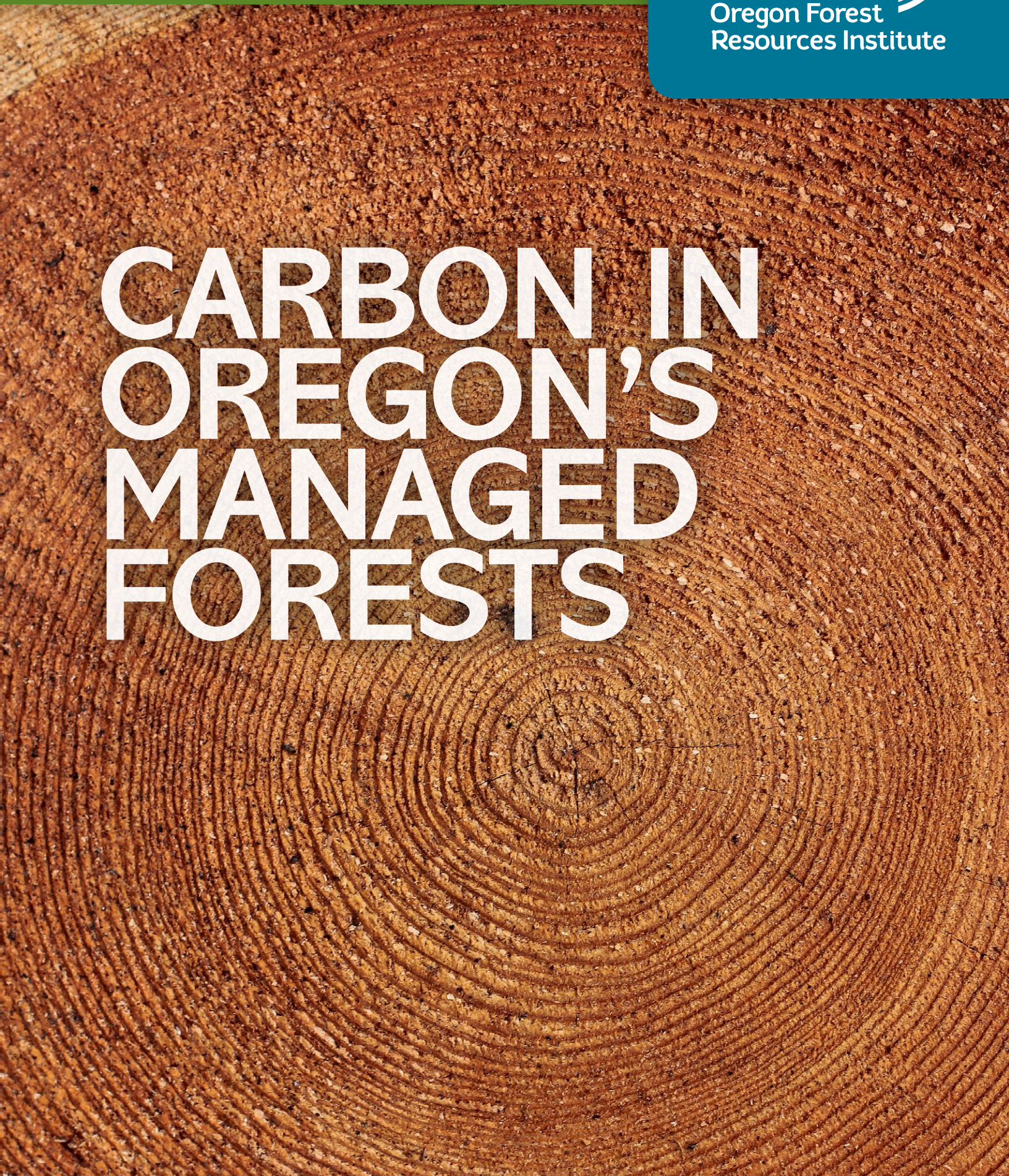
SUMMARY REPORT

Oregon Forest Resources Institute



CARBON IN OREGON'S MANAGED FORESTS

Carbon and FORESTS

WHAT ARE WORKING FORESTS?

Foresters often use the term "working forests" to refer to forests where the landowners or forest managers carefully balance sustainable timber production with protecting other resources – such as water quality and wildlife habitat. Oregon's working forests include private, state and certain federal lands.

The vast forests that cover nearly half of Oregon provide an array of social, environmental and economic benefits to the state and its residents. These benefits include providing clean air and water, wildlife habitat, recreation and timber to make wood products. Another important benefit of Oregon's forests is their ability to capture and store atmospheric carbon in growing trees as well as wood products.

By absorbing carbon dioxide, a greenhouse gas that's a major contributor to global warming, our forests are a key ally in the fight against climate change. During photosynthesis, trees turn carbon dioxide into solid carbon that's stored in the wood, and they release oxygen as a byproduct. As a result, Oregon's forests store significant amounts of carbon, sequestering it from the atmosphere. That carbon remains sequestered even after trees are harvested and made into wood products.

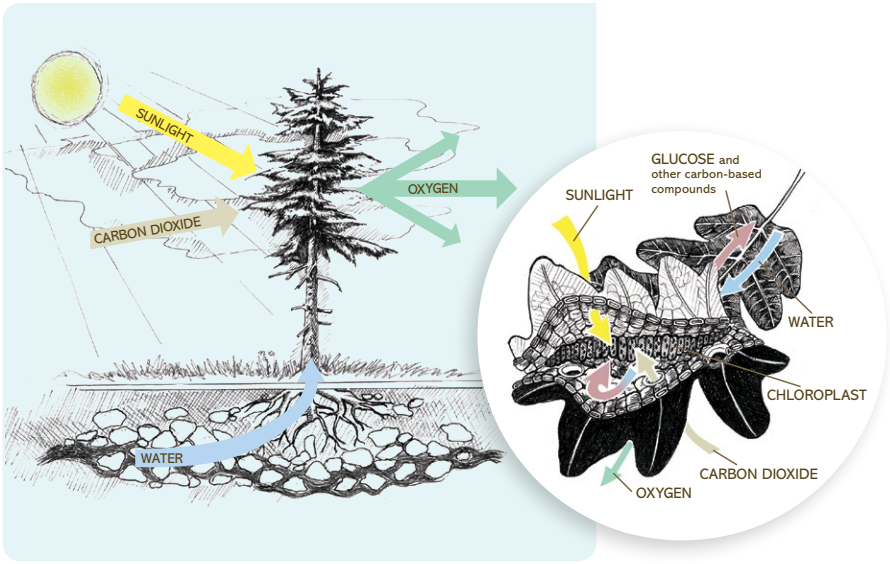
The *Carbon in Oregon's Managed Forests* report synthesizes the latest science on carbon sequestration and storage in Oregon's working forests, which are primarily managed for timber production, and the wood products they produce. This summary booklet provides an overview of the report, including highlights from chapters covering:

- the current status of carbon sequestration and storage in Oregon's forests
- managing forests to increase their carbon storage
- carbon and wood products
- potential carbon markets

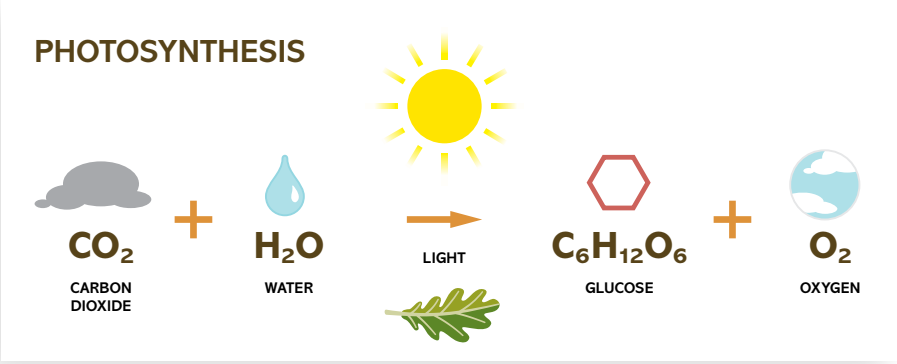
The report reveals the major role Oregon's working forests play in keeping carbon out of the atmosphere, underscoring the importance of using strategies that enhance these forests' carbon-sequestering superpowers to combat climate change.

WHY CARBON SEQUESTRATION AND STORAGE IN FORESTS AND FOREST PRODUCTS IS IMPORTANT

- **Climate change is happening.** The hottest years on record have been in the last decade. Unusual weather events such as hurricanes and drought are increasing. Ice caps in Greenland and Antarctica, as well as glaciers, are decreasing in size.
- **Climate change impacts forests.** Extensive research has shown that climate change is affecting forests. Major impacts include increased drought leading to reforestation challenges, longer wildfire seasons, and a long-term shift toward tree species that can tolerate warmer climates.
- **Forests sequester carbon.** Forests are one of the largest terrestrial stores of carbon, and Pacific Northwest forests are among the greatest sequesterers on Earth, due to their fast growth rates and the potential to produce large volumes of timber, some of which can be used to make long-lasting, carbon-storing wood products.
- **Wood products store carbon.** Half the dry weight of wood is carbon removed from the atmosphere by trees as they grow. This can remain locked away for decades in wood products, especially when used in home or other building construction. Wood also requires less energy to produce, and therefore results in fewer carbon dioxide emissions than other building materials.



Forest carbon sequestration starts with photosynthesis, the process plants use to take carbon dioxide out of the atmosphere. Chloroplasts inside leaves and needles use carbon dioxide from the air, water from the soil and energy from sunlight to produce glucose, a simple sugar. Trees use glucose to make wood, storing solid carbon in the process. Oxygen is released into the atmosphere as a byproduct.



This simplified chemical equation shows how carbon atoms from the carbon dioxide molecules are moved to glucose molecules through the process of photosynthesis.

ABOUT THE REPORT

The *Carbon in Oregon's Managed Forests* report was produced by the Oregon Forest Resources Institute (OFRI) to synthesize the current information on carbon sequestration and storage in Oregon's working forests and wood products. The report updates a similar report commissioned in 2006. Key points from the report are summarized on the following pages. To download the full report, go to **OregonForests.org/Carbon**.

THE AUTHORS

Carbon in Oregon's Managed Forests was prepared by:

Technical editors: Mike Cloughesy, Oregon Forest Resources Institute, and Edie Sonne Hall, Three Trees Consulting

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Carbon in OREGON'S FORESTS

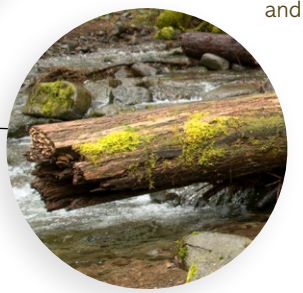
Through the process of photosynthesis, forests naturally sequester carbon dioxide from the atmosphere and store it as solid carbon. Stored carbon is found throughout the forest in carbon "pools." These include:

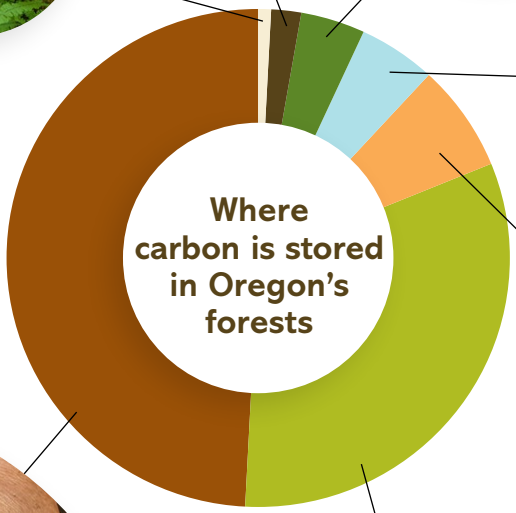
2% standing dead trees or **"snags"**

4%
litter on the forest floor
such as fallen leaves, needles and bark

1%
understory vegetation, including plant roots

5%
dead woody material
such as fallen branches and logs





The U.S. Forest Service's Forest Inventory and Analysis (FIA) Program estimates that just under half of Oregon's stored forest carbon is found belowground in soils, and about a third is found aboveground in live trees. The remaining carbon is distributed among roots, down wood, the forest floor, dead trees and understory vegetation.

7%
live and dead
tree roots

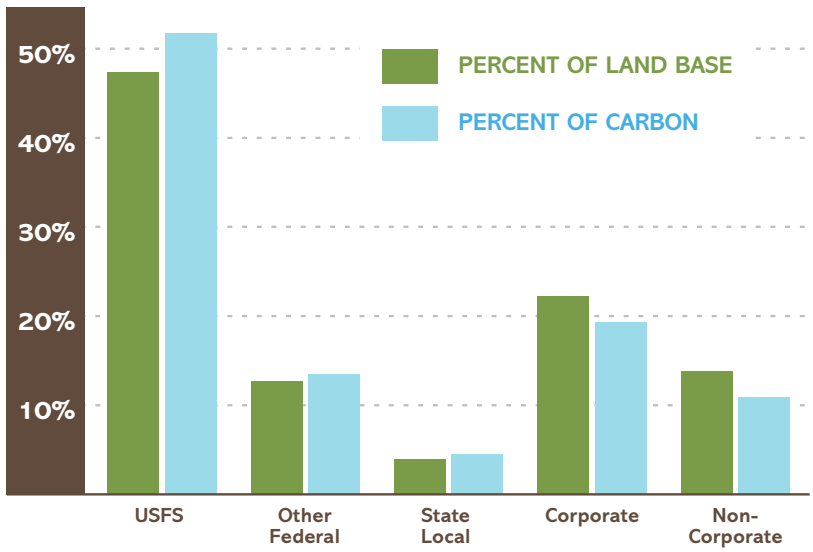
49%
soils

32%
live trees

With the help of measurements taken in the field, scientists can estimate the amount of carbon physically present in Oregon's forests by the pool where it's located, such as the amount of carbon stored in live trees. Total forest carbon is the sum of the carbon stored in all of a forest's carbon pools.

Carbon can move between various forest pools and eventually be released back into the atmosphere in a process known as "carbon flux." That means that although forests amass large quantities of carbon as trees grow, they don't store carbon indefinitely. When trees die and start to decay, for instance, they release carbon.

Percent of forest land base and forest carbon by ownership



HOW MUCH CARBON IS STORED IN OREGON'S FORESTS?

The most recent comprehensive analysis of how much carbon is stored in Oregon's forests was conducted by the U.S. Forest Service's Forest Inventory and Analysis (FIA) Program at the Pacific Northwest Research Station, in partnership with the Oregon Department of Forestry (ODF). It used field measurements taken between 2001 and 2016.

For the 10-year reporting cycle between 2007 and 2016, FIA estimates there were approximately 3.2 billion metric tons of carbon stored on both public and privately owned Oregon forestland in all carbon pools, including forest floor and soils, as shown in the graphic on the previous page.

HOW MUCH CARBON ARE OREGON'S FORESTS SEQUESTERING?

In addition to measuring the carbon stored in the various forest pools, the FIA-ODF carbon inventory for Oregon also estimated the flux, or change, in each of the pools. Flux in the positive direction is called sequestration, while a negative flux is called emissions. As shown in the chart (below), the estimated total net flux in Oregon is 30.9 million metric tons of carbon dioxide equivalent per year. This rate of forest carbon sequestration is the highest of the western states, and one of the highest in the country.

CARBON POOL	NET FLUX *million metric tons CO_2 equivalent*
Aboveground live	**31.6**
Aboveground dead	**-7.0**
Belowground live	**6.3**
Belowground dead	**-0.3**
VEGETATION NET FLUX	**30.5**
Forest floor	**0.6**
Soil organic C	**-0.2**
TOTAL FOREST NET FLUX	**30.9**

Scientists estimate carbon sequestration as carbon dioxide equivalents, in order to compare it with carbon dioxide emissions. One ton of carbon equals 3.667 tons of carbon dioxide. The U.S. Energy Information Administration estimates that in 2016 Oregon's carbon dioxide emissions from burning fossil fuels was 37.9 million metric tons. Thus, Oregon's forests sequestered more than 90% of the carbon that was emitted in the state from burning fossil fuels.

There is a close relationship between the proportion of Oregon forestland that falls under each type of ownership and how much carbon is stored there. For instance, the national forests, which are managed by the U.S. Forest Service and account for just under half of Oregon's forests, are storing slightly more than half of the state's forest carbon.

MAXIMIZING forests' carbon-storing POTENTIAL

Photosynthesis enables trees to sequester a significant amount of carbon from the atmosphere, storing between 450 and 650 metric tons of carbon in the earth's forests and between 1,500 and 2,500 metric tons in soils, respectively.

For this reason, scientists around the world have been studying the role forests can play in mitigating climate change. The Intergovernmental Panel on Climate Change, a United Nations body responsible for assessing international science related to climate change, has recognized the importance of using sustainable forest management practices that enhance forests' natural abilities to sequester carbon, as well as the increased use of wood products to help reduce carbon dioxide emissions.

Given the capacity of forests to capture and store carbon in the ecosystem and wood products, the timber industry is frequently discussed as a critical component of reducing atmospheric carbon. And Oregon – with its abundant, fast-growing forests and status as the top U.S. producer of softwood lumber and plywood – is well situated to contribute.

Oregon's managed forests already sequester and store significant amounts of carbon, but there are a number of ways they can further contribute to reducing atmospheric

The potential solutions – forest sector carbon cycle

There are many ways Oregon's forest sector, the part of the state economy that's derived from forests, can be part of the solution in the fight against climate change.

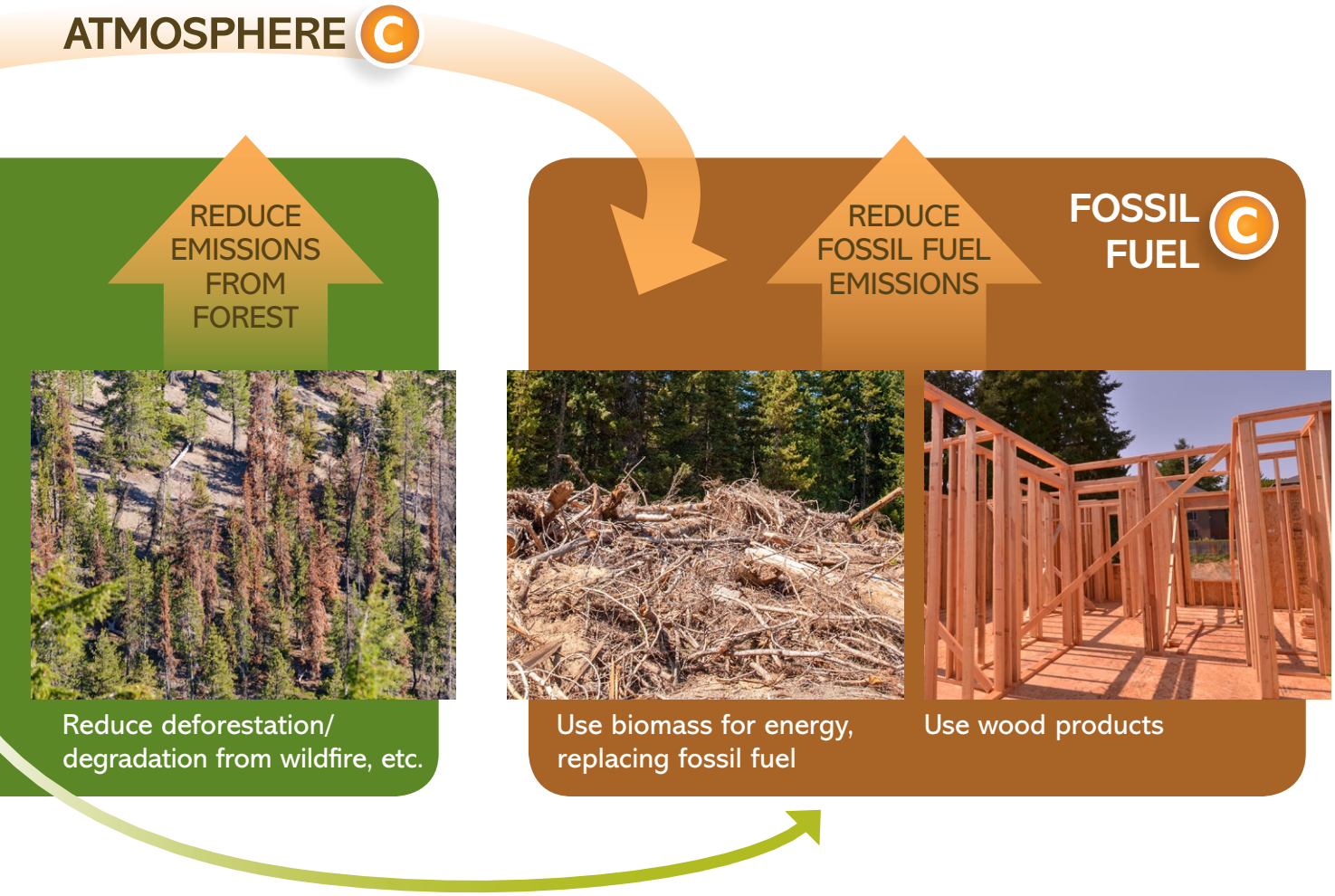
carbon. These include preventing the conversion of forestland to other uses, such as housing or other urban development, as well as decreasing the risk of high-severity wildfires and insect or disease outbreaks that can kill large numbers of trees.

Planting trees to create more forests would help take even more carbon dioxide out of the atmosphere. Active forest management aimed at improving a forest's overall health and productivity, as well as resilience to wildfires, can help it capture and store even more atmospheric carbon. Letting trees grow to their peak carbon storage age before harvest can also increase the carbon stored in existing forests and forest products, although there would be financial trade-offs with this strategy for landowners who primarily manage their forests for timber production.

ENHANCING FOREST CLIMATE MITIGATION

The United Nations' Intergovernmental Panel on Climate Change, and its Food and Agriculture Organization, make a number of recommendations based on the latest scientific research regarding ways forests can help us sequester more carbon and reduce carbon dioxide emissions. These include:

- Prevent deforestation by ensuring forests aren't converted to housing or other development.
- Manage forests to store more carbon long-term, by reducing their vulnerability to threats that can cause mass tree mortality and increase forest carbon dioxide emissions, such as drought, insects and wildfire.
- Expand forestland by returning deforested areas to forests.
- Enhance forest carbon sequestration through forest management while producing wood products that can be substituted for materials that require more energy and carbon dioxide emissions to produce, such as concrete and steel.
- Use mill waste and woody debris, also known as biomass, to produce renewable domestic energy.



The role of WOOD PRODUCTS in carbon storage

Half the dry weight of wood is carbon removed from the atmosphere by trees as they grow. That means using wood products in place of materials that don't store carbon and take more energy to produce can help combat climate change.

In fact, wood products derived from sustainably managed forests, where the amount of timber harvested doesn't exceed growth, can store more carbon in the final product for decades than was released when they were harvested and manufactured. Wood products that store carbon long-term include those used for home and other building construction, such as lumber and plywood, the two most commonly made wood products in Oregon.

In addition to the net 30.9 million metric tons of carbon dioxide equivalent sequestered in our state's forests each year, the *Carbon in Oregon's Managed Forests* report estimates that the lumber and plywood manufactured in Oregon each year contain an estimated 10.2 million metric tons of carbon dioxide equivalent. Another 8.4 million metric tons of carbon dioxide equivalent is stored each year in products such as particleboard and hardboard, which are made with the wood residuals left over after milling logs into lumber. The total carbon sequestered in Oregon by our forests and the wood products made here is estimated to be 49.5 million metric tons of carbon dioxide equivalent each year.

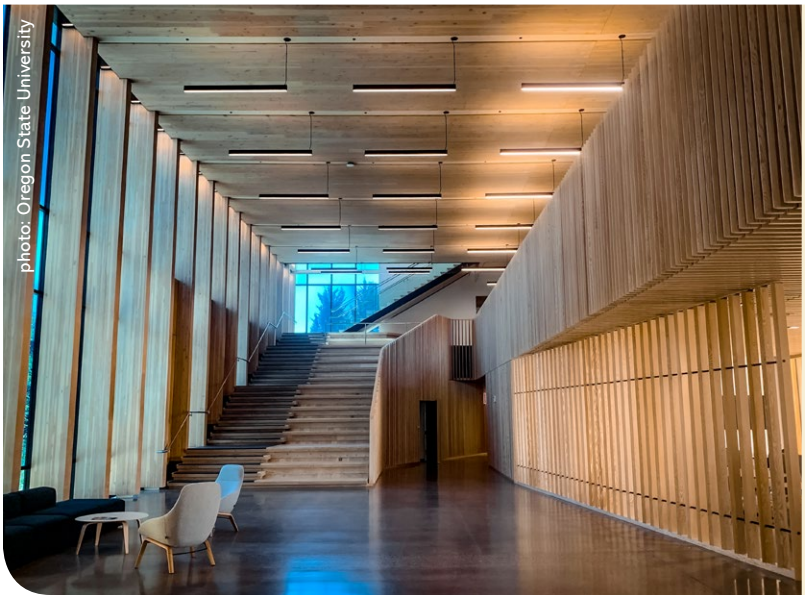
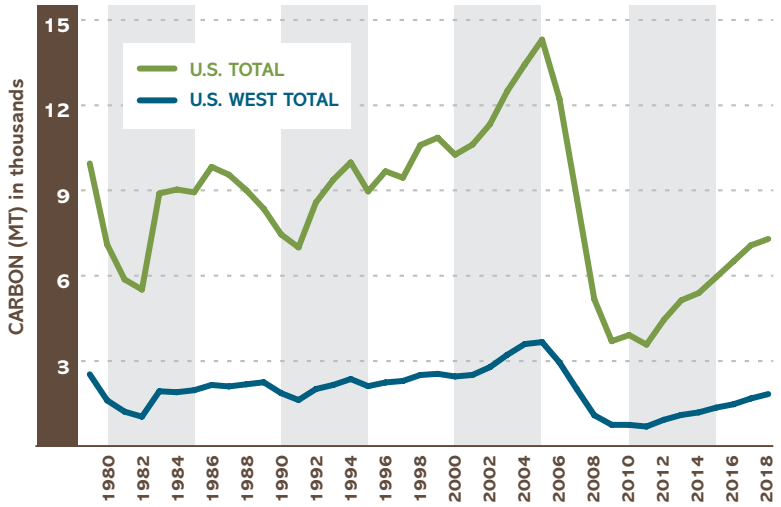


photo: Oregon State University

A SUSTAINABLE BUILDING MATERIAL

Wood performs well in life cycle assessments (LCAs), a method of tracking the overall environmental impact of a product, from the extraction of the raw materials used to make it through to the product's disposal. LCAs have shown that making wood products typically consumes far less water and requires far less energy, and therefore generates fewer carbon emissions, than producing other equivalent construction materials. For that reason, wood is increasingly being recognized as the material of choice for sustainable building projects. This includes constructing larger and taller buildings, such as Oregon State University's Peavy Hall (pictured at left), using engineered wood products in place of or in combination with concrete and steel.

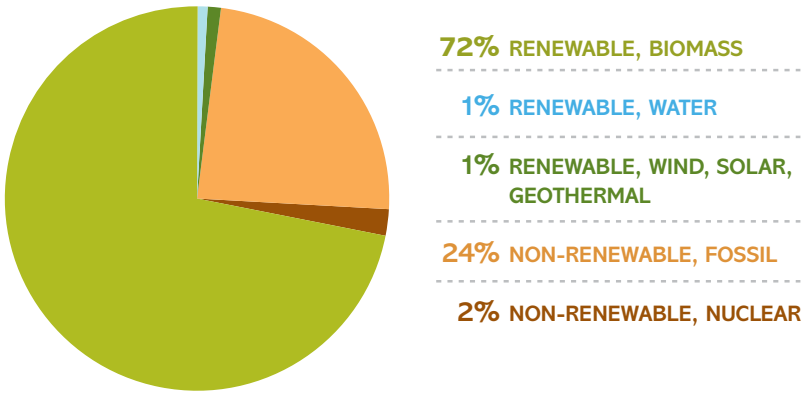
Annual new carbon storage for single-family housing stock



Source: U.S. Census 2019

Most single-family homes in the U.S. are built with wood. That means when housing construction is on the upswing, the total amount of carbon stored in residential structures also increases. The carbon storage associated with total single-family housing starts annually from 1979 to 2018 ranged from 3.6 to 14.6 million metric tons nationally.

Energy sources for softwood lumber production in the Pacific Northwest



One advantage of wood from a carbon emissions standpoint is that manufacturing wood products requires less energy from cradle to gate than other materials. For Pacific Northwest lumber mills, most of that energy comes from renewable sources, primarily from using wood residuals from the milling process to generate biomass energy.

photo: LEVER Architecture

Case study:

ALBINA YARD

The Albina Yard commercial office building in Portland is among a growing number of nonresidential structures in Oregon constructed using mass timber products such as cross-laminated timber (CLT). The four-story, 16,000-square-foot building, which was built in 2015 using CLT and glulam beams manufactured in Oregon, stores 80.5 metric tons of carbon, the equivalent of offsetting 295 metric tons of carbon dioxide emissions.

photo: Stacy McNeil, Green Diamond Resource Company

GREEN DIAMOND RESOURCE COMPANY
forestland near Klamath Falls is being managed for carbon sequestration and storage as part of a registered carbon offset project.

MARKETS
for forest carbon

Forests' vital role as a natural mechanism to remove and store carbon from the atmosphere makes them a crucial part of mitigating climate change. U.S. forests and associated wood products currently capture and store 16% of the country's annual carbon dioxide emissions from burning fossil fuels. Carbon markets that incentivize landowners to take steps through carbon offset projects that increase carbon storage on their forests – while providing a range of social and environmental co-benefits such as wildlife habitat – help take advantage of these forests' climate mitigation abilities.

Sustainably managing forests has been recognized as a relatively cost-effective strategy for offsetting greenhouse gas emissions. Nature-based solutions can help absorb about a third of the carbon pollution produced in the U.S., according to recent research led by The Nature Conservancy. These solutions include reforestation, practices that improve soil health, and forest carbon management.

U.S. forests have the potential to store even more carbon through enhanced forest management practices. America's private, family-owned forestlands offer some of the greatest opportunities to sequester and store more carbon. By managing just 20% of family-forest acres in the U.S. with practices that increase carbon sequestration by 2030, approximately 3.5 trillion metric tons of carbon dioxide could be sequestered by the end of the century.


photo: Justin Kostick, Green Diamond Resource Company

TYPES OF CARBON MARKETS

There are three types of carbon markets used across the U.S. to mitigate climate change:

Compliance carbon markets are marketplaces where regulated carbon emitters obtain and surrender emissions permits, or allowances, to meet predetermined regulatory greenhouse gas reduction targets. In the case of cap-and-trade programs, participants can trade allowances to make a profit from unused allowances or to meet regulatory requirements. In Oregon, the Confederated Tribes of Warm Springs and Green Diamond Resource Company both operate registered and approved forest carbon offset projects under California's cap-and-trade program.

Voluntary carbon marketplaces involve companies purchasing offsets with the intent to resell them or meet carbon-neutral or other environmental claims, or airlines using them under a United Nations-mandated program to offset carbon emissions from international flights. Voluntary offsets are primarily driven by private corporations seeking to achieve corporate social responsibility objectives. In Oregon, the city of Astoria operates a registered and approved voluntary forest carbon offset project within its watershed.

Incentive programs encourage forest landowners to manage their forests to enhance carbon sequestration and storage. These include programs run by the federal government's Natural Resources Conservation Service and a new program being developed by the American Forest Foundation and The Nature Conservancy. Called the Family Forest Carbon Program, it incentivizes landowners to adopt specific forest management practices that have been scientifically demonstrated to increase carbon sequestration, improve forest health and provide other important ecosystem benefits.

OREGON FOREST CARBON OFFSET PROJECTS

A number of public and private Oregon forest landowners already participate in forest carbon markets. Here are three examples of forest carbon offset projects in the state:

The **city of Astoria** has owned and managed its forested watershed since the 1950s, primarily to provide fresh drinking water to its residents and to generate timber harvest revenue that supports city services. In 2014 the city adopted a revised forest management plan for the watershed that began its commitment to sequester carbon beyond all legal and regulatory requirements, essentially trading off some timber revenue for carbon revenue. That same year, the city initiated a voluntary improved forest management plan under the American Carbon Registry. To date, the project has produced 260,000 carbon offsets that have been purchased by The Climate Trust.

Green Diamond Resource Company registered two California Air Resources Board improved forest management compliance projects in 2015, on about 575,000 acres of forestland near Klamath Falls that had been heavily logged by the previous owners. These projects represent a long-term commitment to improve forest health, increase productivity, and enhance resiliency to pest outbreaks and wildfires while storing greater amounts of carbon over the next 100 years. To date, nearly 1 million carbon offsets have been generated by these projects.

The **Confederated Tribes of Warm Springs** in central Oregon decided to pursue a forest carbon offset project on 24,000 acres of the 440,000-acre Warm Springs Reservation forest through California's cap-and-trade program in 2015. A small parcel burned during the initial stages of project development, reducing its size to 22,000 acres. To date, 2.7 million carbon offset credits have been issued to this project.

ABOUT THE OREGON FOREST RESOURCES INSTITUTE

The Oregon Legislature created the Oregon Forest Resources Institute (OFRI) in 1991 to advance public understanding of forests, forest management and forest products, and to encourage sound forestry through landowner education. A 13-member board of directors governs OFRI. It is funded by a portion of the forest products harvest tax.

Oregon Forest Resources Institute

OregonForests.org

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