

The Forest Carbon Cycle:

Determining the Carbon Sequestration Potential of the Burnaby Mountain Conservation Area

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For: SFU Community Trust
July 15th, 2011

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This report was prepared as part of a student internship program for SFU Community Trust by Grant Fletcher, a masters candidate in Urban Planning at McGill University. The work was completed under the direction of Dale Mikkelsen, director of development at SFU Community Trust in the summer of 2011. This report seeks to determine the carbon sequestration capabilities of the Burnaby Mountain Conservation Area. It focuses on 320ha of forested land transferred to the City of Burnaby in exchange for the development rights to UniverCity, the residential development on Burnaby Mountain. Greenhouse gasses, particularly carbon in the form of carbon dioxide (CO₂), are significant contributors to changes occurring in the earth's climate¹. The sequestration capacity of the Burnaby Mountain Conservation Area is determined by examining the absorption and dispersion of carbon through the forest carbon cycle.

Background Context

UniverCity

UniverCity is a master planned sustainable community atop Burnaby Mountain in Metro Vancouver, BC. Designed to be compact, mixed-use and transit-oriented, the idea for the community began in 1963, when Arthur Erickson and Geoff Massey submitted their initial plan for SFU. Complementing their vision for the mountain-top campus, their plan saw the new university anchoring a dense residential community. It took another 30 years before the implementation of this initial plan would begin with SFU agreeing to transfer more than 320 hectares of University-owned land to the City of Burnaby to more than double the size of the Burnaby Mountain Conservation Area. In return, the city approved an Official Community Plan (OCP) in 1996, allowing SFU to begin development of a residential community, later named "UniverCity".

The 1996 OCP envisions a dense, mixed-use community on approximately 65 hectares of land surrounding the SFU campus. It allows for up to 4,536 residential units in two distinct neighbourhoods to the east and south of SFU's campus, each with its own elementary school and neighbourhood park. The OCP includes provisions for a commercial core, community facilities, and an extensive network of pedestrian paths and bike trails.

SFU Community Trust is responsible for overseeing the development of the community through the provision of zoned, serviced, subdivided sites to private sector developers on a prepaid, long-term (99-year) leasehold basis. UniverCity is currently home to approximately 3,000 residents and is planned to accommodate more than 10,000 when fully built out.

¹ <http://www.climatechange.gc.ca/> http://en.wikipedia.org/wiki/Climate_change
<http://www.davidsuzuki.org/issues/climate-change/>

The Carbon Cycle

The carbon cycle describes the exchange of carbon through the biosphere, atmosphere, oceans and sediments (including fossil fuels). These are also known as carbon pools or reservoirs. Carbon in the atmosphere receives the most attention as this poses the greatest threat to our survival. The carbon cycle contains both carbon sources and carbon sinks. Carbon sinks actively absorb carbon from the atmosphere and include both natural sinks (the oceans and vegetation) and artificial sinks (carbon capture and storage technologies). Sources release previously stored carbon back in to the atmosphere. These can include decomposing organic matter, the burning of fossil fuels and geological activities such as fissures and volcanoes. The burning of fossil fuels has become a major source of atmospheric CO₂.

Historical Atmospheric Carbon

Pre-industrialization levels of atmospheric CO₂ were reasonably stable through glacial and interglacial periods, oscillating between 180ppmv and 280ppmv (Falkowski et al., 2000). The carbon cycle maintains equilibrium as carbon is absorbed from and released into the atmosphere by trees, vegetation and oceans. With the discovery and subsequent use of fossil fuels beginning in the mid-19th century, it appears as though we have disrupted the carbon equilibrium that characterized our planet for the preceding 420,000 years (ibid). Atmospheric CO₂ has risen to levels 100 ppmv greater than previously recorded in the past 420,000 years (ibid). This unprecedented increase has also happened between 10-100 times faster than previously recorded (ibid). This 'shock' to the carbon cycle could have disastrous effects for our species and our planet.

Forests as a Carbon Sink

One potential remedy to minimize the effects of this carbon shock is to use the areas of the carbon cycle that store and sequester carbon to pull additional carbon from the atmosphere. Forests have long been thought of as carbon sinks. However, they can occasionally be sources. While vegetation grows, it is continually pulling carbon out of the atmosphere through the process of photosynthesis. So long as this process continues uninterrupted, forests are highly effective carbon sinks. They can however, turn into sources when there are major fires, insect outbreaks, or logging activities. The Canadian government studied whether forests in Canada were carbon sources or sinks when deciding to include Canada's forests in its

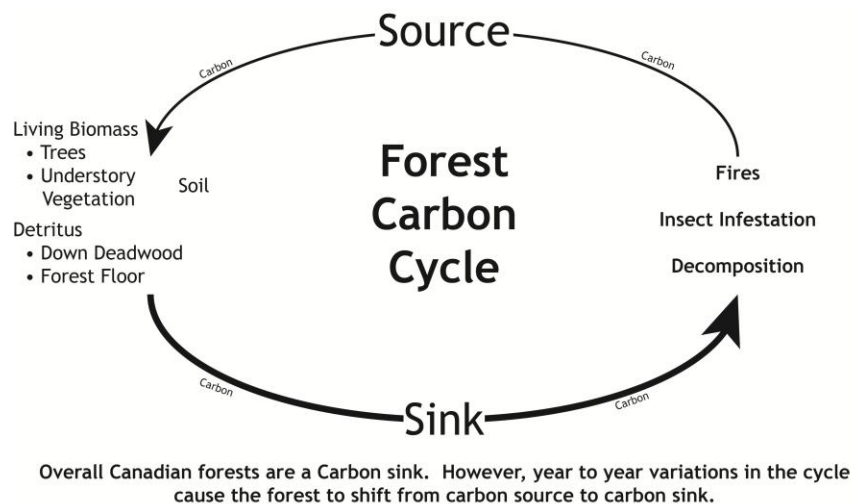


Fig.1 Forest Carbon Cycle

calculations for the Kyoto protocol. They found that overall, between 1990-2005, Canada's forests have been a sink except for 5 years when they experienced major fires or insect damage and became sources (Natural Resources Canada, 2007).

Burnaby Mountain Conservation Area

The Burnaby Mountain Conservation Area comprises 820ha on Burnaby Mountain in Burnaby, British Columbia. In 1996, an agreement between the City of Burnaby and Simon Fraser University saw the transfer of 320ha of land from SFU to the City of Burnaby. The addition of this land more than doubled the size of the conservation area to over 500ha. As a result, development rights on the east and south slopes of the mountain were granted by the City (fig.2). These lands would eventually become 'UniverCity' the mixed-use development at SFU and are the focus of this analysis (UniverCity.ca).



Fig.2 Simon Fraser University, UniverCity and the Burnaby Mountain Conservation Area (around perimeter. Not all shown).

The Forest

Logging activity between the late 1800s and 1940 removed most of the native coniferous stands on Burnaby Mountain. The current forest is between 70-80 years old and consists of a mix of mature and immature deciduous and mature coniferous stands (Stewart Environmental Ltd. 1996)². The areas dominated by mature deciduous stands contain a well-developed coniferous understory. As this forest matures, coniferous species will begin to once again dominate the forest.

Potential for Carbon Sequestration

The forest type in the Burnaby Mountain Conservation Area is Coastal/Pacific Temperate Rainforest. This forest type holds more biomass per unit area than any other ecosystem on the planet (Black, Jassal & Fredeen). Forests along the coast show greater potential for carbon sequestration than those elsewhere in BC (ibid.). This is due to the longer average growing season experienced on the coast. US research shows that forests in the Pacific Northwest contain the largest carbon stocks and sequesters the most carbon of all forests in the continental USA (Woodbury, et al. 2007). Based on this analysis, the forest in the Burnaby Mountain Conservation Area should be acting as a strong carbon sink.

² This report only examined the South Neighbourhood encompassed by the ring road (Fig.2). Data from this report was extrapolated to the entire conservation area. Without a full study of the trees in the conservation area, assumptions of tree types and age were based on data gathered from the south slope.

Yearly Carbon Sequestration

Age, climactic zone, climax species, soil composition, amount of precipitation and management techniques all affect the sequestration rate and the size of carbon reserves in forests. In obtaining a yearly sequestration rate, we must look at both the carbon absorbed through photosynthesis and carbon released from decaying organic matter, fire and plant respiration. When determining the sequestration ability of the forest on Burnaby Mountain, it was generally assumed that the risk of forest fires would be zero as we have the ability to mobilize firefighting personnel and extinguish fires quickly given the proximity of fire stations to the mountain. The potential for major losses of buildings and life at SFU and UniverCity would also be a major incentive for dealing with fires quickly. In estimating the yearly amount of carbon sequestered, this report assumes that the dominant species in the conservation area is Douglas Fir. While in reality this is not the true makeup of the forest, coniferous trees are the historically dominant species and as the deciduous trees mature and die, coniferous Douglas Fir, Western Hemlock and western Red Cedars will come to dominate the forest. As Douglas Firs have the most widely available sequestration data, they were the only choice in performing this analysis without conducting primary research.

EPA Estimates

The United States Environmental Protection Agency (EPA) uses research conducted by Birdsey (1996) to determine estimates of yearly carbon sequestration. Using this data, the EPA established the sequestration rate of a Douglas Fir forest as 0.74 - 5.19 metric tons of carbon per hectare per year over a 120 year period (Environmental Protection Agency, 2010). These values were determined for managed areas re-established after clear-cutting. Lower values are seen in forests throughout the Rocky Mountains while the higher values are characteristic of forests along the pacific coast. No accumulation of carbon in soils is assumed. The forest in the Burnaby Mountain Conservation Area is located in the coastal region justifying the use of the higher limit. However, this forest was not replanted and is not managed; meaning it has grown and matured organically and therefore will not sequester carbon at the levels established by the EPA. Taking these factors into consideration, this report uses a mid-high estimate in this range to determine the yearly sequestration rate for the 320ha of forest set aside during the negotiations for UniverCity. Removing 1.5 t/ha/year to compensate for the lack of management, an average yearly sequestration rate of 1180t/year was determined according to this analysis.

Carbon Budgeting Model – Canadian Forest Service

The Kyoto protocol, sustainable forest management, and forest certification requirements necessitated the development of a carbon accounting tool for the forest industry in Canada. The Canadian Forest Service developed a software package (CBM-CFS3) to help the industry account for carbon under different management and climactic scenarios. This software was used to determine the total carbon sequestration capability of the 320ha portion of the Burnaby Mountain Conservation Area.

To perform this analysis, yield-growth curves were developed using software developed by the BC Forest Service (TIPSY 4.2). Forests were assumed to be Douglas Fir with an average age of 75 years, height of 25m and density of 1200 trees/ha. This data was then used in CBM-CFS3 to determine the

carbon sequestration capabilities of the Burnaby Mountain Conservation Area. This software uses data collected from test plots around the country to determine the carbon levels in aboveground biomass, belowground biomass, litter, dead wood and soil. It also accounts for the growing conditions within specific ecological zones. As can

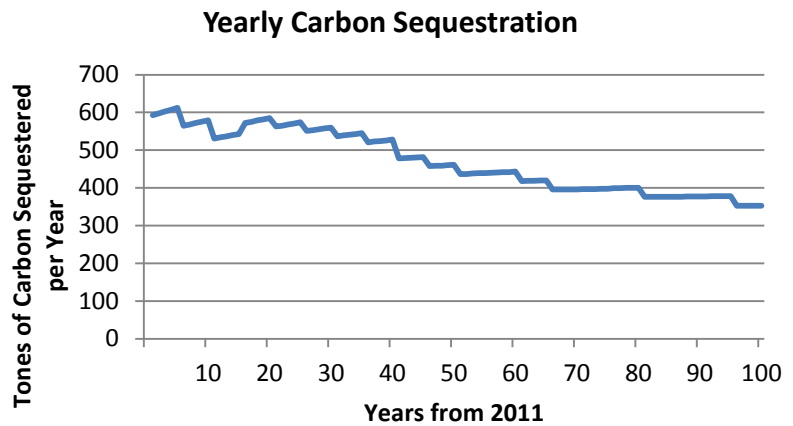


Fig.3 Yearly Carbon Sequestration Capacity of the Burnaby Mountain Conservation Area

be seen in Fig.3, the carbon sequestration capacity of the forest will decrease as the forest matures, dropping from 593t/year in 2011 to 353t/year in 2111. Over this 100 year period, the forest will sequester an average of 470 tons of carbon per year.

Discussion

While researching for this paper, it became very clear that the science behind the forest carbon cycle is in its infancy and there is still debate around how the different layers of the forest interact in the carbon cycle. Using sequestration tables developed by Birdsey (1996) and used by the EPA, the carbon sequestration rate of the Burnaby Mountain Conservation Area (320ha) is 1180t/year. Using the Carbon Budgeting Model developed by the Canadian Forest Service, the sequestration rate is 470t/year. The dramatic difference between these numbers illustrates the difficulty in estimating the carbon sink and source potential of the forest carbon cycle. It is difficult to determine which number is more accurate. The Birdsey report appears to have a solid methodology and is relied upon by the EPA for their representative carbon sequestration rates. The CBM-CFS3 software was developed in accordance with global standards and is used on a daily basis across Canada by the forest industry. One potential explanation to the dramatic difference in sequestration rates is the distinction between gross and net sequestration. The Birdsey report appears to be measuring the gross sequestration rate, ignoring the carbon that is released back into the environment from the forest as trees respire and wastes decompose. The CBM-CFS3 measures net carbon sequestered, accounting for carbon that is both absorbed and released throughout the forest carbon cycle. This method provides a more comprehensive, realistic and accurate estimate of the sequestration capacity of the forest on Burnaby Mountain and therefore should be used in discussions on carbon sequestration.

To enhance the sequestration capabilities of the conservation area, the forest should be managed to promote the growth of species that sequester more carbon. This can be done by

thinning the existing deciduous forest to allow coniferous trees to once again dominate the forest. Strategic fertilization has also been shown to increase yields and accelerate the sequestration of carbon (Johnson, 1992).

It is clear that this forest will be a carbon sink for the foreseeable future. However, the issue of permanence must be addressed. The forest will be sequestering carbon as long as it remains a forest. There is a potential for fire, however, the greatest threat is a change in land use. The entire mountain was designated as parkland in the 1920s. This designation changed when, in the early 1960s, the province was looking for a location for a new university campus. It was not until the land deal in 1996 that brought the 320ha of SFU land into the conservation area that the area was re-established to its previous size (minus the mountain top). As has happened in the past, policy can change and the conservation area could conceivably be developed, thereby creating the potential for the release of most of the sequestered carbon back into the environment. However, with the strong legal protection the conservation area currently has, the likelihood of development in the area is very small.

It is important that the conservation area be acknowledged for the role that it plays in sequestering carbon and improving the environment. However, it should not and cannot be used by the SFU Community Trust, residents or builders as an excuse to continue life as usual. The permanence of the conservation area is continually in question and consequently, so is the carbon stored within. Additionally, the area is now owned by the City of Burnaby and is therefore offsetting carbon for the entire municipality, not just the UniverCity development. The Burnaby Mountain Conservation Area is a wonderful asset for the entire Metro Vancouver region and while it will continue to sequester carbon for years to come, it should be used, not as an offset, but as a catalyst for reduced carbon emissions.

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