Modeling Above-Ground Carbon Dynamics Under Different Silvicultural Treatments on the McDonald-Dunn Research Forest

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Introduction

Due to increasing awareness and concern about the impacts of climate change, there has been a growing emphasis on forest carbon as a potential solution for mitigating greenhouse gas emissions. This study compares the different suites of management decisions and identifies practical combinations of rotation ages and thinning applications that will optimize carbon sequestration while meeting other objectives over a 240-year projection timeframe. This study took place in the McDonald–Dunn Forest, part of the Oregon State University Research Forests, which encompasses approximately 11,250 acres of forested lands within the eastern foothills of the Oregon Coast Range.

Study Overview

The primary goal of this project was to compare the efficacy of different forest management techniques in relation to maximizing forest carbon. Assessments were conducted using modeling software to project long-term changes in forest carbon storage under different management trajectories. The objective was to find a suite of treatment options that maximized carbon storage for multiple rotation ages. The relative performance of treatments was assessed within individual site classes: I, II, III, and IV.

A total of 311 stands with four different productivity levels — high (site class I), medium high (II), medium low (III) and low (IV) — were inventoried in 2019 and 2020. The researchers examined the effects of thinning intensity, frequency, and timing of thinning treatments on above-ground live carbon sequestration. All thinning treatments were specified as "thinning from below." Thinning from below targets the removal of smaller, suppressed trees in the lower canopy. This can increase growth rates by alleviating the competition for resources and space. In terms of effects on stand carbon, thinning from below is thought to increase above-ground carbon stocks because it retains the larger, more vigorous trees and allows them to accumulate biomass faster in the future.

In addition to exploring various thinning intensities, frequencies, and timings, they incorporated different rotation ages (40, 60, 80, and 120 years) into the experiment. These rotation ages were selected based on specific management objectives for the McDonald–Dunn Research Forest, including timber production (40-year rotation), ecological forestry (60- and 80-year rotations), and ultra-long rotation (120-year rotation).

The researchers used the Forest Vegetation Simulator (FVS), a powerful tool for evaluating the impacts of different management options on forest growth and yield. This tool is widely used in forest management and planning in the United States and Canada. Quantity and species composition of natural regeneration were determined from the McDonald–Dunn inventory data. Each simulation was set to span from an initial clearcut in 2023 to the year 2263, covering 240 years. This enabled comparisons between various rotation ages, ranging from two 120-year rotations to six 40-year rotations, four 60-year rotations to three 80-year rotations, and so on. The total gross sequestration in each scenario was determined by aggregating the harvested above-ground live carbon per hectare and the carbon contained in trees that died over the 240-year projection period at ten-year growth cycles.

Findings

The timing, intensity, and frequency of thinning treatments applied heavily influenced the optimal scenario for total above-ground live carbon sequestration. The researchers found that as productivity increased, the rotation length associated with the highest carbon sequestration estimate decreased. This can be attributed to patterns in tree growth rates, as annual increments follow a peaking model over tree size or age, which is skewed towards larger sizes or older ages. However, 40-year rotations sequestered the least amount of carbon over the projection period.

The analysis revealed several trends regarding the optimal thinning intensity for each rotation age and site class:

1. With decreasing site productivity, the advantages of incorporating one or more moderate-intensity treatments became more pronounced.

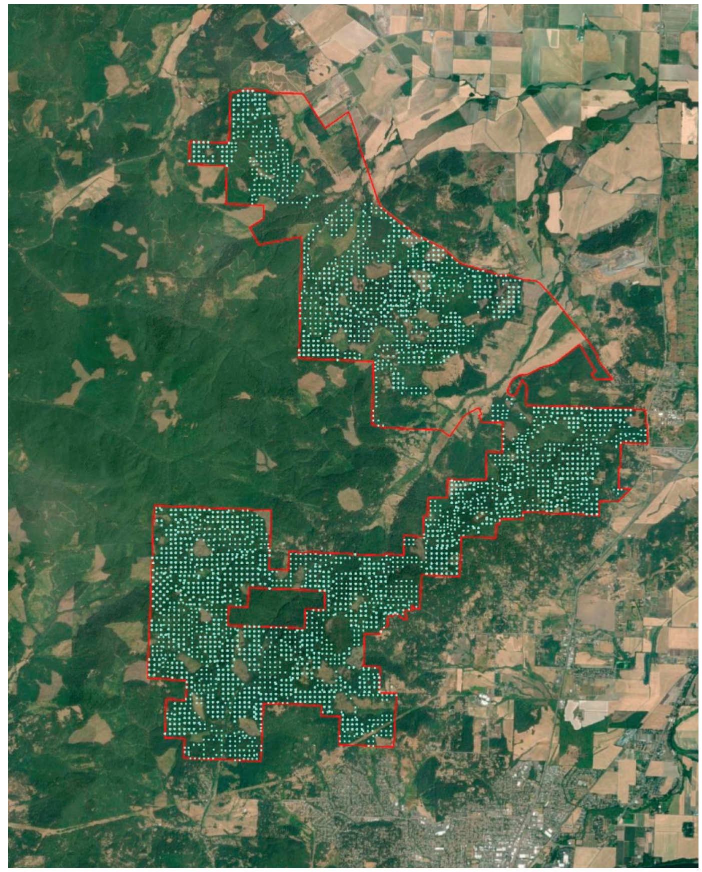
2. Moderate-intensity treatments were particularly advantageous in longer rotations compared to shorter rotations, especially for stands with lower productivity.

3. High-intensity thinning was found to negatively impact total sequestration over the projection period when compared to scenarios that included low-, moderate-, or a combination of low- and moderate-intensity treatments within the rotations.

The results suggest that 80-year rotations warrant two iterations of thinning because the extended rotation length allows for increased accumulation of understory hardwood vegetation. Therefore, more removals are necessary to optimize conifer growth, allowing maximum sequestration potential. In 120-year rotations, the ideal frequency of thinning treatments varied among different productivity levels.

Impact

This information will be important for land managers in balancing timber harvesting and other objectives with forest carbon goals.



Aerial imagery of the McDonald–Dunn Research Forest displaying the forest boundary (indicated with red boundary line) and location of plots measured across 2019 and 2020.

Publications/References

Full paper: https://www.mdpi.com/1999-4907/14/10/2090

OSU Press Release: https://today.oregonstate.edu/news/forest-modeling-shows-which-harvest-rotations-lead-maximum-carbon-sequestration

OSU Research Forests page: https://cf.forestry.oregonstate.edu/research/climate-change-carbon-and-forests