Exploring the landscape of embodied carbon

FORESTS & ECOSYSTEM SERVICES

A new look at the relationship between forest land ownership, timber production, and climate in the Pacific Northwest.

We are in the midst of an unprecedented explosion in the volume of data flowing from satellites that now offer imagery of Earth's surface on an almost-daily basis. The raw imagery alone allows us to quickly see how the Earth changes over time. It's hard not to marvel at how elegantly these images reveal the complexity and beauty of our planet's diverse places and their dynamic nature.

The real power to learn about what's happening on our planet, and particularly to our forests, emerges more clearly when we figure out how to systematically translate the raw data in each of these pixels (including wavelengths of light not visible to the human eye) into information we can readily understand and interpret, such as the amount of canopy cover, abundance of different species, the size or volume of trees, and types of disturbances. For those of us working at the intersection of equity, economy, and the environment, we are just beginning to scratch the surface of a treasure trove of imagery blanketing our planet that reaches back nearly 50 years.

Top image: The mouth of the Columbia River, as seen from the Sentinel-2 satellite on September 2, 2020.

Ecotrust

FOREST PRODUCTS CAN OFFER BENEFITS & BURDENS

Over the past couple years, our team has been working with dozens of architects and engineers trying to figure out how they can better direct their purchasing power to improve the management and conservation of working forests. Most of the green builders we interact with are part of a growing movement interested in reducing the climate and other impacts (e.g., carbon footprints) of buildings.

In this community, there is a large and expanding interest in using wood products—especially "mass timber"—as carbon-friendlier alternatives to materials like concrete and steel. Builders at the cutting edge, however, are not really asking whether or not they should buy wood, but rather who and where they should get it from. They are increasingly concerned about differentiating suppliers within the forest sector. Many of them are looking for wood from tribally managed forests, recognizing that Indigenous communities have been successfully stewarding these forests for millennia. These builders and designers also recognize that forest management choices matter, and that different forest practices will necessarily involve different climate, community, and biodiversity impacts that may accumulate over time.

And yet, in contrast to suppliers of different types of concrete and steel who are actively competing to attract demand from green builders by developing climate-friendlier versions of their products, the forest sector has been reluctant to follow suit. While suppliers from these other sectors are actively trying to differentiate themselves based on their climate impacts, the timber industry and most advocates of forest products have essentially locked arms on a comparatively generic marketing campaign that can basically be summed up as "wood is good."

In the article "Doing better than carbon neutrality for forest products" Director of Forestry Analytics and Technology, David Diaz, provides a more detailed background about how the building sector found itself in this near-void of information about the importance of forest practices. The short version of the story is that green builders seeking actionable information about the varying climate impacts of different wood sources have been hamstrung for nearly a decade by a prevailing assumption that all forests being managed to produce timber are exactly carbon neutral. That is, the "biogenic carbon neutrality" assumption pretends that all working forests are neither accumulating nor losing carbon stocks over time, or in other words, that the change in forest carbon stocks over time is exactly zero.

The public archive of satellite imagery we now have at our fingertips becomes dramatically more useful when we can pair it with information collected on the ground about things that we care about, like forests. To move beyond the gross simplifying assumption that all working forests are carbon neutral, we're particularly interested in learning how carbon stocks are changing in forests while they are managed to generate timber products.

If carbon stocks are going up over time from a place producing timber, we can imagine there being a carbon sequestration benefit related to the wood produced there. Conversely, if carbon stocks are going down over time from a place producing timber, we can imagine a carbon emissions burden related to the wood produced there.

CALCULATING UPSTREAM EMBODIED CARBON

In more direct and analytical terms, the basic idea for replacing the continent-wide zero that currently represents the "upstream" (i.e., in the forest) carbon benefit or burden that is carried by forest products from any region is to simply measure how much the carbon stocks have changed over a specific timeframe (e.g., the past 20 years), and then to allocate that burden (if carbon stocks have decreased) or that benefit (if carbon stocks have increased) to the amount of timber that came from that place during that time frame. This concept was originally introduced by Eric Johnson in a 2009 article titled "Goodbye to carbon neutral: Getting biomass footprints right."

To calculate "upstream" embodied carbon for timber, we need to be able to answer two basic questions:

1. *How much have carbon stocks gone up or down in a specific area of interest over a specific timeframe?*

2. *How much timber has been produced from that same area and timeframe?*

Once we have this information in hand, the math is pretty simple:

3. *Divide #1 by #2 to allocate the carbon benefit or burden accruing on the land to the products that came from it.*

And so, our team went looking for publicly available data on carbon stock change and timber output.

DEFINING UPSTREAM EMBODIED CARBON

In our work, we use the phrase **upstream embodied carbon** to refer to the carbon benefit or burden that timber entering the market carries based on the observable increases or decreases of in-forest carbon stocks where it was harvested.

"Upstream" refers to the fact that these changes accumulate in the forest and is intended to contrast with "downstream" carbon accounting of forest operations, transportation, and manufacturing processes as a living tree gets turned into a log and then processed into a finished wood product put to use in the built environment.

The **"embodied"** part of this phrase refers to the fact that the carbon impacts occur prior to a building opening its doors. After a building opens, all the impacts associated with its operation and maintenance are considered "operational" instead of "embodied".

The phrase "**end-of-life**" is commonly used to refer to emissions that occur after a building has reached the end of it's useful life and the materials in it are disposed of or reused.

METHODOLOGY

Eyes on the ground, eyes in the sky

To figure out how much timber is produced from different landscapes over time, we had to pull together a few different data sources. The Montana Bureau of Business and Economics offers a simple interactive web app that allows you to browse county-by-county throughout Washington, Oregon, California, Idaho, or Montana and see reports on how much timber has been produced by different types of owners every year from 2002-2017. Oregon offers county-level timber output records going back to 1962, and Washington's timber output records go back to 1965. Each of these reports on timber output describe how much timber was produced by these landowner categories: Federal, State, Industry, Tribal, and Non-Industry Private (e.g., private family-owned forests). However, the categories used in each State are not always consistent (e.g., sometimes all private landowners are lumped together, and sometimes tribes are lumped together with all private landowners).

Thankfully, when you start in on work dealing with forest carbon cycling at continental scales, you'll often find smarter and better-funded people than you who have already done most of the data gathering and number crunching. In this case, we were thrilled to come across a dataset produced by the Oregon State University Environmental Monitoring, Analysis and Process Recognition Lab headed up by Dr. Robert Kennedy. These researchers trained Machine Learning models to predict the amount of forest biomass they could see from plots measured as part of the US Forest Service's Forest Inventory & Analysis (FIA) program based on a time-series of imagery produced by the NASA Landsat satellite program. They then applied those models for every year from 1990-2017 across the landscape wherever imagery is available.

The result is a map of aboveground forest biomass across the contiguous USA for every year from 1990-2017. Across all the forested land in the contiguous USA, this dataset provides an estimate of how much aboveground live tree biomass exists in 30-by-30 meter square chunks (or pixels). That's a lot of data, and they have the potential to offer unprecedented visibility into how forests in different places across the USA have changed over the past 30 years. If you are interested, you can view, interact with, and download the data like we did using this cool web app from the eMapR Lab.

The next question is "*Who owns what*?"

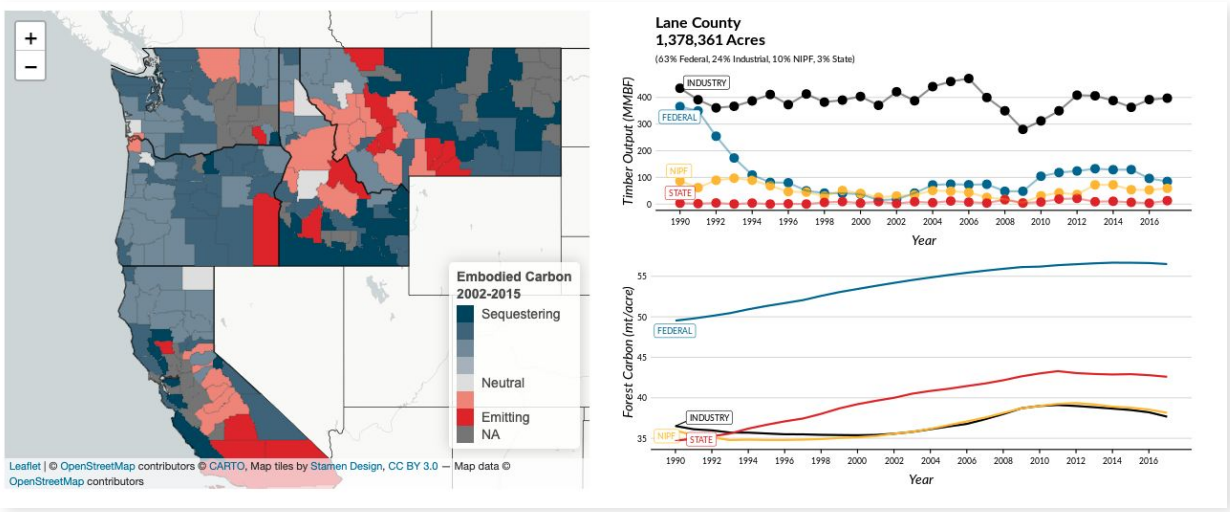
So now we've got data in-hand showing how every 30x30m chunk of forested land in the contiguous USA changed from year to year between 1990 and 2017. We also know how much timber different types of forest owners have harvested every year over the same time frame. We used two additional publicly available datasets to distinguish which landowners are responsible for which forests across the landscape and to exclude areas that are not or cannot be involved in timber production.

To figure out which forest lands are managed by different owner types, we used a map produced by US Forest Service researchers categorizing forest ownership across the contiguous USA based on data gathered from 2012-2017. And because we are primarily interested in forests that are (or at least can legally be) managed for harvesting and selling timber, we screened out any areas that are reserved from commercial timber harvest according to the Protected Areas Database of the United States produced by the US Geological Survey. For example, National Parks and wilderness areas are excluded when we calculate the upstream embodied carbon for wood produced on federal lands.

VISUALIZING CARBON STORAGE & TIMBER OUTPUT OVER TIME

In general, having stock change and timber output data gathered in the same place allows you to see some interesting trends. We prepared a simple interactive map so that you can explore the data yourself. Among other things, you can find some regions and owner types that seem to be adding to their carbon stocking over time and others that appear to be losing carbon stocks over time. There is often a relationship between how much timber is being produced and how much carbon stocks grow or decline. It's also critically important to notice that most areas and owners in the northwestern US are increasing their carbon stocks over time while also producing timber from them. It's equally as important to notice the huge amount of variability that exists among landowners and between the states.

SEE FOR YOURSELF!



The above image is a sample output from our interactive map. On the left, is a clickable map of data available by county. To the right Timber Output and Forest Carbon are graphed with available data divided by landowner type. Learn more and interact with the map at **ecotrust.org/mapping-forest-carbon-data**.

While our analyses do include tribally managed forest lands, tribal timber data at the county scale are not reported here alongside other owner types, because this would often uniquely identify individual tribes. Ecotrust is working with northwestern tribes and intertribal organizations to explore embodied carbon disclosures based on Tribal data sovereignty and self-determination.

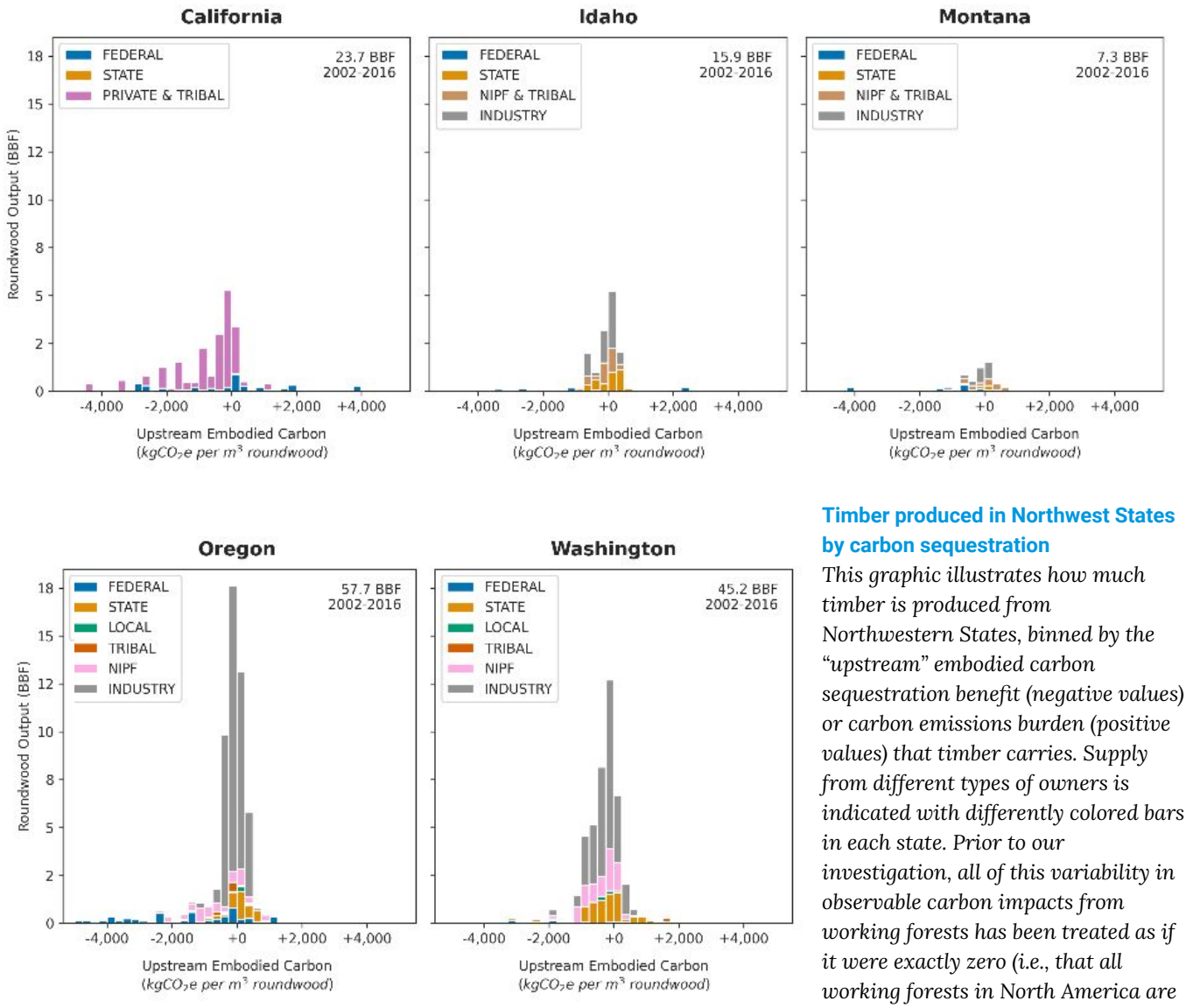
WHAT DOES IT MEAN?

Although we did find that the upstream embodied carbon for logs coming out of Northwestern forests is centered around zero in every state, two findings in particular are worth noting:

The wood supply has a wide range of variation in every state and every owner type.

The scale of this variation is often larger than all of the *combined* "downstream" emissions traditionally included in forest product life cycle assessments.

In other words, while the assumption of carbon neutrality does represent a middle-of-the-road or average case, it ignores the huge influence that different forest owners and management approaches are having, which can carry a much bigger impact than increasing efficiencies in transportation or manufacturing processes, for example.



Timber produced in Northwest States by carbon sequestration

This graphic illustrates how much timber is produced from Northwestern States, binned by the "upstream" embodied carbon sequestration benefit (negative values) or carbon emissions burden (positive values) that timber carries. Supply from different types of owners is indicated with differently colored bars in each state. Prior to our investigation, all of this variability in observable carbon impacts from working forests has been treated as if it were exactly zero (i.e., that all working forests in North America are exactly carbon neutral).

KEY TAKEAWAYS

Stepping back for a broader view

Paying attention to **who is managing forests and where wood is coming from can advance decarbonization in the built environment, and have a major influence on the carbon footprint of individual projects**.

Although we did find that the upstream embodied carbon for logs coming out of Northwestern forests is centered around zero in every State, **the wood supply has a wide range of variation in every State and every owner type.**

The scale of this variation is often larger than all of the combined "downstream" emissions traditionally included in forest product Life Cycle Assessments. In other words, while the assumption of carbon neutrality does represent a middle-of-the-road or average, it ignores the huge influence that different forest owners and management approaches are having. These landscape-level decisions can carry a much bigger impact than increasing efficiencies in transportation or manufacturing processes, for example.

Rather than purchasing from suppliers with the lowest bid, **architects and builders who choose to buy wood that carries a larger embodied carbon benefit represents a tangible and significant opportunity to mitigate climate impacts and support the people and places producing climate-smarter wood.**

These data can help us understand the climatic consequences of management decisions by forest landowners and increase visibility for climate-smart forestry leaders, like many of our region's tribes, so that wood buyers in the marketplace can find and support them through their purchasing power.

Ecotrust

Ecotrust's mission is to inspire fresh thinking that creates economic opportunity, social equity, and environmental well-being. Our staff of 60+ scientists, storytellers, subject matter experts, and emerging leaders work in partnership from California to Alaska in pursuit of radical, practical change. Join us. *ecotrust.org*

GET IN TOUCH

David Diaz
Director of Forestry Analytics & Technology
ddiaz@ecotrust.org