Forest Carbon and Management Options in an Uncertain Climate

Extension Report

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Abstract

One of the current climate change mitigation strategies is the management of forested ecosystems to ensure that they remain a sink for carbon now and into the future. With British Columbia's climate expected to continue to warm into the future, our forests will also change in response. If a choice is made to manage for carbon as one of the many landscape objectives, forest managers will need to know how best to do so given the likely changes in natural disturbance regimes that may accompany the changing climate.

KEYWORDS: carbon management; silviculture; natural disturbance

One of the current climate change mitigation strategies is the management of forested ecosystems to ensure that they remain a sink for carbon, now and into the future. With British Columbia's climate expected to continue to warm into the future, our forests will also change in response. If a choice is made to manage for carbon as one of the many landscape objectives, forest managers will need to know how best to do so, given the range of available tools. This note is based on a more detailed synthesis entitled *Natural Disturbance Effects on Carbon Dynamics and the Role of Forest Management on this Process* (Swift and Cuzner 2011) in the FORREX Series 28 and focuses on the suite of available activities a forest manager may wish to consider if carbon is selected as a management objective.

Forest carbon and its management aims to enhance the removal of carbon dioxide from the atmosphere by trees, and the storage of carbon in wood, biomass, and forest soils, while minimizing or reducing the release of carbon dioxide and other greenhouse gases (GHG) back into the atmosphere. This cannot be viewed in isolation of the complex nutritional cycle that exists within every ecosystem. The capacity of a forest or an ecosystem to sequester and store carbon is a function of many variables, including the aspect and elevation of the site, its nutritional status, its disturbance history (harvesting, fire, insects, etc.), its stand characteristics (e.g., tree species, stand volume and structure, amount of deadwood, ground vegetation), and the influence of logging, among other factors.

If the landscape objective of forest management is to sequester as much carbon as possible in both the short- and long-term, there are various supporting strategies available (Table 1 and Table 2). A key component of those strategies will be the need to enhance

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the resilience of the forest estate to projected shifts in natural disturbance regimes due to the changing climate. It will also important to continue to balance forest values since a long-term focus on maximizing carbon sequestration can result in detrimental impacts on other forest values, such as biodiversity, and the use of forests for building products.

Managing Carbon Sequestration as Part of a Landscape Strategy	
Forest Management Strategy	Forest Management Consideration
• Set forest carbon management as a landscape objective and in a landscape context. It will be important when doing so to understand the existing carbon balance on that landscape. • Select sites within that landscape for the management of carbon that are projected to be relatively stable under climate change conditions (i.e., dry sites may become drier and thus may shortly become a source rather than a sink). If possible aim for a forest with a high productivity and a low vulnerability to large-scale disturbance. • Use mixtures of fast-growing, shade-intolerant and shade-tolerant species adapted to the site (faster shade-intolerant species will sequester carbon sooner, but shade-tolerant species can sequester carbon for a longer period of time). • Use native species and seed sources that are adapted to the potential future climate conditions (assisted species range expansion). • To promote resistance, consider using a diversity of species and age classes when replanting, or of other treatments after a disturbance event. • Ensure total site occupancy over time (high initial density, grown at highest stocking density that the site can support over time). If site has a history of good natural ingress with a variety of species, planting densities can be varied or adjusted to accommodate this succession. • Forestall damage through thinnings of overstocked stands to reduce losses due to tree mortality. • Remove alien invasive species that occupy sites where trees may grow. • Consider both even-aged and uneven-aged harvesting strategies across the landscape to create a diversity in forest structures.	• Even-aged management must consider the regeneration delay period as a source of CO_2 emissions. The length of management period should consider trends in forest health, as pests can be a significant CO_2 producers. • Uneven-aged management will need to consider the number of tree removal interventions (carbon is managed better with a number of smaller interventions than a few large removals). When creating structure on the landscape, wildfire and forest health considerations should be taken into account as these events can generate large amounts of CO_2 emissions. • Losses of soil carbon during harvesting, site preparation, and other management activities (including burning) need to be accounted for or mitigated. • Upstream GHG costs will need to be considered for all treatments. • Management costs associated with a carbon management objective may exceed the value of forests for other uses, such as wood products, biodiversity, etc.

Table 1: Managing Carbon Sequestration as Part of a Landscape Strategy

There are also ways to modify our silvicultural toolkit when we are considering managing a stand for carbon sequestration. These activities are included in Table 2.

Although most of the practices outlined in this note appear to be part of existing proper forest management activities, if the overall objective of the prescribed treatment is to enhance GHG removal from the atmosphere, then the implications of these treat-

Table 2: How silviculture activities can be used to support carbon

Silvicultural Tool	Consideration for carbon sequestration
Choice of species	• Initially, fast-growing, shade-intolerant species (higher rates of carbon sequestration at younger age than shade-tolerant species), but this should be balanced within the context of the landscape objectives, species distributions on the landscape, and specific site conditions where the species will be planted. • Strive for mixed-species (shade-intolerant and shade-tolerant), mixed age stands over time – this also helps build resiliency into the system.
Slash disposal	• Burning slash will release pollutants into atmosphere, in addition to releasing CO2, methane, and nitrous oxide (greenhouse gases). • If slash can be left without compromising site productivity or fire risk, the carbon will continue to be stored for decades or centuries. • Incorporating wood residue into the soil could prolong carbon storage in the soil. • Slash could be removed for bioenergy (and offset the use of fossil fuels) if carbon balance or site productivity would not be significantly affected.
Site Preparation	• Can increase root and tree growth resulting in improved biomass production. • Try to limit loss of soil carbon which may occur through increased oxidation of soil carbon, temperature (which increases respiration of soil organisms), disturbance, and soil erosion. • Use techniques that incorporate wood residues into the soil to increase or prolong carbon storage in soil. • Reduce the amount of tillage to minimum levels only, but balance with the potential for competition.
Regeneration	• Prompt regeneration to ensure that carbon sequestration can be initiated as soon as possible. • Prompt tree regeneration to minimize the amount of time soil is exposed and the canopy is open. Regeneration also reduces the risk of the site being occupied by brush species. Young stands are usually considered a carbon sink until crown closure. Look to use a seed source that can assist in range expansion. • Using genetically improved seed has benefits related to improving early growth and establishment, but the site should not be significantly vulnerable to issues associated with environmental shifts.
Brushing	• Controlling competing vegetation with some form of brush control produces best results when applied as part of the site preparation treatment. • Use when site has the potential to become occupied quickly with competing species since these typically have a lower leaf area and less CO2 sequestration capacity than trees.
Fertilization	• Can increase rates of growth and leaf area production and therefore the rate of carbon uptake and sequestration when applied in proper amounts and if nutrients are a limiting factor. It is important to consider the upstream source and cost of energy used for manufacturing, transportation and application, as well as the release of emissions into the atmosphere by the fertilizer. • Emissions from helicopter use are substantial.

table continued on page 4

Table 2 (continued): How silviculture activities can be used to support carbon

Thinning and partial harvesting	• Use to control stocking levels and stand density to increase value or quality of wood rather than increase carbon storage. • Both treatments make openings in the canopy, and, in the context of carbon storage, it is preferable to conduct light but frequent thinnings, rather than heavy, infrequent ones (which can create large openings in the canopy that require a longer time to regain leaf area and capacity for carbon storage). • Can protect forest soil storage with the continuous canopy if equipment footprint is minimal.
Rotation length	• Longer rotations and larger trees increase onsite carbon storage. • Longer rotations in even-aged management favour carbon accumulation because less time is taken up in reforestation and rebuilding the canopy. • Longer rotations can incur larger management costs as the value growth rates of timber fall below the expected costs in wood products. This will need to be balanced with other management objectives. • Longer rotations and management cycles may also involve more thinnings or partial harvesting in order to maintain the health of the forest and to increase its resilience to future disturbance. • Shorter rotations could be considered for sites that may be demonstrating mal-adaptation to their management strategies, thus becoming a source of carbon. If short rotations are used, prompt reforestation should occur as soon as possible to initiate carbon sequestration.
Infrastructure	• Minimize helicopter use, road-building, and transport as part of carbon conserving and emissions reduction.

ments for this objective need to be fully understood. To do this, forest managers will need to equip themselves to assess the implications of these proposed treatments on the forest carbon balance of their landscape. To do this will require an understanding of both GHG emission evaluations and carbon accounting. Although this note does not go into the details of this, there are tools and experts available to assist in this process (e.g., the Canadian Forest Service Carbon Accounting Model – CBM-CFS3 http://cfs.nrcan.gc.ca/pages/94).

The management options selected today will be subject to the realities of an uncertain climate over the next 30 years. Activities that enhance forest carbon, such as species diversity and prompt regeneration, can go a long way to help these managed stands resist some of the potential negative impacts of climate change. For more information on how carbon may be affected by some of these potential changes, such as shifts in natural disturbance, readers are encouraged to refer to the longer synthesis document in FORREX Series 28, as well as to the list of resources below.

For more information

This summary is based on information contained in the full synthesis article:

Swift, K. Forthcoming. Natural Disturbance effects on carbon dynamics and the role of forest management in this process. FORREX Series 28.

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Test Your Knowledge

How well can you recall the main messages in the preceding article?
Test your knowledge by answering the following questions.

Forest Carbon and Management Options in an Uncertain Climate

1. Forest carbon and the management of forest carbon is about:
   a) Enhancing the removal of CO_2 from the atmosphere in trees
   b) The storage of carbon in wood, biomass, and forest soils
   c) Minimizing or reducing the release of CO_2 and other green house gases back into the atmosphere
   d) All of the above

2. The capacity of a forest or an ecosystem to sequester and store carbon is a function of:
   a) Aspect and elevation
   b) Site productivity
   c) Disturbance history
   d) Stand characteristics
   e) All of the above

3. Thinning as a silvicultural tool will increase carbon storage.
   a) True
   b) False

ANSWERS: 1) d; 2) e; 3) b