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CARBON SEQUESTRATION THROUGH CHANGES IN LAND USE IN OREGON: COSTS AND OPPORTUNITIES

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Prepared By:
Aaron Dushku, Sandra Brown, Silvia Petrova, Timothy Pearson, Nick Martin, Jonathan Winsten, and John Kadyszewski

Winrock International
Ecosystem Services Unit
1621 N. Kent St, Suite 1200
Arlington, VA 22209

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Prepared For:
Public Interest Energy Research (PIER) Program
California Energy Commission

Guido Franco
Project Manager

Beth Chambers
Contract Manager

Kelly Birkinshaw
Program Area Lead
Energy-Related Environmental Research

Laurie ten Hope
Office Manager
Energy Systems Research

Martha Krebs
Deputy Director
ENERGY RESEARCH & DEVELOPMENT DIVISION

B. B. Blevins
Executive Director

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1. Sohngen, B., J. Cathcart, and T. Ifie. 2005. *Baselines, Carbon Supply Curves, and Pilot Actions for Terrestrial Carbon Sequestration in Oregon.* Report to Winrock International.

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.

Carbon Sequestration Through Changes in Land Use in Oregon: Costs and Opportunities is a final report for the West Coast Regional Carbon Sequestration Project (contract 500-02-004, work authorization number MR-021), conducted in part 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/ or contract the Energy Commission at (916) 654-5164.

Abstract

This report estimates the carbon sequestration potential from several land use activities in Oregon: afforestation of rangelands; afforestation of croplands; changes in forest management, including extending timber harvest rotations and widening riparian buffers; and hazardous fuel reduction to reduce emissions from wildfire in fire-prone forest ecosystems. For each activity, methods and results are presented for estimating the total quantity of carbon that could be sequestered, followed by an economic analysis summarizing the total costs of converting crop- or rangelands or changing forest management to sequester carbon. Carbon supply curves illustrate the total area of land that would be converted or put under different management, and total quantity of carbon thus sequestered, at different assumed prices of carbon credits. The report concludes with a summary of next steps and further refinements for the second phase of the West Coast Regional Carbon Sequestration Partnership project.

Keywords: Carbon sequestration, afforestation, reforestation, forest management, hazardous fuel reduction, CSCH, cut-skid-chip-haul, WESTCARB

Executive Summary

Introduction

In the search for effective ways to sequester the carbon dioxide gases that contribute to global climate change, several studies have estimated the potential of various regions of the United States for terrestrial carbon storage—that is, carbon fixation in plant matter. These studies were based on biological and technical criteria coupled with coarse-scale consideration of the economic costs associated with changing land management practices. Recent work by Winrock International for California—and for all states in the U.S. Department of Energy's Southeast Regional Carbon Sequestration Partnership—has focused on (1) adding more detailed analysis of opportunities on both agricultural and forest lands; (2) biological rates of carbon sequestration, taking into consideration variations in site conditions across the landscape; and (3) more detailed analysis of all costs. By considering the varying carbon sequestration potential of different land classes and other economic factors, more realistic estimates of carbon storage potential and associated costs can be obtained. Realistic, finer-scale assessments—estimating the quantity of carbon credits that might be available at different price points for different classes of land use activities—are vital to helping policy makers and the private sector prepare for an uncertain regulatory future.

Purpose

This study is part of a larger project conducted by the West Coast Regional Carbon Sequestration Partnership (WESTCARB): "Baselines, Carbon Supply Curves, and Pilot Actions for Terrestrial Carbon Sequestration." The broad purpose of the WESTCARB effort is to (1) quantify terrestrial carbon sequestration opportunities across the West Coast Partnership region (Arizona, California, Oregon, and Washington) and (2) estimate the carbon credits that might be available at different price points. Focusing on the state of Oregon, the present study estimates the potential carbon supply from afforestation of rangelands and croplands and from changes in forest management.

Project Objectives

Using methods developed by Winrock International in previous research, this study developed carbon supply curves for potential land-use and forest management activities in Oregon. Specific objectives were to:

- Estimate carbon supply for different types of potential terrestrial project activities, including afforestation of cropland, afforestation of rangeland, and changes in forest management.
- Assess the potential for hazardous fuel removal from forests with high fuel loads as a carbon sequestration activity. By preventing catastrophic, high-intensity fires, hazardous fuel removal could potentially reduce carbon emissions.

Undeveloped land in Oregon is classified into three main groups: forests, rangelands, and agricultural lands. Forests (about 26.1 million acres or 10.6 million hectares) include conifers,

hardwoods, and mixed classes; rangelands (about 27 million acres or 10.9 million ha) include a variety of non-woody and woody ecosystems; and agricultural lands (about 6.4 million acres or 2.6 million ha) include a wide range of non-woody crops such as wheat and hay and woody crops such as vineyards and orchards. Given the economic value of various crops, the analysis considered only those agricultural lands growing wheat and hay.

For rangelands and croplands (growing wheat and hay), the potential carbon sequestration yield was estimated for afforestation projects using native species with no subsequent harvesting—that is, for forest restoration. Historical evidence suggests that, in many areas, large tracts of forest may have once stood on present-day grazing and agricultural lands. The general approach was to identify and locate existing rangelands and croplands where biophysical conditions could favor forests, estimate rates of carbon accumulation for the forest types projected to grow in those locations, and assign monetary values to each contributing cost factor. The carbon supply was estimated for three time durations—20 years, 40 years, and 80 years of forest growth—to reflect the impact of activity duration on the likely carbon supply and to provide an assessment for both near-term and longer-term planning horizons.

Carbon sequestration options for forestlands focused on three alternative activities for 20-year and/or permanent contract periods: (1) allowing timber to age past economic maturity (lengthening rotation time); (2) increasing the riparian buffer zone by an additional 200 feet (61 meters); and (3) removing hazardous fuels in order to decrease the incidence of catastrophic forest fires (which would emit large quantities of greenhouse gases) and subsequently burning the removed fuels in biomass power plants.

Cost estimates for the first two options—allowing timber to age and enhancing riparian zone management—were based on specific counties for public and private landowners, and then extrapolated to all counties throughout the state. For the hazardous fuel reduction alternative, the analysis used a "Suitability for Potential Fuel Reduction" (SPFR) score on forest landscapes with the potential for significant carbon loss from moderate- to high-intensity wildfires. The SPFR scores were created in a geographic information system using slope, distance to biomass plants, and distance from roads as equally weighted factors in the decision-making process.

Project Outcomes

This report presents land use activity costs and potential carbon sequestered in terms of metric tons (t = tonnes) of carbon dioxide (CO_2) and carbon (C).

Afforestation of Rangelands and Croplands
Table ES-1 summarizes the amount of carbon and the area available for afforestation of rangelands and croplands at three commonly used price points:

- ≤ \$2.40/t CO_2 (\$8.81/t C)
- ≤ \$10.00/t CO_2 (\$36.67/t C)
- ≤ \$20.00/t CO_2 (\$73.33/t C)

As shown in Table ES-1, at a price of ≤ $2.40/t CO_2, no net carbon could be sequestered after 20 years by afforesting rangelands or croplands, but after 80 years about 732 MMT CO_2 could be sequestered on rangelands. If prices per t CO_2 rose to $20, it would be possible to convert more productive rangelands and croplands with higher opportunity costs, and thereby sequester almost 280 MMT CO_2 in just 20 years. The total amount rises sharply to more than 1,813 MMT CO_2 at 40 years and approximately 4,203 MMT CO_2 at 80 years. Converting this total amount at 40 years to an approximate annual rate results in about 45 MMT CO_2/yr.

Table ES-1. Carbon supply (million metric tons CO_2) and area (million acres) available at selected price points ($/tonne CO_2) for afforestation on existing rangelands and croplands of Oregon over 20-year, 40-year, and 80-year durations

	Quantity of Carbon (MMT CO_2)			Area Available (million acres)*		
Activity	20 years	40 years	80 years	20 years	40 years	80 years
Rangeland Afforestation						
≤$2.40	0.0	0.489	732.2	0.0	0.001	1.4
≤$10.00	0.195	337.3	2,156	0.001	1.42	12.3
≤$20.00	117.7	1,336	2,827	1.40	15.6	19.1
Cropland Afforestation						
≤$2.40	0.0	0.0	0.0	0.0	0.0	0.0
≤$10.00	0.279	457.2	997.9	0.002	1.91	1.93
≤$20.00	162.0	477.2	1,376	1.91	2.15	5.06

* To convert to million hectares, multiply by 0.4047.

Changes in Forest Management

Although Oregon has substantial forest area, the cost of carbon sequestration from changing forest management practices is relatively high and the quantity of carbon that could be sequestered is relatively small. If all of the private and nonfederal public land nearing the economically optimal rotation period (790,000 acres or 319,700 ha) were contracted to increase rotation ages up to 15 years, 35.6 MMT CO_2 could be sequestered for an average cost of $37/t CO_2.

Extending Timber Harvest Rotations

The potential area of mature forests where the riparian buffer zone could be increased by an additional 200 feet was estimated at 20,700 acres (8,375 ha). The additional carbon that could be stored on these lands if the forests were conserved is 1.25 MMT CO_2 at an average cost of $40/t CO_2.

Hazardous Fuel Reduction

The area of Oregon forests with historically low- and mixed-severity fire regimes, yet mapped today as containing high quantities of hazardous fuel, is estimated to be 10.3 million acres (4.17 million ha). A commonly used potential hazardous fuels treatment is Cut-Skid-Chip-Haul

(CSCH), a treatment in which hazardous fuel is harvested in the woods, bunched and skidded to a landing, chipped into a chip van, and hauled to a biomass energy facility for electricity and/or heat generation. The area of forestlands with historically low- and mixed-severity fire regimes in the state to which this treatment could be applied is approximately 2.9 million acres (1.17 million ha).

Two removal scenarios were analyzed: hazardous fuel removal of 4 bone dry tons (BDT) per acre on these lands would yield 12 million BDT biomass fuel for use in energy facilities, while removal of 8 BDT per acre would yield 23 million BDT. Total costs and potential revenue from these removals were estimated.

During moderate to intense fires, 10 to 70 percent of the biomass stock burns and is emitted as CO_2.
A preliminary analysis suggests that, considering the differences in CO_2 emissions between high-, medium- and low-intensity fires, HFR treatments that reduce fire intensity would avoid sufficient emissions to be able to cover—at commonly used prices of \$2.40/t CO_2 and \$10/t CO_2—the subsidies needed to pay for CSCH. This result supports the argument for qualifying hazardous fuel reduction as a carbon offset project.

Conclusions

The key conclusions from this work are:

- The largest terrestrial sequestration opportunity, both in terms of absolute quantity and costs, is afforestation of rangelands.
- Changing forest management by lengthening rotation age beyond the economical rotation period has limited potential both in terms of quantity and costs.
- Forest fire appears to be the most important management issue to address, and hazardous fuel removal has the potential to avoid substantial carbon dioxide emissions.
- Forest conservation, such as extending riparian buffers, is limited in scope and tends to be expensive.

Recommendations

Further characterization work is needed to refine these analyses and to evaluate additional carbon sequestration opportunities for the state and region. It is recommended that further work focus on two areas: afforestation using native or fast-growing species such as hybrid poplar for timber production or biomass energy; and refinements to the analysis of hazardous fuel reduction in wildfire-prone forests.

Afforestation for Harvest
The present study considered only forest restoration with native species. The economics and carbon supply would differ for afforestation projects that plant trees for timber and non-timber products using both native and fast-growing species. Further investigation is needed to determine how the associated changes in carbon sequestration rates for different species and changes in project economics would affect the total carbon supply across the region.

Hazardous Fuel Reduction

Recommended next steps include (1) analysis of other fuel removal treatments (besides CSCH) and how the constraints on each treatment affect the amount of forestland that could be treated, and (2) development of baselines for various wildfire-prone forest types. Such baselines should include field data and models to quantify the likelihood of fires occurring (the fire return interval) as well as the effects of different intensities of fire on greenhouse gas emissions (how much of the forest's carbon stock in different pools is emitted under different fire intensities and stand structures). More detailed economic analysis is also needed to determine if fuel removal produces sufficient emission reductions to pay for currently uneconomic treatments.