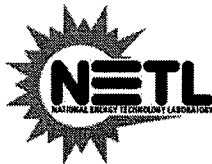


**BASELINE GREENHOUSE GAS  
EMISSIONS AND REMOVALS FOR FOREST  
AND AGRICULTURAL LANDS IN OREGON**

**PIER COLLABORATIVE REPORT**



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## Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (Energy Commission), conducts public interest research, development, and demonstration (RD&D) projects to benefit California's electricity and natural gas ratepayers. The PIER Program strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

In 2003, the California Energy Commission's Public Interest Energy Research (PIER) Program established the **California Climate Change Center** to document climate change research relevant to the states. This Center is a virtual organization with core research activities at Scripps Institution of Oceanography and the University of California, Berkeley, complemented by efforts at other research institutions. Priority research areas defined in PIER's five-year Climate Change Research Plan are: monitoring, analysis, and modeling of climate; analysis of options to reduce greenhouse gas emissions; assessment of physical impacts and of adaptation strategies; and analysis of the economic consequences of both climate change impacts and the efforts designed to reduce emissions.

**The California Climate Change Center Report Series** details ongoing Center-sponsored research. As interim project results, the information contained in these reports may change; authors should be contacted for the most recent project results. By providing ready access to this timely research, the Center seeks to inform the public and expand dissemination of climate change information; thereby leveraging collaborative efforts and increasing the benefits of this research to California's citizens, environment, and economy.

*Baseline Greenhouse Gas Emissions and Removals for Forest and Agricultural Lands in Oregon* is a final report for the West Coast Regional Carbon Sequestration Partnership project (contract number 500-02-004, work authorization 021), conducted by Winrock International. The information from this project contributes to PIER's Energy-Related Environmental Research Program.

For more information on the PIER Program, please visit the Energy Commission's website [www.energy.ca.gov/pier/](http://www.energy.ca.gov/pier/) or contact the Energy Commission at (916) 654-5164.

## Abstract

The project described in *Baseline Greenhouse Gas Emissions and Removals for Forest and Agricultural Lands in Oregon* sought to quantify the baseline of changes in carbon stocks on forest and agricultural lands in Oregon for the 1990s. These baselines provide an estimate of the emissions and removals of greenhouse gases attributable to changes in the use and management of land and are useful for identifying where major opportunities could exist in Oregon for enhancing carbon stocks and/or reducing carbon sources to potentially reduce greenhouse gas emissions.

The analysis revealed that forests were responsible for a net removal of carbon dioxide from the atmosphere of 27 million metric tons of carbon dioxide per year between 1987 and 2003, and that agricultural lands were responsible for a net emission of 0.06 million metric tons of carbon dioxide per year. On non-federal lands, emissions from forests caused by development were estimated at 1.4–1.5 million metric tons of carbon dioxide per year, and between 1990 and 1996 (excluding 1994) 0.81 million acres of forest and rangeland were burned by fires, with an estimated emission of 1.03 million metric tons of carbon dioxide per year. Nitrous oxide and methane emissions (in carbon dioxide equivalents) from agricultural lands are more than 100 times higher than carbon emissions attributable to land use change.

**Keywords:** Carbon sequestration, carbon storage, carbon dioxide, greenhouse gas, emissions, forest fire, agriculture, Oregon, WESTCARB, Regional Carbon Sequestration Partnership

# Executive Summary

## Introduction

This study is one of a series of carbon sequestration research projects conducted by the West Coast Regional Carbon Sequestration Partnership (WESTCARB), which is managed and co-funded by the California Energy Commission.

## Purpose

The purpose of this WESTCARB project was to derive a carbon sequestration baseline for Oregon's forest and agricultural lands.

## Project Objective

This project sought to establish baseline carbon stocks and changes in stocks for the forest and agricultural sectors in Oregon during the most recent 10-year period for which data are available (generally the decade of the 1990s). Such baselines can assist in identifying opportunities where carbon removals (sequestration) in each sector might be increased, or carbon emissions decreased, through changes in land use and management.

## Project Outcomes

### Baseline for Forest Lands

The forest baseline is separated into three components: a general forests baseline, a baseline effect of development, and a baseline effect from fire. The general forests baseline is presented at the state level for all forest lands, based on U.S. Department of Agriculture (USDA) Forest Service data, detailing change in forest area and change in carbon stocks, but with no attribution to the causes for the change. Using additional databases, the specific cases of emissions associated with development and emissions associated with fire are further examined.

#### *General Forestlands Baseline*

Between 1987 and 2003 there was an estimated increase in forest area in Oregon of 2.1 million acres (ac) (850,000 hectares, ha), or 94,000 ac per year (ac/yr) (38,000 ha/yr) between 1987 and 1997, and 175,000 ac/yr (71,000 ha/yr) between 1997 and 2003.

This increase is equivalent to an estimated increase of 431 million metric tons carbon dioxide (CO<sub>2</sub>) equivalent between 1987 and 2003, or 23.0 million metric tons CO<sub>2</sub> equivalent per year between 1987 and 1997, and 34.4 million metric tons CO<sub>2</sub> equivalent per year between 1997 and 2003.

The total emissions for Oregon (excluding forests) for 2000 were estimated as 67.7 million metric tons CO<sub>2</sub> equivalent (from the Governor's Advisory Group on Global Warming). Forest sinks, therefore, potentially can offset as much as 50 percent of the state's emissions.

#### *Baseline Effect of Development on Forest Lands*

The baseline for emissions from development on non-federal lands was estimated using land use data from the National Resources Inventory of the USDA and carbon data derived from the USDA Forest Service's Forest Inventory and Analysis Database, for the period 1987 to 1997. Because of data limitations the analysis is limited to non-federal lands and to the gross CO<sub>2</sub> emissions from above-ground live tree biomass on conversion of non-federal forestland to developed land uses. Because the focus is on non-federal lands, the analyses should only be used to explore decisions on private lands.

Between 1987 and 1997, 69,000 ac (28,000 ha) of non-federal forest were converted to development. This is equal to 6,900 ac per year. Large losses were concentrated in the coastal regions. For gross carbon emissions, two scenarios were considered. Under Scenario 1 all tree biomass in the converted area was immediately emitted as carbon dioxide. Under Scenario 2 for developed areas of less than 10 ac (4 ha), it was assumed that 50 percent of the carbon was retained in the form of residual trees.

Under Scenario 1 an estimated 15.4 million metric tons CO<sub>2</sub> equivalent were emitted due to development, or 1.54 million metric tons CO<sub>2</sub> equivalent per year. Under Scenario 2, 13.9 million metric tons CO<sub>2</sub> equivalent were emitted, or 1.39 million metric tons CO<sub>2</sub> equivalent per year. Development was concentrated in the northwest region of the state where the major city of Portland is located. In this region 56 percent of the emissions under Scenario 1 or 58 percent of the emissions under Scenario 2 occurred, although the region represents only 9 percent of the state's area.

The emissions from development on non-federal lands of 1.39–1.54 million metric tons CO<sub>2</sub> equivalent per year represent about 2.3 percent of the total gross emissions for the state of 63 million metric tons carbon dioxide equivalent per year in 1995 (from Governor's Advisory Group on Global Warming). Oregon's forests have a net sequestration of 22 million metric tons CO<sub>2</sub> equivalent per year between 1987 and 1997, after accounting for the emissions from development of about 1.4 million metric tons CO<sub>2</sub> equivalent per year.

#### *Baseline Effect of Fire on Forest Lands*

The emissions from fire were examined through overlaying the wildfire database for Oregon on the National Oceanic and Atmospheric Administration (NOAA) Advanced Very High Resolution Radiometer satellite imagery showing change in normalized differential vegetation index. (The normalized differential vegetation index measures "greenness" of landscapes; greenness decreases immediately after fire). This process determined the location, size, and intensity of fires between 1990 and 1996 (although 1994 was excluded due to poor image quality). Carbon values were applied to these fires using data from the Forest Inventory and Analysis Database and proportional emissions from the detailed baseline fire analysis for

Northern California. The analysis considered all forests and rangelands in Arizona, federal and non-federal.

Across the six years analyzed, fires with a total area of 328,000 ha (0.81 million ac) were recorded. This is equivalent to an average 54,700 ha per year (135,100 ac/yr) for the period studied. Emissions totaling 25.0 million metric tons CO<sub>2</sub> equivalent were estimated to have occurred from fire during the six-year period. On an average annual basis this is equal to 1.03 million metric tons CO<sub>2</sub> equivalent per year.

Forty-eight percent of the burned area and 83 percent of the emissions were in forest rather than rangeland. Fire incidence varied by year, with high emissions in 1996 and low emissions in 1993 and 1995. Seventy-nine percent of area burned, and 83 percent of the emissions were from federally owned land; 18 percent of the area burned and 13 percent of the emissions were from private land. Emissions from fire occurred throughout the state but were markedly lower in the northwest.

The emissions from fire of 1.03 million metric tons CO<sub>2</sub> equivalent per year during the six-year period represented about 1.6 percent of the total gross emissions for the state of 63 million metric tons CO<sub>2</sub> equivalent per year in 1995, according to the Governor's Advisory Group on Global Warming.

### **Baseline for Agricultural Lands**

Agricultural land area in Oregon amounts to about 6 percent of the total land area. The state lost agricultural land area from 1987–1997 through conversion to other land uses, in particular to urban development/transportation and from retiring agricultural land from cultivation. In some counties, the area of woody cropland actually increased, but these increases were more than offset by decreases in non-woody cropland. Accompanying these losses in area were losses in standing carbon stocks on agricultural land, so that conversion of agricultural land to other uses was responsible for a net annual source (emission) of CO<sub>2</sub> to the atmosphere. Losses of agricultural carbon stocks over the 1987–1997 period were estimated at 160,000 tons. The estimated net annual source from Oregon agricultural lands was 0.06 million metric tons CO<sub>2</sub> equivalent.

Emissions of CO<sub>2</sub> from agricultural land conversion, while the primary focus of this report, represent only a portion of the total greenhouse gas emissions attributable to the agricultural sector. The primary non-CO<sub>2</sub> greenhouse gases associated with agricultural activities are nitrous oxide (N<sub>2</sub>O) and methane (CH<sub>4</sub>). Nitrous oxide is emitted from agricultural soils, especially after fertilizer application, and has approximately 296 times the global warming potential of CO<sub>2</sub>. Methane is emitted by livestock and through manure management, and has approximately 23 times the global warming potential of CO<sub>2</sub>. Examination of data from Oregon indicated that greenhouse gas emissions from N<sub>2</sub>O and CH<sub>4</sub> in the agricultural sector dwarf the annual CO<sub>2</sub> source from agricultural land conversion: CO<sub>2</sub> emissions from land conversion represented about 1 percent of the total CO<sub>2</sub> and non-CO<sub>2</sub> greenhouse gas emissions attributable to the agricultural sector.

## Conclusions

### General Forests Baseline

- An estimated 383,000 ha (946,000 ac) of forest were gained on federal and non-federal lands in Oregon between 1987 and 1997 at a rate of 38,326 ha/yr (94,704 ha/yr). These gains are equivalent to 0.33 percent of the forest area per year between 1987 and 1997 and 0.59 percent of the forest area per year between 1997 and 2003.
- A gross sequestration of an estimated 229.9 million metric tons CO<sub>2</sub> equivalent (23 million metric tons CO<sub>2</sub> equivalent per year) occurred between 1987 and 1997, and 204.6 million metric tons CO<sub>2</sub> equivalent (34 million metric tons CO<sub>2</sub> equivalent per year) occurred between 1997 and 2003.
- The emissions for Oregon (excluding forests) for 2000 were estimated as 67.7 million metric tons CO<sub>2</sub> equivalent. Sinks, therefore, potentially can offset as much as 50 percent of the state's emissions.
- For just non-federal forested lands, there is a net loss of 5,000 ha (12,000 ac).

### Development Baseline

- An estimated 28,000 ha (69,000 ac) were lost to development in Oregon State between 1987 and 1997 at a rate of 2,788 ha (6,889 ac) per year. This forest loss is equivalent to a gross emission of between 13.9 and 15.4 million metric tons CO<sub>2</sub> equivalent, or 1.39 to 1.54 million metric tons CO<sub>2</sub> equivalent per year.
- The emissions were concentrated in the coastal region and in particular in the Northwest—the region in which Portland is located.
- These emissions compare with the estimated gross sequestration from forests in Oregon of 23 million metric tons CO<sub>2</sub> equivalent per year between 1987 and 1997 and gross emissions for the state of 63 million metric tons CO<sub>2</sub> equivalent per year in 1995. Emissions from deforestation therefore offset between 6 percent and 7 percent of the forest sequestration and represent between 2.2 percent and 2.4 percent of the total emissions in the state.

### Fire Baseline

- Across the six years analyzed, researchers recorded fires with a total area of 328,000 ha (0.81 million ac)—equivalent to an average 54,700 ha per year (135,100 ac/yr). Emissions totaling 6.8 million tons of carbon, or 25.0 million metric tons CO<sub>2</sub> equivalent, were estimated to have occurred from fire during that period. Averaged annually, this is equal to 0.28 million tons of carbon per year (1.03 million metric tons CO<sub>2</sub> equivalent per year).
- Forty-eight percent of the burnt area and 83 percent of the emissions were in forest as opposed to rangeland. Fire incidence varied by year, with high emissions in 1996 and low emissions in 1993 and 1995.

- The emissions from fire of 1.03 million metric tons CO<sub>2</sub> equivalent per year during the six-year period represented about 1.6 percent of the total gross emissions for the state of 63 million metric tons CO<sub>2</sub> equivalent year in 1995.

#### Agricultural Baseline

- In 1997, agricultural land represented 5.9 percent of the total land area. Non-woody crops were about 96 percent of all agricultural land. Woody crops are concentrated primarily west of the Cascades, but in most counties constitute less than 2 percent of the total land area, while non-woody crops are concentrated primarily in the northern counties along the Columbia River and constitute up to 24 percent of the land area.
- Statewide, there was a loss of agricultural land of 4.8 percent between 1987 and 1997, coming in approximately equal proportions from conversion of woody and non-woody cropland.
- Total carbon stocks in all agricultural land in Oregon were estimated at 3.2 million tons. Between 1987 and 1997, there was a total loss of about 160,000 tons of carbon, or 4.8 percent of the carbon stored in agricultural lands in 1987.
- Non-CO<sub>2</sub> greenhouse gas emissions from N<sub>2</sub>O (emitted from agricultural soils after fertilizer application) dwarf the annual CO<sub>2</sub> source from agricultural land conversion in Oregon.