Answer	Author of answer
36	Backgro und and basics	1.3 Manufactu ring and the Forest Products Industry	Mill energy consumption -- what are the typical fuel sources?	Typical energy sources are electricity for sawing and planing and biomass or natural gas for drying.	James Salazar
37	Backgro und and basics	1.3 Manufactu ring and the Forest Products Industry	What happens to waste wood? Is it all used for bioenergy or something else?	There is no waste wood. 99+% of the log that comes to the sawmill for primary breakdown is used. The rest is swept up from the floor and log yard. Allocation varies by region depending on product demand, log quality, and price differentials. It might go to lumber, pulp (for paper/textiles), or as inputs to MDF, particle board, OSB, or other engineered product manufacturing. If there is insufficient demand, a tree might not make it to the mill (see discussion on small diameter timber below). That wood remains in the forest or is burned to reduce fire risk as part of normal forest management activities (and usually the law/regulation in the state/province where the harvest occurs). There are plenty of ecological arguments to retain forest residues on the land where they serve all sorts of functions in the regenerating forest. In many jurisdictions there are requirements to retain wood (of various sizes) in the forest to maintain these functions. Forests aren't always replanted after fire, especially on public lands as there simply aren't the funds to do so, and the expectation is that natural regeneration will fill the void. On private forest lands they are typically reforested after salvage harvest, sometimes by planting, sometimes by natural regeneration where its success is assured. In all cases results are mixed depending on the severity of the impacts on the forest soil which also burns during very hot fires, releasing its carbon content and reducing the forest productivity for future forests. (i.e. it can sustain less carbon sequestration).	Elaine Oneil

#	Session	Presen-tation	Question	Answer	Author of answer
38	Background and basics	1.3 Manufacturing and the Forest Products Industry	What is approximate breakdown of wood product consumption/production? Eg. how much wood consumed (in, for example, North America) for studs and other small dimensional lumber vs. plywood vs OSB vs glulams, CLT, etc, etc. Given estimates about the potential increased use of mass timber in buildings, how much does this change the total and relative proportions here?	Production statistics for the various commodity wood products are documented in the US regional LCA reports that are available on https://corrim.org/lcas-on-wood-products-library/	James Salazar
39	Background and basics	1.3 Manufacturing and the Forest Products Industry	What is the end of life for wood products, specifically CLT and glulam?	The typical end-of-life fate for wood products is landfilling.	James Salazar
40	Background and basics	1.3 Manufacturing and the Forest Products Industry	What units are used to quantify tree volume, lumber, and carbon stocks by foresters? By builders?	It depends where you are. In the US tree volume and lumber is measured in MBF (thousand board feet) but in Canada they are both measured in cubic meters (m3). There are required conversions to go from MBF (tree volume) to MBF lumber and they vary based on tree diameter and regional log scaling rules. In addition there is something called mill overrun - which is essentially the difference between MBF in logs and MBF in lumber. Whole books have been written on these conversions - see Briggs, D. G. (1994). Forest Products Measurements and Conversion Factors: With Special Emphasis on the U.S. Pacific Northwest, College of Forest Resources, University of Washington. They are a source of uncertainty in the LCA calculations which convert everything to a mass basis.	Elaine Oneil

#	Session	Presen-tation	Question	Answer	Author of answer
41	Backgro und and basics	1.3 Manufactu ring and the Forest Products Industry	Which regions in the world and the U.S. have more climate-friendly forestry practices? Which places have worse practices?	Recognizing that "climate-friendly" forestry practices depends on the definition, and that there are almost always some good and bad actors in every region...best practices and certification tend to be correlated with rule-of-law, environmental regulation, and industry organization. The U.S., Canada, W. Europe, Japan, Australia, New Zealand, and Chile are well regulated and have predominantly climate-friendly forestry practices with strong industry associations that promote and enforce best practices. Forestry practices are worse in less developed nations where rule-of-law is weak and regulations are unenforced or nonexistent.	Edie Sonne Hall/ Kent Wheiler
42	Backgro und and basics	1.3 Manufactu ring and the Forest Products Industry	Kent indicated that if timber is from North America it is relatively sustainable, but I've heard there is a drastic difference between business-as-usual forestry and FSC certified practices as far as carbon release from soil, etc. Can he discuss?	Any efforts to reduce soil disruption (e.g. from creating deep ruts in the forest floor) is going to minimize soil disruption. Certification generally promotes practices to reduce remaining tree mortality and disruption of the soil, particularly around waterways as an effort to reduce erosion and nearby water turbidity. All that noted, when forests are reforested or recover as forests, that land will not lose carbon the way conversion to agriculture land would over time. Soil carbon is considered much more stable, generally, as long as that forest cover remains forest and is not converted to other uses.	Lauren Cooper
43	Backgro und and basics	1.3 Manufactu ring and the Forest Products Industry	Transportation is a large carbon input for structural timber. Can you talk more in-depth about where manufacturing facilities are and where Type IV buildings are being built? Where is the opportunity to build type IV near the forests where SPF or DFL is grown?	See maps from Pat's presentation about sawmill location and distribution Centers. https://www.woodworks.org/mass-timber-interactive-map/. There are several CLT mills in the BC/PNW and Intermountain area. One in Alabama and one under contruction in Arkansas. Quebec and Ontario both have manufacturing already open or about to open	Pat Layton

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44	Background and basics	1.3 Manufacturing and the Forest Products Industry	What types of wood products come from which parts of the U.S.?	See Maps for structural products in Pat's presentation. In some regions and states you can find tools like this to identify sources of wood products in a state or region. http://www.askforwood.org/tools/forest-products-locator Many state forestry organizations can provide you with a list of primary and secondary wood products manufacturers in their states.	Pat Layton
45	Background and basics	1.3 Manufacturing and the Forest Products Industry	During manufacturing, does all the wood come from the same source/forest?	No, it does not. Many harvests of forests are only from 40 to 120 acres in size (forest certification standards on size of cut) or because landowners don't cut their whole forests at once. The lower limit is due to the economics of logging. To get enough wood into an operational primary mill, you must cut from numerous sites at the same time to keep the mill in operation. But the wood from a primary mill will come from the "wood basket" around the mill. This wood basket or wood supply region will likely be within a 50- to 75-mile radius around the mill.	Pat Layton
46	Background and basics	1.3 Manufacturing and the Forest Products Industry	How do regional power grids affect net CO2 emissions for manufacturing products?	Regional electricity grids that rely more heavily on hydroelectricity or nuclear have lower associated CO2 emissions than grids that rely more on fossil fuel sources.	James Salazar
47	Background and basics	1.3 Manufacturing and the Forest Products Industry	Slide 19 [of Kent's presentation] shows that nearly 90% of harvested wood is converted to forest products. Does this figure relate to the whole carbon of the original standing tree or only the logs recovered? What would be the conversion if we consider the original standing tree?	See source of image in original report: https://www.dovetailinc.org/upload/tmp/1581627196.pdf	Elaine Oneil

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48	Backgro und and basics	1.3 Manufactu ring and the Forest Products Industry	Slide 19 [of Kent's presentation] shows that only 11-12% of harvested wood is recovered for energy production. Does this mean that additional fossil fuels are needed for the processing of the harvested wood to the final forest products?	Yes, some fossil fuels are used in wood product manufacturing.	James Salazar
49	Backgro und and basics	1.3 Manufactu ring and the Forest Products Industry	Are the growing forests in the South and NE a complex mix of species, ages and being managed for more then just timber production?	Yes they are and for more information about what is growing within a state, please check with your state foresters office for information about what is being grown, the ages of the forests and other information about forests within a state. There is also a large database about private forest landowners and why they own and manage forest land available. See https://www.fia.fs.fed.us/nwos/	Pat Layton/ Edie Sonne Hall
50	Backgro und and basics	1.3 Manufactu ring and the Forest Products Industry	What percentage of carbon at harvest is converted to long-lived or short-lived forest products and biomass for energy?	This is dependent on the forest type, type of silvicultural treatment, markets, among other factors.	Grant Domke

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51	Backgro und and basics	1.3 Manufactu ring and the Forest Products Industry	So when we are thinning, what are we doing with the removed materials? I have heard a lot of great-sounding discussion about using small diameter trees removed as part of thinning in, for example, CLT, but I have yet to see a CLT plant that is actually geared to make CLT by milling 3-5" dia. trees.	Elaine Oneil: If it is a commercial thin as part of a private landowner forest management activity, it usually goes to the pulp market or the chip n' saw/tonwood where they take whatever boards they can and turn the rest into chips and sawdust for use in other products. If it is a thinning for fire risk reduction then it will go to the same place if there is a market. Where there isn't a market (very common in the interior west) it is burned at the landing (common) or shipped for biomass. For example at the Ecological Restoration Institute in Arizona they are doing restoration work to create natural fire-safe conditions. The market that pays them enough to get it off the landing and to a facility in the biomass market in South Korea. In Korea it is burned for energy. See https://eri.nau.edu/forest-operations-biomass/ for more information. They have had no success finding markets closer to home despite herculean effort on that front. David Diaz: CLT relies upon the layering of lumber, or lamstock, which is produced from sawlog-sized trees (trees with a diameter at breast height greater than 7.0 inches). Trees with diameters smaller than this can not generally be processed into suitable lumber, and are more typically utilized as pulp if they are removed from the harvest site. There are several different approaches, largely related to fire risk and whether tree planting will follow, which are commonly used for dealing with the non-merchantable smaller-diameter trees that are often left in the forest.	Elaine Oneil, David Diaz

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52	Backgro und and basics	1.3 Manufactu ring and the Forest Products Industry	Does the market response apply equally in the case of publicly-owned forests as we have in Canada?	There is a different mechanism in Canada because most of the forest land is publicly-owned and harvested under a variety of long term tenure arrangements. I can speak to British Columbia (BC) where I am familiar with their forest tenure and regulatory system. In BC about 95% of the forest land is owned by the province which leases either a volume-based or acreage-based tenure over a 15-25 year renewable term. The province sets the harvest levels based on its inventory, and the tenure holder (TH) has to meet its volume allotment (+/- 10% over 5-10 year averages). So the market mechanism is that with strong markets the TH would harvest a little more and vice versa, but there are limits on that variability. The BC government also sets the minimum stumpage price ($ to BC government for the wood) that the TH has to pay, and in strong market cycles the payments are higher even on the non-competitive (tenured) wood because of the complex formulas they employ. In addition the TH has to build and maintain all roads in their area, harvest to minimum specifications, pay the stumpage, reforest the sites to specific standards, and ensure those forests are managed so they get to "free-to-grow" - which is usually a 12-15 year commitment after harvest. Most tenures require that the TH maintain its milling capacity. Here's where it gets interesting. In cases like the mountain pine beetle epidemic that affected millions of ha of forest and the wildfires that followed, BC is on the hook to reforest the sites UNLESS they are harvested in which case the TH is on the hook to manage the free-to-grow. So there is plenty of 'negotiation' to get TH to salvage dead and dying wood (i.e. BC won't approve harvest plans unless they address the dead and dying wood), so that the forests are regenerated. BC has very specific goals of ensuring their forests stay forests and are adequately reforested. They use this market-based public/private tenure arrangement to meet those goals. If they didn't then the land isn't adequately reforested unless there are tax $ to do so. Having worked on these 'backlog' sites I can say that the harvest-and-reforest alternative generates much better results in terms of forest regeneration and carbon sequestration.	Elaine Oneil

#	Session	Presen-tation	Question	Answer	Author of answer
53	LCA and Wood	2.1 Carbon Neutrality	How/why is biogenic waste treated as carbon-neutral fuel?	There are two primary approaches to assessing the emissions associated with the use of residuals/wastes for fuel. The first is simply to treat them like all other biomass derived from trees. If the calculation you are doing indicates that there are zero net emissions associated with harvested trees, then all things produced from those trees, including wastes, can be considered to have the same zero net emissions. Another approach is to compare emissions associated with using the waste to emissions under a scenario where the waste is disposed. If the waste was destined for disposal and using it instead yields the same emissions, then there are no additional emissions associated with its use. Under these conditions, some will consider the use of the waste to be "carbon neutral".	Reid Miner
54	LCA and Wood	2.1 Carbon Neutrality	What does it mean for biogenic carbon to be treated as "carbon neutral"? How does this relate to concepts of sustainability in forestry and in the built environment?	In my opinion, saying that a wood source is "carbon neutral" means that the wood is produced and harvested under conditions that result in net zero emissios of biogenic carbon and stable forest carbon stocks over multiple harvests. There are many ways to calculate biogenic carbon emissions. However, and unfortunately, there is no agreement on which approach is the correct one for a specific situation.	Reid Miner
55	LCA and Wood	2.1 Carbon Neutrality	Regarding carbon sequestration, what is "leakage", how is it accounted for, and what numbers have been estimated for it?	Leakage can be thought of as indirect effects. These effects can be positive (i.e., result in lower overall emissions) or negative (i.e., result in higher overall emissions). A simple example might be an effort to reduce deforestation by walling off an area of forest. If, as a result, deforestation increases outside of the walled area, it would be considered negative leakage (i.e., the carbon benefits of your wall partially "leaked" away). To understand positive leakage, consider a new product system that results in increased demand for wood. A simple biophysical calculation might indicate that this will result in less carbon in the forest. If it turns out, however, that landowners respond to the new demand in ways that offset this loss of carbon, this offset can be thought of as positive leakage because the inidrect effect (i.e., landowner response) causes emissions to be lower than you calculated.	Reid Miner

#	Session	Presen-tation	Question	Answer	Author of answer
56	LCA and Wood	2.1 Carbon Neutrality	How is carbon neutrality calculated for North America?	Most countries are required to report annual GHG emissions under the United Nations Framework Convention on Climate Change (UNFCCC). Biogenic carbon dioxide emissions are calculated by comparing the carbon stocks in forests and forest products at the beginning and end of the year. If stocks increased, it means emissions of biogenic carbon dioxide were less than zero. If stocks decreased, it means that biogenic carbon dioxide emissions were greater than zero. (There are nuances regarding imports and exports of wood and wood products, but they can be considered variations on this general approach). In addition, nations are required to report, for information purposes only, emissions of biogenic CO2 associated with use of biomass for energy, but these are not added to fossil fuel CO2 emissions because that would double count the biogenic CO2 emissions (as these emissions are already captured by the stock-change calculations required under the UNFCCC). Many other methods could be used to calculation biogenic carbon emissions for a country, but under the UNFCCC, the methods are specified as described here.	Reid Miner
57	LCA and Wood	2.1 Carbon Neutrality	Is the carbon flux still neutral or negative on a regional-scale or smaller scale?	Net flux of forest carbon varies by region. The smaller the spatial scale of the analysis, the more variable the flux from year to year and site to site. Also, there are fewer data available at smaller scales. Under the Forest Inventory and Analysis (FIA) program, the US Forest Service collects forest data at regular intervals. The US Forest Service often aggregates these data at the regional level (North, South, Rocky Mountain and Pacific Coast), but data are also sometimes aggregated at smaller spatial scales. The Forest Service recently issued a paper showing forest carbon emissions on a state-by-state basis (see Greenhouse Gas Emissions and Removals from Forest Land, Woodlands, and Urban Trees in the United States, 1990-2018). This report indicates that in 2018, net forest carbon sinks (i.e., forest carbon stocks increasing) existed in all but six states, Colorado, Idaho, Montana, New Mexico, Utah and Wyoming. These are not large wood producing states but are often affected by fires.	Reid Miner

#	Session	Presen-tation	Question	Answer	Author of answer
58	LCA and Wood	2.1 Carbon Neutrality	What are the end-of-life GWP impacts of wood?	The impacts vary enormously by type of management. - If recycled, the impacts need to be determined based on the specific material and its use. - If burned, the carbon in the waste returns to the atmosphere as biogenic CO2 and the impacts can be calculated using the same approach as used to calculate net life cycle emissions of forest carbon. In some cases it can be important to also consider the char remaining after combustion. This is normally a small amount but the carbon can be very stable in the environment, resulting in long-term storage of the carbon. - If landfilled or composted, the impacts are more complex. The carbon will partition into essentially three components - biogenic CO2, biogenic methane and non-degradable carbon. This is discussed in more detail below.	Reid Miner

#	Session	Presen-tation	Question	Answer	Author of answer
59	LCA and Wood	2.1 Carbon Neutrality	What happens to end-of-life wood products after they are disposed in a landfill? How quickly do they degrade, and does the degradation result in methane emissions?	The fate of forest carbon in landfills varies enormously. Several concepts are key to understanding landfills. - First, landfill design and operation varies, but in the US and most developed countries, landfills are designed to prevent water from infiltrating which prevents oxygen from entering. This results in an anoxic environment. - Second, lignin does not degrade under anoxic conditions, so many landfills are essentially tombs for lignin and other forest carbon (e.g., cellulose and hemicellulose) that is "protected" by lignin. - Third, degradation rates (for the degradable portion of the carbon) are affected by many variables and are difficult to measure. Nonetheless there are commonly-used degradation rates published by EPA and others. - Fourth, under anoxic conditions the degradable fraction of the carbon is converted into a 50/50 mixture of biogenic CO2 and biogenic methane. On a pound-for-pound basis, methane is a far more potent GHG than CO2. As a result, most landfills are capped to capture methane, which is burned to convert it to CO2 before being released. The efficiency of these capture systems varies (50 to 95%), but is often assumed (e.g., by EPA) to be 75%. All of these factors are used in a calculation to estimate methane emissions. There are a number of tools available to do this. In general, these calculations show net landfill methane emissions associated with landfilled wood products to be very low, primarily because of the high lignin (non-degradable) content in wood products and the protection from degradation this lignin provides to non-lignin components. Indeed, where methane is captured and burned efficiently, net GHG emissions from landfilled wood products can be less than zero (i.e., the material is a net sink). Net GHG landfill emissions from paper products are likely to be larger than those for wood products.	Reid Miner

#	Session	Presen-tation	Question	Answer	Author of answer
60	LCA and Wood	2.1 Carbon Neutrality	How is the carbon benefit from product substitution modeled given that wood, steel and concrete do not provide the same function (structural, thermal, acoustics, fire, etc) in a building? Is such calculation taking into account concrete recarbonation, steel recycling or the reduction in production carbon intensity over time?	Product substitution effects can only be estimated where the product functions are comparable. These are done through comparing LCAs that have the same functional unit (e.g. house with the same R-value, wall system of the same service function etc..). It is essentially impossible to design a substitution study so that product functions are exactly the same. Nonetheless, with care, it is often possible to design a study so that the functions are close enough to provide important insights into the key differences in environmental attributes.	Reid Miner

#	Session	Presen-tation	Question	Answer	Author of answer
61	LCA and Wood	2.1 Carbon Neutrality	How is the carbon benefit from energy substitution modeled? Is this based on replacing the fuel with the highest carbon intensity (e.g coal)? Does it subtract the energy consumed within the forest products industry to process the wood harvested to the final forest products?	There have been many different approaches used to estimate the net carbon impacts of substituting forest-based energy for fossil fuel-based energy. Depending on the approach and assumptions used, the results range from showing significant net benefits from using forest-based energy to indicating that forest based energy is "worse than coal." Where studies are focused on an increase in demand for forest-based energy, the most important sources of variablity in results are the following: (1) the feedstock being studied (e.g., a waste material vs roundwood), (2) the starting point for accounting (with start-at-germination showing most benefits and start-at-harvest showing least benefits from forest-based energy), (3) the starting condition and growth rate of the forest (with lower preharvest carbon stocks and faster growth rates giving improved performance of forest-based energy), (4) the time horizon used (with longer time horizons revealing larger benefits from forest-based energy), (5) the type of energy being displaced (with forest-based energy displacing coal showing the largest benefits, displacing natural gas showing smaller benefits and displacing solar or wind power showing small benefits or even negative impacts), (6) the approach used to allocate emissions to co-products (an issue raised by the questioner), and (7) assumptions about future forest conditions, and/or the fate of waste materials, in both the scenario where forest-derived feedstock is used for energy and the scenario where the material is not used for energy, including the effects of landowner responses over various spatial scales. In my opinion, the studies that do the best job of addressing these factors (for any study of carbon impacts and forest products) are those that link biophysical carbon modeling with economic modeling. Examples include the US Forest Service family of models, the FASOM model used by a variety of researchers including EPA, the SRTS Model used by a variety of researches including those at North Carolina State University, and the Global Timber Model used by a variety of researchers, including those at Ohio State University.	Reid Miner

#	Session	Presen-tation	Question	Answer	Author of answer
62	LCA and Wood	2.1 Carbon Neutrality	Please clarify which of the principle greenhouse gases (CO2, Methane, NO2) are considered as carbon neutral when assessing biomass emissions.	The "neutrality" calculations are for biogenic carbon. The carbon removed from the atmosphere is contained in CO2, so, for purposes of calculating "neutrality", the net flux back into the atmosphere deals with carbon in units of CO2. If some of the biogenic carbon returns to the atmosphere in methane (CH4), its warming potential is dealt with separately. Consider the following simplified example. In the forest, we remove 10 units of carbon from the atmosphere. In the rest of the value chain, all 10 units of biogenic carbon are returned to the atmosphere, 9 in CO2 and 1 in CH4. The net flux of carbon is zero (10 in and 10 out) and the carbon is "neutral". However, we have to account for the fact that one of the units of carbon returned to the atmosphere as methane. So in our calculations, we separately include an emission of methane using its global warming potential (i.e., about 28 times the warming of CO2 over 100 years). Nitrous oxide is not considered in the "neutrality calculations" and is dealt with in the same way as for fossil fuels.	Reid Miner

#	Session	Presen-tation	Question	Answer	Author of answer
63	LCA and Wood	2.1 Carbon Neutrality	Where are each of the four “approaches” for biogenic CO2 calculations used?	There is no simple answer to this question. In part, it depends on whether you want to know the attributes of a product (i.e., an attributional analysis) or want the know the overall consequences of choosing one product or policy over another (a consequential analysis). EPDs are attributional. Attributional studies and EPDs avoid approaches that involve counterfactuals. There are several reasons, but they include the fact that counterfactuals introduce considerable uncertainty (and opportunities for mischief). Beyond this general conceptual difference (i.e., attributional versus consequential), unfortunately, we often see that an approach is selected and applied with the objective of influencing the results of the calculations. It is also common to see an approach selected based on the data and expertise at hand. In addition, you will find that if you want to comply with various standards, the approach may be specified. My recommendation is to start with a thorough understanding of the question you are trying to answer. Let me suggest two common questions and an approach I might use for each. - Question 1: What are the biogenic carbon emissions associated with a product I am purchasing (an attributional question)? This can be addressed using approaches 1, 2, or 3. Where the supply area can be reasonably defined, I prefer Approach 3 as it (a) captures the real-time net effects of activities that increase and decrease carbon stocks on the land and (b) relies on actual date instead of projections. A variation on Approach 3 is specified in the EPD under discussion here. Where the supply area cannot be reliably defined, Approach 1 is useful except where there is reason to think that it misses important carbon impacts related to the product in question (e.g., deforestation). - Question 2: What is the overall biogenic carbon impact of a public policy that results in increased substitution of wood product A for non-wood product B? This "consequential" question is sometimes addressed by comparing two "current snapshots" (e.g., attributional EPDs) but this can miss important indirect impacts on biogenic carbon that occur outside of the system boundaries of attributional studies. Instead, I feel that the most reliable insights into these substitution effects can be obtained by using an economic model combined with Approach 3 (landscape fluxes) and Approach 4 (counterfactuals), where a counterfactal scenario looks at the same forest landscape under conditions where the forest is not used to produce Product A.	Reid Miner

#	Session	Presen-tation	Question	Answer	Author of answer
64	LCA and Wood	2.1 Carbon Neutrality	Since a healthy, established forest is in a constant net positive flow of carbon absorption, wouldn't it be more accurate to use a calculation for forest carbon neutrality that acknowledges that constant net positive flow as the equilibrium rather that an equal in-out of carbon as the equilibrium?	There is a really important correction to the first part of this question - no forest is in a constant net positive flow of carbon absorption indefinitely. Of course forests vary, even healthy, established ones. This is one reason why I prefer approaches that use actual data on carbon fluxes instead of assumptions. Carbon stocks cannot increase to infinity so at some point a pseudo equilibrium is reached. I say "pseudo" because nature is not static and there are always factors contributing to time-variable increases and decreases in forest carbon, even in forests that, over longer periods, have stable carbon stocks. The questioner may, however, be asking about baseline conditions for studying forest carbon. - If you are interested in looking at the impacts of a product substitution or public policy (as opposed to a snapshot) it will often be useful to look at the forest under two conditions, representing two scenarios (i.e., with and without the substitution or policy of interest). - If the forest is steadily accumulating carbon, this can be included in the analysis and the impact of the policy or substitution on the rate of accumulation can be examined. In such studies, it is important to consider the effect of economic forces on forest carbon.	Reid Miner

#	Session	Presen-tation	Question	Answer	Author of answer
65	LCA and Wood	2.1 Carbon Neutrality	The substitution effect slide says that harvesting wood pellets for fuel would make forest harvesting for fuel even better than neutral, that is carbon positive. If this is the case, it implies that more wood fuel consumption would lead to a greater carbon positive calculation, vs. leaving the forest as a carbon sink would be less carbon positive. However, this doesn't seem to work on a time scale, as there is an immediate conversion of carbon into emissions for fuel pellets that are burned, and a healthy forest would have continued positive carbon storage. How does the immediate emissions for harvested fuel figure into the equation?	I think the slide in question says that bio-based fuels or products can have net benefits even if the biogenic carbon is not neutral (but please correct me if I am missing something). All this means is that biogenic carbon emissions are only one part of a substitution effect analysis. For instance, consider a wood product with 1 unit of biogenic GHG emissions and 2 units of fossil fuel GHG emissions for a total of 3 units of GHG emissions. If we substitute this for a functionally equivalent non-wood product with 7 units of fossil fuel GHGs, our substitution has reduced emissions by 4 units of GHGs, even though our biogenic GHG emissions were greater than zero (not neutral). Of course, the results of substitution effect studies are completely dependent on the specifics.	Reid Miner
66	LCA and Wood	2.1 Carbon Neutrality	Are carbon emissions treated as if they are all released at once or is there a time factor involved in any of the methods discussed? This would include carbon left on site if debris is not burned?	The timing question is becoming increasingly important in discussions of forest carbon. Unfortunately, it is also a very complex issue. In theory, any of the approaches can be applied in time steps, looking at net emissions as a function of time. In addition, all of the approaches should consider all carbon fluxes, including those from debris. Studying timing can be challenging, however, as the timing can be highly variable based on site conditions, even when the long-term net effects are less variable. Where timing is of interest, it may be important to understand not only the timing of emissions but also the timing of the atmospheric warming response to those emissions.	Reid Miner

#	Session	Presen-tation	Question	Answer	Author of answer
67	LCA and Wood	2.1 Carbon Neutrality	What is the time span expected for products to be used and/or reused by product category, ie paper has been considered to be recycled 3 times before end of life?	There have been some excellent studies. I would recommend using the factors used by the US Forest Service, easily found in USEPA's annual inventory of GHGs. (e.g., see EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017, Annex 3.13, Table A-226.) https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks	Reid Miner
68	LCA and Wood	2.1 Carbon Neutrality	Does landfill methane collection and production for energy impact any of this and are all products and all landfills assumed to have equal rates of decay?	Emissions of methane need to be accounted for (see above). Where methane is used as a fuel to offset other fuels, this can also be considered (and is addressed in EPA's annual inventory of GHG emissions and sinks). Studies use various sources of information to describe the decay rates and non-degradable fraction of wood-based products in landfills. The best available data on landfill decay and decay rates is published by the US EPA in their WARM model (See: Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM) – Management Practices Chapters -May 2019 Version, Updated October 2019). The WARM model publishes component-specific decay rates (Exhibit 6-7) and calculates the amount of methane generated for a given amount of wood products (Exhibit 6-5).	Reid Miner and James Salazar
69	LCA and Wood	2.1 Carbon Neutrality	How does the standard define deforestation? Is it permanent removal of forest or a harvest with regeneration (a very temporary state)?	I can't speak to the standard, but deforestation is usually classified as a land use change process. This means that the land is converted from forest to some other use.	Reid Miner
70	LCA and Wood	2.1 Carbon Neutrality	How does the carbon accounting take into account below-ground and annual carbon pools? It sounds like you are only looking at log removal.	Carbon accounting should address all carbon pools. That said, for some purposes, it may be that some of the pools are stable enough over time that they can be ignored in stock change or flux calculations. This can be the case for below-ground carbon, for instance, which is relatively stable in many cases.	Reid Miner

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71	LCA and Wood	2.1 Carbon Neutrality	Reid's diagrams for approaches to the system boundary didn't seem to indicate that the harvesting practices release carbon. Is the carbon associated with this activity accounted for in the box describing production?	All pools and fluxes are included. The arrows on the slides into the forest are on a net basis. They result from a calculation of the differences between all fluxes into the forest and all fluxes out of the forest, including harvest and debris decay, etc.	Reid Miner

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72	LCA and Wood	2.1 Carbon Neutrality	"What don't I know"; It would be great to be presented, in some kind of format, what some key criticisms are of current frameworks for carbon accounting. So far we are hearing from Industry. Are there other voices that can provide additional perspective such as Conservationists?	Criticisms of Life Cycle Accounting for forests and forest products from the conservation community generally point to the underlying assumptions and limited scope of analysis for LCAs rather than a criticism of LCA as an accounting approach in general. - Perhaps the most common criticism is related to the geographic scale of the assumption of neutrality for "biogenic carbon" and definitions of "sustainability." The common practice of treating all "biogenic carbon" as carbon neutral if the total forest area or carbon stocking of forests across a country is non-declining clearly ignores differences among regions and owners that are directly observable. - The fact that soil carbon stocks are often assumed to be stable, or modeled rather than measured, is a common criticism as well, although many studies show that soil carbon is relatively stable over time in a forest system, with the biggest difference occurring in conversion away from- or to- a forest. Due to high variability and cost, direct measurement of soil carbon stock remains a major hurdle. - There is also significant debate in the scientific, industry, and conservation communities over whether and how LCAs should consider alternative land-use or management scenarios (e.g., leaving a forest unmanaged, or assuming some other kind of "baseline") and consider "forgone sequestration". These concerns move into "consequential" rather than "attributional" LCA, which is also where contentious issues surrounding assumptions and methods for estimating the impact of substituting wood for non-wood products are found. - The scope of LCAs has been criticized both in terms of which impacts are commonly considered (e.g., global warming potential) and which are not (impacts on biodiversity, threatened and endangered species, water quality) as well as the differential treatment of some carbon stocks and emissions as in-scope or out-of-scope (e.g., the decomposition of slash after harvests). - LCAs were conceived and traditionally applied for engineered rather than biological systems. Ecosystem science includes many methods for tracking stocks and fluxes through forest and non-forest ecosystems that are conceptually analogous to LCA methods, but many ecosystem stocks and fluxes remain poorly reflected in LCAs. - The timespan considered by LCAs has also been criticised. Unsustainable harvesting and land-use conversion that led to the liquidation of most of the world's temperate old-growth forests over the past 200-300 years is generally out-of-scope, while contemporary deforestation and degradation in tropical forests is generally in-scope, raising concerns similar to those regarding historical liability for greenhouse gas emissions by industrialized nations.	James Salazar

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73	LCA and Wood	2.1 Carbon Neutrality	Please explain more about the Whole Life Cycle of biogenic carbon accounting. Did I understand it correctly that recycling of wood products accounts as negative (carbon emissions) even though the carbon is still stored inside the wood? Why is that the case?	Per ISO 21930 cradle to gate life cycle assessment accounting rules, all carbon leaving the gate is assumed to be an emission (reported in C3/C4) to balance out the carbon removed from the atmosphere in module A1 and emitted during manufacturing in A1-3; therefore no long-term storage is included in the EPD results. Long-term storage can be reported in section 5, under 'additional voluntary information'. Reporting of long-term storage is included in the results in a cradle to grave EPD.	James Salazar
74	LCA and Wood	2.2 How LCA Handles Wood	How does LCA treat the impacts due to fertilizers, pesticides, and road-building in wood LCAs?	Most forestry LCAs do not include pesticide use (they aren't used), though some do include herbicide use. Herbicides and fertilizers are included (where applicable) and all upstream data for the production, transportation, and application of these management inputs are measured. Road building is included in cases where new roads are built to access timber, though for second and third rotational harvests it is not included as road improvements are considered part of the harvest operations.	Elaine Oneil
75	LCA and Wood	2.2 How LCA Handles Wood	What are the end-of-life scenarios for different wood products (building products such as CLT, Glulam, LVL etc, and consumer products such as furniture, cabinets, flooring etc.)?	Potential end of life scenarios include landilling (current typical practice), recycling, and combustion with energy recovery.	James Salazar

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76	LCA and Wood	2.2 How LCA Handles Wood	How much waste is biofuel that is emitted as carbon from cradle to gate? How is it reported in EPDs?	Wood products manufacturing results in negligible waste (<1%) as markets exist for biofuel coproducts. The sale of coproducts are refelected in the current wood product EPDs under indicator BCEP (Biogenic Carbon Emission from Product) in Module A3 (Product Manufacturing).	James Salazar
77	LCA and Wood	2.2 How LCA Handles Wood	How should the issue of previously emitted carbon (e.g. due to forest operations and/or manufacturing) already in the atmosphere be addressed, if at all?	Since the functional unit of the LCA is a m3 of wood, accounting for something that happened maybe before the tree was even planted can't be logically included within the system boundary. If it did we would have to attribute the loss of forest cover from building every city in the world and attribute it to the building material in that city.	Elaine Oneil
78	LCA and Wood	2.2 How LCA Handles Wood	Can we create a metric that captures total carbon impacts of forest products?	You can always create a metric. Whether or not the metric means anything or drives the right behavior is a different story. This webinar series highlighted a couple important nuances that are important with forests and carbon. Carbon is a two-way street in the land sector and the flux from land to atmosphere is caused by both humans (land conversion, harvesting) and nature (fires, insects, mortality). Sometimes the highest-carbon forestry is not the best climate forestry. LCA/EPDs are very good at assessing material and energy inputs and outputs at the manufacturer level but have a hard time capturing the dynamics on land so it is important to have other ways of communicating this information (e.g. through certification and landscape monitoring).	Elaine Oneil/ Edie Sonne Hall
79	LCA and Wood	2.2 How LCA Handles Wood	What is typically included in the system boundaries of a wood product LCA?	Growing the seedling, site preparation, planting, stand tending (may include pre-commercial thinning, brushing, weed control, animal damage control, fertilization), harvesting (both thinning and final harvests, hauling, manufacturing processes (debarking, sawing, re-sawing, drying, planing), packaging, and loaded on the truck for shipment to sales outlet.	Elaine Oneil
80	LCA and Wood	2.2 How LCA Handles Wood	Why is carbon neutrality commonly seen in wood LCAs?	It isn’t assumed or used. We calculate carbon flows in terms of inputs and outputs and measure the difference. That will give a balance of near zero (but not exactly zero).	Elaine Oneil

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81	LCA and Wood	2.2 How LCA Handles Wood	While ISO 21930 considers all certified forestry sustainable, in reality there are broad differences in forest management that ranges from 40 year rotations with 200 acre clearcuts on steep slopes, to 80 year or longer rotations with selective harvest and buffers along waterways and habitat set aside for rare species. Since none of this is considered in current approaches to LCA, what changes are on the horizon to incentivize improvements in forest practices beyond current legal, albeit certifiable under some systems, baselines?	If there was a desire to ensure sustianable wood products, this would require certification of the products themselves from a forest certification body (e.g. SFI or FSC). These bodies undergo period revisions with a public stakeholder engagement process, and many are exploring how climate and carbon may shape the framing of these certifications in the near-term and over time.	Edie Sonne Hall/ Lauren Cooper

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82	LCA and Wood	2.2 How LCA Handles Wood	It was mentioned that several certification methods or reporting could be used to qualify as biogenic carbon. There wasn't any discussion about the difference in quality between sustainable certifications. How could one certification, or method of forestry, that helps to protect watershed, soil quality, habitat, diversity of tree variety, be calculated for long term carbon protection, vs. another certification, that has much lower standards? How can the numbers be crunched for quality of forestry related to long term carbon sequestration?	Forest Management certification standards all support the goal of sustainable forest management (SFM), such as conservation of water quality, biodiversity, wildlife habitat, and protection of forests with exceptional conservation value. These are all third party audited, where an auditor assess on the ground practices against a series of agreed upon standards. There are variations in requirements both within and between standards. If there is a particular metric that is of interest to you, as a consumer, I would encourage you to find out where the wood was sourced from as that will determine the standard and specific requirements under which the SFM certificate is operating. At the end of the day, ALL SFM certification systems in all regions address the goals stated above.	Edie Sonne Hall

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83	LCA and Wood	2.2 How LCA Handles Wood	Thank you for your informative talk. If the LCA boundary was drawn either side of the 'recycled' box in your LCA diagram, representing the reuse of reclaimed wood from demolition, what would be the embodied energy and biogenic energy value in kgCO2e/kg of reclaimed wood floorboards which were planned to be reused as floorboards in a building (planned to still be in use in 200 years time if that is relevant)? Please ignore all external energy costs such as the human energy used to reclaim the floorboards, processing, transport and storage prior to reuse.	Construction product LCA follows ISO 21930 which specifies the "cut-off" approach to allocating the impacts of products between different product systems (i.e. the original product and the recycled product). This means that all manufacturing impacts are allocated to the "virgin" material product system wheras the recycling processes are allocated to the "recycled" material product system.	James Salazar

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84	LCA and Wood	2.2 How LCA Handles Wood	We often hear about 'old growth conversion' as a land use change (it's not). As well, there is often a sentiment over letting trees grow until they are really old to store carbon. Can you suggest what the difference in carbon sequestration might be between say, a 300-year old forest, and whatever number of rotations (2? 3? 4? 5?) can be undertaken over the same time frame, incorporating biogenic uptake and returns as well as the cumulative impact of CO2 over the time period?	The answer to this question really depends on whether and how you account for wood product storage and substitution. A good early article on this is Perez-Garcia et al., 2007. "An Assessment of Carbon Pools, Storage, and Wood Products Market Substitution Using Life-Cycle Analysis Results." Wood and Fiber Science 37, 140–148. https://wfs.swst.org/index.php/wfs/article/view/840/840. These researchers found that leaving a forest alone would store the most carbon compared to any alternative management scenarios unless substitution effects for other wood products are added. It is worth noting however, that there is ongoing and significant scientific debate about how to accurately account for substitution. For example, a recent sensitivity analysis of substitution (Harmon, M.E., 2019. Have product substitution carbon benefits been overestimated? A sensitivity analysis of key assumptions. Environ. Res. Lett. 14, 065008. https://doi.org/10.1088/1748-9326/ab1e95) argues the methods used by Perez-Garcia and in other subsequent studies by other authors may overestimate substitution effects by 2- to 100-fold.	David Diaz

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85	LCA and Wood	2.2 How LCA Handles Wood	For national reporting with UNFCC or other entities, what are the standards that studies and other research must adhere to? If there isn't an agreement on best practices for LCA, are there issues with the data collection and reporting methods? How do governing bodies prevent people from skewing the data in their favor, as can happen with LCAs (by including/excluding certain elements, or gerrymandering the system boundary)?	National Reporting with UNFCC follows IPCC guidance. Each country reports their methodology to the IPCC.	Edie Sonne Hall/ Lauren Cooper
86	LCA and Wood	2.2 How LCA Handles Wood	Ultimately (aside from non-decaying landfill) all negative biogenic carbon is a delayed emission, correct? Isn't the real benefit to wood products the fact there is an opportunity to remove and store carbon in wood (buildings or landfill or whatever) while the forest is recapturing the emitted carbon in new forests?	The relevant standards (ISO 21930 and the Wood Products PCR) specify that no credit is granted based on delayed emission and that delayed emissions may only be reported as additional information. The carbon storage benefits in the EPDs are for permanent carbon storage. The USEPA has determined based on experimental data that 88% of lumber carbon is stored permanently in the landfill. https://www.epa.gov/sites/production/files/2019-10/documents/warm_v15_management_practices_updated_10-08-2019.pdf	James Salazar

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87	LCA and Wood	2.2 How LCA Handles Wood	What are the units in the last slide of James' presentation? (the one with five rows breaking down types of biogenic carbon emissions by life cycle stage)	All units in the EPDs for biogenic carbon are kg CO2eq.	James Salazar
88	LCA and Wood	2.2 How LCA Handles Wood	The release at the end of service life is not guaranteed, and if we design with circular economy principles then the sequestration can be extended, how can that be accounted for?	We are in the process of publishing a paper that explores this idea of extending the useful life. With any luck it will be available before the end of 2020. We have also published the results of our circular economy workshop and soon will publish the presentation on that topic at the Forest Products Society International (virtual) Conference. Check back on the CORRIM website for future updates.	Elaine Oneil
89	LCA and Wood	2.2 How LCA Handles Wood	Why do LCA's take credit for waste-to-energy incineration?	LCA are input/output models. They report fuels and materials that go into a process and what comes out in terms of emissions, products, co-products, and waste. When waste wood is utilized for energy it is being assigned a higher value than if it were to be sent to the landfill. This is actually consistent with, and a good example of, circular economy principles. If that is 'taking credit' for keeping something out of a landfill, then yes it is taking credit. It is probably more accurate to say that the LCA is reporting on the facts of what occurs during the industrial process where renewable fuels (biomass with a two way flow from the atmosphere to plant materials) are used in place of fossil fuels (one way flow of CO2 from the ground to the atmosphere).	Elaine Oneil
90	LCA and Wood	PCRs and EPDs	How is forestry carbon accounted in EPDs today? How should it be accounted moving forward?	Refer to James Salazar's presentation	Elaine Oneil

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91	LCA and Wood	PCRs and EPDs	How to include different carbon sequestration rates (of different types) of trees in EPDs?	It is already built into the data for each regional LCA based on a set of management assumptions reflecting average (or a range) of yields. The EPD uses a weighted allocation of total North American production to allocate among regions.	Elaine Oneil
92	LCA and Wood	PCRs and EPDs	What are current and future opportunities for accounting for the impacts of forest management on forest carbon in LCAs and reporting them in EPDs?	Forest management impacts are built into the current EPD and reported in the forestry component of those reports. While the data is of necessity abbreviated in the EPD, the LCA reports include all forest management data as do peer-reviewed publications on the subject.	Elaine Oneil
93	LCA and Wood	PCRs and EPDs	What are the key assumptions behind the current PCR for wood products?	(a) That the survey adequately represents the regional production. While we can never know the differential between those that respond to surveys and those that don't, because wood is a commodity product and the price margins are therefore very small the industry as structured favors the most efficient producer. During the 2008 downturn, many small, less efficient producers left the market. It is now dominated by large, highly efficient, highly mechanized processing facilities that drive towards a highly uniform product at the lowest possible price. This tends to even out the variability in production emissions at the regional level. (b) That the forest which provides the raw materials is continuing to be managed for forestry so the forest carbon on the land base is stable. In prior EPDs this was an optional component of the report. Under the new PCR, the reporting of this component is now mandatory and consistent with ISO 21930 standards regarding forest carbon. (c) Average regional grids are used by the industry. This may not actually be so, as they can produce energy themselves with their own boilers so they may be better than the average grid in places with heavy dependence on fossil inputs to the grid or slightly worse in regions with less dependence on fossil inputs to the grid.	Elaine Oneil

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94	LCA and Wood	PCRs and EPDs	How are industry-wide EPDs calculated?	(a) First: Regional data are developed based on surveys of the manufacturing industry (lumber mills, plywood plants, glulam manufacturers etc) and the wood suppliers. It is real data based on real facilities. Because it is also market data, we are required to anonymize the data as a prerequisite for getting it. Just like in the building and construction industry, competitors do not share their bid sheets, and neither do forest products companies. In some cases, the wood supplier (forestry) data is developed from modeled data on forest growth, forest inventory, and management practices informed by the literature and time series studies on forest operations. In others, it is based on survey data, just like manufacturing. (b) That regional data is developed into an LCA report (typically 60-100 pages of detailed analysis and outputs). Data are weighted based on production estimates. (c) Those regional data are then aggregated into a North American-wide EPD based on the relative percentage of market share that each region has in the market. This goes back to the notion that wood is a commodity product and therefore it can (and is) shipped to any part of North America (or the world) based on market demand and available supply.	Elaine Oneil
95	LCA and Wood	PCRs and EPDs	With limited EPDs available in the market, what do we not know about the embodied carbon of wood products (e.g. variation?)	Quite a bit. Those data are in all the regional LCA reports that are the basis for the weighted average inputs to generate a North American-wide EPD. The weighting is based on regional production, so the embodied C values are dominated by 3 main regions (the SE US, the PNW US, and British Columbia).	Elaine Oneil

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96	LCA and Wood	PCRs and EPDs	Why do wood EPDs not distinguish between tree species and forest types?	EPDs are a summary document of a much larger analysis that includes both the manufacturing and the forest management and growth. The data on tree species and management is embedded in the input values to the process but it is upstream of the main output. In other words, a single tree could go into a piece of lumber, OSB, plywood, glulam, MDF or particle board, and in fact may go into multiple products – so the granularity of 'this tree going to that process' is not apparent in the EPD, but is tracked in the upstream data that gets rolled into the final output (on a weighted average basis) in the 'forestry' column of the EPD. Tree species isn't all that big of a driver in the LCA as the variability in SG (specific gravity) which is the driver for carbon content is not that significant between the major softwood species used for most industrial wood products in the US. Yield and management strategies can have an impact on the LCA values, but if we assess regional data most wood comes from remarkably similar types of management within a regional context. Hence we refer to the PNW as the Douglas-fir region because it produces mostly Douglas-fir with a bit of HemFir (hemlock/true firs), the SE as the SYP (southern yellow pine), and British Columbia wood comes as SPF (spruce/pine/fir) or if it comes from the coastal zone HemBal (Hemlock/true firs). Again – the EPDs are reporting on commodity products that represent a significant portion of the world's softwood lumber production.	Elaine Oneil
97	LCA and Wood	PCRs and EPDs	How are variations in forestry practices reflected in wood EPDs?	Forestry operations are aggregated to a single input number for each region based on an estimate of the range of management, growth, and harvesting operations that occur in that region. There is some variability included and a weighting assigned based on either a) surveyed data or b) modeled data. Operational factors include weighting of production numbers (forest industry, small private, state and federal harvest volumes) where appropriate.	Elaine Oneil

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98	LCA and Wood	PCRs and EPDs	Is soil carbon significant? Is it included in EPDs?	Soil Carbon isn't included in EPDs because forests that remain forests are assumed to have stable soil carbon over time. As discussed earlier, soil carbon is highly variable and also expensive to measure. Nave et al. (2010), *Forest Ecology and Management,* found that (micro) climate, native substrate, ground cover, time, and even depth influence results when tracking the soil organic carbon (SOC) and mineral C. Nave et al (2019) underscores the importance of site specificity and concludes they were unable to assign a management practice to a SOC change in particular.	Edie Sonne Hall
99	LCA and Wood	PCRs and EPDs	Will variations in carbon uptake be reflected in the PCRs for wood products? What are the primary barriers to this happening?	It is already built into the data for each regional LCA based on a set of management assumptions reflecting average (or a range) of yields. The EPD uses a weighted allocation of total North American production to allocate among regions.	Elaine Oneil

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100	LCA and Wood	PCRs and EPDs	Do EPD's include biodiversity impacts? For example, it might be possible to use one of the forest management certification systems to determine how close to a "native biodiversity index" a forest is. And by native I mean what that spot on the planet was supporting 10,000 years ago (or pick another reasonable starting point). I realize the climate is changing but I am picturing something like the koppen-geiger climate map with a biodiversity index for each region.	Capturing biodiversity within an EPD is pretty hard. The National Council on Air and Stream Improvement summarized the difficulties in this short paper, https://www.ncasi.org/wp-content/uploads/2019/07/Effects-of-Forest-Management-on-Biodiversity-in-LCA-7-19.pdf.	Elaine Oneil/Edie Sonne Hall
101	LCA and Wood	PCRs and EPDs	Same as the question above but instead of a native biodiversity index, a native carbon sequestration index per climate region.	You could probably create a map of pre-industrial carbon STORAGE per climate region but likely the native carbon sequestration of a region would be zero or would have large emissions (e.g. fire, hurricane) followed by sequestration).	Elaine Oneil/ Edie Sonne Hall
102	LCA and Wood	PCRs and EPDs	Elaine Oneil is suggesting that carbon intake can be doubled or tripled with management (thinning, brush control, etc). I'd like to dig a bit more into this. To what extent can this be confirmed, improved, encouraged, accounted for?	The data show that it has already occurred and it is accounted for in our yield estimations and predictions. Research on the growth benefits of different management activities (planting, fertilization, herbicides, burning, thinning etc) have been studied over many years and reported throughout the literature. Major research initiatives are established regionally, e.g. PNW (Stand Management Cooperative), Inland West (Intermountain Forestry Cooperative), and SE (NCSU Tree Improvement Cooperative) to name a few of the more prominent ones.	Elaine Oneil

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103	LCA and Wood	PCRs and EPDs	Why does the industry use clearcutting as a forest management tool and is the use of herbicides always necessary? Are there studies to related to herbicide use and their long-term impact on the forests?	It is more efficient to clearcut harvest but that isn't the only, or even the main, reason it is the preferred method of growing softwood forests in North America. Our dominant softwood species are Douglas-fir (PNW), pines (all regions), spruce (Canada/NE), with a lesser amount of true firs, hemlocks and the like. Douglas-fir, pines and spruce are all shade-intolerant. That means they don't grow well, or in some cases at all, if planted under the remaining forest canopy. So if you were to do partial harvests, there is no regeneration, or if there is, it is a shade-tolerant species like the true firs (called balsam in Canada). However, these species grow slowly, don't utilize site resources and therefore don't accumulate much carbon. They also tend to be the lower-quality material that shrinks and warps and drives the builders crazy when they try to use it. So forest management systems that are focused on growing softwood tree species that provide a high-quality product in a short amount of time using native species lend themselves to these 3 shade-intolerant pioneer species. They need full sunlight to grow. The best way to give it to them is to clearcut and regenerate a new stand immediately as part of the forest renewal and management strategy. We can tinker with all sorts of things in a management system, but shade intolerance isn't one of them. Herbicides are used on many stands, but not all, in our dominant tree-growing regions. They reduce competition from weedy species that would otherwise kill the newly planted tree seedlings. The same effect used to be accomplished with broadcast burning which was used to reduce competition from weed species and clear harvest residues, but broadcast burning has largely gone out of favor as a site preparation tool due to air quality concerns (too much smoke and particulate matter). The herbicide use ensures the trees survive and thrive which shortens the period that the new stand stays in an open grown condition and allows that forest to grow quickly and without areas that have no trees on them. As herbicides are expensive to apply, the bare minimum to get the job done are applied. Without them many planted forests would suffer significant tree mortality with the result being a field of brush, weeds, and a few straggly trees instead of a stand of conifers to replace the ones that were harvested and converted to wood products.	Elaine Oneil

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104	LCA and Wood	PCRs and EPDs	How can forest harvest be in balance the natural ecosystem of a forest, particularly in National Forests that show fire and beetle losses? For example, how can thinning of forests help to reduce forest fires, while preserving the forest ecosystem and using the thinning as a building product? How can diverse forests, rather than plantations, be encouraged? How can forest plantings be managed without the use of herbicides? How can national forests be a leader in this effort?	Very little harvest occurs on National Forests. They are not a leader in providing wood products. To understand the need for thinning the best vignette I have seen is from a TED talk by Paul Hessburg, a research ecologist with the USFS. https://www.ted.com/talks/paul_hessburg_why_wildfires_have_gotten_worse_and_what_we_can_do_about_it The thinned material may not be large enough to be used for building products, but restoring that forest to a condition that is more aligned with the prevailing climate is benefit enough. Low-intensity management and/or managing for a diversity of values and/or tree species has some co-benefits, but efficient production of wood for the building trade is not one of them. Here is a simple example to illustrate that point. If one manages Douglas-fir according to the PNW industrial model they can attain over 500 m3/ha over a 45-50 year rotation. If managed for mixed forests using low-intensity management that same stand might have 100, 150 or 200 or maybe 300 m3/ha thus requiring more land (in my example 1.6-5x more land) to obtain the same amount of building materials. The question is: do we have enough forest land to have that kind of low intensity management and still meet wood demand by the building trade? I would contend that choices in management intent need to be made, and having some acres managed intensively leaves opportunity for other forest acres to be managed for other values or not managed at all. It also provides the economic return that keeps intensively managed forests forested instead of opening them up for development and conversion which is one of the greatest risks we face in the PNW in terms of forest land loss.	Elaine Oneil

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105	LCA and Wood	PCRs and EPDs	The Softwood Growing Stock Changes chart, showing that forest carbon stock has steadily grown over the decades due to good forest management, goes back to the 1950's. If the study went back to the 1700's, before the mass deforestation of the U.S., could this historical data show value for carbon stores in leaving some forests to grow to a similar old growth state as it was 200 years ago?	Yes, you could estimate pre-industrial carbon storage. Riparian buffers and many areas set-aside from harvest are on this pathway to return to "old-growth" status. However, it is important to recognize that the climate has already changed and natural disturbance cycles are different (fire frequency has increased, insect outbreaks have persisted longer, etc...). So their new normal of storage may be different than the past. Also see answer to question below.	Edie Sonne Hall
106	LCA and Wood	PCRs and EPDs	In the slide depicting stand-level carbon sequestration (natural vs managed forest, slide 19 of Elaine Oneil's presentation), why do both lines start at zero? Is the assumption that both were harvested at year zero, then only the managed forest was re-harvested at year 55 and the non-managed forest was never re-harvested? It seems like the harvest cycles don't align, or I'm mis-interpreting something about the message this graph is trying to convey.	The slide looks at carbon accumulation under management or no-management alternatives and treats all other carbon elements (soil, stumps from prior harvest, forest residues) as the same in both cases. So, starting after harvest, the land owner either does site-prep and plants because they want a tree crop in the future, or leaves the area for natural regeneration. If they plant, the managed line shows carbon accumulation on site class III ground for Douglas-fir planted at 400 trees per acre, commercial-thinned at year 25 and harvested at year 50. If they don't plant and don't have any expectation of harvesting, they would not harvest at year 50 - though they could - but with far less wood yield. In this case, the carbon accumulation is for a forest stand that came back to alder with a yield of 16,000 board feet per acre, which seems to be an average yield for this kind of forest, experiencing this kind of 'log it and leave it' approach to management. Now, it is possible to get lucky and get a higher wood volume without management, but it is also possible to have the entire area remain a scotch broom brush field for 20-30 years and get virtually no forest regeneration. This is meant to represent the potential differences in expected outcomes with and without management. It is also why we have not experienced a reduction in average standing volume per acre in PNW forests in any survey period since 1953 when we were still harvesting old-growth forests. Management concentrates the resources (water, soil, sunlight) on the crop trees - no management choices do not.	Elaine Oneil

#	Session	Presen-tation	Question	Answer	Author of answer
107	LCA and Wood	PCRs and EPDs	What is the source of the data on the forest management activities that allow you to calculate the average CO2 by region? For example, in the SE we have seen significant changes in ownership classes in the last 20 years and the level of intensive management has changed given that activity. Is this based only on plantations or does it include natural regeneration of stands in the data?	https://corrim.org/lcas-on-wood-products-library/ provides links to all the forestry source data by region.	Elaine Oneil
108	LCA and Wood	PCRs and EPDs	Somehow I'd like to get at the forestry management approach that optimizes carbon storage including soil carbon, while providing the construction industry as much sustainable low EC / stored C material as possible. I'm skeptical that SE forests with an 18 year rotation gets us there.	Couple parts to this question: 1) I think perhaps this goal might be tweaked to recognize that optimizing carbon storage in forests should also take into account other ecosystem services (eg water, biodiversity etc...) as well as climate adaptation. So if that is the case then optimizing carbon storage may not be the same as maximizing carbon storage (i.e. the difference between carbon smart forestry and climate smart forestry). But the sentiment of the question is taken. 2) In terms of the second part, I think this may be referring to how to manage a forest so that the rotation age maximizes the amount of growth (sequestration) from that stand. This occurs at the culmination of mean annual increment and this is different depending on the species. It turns out the CMAI for loblolly pine (the principle species in SE managed forests) has a CMAI of 25 years. So, in fact, 25 years is the best way to maximize carbon coming into a product off of those forests. A Douglas fir forest has a CMAI much higher (55-80 years depending on level of management intensity). CMAI = cumulation of mean annual increment (measure of growth volume)	Elaine Oneil/ Edie Sonne Hall

#	Session	Presen-tation	Question	Answer	Author of answer
109	LCA and Wood	PCRs and EPDs	If "high-intensity forestry management" is so great for growing healthy trees, what are the effects to the native ecosystems? If these are typical management practices, such as "animal damage control" and focusing the resources to the trees, what kinds of studies and measures are being taken to protect other important species within these forests?	The Pacific Coast (BC, WA, OR, CA) all have forest practices acts, so despite this being the West Coast, it is not the Wild West out there in terms of what can and can't happen in the woods. These regulatory frameworks identify what needs to happen to protect and sustain fish and wildlife, water, steep slopes, and rare and endangered species. Some jurisdictions also require protection of cultural resources and visual quality objectives. There are many areas of forest reserved from harvest in all jurisdictions that provide other needed habitat elements like old growth and mixed species forests. For example, in WA, nearly 52% of all forests are reserved from harvest, including portions of private land (industrial and small private) to protect water, fish and wildlife populations, and steep slopes.	Elaine Oneil

#	Session	Presen-tation	Question	Answer	Author of answer
110	LCA and Wood	PCRs and EPDs	Wood and forestry management practices are being hailed as the most sustainable type of construction due to the nature of wood and potential for forestry management, but what is being done/studied in terms of potential risks and downfalls? What is being done to combat the use of skewed data or less-than-ideal practices in the name of sustainable wood manufacturing? How are we offsetting the carbon emissions of manufacturing plants, equipment, the workers who drive miles into work each day? Wood cannot be shown as the ultimate hail mary if concerns "outside" the system boundary are ignored, particularly on purpose.	It is important to generally know the country where your wood is coming from as that will tell you the relative risk you have a sourcing wood from unsustainable practices. In the US and Canada, this risk is low and there is ample information and annual reports that substantiate this. In addition, 47% of all forests in Canada are certified and 19% in the US, which is well above the global average of 11%. Some important resources are shared below: This would be a whole class so I am going to give some references. At the national level, both the US and Canada track performance on key sustainability indicators: see https://www.fs.fed.us/research/sustain/criteria-indicators/ for the US and https://www.nrcan.gc.ca/our-natural-resources/forests-forestry/state-canadas-forests-report/sustainability-indicators/20016 for Canada. These indicators cover both private and public lands. Certified forests also report out on progress annually: See the SFI annual progress report (https://www.sfiprogram.org/progressreports/), FSC report (https://annual-reports.fsc.org/en). The USFS BMP report (https://www.fs.fed.us/naturalresources/watershed/bmp.shtml) summarizes best management practices associated with forest management within watersheds and implementation percentage by state. The State of America's Forests (www. usaforests.org), compiles a WEALTH of information associated with US forest benefits, threats, and stewardship. The Land Grant Universities and others are doing research about forests and have since the beginning of the 20th century. NCASI.org is another large research program on forestry, water and wildlife. Many manufacturing plants have biomass energy and some are adding solar power to support mills. I think you will find that forest/wood production is different from other non-wood competing products in the market place. In countries with poor governance and/or competing land uses it is important to source wood from certified forests.	Elaine Oneil/ Edie Sonne Hall
111	LCA and Wood	PCRs and EPDs	Do differences in tree harvesting methods result in different amounts of forest soil disturbance? Is soil carbon that is released taken into account?	As mentioned before, soil carbon is highly variable and difficult to measure. Meta-analyses of field studies across many regions and forest types have shown mixed results related to harvesting and residue management. Nave et al 2019, notes site specificity and difficulty in assigning "cause" to the variation in their meta-analysis: can't assign a management practice to a soil organic carbon (SOC) budget in particular. Also, soil microbial communities influence the C flux. These communities are dynamic and shift in functional group composition as the conditions shift. Soil C response to disturbance will vary with scale – landscape scale will be "steady" and small units will have large flux of C in and out as the above ground conditions change.	Edie Sonne Hall

#	Session	Presen-tation	Question	Answer	Author of answer
112	LCA and Wood	PCRs and EPDs	There was a lot of discussion re: C flux and providing -1 kgCO2e; or noting C stock is increasing. However, it fluxes each year; and the trend since 1990 and 2005 is decreasing the C stock. Doesn't seem wood can claim -kgCO2(e)?? See table below. Table 6-1: Net CO2 Flux from Land Use, Land-Use Change, and Forestry (MMT CO2 Eq.) Forest Land Remaining Forest Land 1990 (733.9) 2005 (678.6) 2014 (618.8) 2015 (676.1) 2016 (657.9) 2017 (647.7) 2018 (663.2)	These numbers are actually the net C flux, not the total carbon stock. So in year 1990, the remaining forest land sequestered an additional 733.9 MMT CO2e from the year before (consider it how much the total carbon stock grew). In 2018 the forest land base sequestered an additional 663.2 MMT CO2e. So the annual rate of carbon growth was less in 2018 than in 1990 but the actual amount of carbon in the forest is still much greater.	Edie Sonne Hall

#	Session	Presen-tation	Question	Answer	Author of answer
113	LCA and Wood	PCRs and EPDs	Can someone put the industry perspectives shown today into an even larger framework namely what forests were doing 10,000 years ago (when they were not being farmed by humans?) Were they operating in an equilibrium that they are constantly trying to achieve today yet would need 400 years alone to achieve? Can that "native" global carbon equilibrium be revealed on the graphs we saw today, in order to see the past but also a possible future? (best case and worst case, but context for aiming our efforts).	Edie Sonne Hall: This is a great question. A tree grows in a sigmoidal growth curve, which means that it starts off slowly, grows rapidly, and levels off such that eventually it stops putting on additional biomass (it may have new growth in a given year but that is offset by decay from older branches etc.). Each species' growth curve is different. Without natural disturbances you would have a series of old trees but no additional sequestration. Of course there has never been such thing as a system without disturbance. There have always been disturbances such as fire, wind events, drought, insects etc... At a landscape level, many times these natural disturbances evened each other out but there certainly were periods of large loss of carbon stocks and large gains of carbon stocks (e.g. in large fire events) at the regional scale. We know from Forest Service research that in the US, carbon stocks were largely stable between 1630 and 1755. But this isn't because there were no disturbances -- they just balanced out. In addition to natural disturbances, there is evidence of "human" impact on natural environment since the advent of agriculture. Methane emissions from rice cultivation started about 5000 years ago. Even in the period of time with stable carbon stocks in the US, Native Americans were clearing land with fire for grasslands and shifting agriculture. So bottom line is that with zero disturbances there is an equilibrium that equates to zero net carbon sequestration. There is net sequestration only after there has been a reduction in carbon stocks (either due to natural or human disturabance). David Diaz: Historically, extensively (as opposed to intensively) managed and unmanaged forests several hundreds of years ago contained much higher carbon stocks than they do today. A useful review of this for the USA is provided by Houghton and Hackler (2000). "Changes in terrestrial carbon storage in the United States. 1: The roles of agriculture and forestry" Global Ecology and Biogeography, Vol. 9, No. 2, pp. 125-144. A global focus taken by Houghton R.A. (1998) Historic Role of Forests in the Global Carbon Cycle. In: Carbon Dioxide Mitigation in Forestry and Wood Industry. Springer, Berlin, Heidelberg, claims "From 1850 to the present, however, human clearing and harvesting of forests has contributed about a third of the increased concentrations of CO2 observed in the atmosphere. Over the period 1850 to 1990 about 100 PgC are estimated to have been transferred from forests to the atmosphere as a result of human activity, two thirds from tropical forests and one third from temperate zone and boreal forests." Regional studies that compare maximum potential storage if the landscape reverted to old-growth should be tempered by the recognition that a mosaic of forest conditions existed historically, and not all areas were old-growth. Some regional examples include Rhemtulla et al (2009) "Historical forest baselines reveal potential for continued carbon sequestration" PNAS 106 (15) 6082-6087 for Wisconsin and Smithwick et al (2002) "Potential Upper Bounds of Carbon Stores in Forests of the Pacific Northwest" Ecological Applications, Vol. 12, No. 5 (Oct., 2002), pp. 1303-1317.	Edie Sonne Hall, David Diaz

#	Session	Presen-tation	Question	Answer	Author of answer
114	LCA and Wood	PCRs and EPDs	Why does CORRIM focus on cradle-to-grave? Why does this make more sense for wood products than whole lifecycle consideration?	The wood LCA were first developed to answer the question - what is the environmental footprint of growing trees and producing wood products? That takes is from the cradle to gate. Those LCA are all cradle to gate and that is what is used to produce the Environmental Product Declarations which only go to the gate. CORRIM has done some comparative analysis through construction using the LCA data. We have yet to look in-depth at what happens when it enters the landfill, but others in the wood science space have taken that on. Thinking about the grave depends on what happens to the wood when it enters the use stream - so that really depends on how the AEC community designs and builds buildings and how society uses them (and for how long). We are in the process of expanding the research to the whole building stage and just recently have entered into the circular economy discussion (see https://corrim.org/circular-economy-workshop/). Again - the story of how to elongate the wood life cycle ends up being a whole society story, not a wood production story and there is much to learn in that space.	Elaine Oneil
115	LCA and Wood	PCRs and EPDs	Your presentation did a very good job of showing the variability across different growing regions. It's evident the more location specific data exist, but it stops at the Mill. How can we start bringing this information through the system with EPD's that go beyond national average data? What is the right granularity of this data, if a goal is to reward best practice wood management over worst practice wood management?	The EPD are based on regional LCA which are aggregated based on a weighting of volume of wood products produced in each region. The regional LCA have as their upstream data the forestry data relevant to that region. That forestry data is also aggregated to a single input per m3 of log but again is based on a weighted average of growth, forest management, and harvest conditions. All that data is publicly available on the CORRIM website if people are interested in examining it. With each iteration of forestry updates we get more sophisticated in the amount of variability we can include. That said - the operational impacts of forest management activities are minor relative to what happens at the mill.	Elaine Oneil

#	Session	Presen-tation	Question	Answer	Author of answer
116	LCA and Wood	PCRs and EPDs	Elaine Oneil presented a graphic showing the "natural regen" growth trajectory for an area on her property and compared it to the trajectory of an intensively-managed stand to make an argument for intensifying management to achieve greater carbon sequestration. Can she compare what growth trajectory would be expected based something more rigorous and generalizable, such as the McArdle Yield Curves (https://naldc.nal.usda.gov/download/CAT40000043/PDF) or Bob Curtis Yield Curves (https://www.fs.fed.us/pnw/olympia/silv/publications/opt/235a_CurtisEtal1982.pdf) that are intentionally designed to capture naturally-regenerated Douglas-fir? This example of her property that regenerated to hardwoods seems cherry-picked to argue that natural forest development is undesirable, at least from a carbon perspective.	For the purposes of this discussion I don't think it is useful. Those yield curves (McArdle, Curtis) are based on fully stocked Douglas-fir stands that had been established naturally after major disturbance - either wildfire or significant windthrow with substantial soil disturbance and were measured well after establishment to assess growth potential. Neither is reflective of the site conditions that occur post-harvest now when forests are logged and left in an unmanaged condition. If the harvest sites aren't planted, or planted and the plantation fails due to lack of management, there will be far less wood yield. In my example, the carbon accumulation is for a forest stand that came back to alder with a yield of 16,000 board feet per acre which is an average 'experienced' yield for this kind of forest that has been subject to a 'log it and leave it' kind of management. Now it is possible, (but unlikely) to get a fully stocked Douglas-fir stand (which is what the McArdle and Curtis curves measure) without site disturbance, but it is also possible to have the entire area remain a scotch broom brush field for 20-30 years and get virtually no forest regeneration. This example is meant to represent the potential differences in expected outcomes with and without management. It is also why we have not experienced a reduction in average standing volume per acre in PNW forests in any survey period since 1953 when we were still harvesting old-growth forests. Management concentrates the resources (water, soil, sunlight) on the selected crop trees. No-management choices leave you with what Mother Nature delivers -- good, bad, or indifferent.	Elaine Oneil

#	Session	Presen-tation	Question	Answer	Author of answer
117	LCA and Wood	PCRs and EPDs	There is a perception that Old Growth forests should not be harvested because of their carbon storage. Can you give us a sense of the carbon impact over multiple forest rotations?	This varies tremendously depending on the forest type, but every site has a maximum carrying capacity and every living thing (including us) has a natural cycle of fast growth in its youth, slower growth in middle years, and decline in its elder years. The elder years might be 80 years for an alder stand or 800 years for a cedar stand. Some old growth forests are storing less carbon than a well-managed Douglas-fir plantation at 40-50 years of age which explains why we haven't really changed our standing carbon values in the PNW since 1953 when we were still harvesting old growth. Why? - because the trees are dying, the canopy gaps are filling with understory trees that do not necessarily store much carbon, and the dead wood is decaying and releasing its carbon. I have been in old growth stands where there are more dead trees on the ground than there are still standing and those standing ones are dying too, so they certainly don't last forever. In most cases, one can accumulate more wood fiber (and hence more carbon removed from the atmosphere) per acre by multiple rotations than by establishing one forest that is left to grow indefinitely. That said there are examples of PNW old-growth Douglas-fir stands that carry nearly double the average volume, but data reported for the region (1953-2017 FIA data) do not support the idea that this was commonly achievable. The atmosphere sees the greatest carbon benefit if we can grow the trees efficiently and quickly, find ways to store the wood products for LONGER than the rotation, and find ways to use wood in place of other products that use a lot of fossil fuels in their production and construction. If wood products are stored for SHORTER than the rotation, then the co-benefits are reduced.	Elaine Oneil

#	Session	Presen-tation	Question	Answer	Author of answer
118	LCA and Wood	PCRs and EPDs	There was a comment about slash being outside of the accounting boundary, both in terms of an output, but also in terms of an input. But isn't climate science measuring total carbon and aren't we aiming to achieve the goals they say we need to meet and isn't all carbon (slash included) part of their global carbon (ppm) measurement? If they are being selective about what is in their boundary (EPD) then who is accounting for the uncounted (slash and other) carbon equivalents that are also the consequence of our design decisions?	We did an exercise of adding it in and then taking it out which is reported out in the 2017 PNW forest resources paper (see CORRIM LCA library for full report). It changes the mass balance but the net effect is the same - the log plus bark is a net greenhouse gas sink of 927-950 kg CO2e/m3 of harvestable logs and if we account for the residues as well the net greenhouse gas sink per m3 of logs increases to 1459 kg CO2e because you need to account for the sequestration of the residues as well as the additional emissions associated with the residue treatments. If you refer back to James Salazar's presentation where he explains the mass balance requirements in the PCR and ISO standard (i.e. it all has to balance to zero over the entire life cycle including wood in use) then this becomes apparent.	Elaine Oneil

#	Session	Presen-tation	Question	Answer	Author of answer
119	LCA and Wood	PCRs and EPDs	How much wood from the original tree is stored/sequestered in the final wood product?	This depends on a lot of things, chief among them the market demand for different products, the relative price of fossil fuels, and the size and form of the input logs. Most biomass estimators allocate 1/3 of tree volume (and therefore tree carbon) to the roots, 1/3 to the stem or log (that which is removed) and 1/3 to the crown. The round log leaves the forest – if the demand for pulp is very high, that log will be cut to a 4" top or even a 2" top, so less remains in the forest. In other instances it is cut to a 6" top or (even larger diameter in certain kinds of hardwood stands). The tree roots, limbs and tops remain in the forest where they either decay or are burned to reduce fire risk and create plantable spots. The post-harvest operations vary significantly depending on region, forest type, and silvicultural system. In many jurisdictions there is a requirement to leave a minimum amount of slash (limbs and tops and even some large diameter trees) to serve as habitat for different kinds of wildlife and as nutrient inputs for the next forest – so it isn't 'wasted' but it does break down and release some carbon to the atmosphere. The remaining carbon is incorporated into the soil depending on nutrient status of the soil and existing dead wood components. In the mill, the round log is merchandized into components – sawn timber (2x4, 2x6, etc) or plywood, with co-products of chips, bark, and sawdust. The co-products go to the highest bidder – either to pulp and paper, engineered wood (like particle board, MDF, and OSB), to the mulch market, or they are burned for energy. Less than 1% of logs plus bark coming into the mill goes to the landfill (because it falls off in the yard and is too dirty to use or burn.)	Elaine Oneil
120	Tracking Carbon in North America	3.1 Certification, chain-of-custody	What is the cost premium of certification?	This varies on forest product type, market access, and geographic location. Estimates on various wood products can range from 5-50%, though most appear to fall between 15-25%.	Lauren Cooper

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121	Tracking Carbon in North America	3.1 Certificatio n, chain-of-custody	What are some other emerging pathways for certification aside from FSC and SFI?	FSC and SFI are the dominant pathways for certification in the US. Internationally, there are additional approaches to promote and track sustainabiility, including country-level certification schemes (e.g. Indonesian Forestry Certification Cooperation), government-led initiatives (e.g. certified sustainable jurisdictions), and product-led iniatitives (e.g. sustainable palm or deforestation-free beef) that could also be used to promote sustainable timber.	Lauren Cooper
122	Tracking Carbon in North America	3.1 Certificatio n, chain-of-custody	How detailed is the PEFC/FSC chain of custody? Does it help drive change at the landscape scale?	That chain of custody promotes and tracks certified sustainable forest management, including practices well above legal requirements in many states, and it has an influence on forest management.	Lauren Cooper
123	Tracking Carbon in North America	3.1 Certificatio n, chain-of-custody	My understanding is that here in the South, there is almost no FSC lumber available. I've also heard that the FSC lumber that exists down here is largely owned/used by the paper industry. Is this true? What are the hurdles to getting FSC certified lumber in the South? Overhead costs of certification for private owners was mentioned yesterday... is that the main one?	Actually, there are more FSC-certified acres in the South than in the PNW (4.3 million acres FSC in US south versus 2.3 million acres in PNW (with 1.7 of those in California alone). For small landowners, I would say cost of certification probably the main barrier in the US South. Worldwide, however, both of these regions contribute very little to FSC supply as there are 493 million acres certified world-wide (so US South represents 0.8% and PNW represents 0.4% of FSC certified acres). Canada represents 25% of FSC certified acres (125 million) and Russia represents 24% (120 million acres).	Edie Sonne Hall

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124	Tracking Carbon in North America	3.1 Certificatio n, chain-of-custody	Is carbon management a criterion in forest certification schemes?	Currently, no, the certifications do not require carbon estimates. That noted, this is a topic that in coming up in working groups and revisions teams and could become an indicator in the future.	Lauren Cooper
125	Tracking Carbon in North America	3.1 Certificatio n, chain-of-custody	Do any of the certification systems have a scientifically valid soil carbon measurement requirement?	Currently, no, the certifications do not require carbon estimates. That noted, this is a topic that in coming up in working groups and revisions teams and could become an indicator in the future.	Lauren Cooper
126	Tracking Carbon in North America	3.2 Carbon and sustainabili ty tracking	What is the GHG protocol definition for carbon sequestration?	From the GHG Protocol Standard for Corporate Accounting, Carbon Sequestration is "the uptake of CO2 and storage of carbon in biological sinks." https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf, page 96.	Edie Sonne Hall

#	Session	Presen-tation	Question	Answer	Author of answer
127	Tracking Carbon in North America	3.2 Carbon and sustainability tracking	The International Institute for Sustainable Development recently found that the conversion of intact old-growth forests to secondary managed forests could release huge amounts of stored carbon that are never fully recovered. How is this reconciled in national scale accounting?	Individual plot-level data from the National Forest Inventory (NFI) are used to compile estimates of carbon stocks and stock changes in national reporting. While we do not organize estimates by forest conditions (e.g., primary forest, secondary forest) in UN reporting, changes in forest composition and structure are captured in the compilation of the estimates using remeasurements on permanent NFI plots over the reporting time series.	Grant Domke
128	Tracking Carbon in North America	3.2 Carbon and sustainability tracking	Re: national forest carbon stock inventories - is there more we need to unpack about the definitions and qualities of these inventories? This article from Canada indicates definitions of what is being counted (excluding insect/fire kill) is affecting results and analysis: https://www.nationalobserver.com/2020/03/30/opinion/canadas-forests-become-carbon-bombs-ottawa-pushes-crisis-books. Is the US data confirmed, and/or is there a response to the Canadian inventory data?	Canada uses a rule-based system to separate emissions from what they define as natural disturbances and anthropogenic activities. While the US is capable of separating and attributing emissions in the same way, we do not currently separate managed land emissions (and associated removals on lands excluded based on their disturbance classification) in UN reporting.	Grant Domke

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129	Tracking Carbon in North America	3.2 Carbon and sustainability tracking	Why is SWDS doubling since 1990? (slide 16 in Grant's presentation)	Because these estimates are cumulative over the time series and much of the C stored in SWDS is consider permanent.	Grant Domke
130	Tracking Carbon in North America	3.2 Carbon and sustainability tracking	Can/is the variability be quantified/reported on a regular basis for the FIA data?	Estimates of uncertainty (which includes variability) are included each year as part of UN reporting. The FIA program also includes sampling errors in most national- and state-level reporting.	Grant Domke
131	Tracking Carbon in North America	3.2 Carbon and sustainability tracking	How difficult would it be to bring more granularity to this carbon stock pool data, such as at the regional or forest level?	A research effort under the NASA Carbon Monitoring System has used satellite imagery and field measurements from the FIA (and other inventory campaigns) to map forest conditions at 30m x 30m resolution across the contiguous USA from 1986-2018. Data on forest conditions derived from remote sensing are emerging and evolving rapidly. The nationwide NASA CMS forest biomass data have not yet included in any peer-reviewed publications, but seem poised to be released for broader use within the next year. This data only covers total aboveground biomass, and is most sensitive to detecting biomass of standing live and dead trees. It is unlikely to accurately capture downed wood, leaf litter, or soil carbon.	David Diaz
132	Tracking Carbon in North America	3.2 Carbon and sustainability tracking	Can you speak to the order of magnitude increase in emissions from fire from 1990 to 2018 - reasons for it and what can be done about it? (slide 16 in Grant's presentation)	The frequency and severity of wild fire in the US (and beyond) has increased substantially over the last several decades. This has resulted in the substantial increases in fire emissions estimated as part of UN reporting. Please see the following links for detailed information on fire, forests, carbon, and climate. https://carbon2018.globalchange.gov/chapter/9/, https://nca2018.globalchange.gov/chapter/6/	Grant Domke

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133	Tracking Carbon in North America	3.2 Carbon and sustainability tracking	Is USDA working with the One Trillion Tree Initiative to help plant more trees on the poorly or non stocked forest lands?	Yes: https://www.fs.usda.gov/features/trillion-trees	Monica Huang
134	Tracking Carbon in North America	3.2 Carbon and sustainability tracking	Does cutting down a tree leads to reduced carbon removal from the atmosphere, and also loss of carbon from the soil where the tree stood?	Cutting a tree removes the capacity of that tree to sequester CO2 from the atmosphere but the carbon that was seqestered and is stored in the tree may be stored in wood products. Soil carbon processes following harvesting are less well understood and there is not necessarily a loss of soil carbon surrounding the harvested tree.	Grant Domke
135	Tracking Carbon in North America	3.2 Carbon and sustainability tracking	The proposal is that forests are more productive and a greater carbon sink if they are managed. Annually, how much U.S. forest is converted from natural forest to plantations to accomplish this?	While I do not have a specific area for this, please see the amount of land that is planted in a table in Pat's presentation (slide 7). It is a very small part of the landbase. Most of this acreage was originally forests, then agriculture and finally replanted to establish "plantations". If you look at the slide you will see many forests are naturally regenerated and not "plantations".	Pat Layton

#	Session	Presen-tation	Question	Answer	Author of answer
136	Tracking Carbon in North America	3.2 Carbon and sustainability tracking	Lauren mentioned that more mature trees are past an optimal (highest) sequestration rate. EcoTrust in the PNW says that the optimum for PNW Coast Range forests are at 80-100 years of age. Do we have data for other regions?	This question is mixing together "biologically optimal" timber yield harvest age with optimal carbon storage and/or sequestration. "Yield Curves" are available for most commercially important tree species, and can indicate the "biologically optimal" rotation age at which an even-aged forest subject to clearcut harvest would generate the most timber over time. Carbon "optimality" is highly dependent on whether you consider only sequestration rate or whether you also consider total carbon stock accumulated over time. Most tree species show a period of highest growth relatively early in their lives (e.g., 20-30 years of age for Douglas-fir). This period of high growth is not the same thing as optimal financial rotation age or optimal biological rotation age. There is no single definition for an optimal carbon age because it really depends on whether you consider cumulative carbon stocking, just the instantaneous sequestration rate, and which pools in the forest (and products) get accounted for. Addendum by Edie: If you consider biologically optimal age as the "culmination of mean annual increment", we can calculated these for most species based on Smith et al (2006) published yield curves. Here are a few examples: Rocky Mt Doug fir natural- 95 yrs; PWW Doug-fir natural 65 yr; PWW intensively managed- 55 yrs; Natural loblolly pine- 45 yrs; intensively managed Loblolly pine- 25 yrs; NE Oak-pine- 45 yrs; Maple-beech-birch NE- 55 yrs; Mountain Hemlock in Rocky Mts- 125 yrs.	David Diaz
137	Tracking Carbon in North America	3.2 Carbon and sustainability tracking	What is the extent of LIDAR use on forests in the US?	While it is costly, there are many projects harmonizing lidar with field data to estimate tree biomass and carbon stocks in forests of the US. See the following link for the spatial coverage of lidar in the US. https://www.usgs.gov/core-science-systems/ngp/3dep	Grant Domke

#	Session	Presen-tation	Question	Answer	Author of answer
138	Tracking Carbon in North America	3.3 Wood in LCI's and LCA tools	How is biogenic carbon defined differently in different LCA tools?	Maggie Wildnauer: Biogenic carbon can be included or not in the overall GWP result in Tally. In EC3 it's presented as a separate value, as the life cycle inventory of biogenic carbon rather than included in GWP total. However, biogenic carbon is not defined differently in the tools, it's presented differently. David Diaz: EC3 and Tally refer to "biogenic carbon" meaning different things. As I understand it, Tally refers to biogenic carbon referring to carbon in a product. Tally does not account for emissions from biogenic carbon sources if the "biogenic carbon" toggle is turned off or on. EC3 refers to "biogenic carbon" to include both stocks and emissions from biological sources.	Maggie Wildnauer, David Diaz
139	Tracking Carbon in North America	3.3 Wood in LCI's and LCA tools	How does the BATH database relate to the other noted LCI databases?	BATH appears to present data with and without carbon storage, though it looks like the statistics they calculate are based on including biogenic carbon	Maggie Wildnauer
140	Wood and the Building Industry	4.1 Economics of Wood Products	How does adding value to forest products help protect our forests from land development?	In general, higher market values for products incentivize more landowners to produce more forest products and invest in ways to do so. This may involve establishing new forest areas and adopting management strategies that generate higher value products. It is unlikely, however, that higher forest product value will achieve parity with the development value of forestland in areas of high demand. This is a good example of a market failure (externality).	David Diaz

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141	Wood and the Building Industry	4.1 Economics of Wood Products	In a carbon trading scheme/market, what options are possible for establishing who owns and who is responsible for the emissions the carbon in harvested wood products?	Emissions of carbon from forest products would probably be regulated at end-of-life facilities (e.g., landfills, biomass-to-energy plants, etc.). Emissions of forest product carbon during manufacturing could also be considered during manufacturing and use of biomass for heat or energy. This is precisely where the original debate around the carbon neutrality of biomass first emerged. Depending on the carbon regulation, end-of-life entities (esp. landfills) are commonly covered by a cap or carbon-tax if they are of any substantial scale. Regulation of forest product manufacturers and biomass-to-energy or biomass-to-heat utilities is hotly debated and commonly captured in related policies such as Renewable Fuels Standards. Most carbon offset protocols open to US forest owners (ARB, CAR, ACR, VCS) apply a fixed discount factor to carbon removed from forests to account for the amount believed to be retained in products over long timeframe. For example, California's Compliance Offset Protocol for US Forest Products estimates the amount of carbon believed to be stored in products averaged over a 100-year timeframe. Carbon Project Proponents must report the proportion of their harvested wood that is transformed into different product categories, each of which has an associated "100-year average factor". This is typically based on regional reports, but can be provided with a statement from local mills indicating the types of products they generate. These 100-year average factors range from a low of 6% for paper products to a high of 58% for oriented strandboard.	David Diaz
142	Wood and the Building Industry	4.1 Economics of Wood Products	Cutting a partially-mature forest reduces its annual carbon intake for 20-40 years. How do we ensure that carbon uptake has an economic value, so the loss of that uptake is of interest to the landholder?	Putting a price on carbon would be the first step. Forest owners are typically voluntary/opt-in participants in most carbon/climate policies around the world. If you want carbon losses to correspond to a financial penalty, this could probably only be accomplished through regulation (New Zealand is the only country to regulate timberlands inside the cap of its cap-and-trade program) or taxation, or through changs in consumer behavior coupled with enough transparency about carbon stock change for different ownerships and traceability of wood through the supply chain.	David Diaz

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143	Wood and the Building Industry	4.1 Economics of Wood Products	Are there building types you've found well adapted for wood that in the past would typically be steel or concrete?	Many types can be wood, the change to wood is in part dictated by changes to building codes and price.	Pat Layton
144	Wood and the Building Industry	4.1 Economics of Wood Products	Harvesting and transportation are pretty different. Harvesting should be a fixed price per unit, transportation is variable, right? So how much of that 50% is harvesting?	I do not have a single answer for that as it will depend on the region and distance to the mill. Harvesting costs vary dependeing on access via roads, terrain, type of harvest (thinning, selection or clearcut), soils etc. There may be a source for this, but I am not aware of it.	Pat Layton
145	Wood and the Building Industry	4.1 Economics of Wood Products	Don't some trees continue to add biomass and sequester carbon for a very long time? I think in the PNW Douglas fir keep adding mass well past 100 years. But is that less true for tree species in other areas?	Yes you are correct. Different species have different maturation rates and growth patterns. Please see these books to learn more about any North American species. https://www.srs.fs.usda.gov/pubs/misc/ag_654/table_of_contents.htm This is a definite go-to source for me on any basic knowledge about tree and it is free to download.	Pat Layton
146	Wood and the Building Industry	4.1 Economics of Wood Products	Pat mentioned some standards related to the wood products. We also know about FSC that is more about sustainable forestry practices. What standards should we consider?	FSC, SFI and several others are about forests. The other standards Pat mentioned were more about lumber quaility or manufacturing standards for engineered wood products. See https://www.apawood.org/, https://www.spib.org/, http://wwpa.org/	Pat Layton

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147	Wood and the Building Industry	4.2 Going Beyond Neutrality in Embodied Carbon Accounting for Forest Products	Is there a way to index forest-sheds (or bio-zones) in categories like "native biodiversity" and "native carbon sequestration rate" and "native natural fire index"? In other words, I would love to see a 2x4 with data imprinted on it that is qualitative about it's source and kiln-drying, but also it's contribution to ecosystem goals that include watershed management and biodiversity generation... I wonder how close we are to that kind of data. I think owners will become more and more interested in how every dollar they spend is connected emotionally to the world view that they are promoting.	Currently, there is not really a way to do this. Forest ecosystems are very diverse and the number of different values that could or could not be included in such an index will vary dramatically from owner to owner and among consumers. Certification would presumably be required for making claims like this credible. The closest analog that I'm aware is a relatively new Ecosystem Services Procedure within the the Forest Stewarship Council certification process for forest owners. This Procedure is not required for certification, but is an optional add-on that would allow FSC certificate holders to report third-party verified estimates of the biodiversity, soil conservation, carbon, water, and other benefits that can be attributed to their management choices.	David Diaz

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148	Wood and the Building Industry	4.2 Going Beyond Neutrality in Embodied Carbon Accounting for Forest Products	Utilizing NASA Carbon Monitoring System, should non-declining carbon stock be a criteria for FSC, SFI, ATFS, CSA forest certification?	Non-declining biomass (or carbon) could be a helpful indicator for demonstration of sustainable forest across a certificate-holder's ownership, but is probably not adequate for use as a strict prohibition. There are perfectly legitimate reasons to reduce carbon stocks over time, and if a landowner has a smaller property, they would struggle to implement any active management because their property-level stock would decrease. I would expect an indicator like this to be discussed with a certification auditor where the landowner would need to be able to demonstrate that they are aware of the stock change and be able to justify that it is part of a long-term sustainable management plan.	David Diaz
149	Wood and the Building Industry	4.2 Going Beyond Neutrality in Embodied Carbon Accounting for Forest Products	Carbon neutrality is a "conservative assumption", but only in the context of a cradle-to-gate scope. Any analysis of GHG effects of buildings must include consideration of end of life, and that is where the uncertainty lies with wood products. Two-thirds of wood products currently go to landfills at end of life. What happens to that wood is not well understood, but if it releases even a small amount of its carbon as methane emissions, the carbon neutral assumption no longer applies, regardless of whether the forest area is non-declining. I'd like to hear comments on this.	I agree. There are a lot of assumptions that are required to do end-of-life calculations that are beyond the scope of my comparatively narrow focus on "upstream" embodied carbon quantification. Whether methane is generated and/or captured from land-filling of biomass could violate the carbon neutrality assumption of biogenic carbon emissions being neutral.	David Diaz

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150	Wood and the Building Industry	4.2 Going Beyond Neutrality in Embodied Carbon Accounting for Forest Products	if you divide a large number by a small number (as in the very minimal harvest on federal lands) the ratio of carbon stored on the land to carbon harvested will obviously be higher than if you harvest what you are growing (should be close to 1). Please explain what happens when you start to increase your harvest on public lands to get this climate smart wood. Would it not all trend towards a single number for all forests thus reducing overall diversity?	You are correct. For owners with small harvest volume, we see a much larger swing (both positive an negative) across counties. If the denominator (timber output) is small, carbon stock change divided by timber output will be very sensitive to controlled or uncontrolled swings in carbon stocking. The second question seems to be asking for an assessement of a consequential nature as opposed to an attributional one. Answering it seriously would require making assumptions about whether there would be price effects and/or market access effects related to changes in purchasing behavior by some portion of the building sector, whether or not carbon-friendlier land owners would increase harvesting to get more money, and the timeframes over which these decision and market interactions occur. In the context of federal forests, my (informed) hunch is that profit is not a major driver of management decisions, so would not expect to see federal forests intensify commercial timber harvesting to make more money. It would then be up to those landowners who are more market-motivated to provide the supply to meet demand. How those landowners respond will also probably be related to whether they see short- and/or long-term benefits to adding carbon to the landscape while continuing to produce wood. As was discussed earlier, higher prices and demand for wood leads to greater investment in forests. Higher prices and demand for carbon-friendly wood would presumably lead to greater investment to supply it.	David Diaz

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151	Misc	Specification and procurement	What can designer/specifiers/owners of buildings do to support higher carbon storage in forests the most? What can architects/builders do to help keep forests as forests? Are there modifications to specifications that should be made to ensure sustainable sourced wood is used? What should architects / engineers avoid?	Use wood products more to encourage landowners to keep forests as forests and to manage those forests. Do a better job of using the wood you get. CORRIM recently held a circular economy workshop (https://corrim.org/circular-economy-workshop/) where a presenter (Alan Organschi of Gray Organschi Architects) spoke to this need. While I thought the whole event was spectacular if you have only limited time please listen to his talk for some amazing inspirations on using wood as a climate mitigation solution. https://corrim.org/designing-a-global-carbon-sink/ Ask for certification. Ask for any disclosures about the carbon and other environmental impacts that the supplier can provide about the forest or company that produced the logs. Ask for SFI, PEFC, FSC sources. Think local. Question that a specifier can ask: Where was this wood sourced? Are the wood suppliers certified, and/or are they operating in a well regulated environment where rule of law prevails? Are forest resources in the supplying region increasing or declining?	Pat Layton, Elaine Oneil
152	Misc	Specification and procurement	How does transportation affect purchasing and procurement decisions?	Transportation adds costs, so reducing costs and associated environmental issues are impacted as costs rise	Pat Layton

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153	Misc	Specification and procurement	What is the opportunity for AEC teams to deliver the biggest climate benefit in the near term (next 30 years)? Yes, over geologic time periods forests may be in carbon balance but that is irrelevant to the climate challenges we face. So if we are buying wood for construction, how can that do the greatest good right now?	Do a better job of using the wood you get. CORRIM recently held a circular economy workshop (https://corrim.org/circular-economy-workshop/) where a presenter (Alan Organschi of Gray Organschi Architects) spoke to this need. While I thought the whole event was spectacular if you have only limited time please listen to his talk for some amazing inspirations on using wood as a climate mitigation solution. https://corrim.org/designing-a-global-carbon-sink/	Elaine Oneil
154	Misc	Misc	How much do adhesives contribute to the overall GWP of CLT/GLT?	Adhesives typically contribute less than 20% to the overal GWP of CLT/GLT.	James Salazar
155	Misc	Misc	What are other important environmental and/or social considerations - besides carbon - surrounding forestry and wood products industry? (e.g. habitat, rural economy) And what are some perspectives on how to consider potential trade-offs between carbon and these other impacts?	All ecosystem services including those you mentioned. Can forest products be used to prevent the emission of fossil carbon from alternative products?	Pat Layton
156	Misc	Misc	Do other materials deal with land use emissions of biogenic carbon as well? Due, for example to mining for metals, sand, etc.?	All current product category rules for construction products (i.e. wood and other materials) conform to ISO 21930 which specifies the land use/land use change criteria and accounting rules. Additional rules in ISO 21930 specify the treatment of biogenic carbon which applies to the wood product PCR but not to those for metals and other non-biogenic materials.	James Salazar

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157	Misc	Misc	It seems like the upshot from this group of people is that all lumber is the same as long as it comes from “sustainable” forestry, which by their definition just means you replace what you harvest. Is that accurate?	Sustainable forestry is more than replacing what you harvest! Using locally-based products is important, if possible, for the use you need (treated wood decks may not be available from locally-grown woods). We were speaking mostly about carbon in this series, our point was just don't consider only carbon as there are significant tradeoffs. Certified forest products provide assurance that all sustainablity issues, including carbon, are being considered and under continual improvement.	Pat Layton