*Discussion Paper*

**BC Journal of Ecosystems and Management**

# Carbon management in British Columbia's forests: An update on opportunities and challenges

**Mike Greig[1] and Gary Bull[2]**

## Abstract

Forest carbon management is rapidly evolving in British Columbia. The province is perhaps the most active jurisdiction on this front in Canada as it seeks to meet the requirements of its new suite of greenhouse gas legislation, regulations, and policies that influence the management of forest carbon.

This report provides an update since 2008 on British Columbia's position on managing for greenhouse gas emissions, with a focus on the role of forests. Essentially, it is an update of *Carbon Management in British Columbia's Forests: Opportunities and Challenges*, published as FORREX Series No. 24 (Greig and Bull 2008).

This report includes

- a summary of legislative changes since late 2007;
- a review of the evolving institutional and market rules needed for the further development of a carbon offset market, which would include forests;
- some recent advances in forest carbon management in the province; and
- important opportunities and challenges that lay ahead.

Forest carbon management policy and practices will continue to evolve. Forest carbon is now a recognized forest value, at both the carbon offset project level and the sustainable forest management landscape level. Although many pieces of forest carbon management are in place, more work is required to realize the full potential. It is clear that British Columbia's vast forests represent a significant opportunity to manage greenhouse gas emissions and mitigate climate change.

**KEYWORDS:** *British Columbia; carbon accounting models; carbon credits and offsets; carbon markets; climate change initiatives; decision-support tools; ecosystems services; forest carbon stock; greenhouse gas emissions; Kyoto Protocol; natural disturbances; sustainable forest management; voluntary carbon markets.*

## Contact Information

1 Principal at Enfor Consultants Ltd., 118– 3721 Delbrook Avenue, North Vancouver, B.C. V7N 3Z4. Email: mgreig@enfor.com

2 Associate Professor, Department of Forest Resources Management, University of British Columbia, Forest Sciences Centre, 2045 – 2424 Main Mall, Vancouver B.C. V6T 1Z4. Email: gary.bull@ubc.ca



Greig, M., G., Bull. 2011. Carbon management in British Columbia's forests: An update on opportunities and challenges. *BC Journal of Ecosystems and Management 12(3):35-54* ***http://jem.forrex.org/index.php/jem/article/view/157/100.***

## Introduction

Forest carbon management is a rapidly evolving activity in British Columbia. Currently on this front, British Columbia is perhaps the most active province in Canada as it seeks to meet the requirements of its new suite of legislation and companion regulations.

Together, the British Columbia provincial, regional, and municipal governments, First Nations, and the forest industry are considering the role of forests and forest products as carbon sinks, all in an effort to mitigate the effects of climate change. Moving to a more carbon-sensitive economy can also provide new employment and additional economic activity in the forest products sector.

Carbon offset projects are designed to enhance the removal of atmospheric carbon dioxide ($CO_2$) or to reduce greenhouse gas (GHG) emissions. Forest carbon offset opportunities typically enhance removals of atmospheric $CO_2$ by increasing the capacity of the forest to sequester carbon. Emission reduction projects are typically undertaken by conserving forests or by accounting for the carbon retained in harvested wood products. Wood waste can be used as a carbon neutral energy source and reduce GHG emissions from fossil fuels (fuel switching).

This report provides updates on British Columbia's progress on managing for greenhouse gas emissions, with a focus on the role of British Columbia's forests and forest management. Essentially, it is an update of *Carbon Management in British Columbia's Forests: Opportunities and Challenges*, published as FORREX Series No. 24 (Greig and Bull 2008). The report includes a summary of legislative changes in British Columbia since late 2007; a review of the evolving institutional and market rules that need to be in place for the further development of a carbon offset market, which would include forests; some advances in forest carbon management; and some of the future opportunities and challenges facing forest carbon management.

*This report provides updates on British Columbia's progress on managing for greenhouse gas emissions, with a focus on the role of British Columbia's forests and forest management.*

## An Update on British Columbia's Position on Greenhouse Gas Management

British Columbia has experienced rapid changes in policies and practices for managing greenhouse gases in recent years. The provincial government has catalyzed a number of initiatives to address climate change. These initiatives set the stage for the market purchase or sale of carbon offsets to assist in meeting specified greenhouse gas reduction targets that cannot be met through reduced activities or improved energy efficiencies. The following statutes and regulations, outlining requirements to reduce greenhouse gas emissions, provide the context for management of British Columbia's forest carbon. These regulations are discussed in more detail below. A summary list includes

- Greenhouse Gas Reduction Targets Act (2007);
- Greenhouse Gas Reduction (Cap and Trade) Act (2008);
- Emission Offsets Regulation (2008);
- Carbon Tax Act (2008) and Carbon Tax Regulation (2008);
- Climate Action Tax Credit (2008);
- Zero Net Deforestation Act (2010); and
- Wood First Act (2009).

In addition, recent government actions relating to provincial forest carbon management include the following, also discussed in further detail below:

- Pacific Carbon Trust;
- Forest Carbon Offset Protocols;
- Future Forest Ecosystems Initiative and Future Forest ecosystems Scientific Council; and
- Expanding green electricity in British Columbia.

Related actions outside of British Columbia will likely have an impact here. Some of these actions are summarized in the *Framework for Forest Management Offset Protocols* (Canadian Council of Forest Ministers 2009). In addition, there has been a veritable flurry of activity around the development of standards, including the draft North America Forest Carbon Standard, the American Carbon Registry standard and methodologies, and the Voluntary Carbon standard and methodologies and tools.

For the private sector, the British Columbia government has not yet set limits for greenhouse gas emissions.

However, government is taking steps toward introducing a cap-and-trade program and has introduced reporting requirements under the *Reporting Regulation – Greenhouse Gas Reductions (Cap and Trade) Act.* In anticipation of the new greenhouse gas emission requirements and for improved customer relations, many businesses are taking steps to become more energy efficient and carbon neutral. For example, the local airline industry is attempting to be either carbon neutral or to offer voluntary offsets.

## Recent Requirements to Reduce Greenhouse Gases

### *Greenhouse Gas Reduction Targets Act (2007)*

The *Greenhouse Gas Reduction Targets Act* (GGRTA), which came into force January 1, 2008, legislates British Columbia's targets for reducing greenhouse gas emissions and the government's commitment for the public sector to become carbon neutral by 2010 (Government of B.C. 2007). Public sector organizations, such as government operations and school boards whose greenhouse gas emissions are not neutral, are expected to purchase carbon offsets to bring them to a neutral position.

The Act puts into law British Columbia's target of reducing greenhouse gas emissions by at least 33% below 2007 levels by 2020. It also includes the long-term target of an 80% reduction below 2007 levels by 2050. British Columbia also accepted the recommendations of the Climate Action Team for interim targets of 6% below 2007 levels by 2012 and 18% by 2016.

Under the provisions of the Act, the B.C. Ministry of Environment has established an emission offsets regulation to address the quality of greenhouse gas offsets and several other related acts to regulate emissions in British Columbia. Regulations with the potential to influence forest carbon management are described below.

### *Greenhouse Gas Reduction (Cap and Trade) Act (2008)*

The *Greenhouse Gas Reduction (Cap and Trade) Act* authorizes hard caps on greenhouse gas emissions (Government of B.C. 2008a). British Columbia was the first province in Canada to introduce such legislation. This act provides the statutory basis to set up a market-based cap-and-trade framework intended to reduce greenhouse gas emissions from large emitters.

Parts of this act were brought into force when the Reporting Regulation was enacted in November 2009 (Government of B.C. 2008b). Effective January 1, 2010, the regulation requires that B.C. facilities that emit 10,000 tonnes or more of carbon dioxide must report emissions; facilities with emissions greater than 25,000 tonnes are required to have emissions reports verified by a third party (B.C. Ministry of Environment 2010a).

The remaining portions of the Act will be brought into force as the relevant regulations are developed.

In October 2010, the ministry released two consultation papers. One describes the proposed rules by which allowance budgets will be set and emissions may be traded under a British Columbia cap-and-trade system (B.C. Ministry of Environment 2010b). The other outlines a proposed standard for the development of compliance-grade offsets issued by the government (B.C. Ministry of Environment 2010c).

Details of the cap-and-trade system are currently under development in co-operation with other Western Climate Initiative partners. In July 2010, the Western Climate Initiative (WCI) released its *Design for the WCI Regional Program,* which provides the detailed framework for the cap-and-trade program (see Western Climate Initiative 2011).

For more information on the proposed new cap-and-trade system and regulations for British Columbia, see B.C. Ministry of Environment (2010d).

### *Emission Offsets Regulation (2008)*

The *Emission Offsets Regulation* came into force in British Columbia in December 2008. This regulation describes requirements for greenhouse gas offset projects that will be considered by the provincial government, via the Pacific Carbon Trust, to help offset emissions by public sector organizations (PSOs). PSOs include provincially run organizations such as government offices, schools, and government facilities. The provincial government committed PSOs to be carbon neutral by 2010 under the *Greenhouse Gas Reduction Targets Act,* a goal that could be achieved by adopting lower carbon-footprint practices and purchasing carbon offsets to meet that commitment. Local governments, communities, and some universities signed onto the Climate Action Charter, which obligates them to be carbon neutral by 2012, and will utilize carbon offsets that meet requirements of the *Emission Offsets Regulation*.

To have a carbon offset considered for purchase by the provincial government, carbon offset project developers prepare a proposed project proposal in a

format prescribed by the Pacific Carbon Trust (PCT). Applications are made to the PCT, a Crown corporation established by government to acquire carbon offsets on its behalf. PCT oversees the process, including the evaluation by independent verifiers, and takes ownership of the offsets from the project developer.

A key stipulation in any carbon offset project is that offsets must be counted only once and may not have been sold previously under any other greenhouse gas reduction program. Additional criteria are specified in the *Emission Offsets Regulation*.

To guide the development and quantification of a project proposal, carbon offset protocols are used. Requirements under the *Emission Offsets Regulation* are addressed in a new British Columbia Forest Carbon Offset Protocol currently under development for forest-based projects. For more information on GGRTA and EOR, refer to B.C. Ministry of Environment 2010e. The Protocol for Creation of Forest Carbon Offsets in British Columbia is described in more detail later in this report.

### *Carbon Tax Act (2008)*

Carbon taxes were introduced under the *Carbon Tax Act* in July 2008. The carbon tax is applied to the purchase of fossil fuels in British Columbia. Fossil fuels include liquid fuels such as gasoline and diesel, gaseous fuels such as natural gas, and solid fuels such as coal. The tax is applied based on the amount of greenhouse gas emissions created by the fuel. To determine the tax rate, greenhouse gas emissions for each fuel are calculated and this value is converted to carbon dioxide equivalents ($CO_2e$). For example, gasoline has a different carbon tax than propane. (For more information on how the carbon tax works, see B.C. Ministry of Finance n.d.)

Unlike fossil fuels, wood fuels are considered by the government to have no net GHG emissions and hence are considered carbon neutral. This is because a tree absorbs (sequesters) the same amount of as much carbon (or $CO_2$) when it grows as it releases when it is burned or decomposes naturally (refer also to previous section on the *Greenhouse Gas Reduction Targets Act*). Using wood to derive energy can be achieved with no net increase of $CO_2$ into the atmosphere. There is no carbon tax on wood fuels in British Columbia.

An increasing carbon tax scale is used for fossil fuels. The tax rate on fossil fuels in 2010 was $20 per tonne of $CO_2e$, increasing to $25 per tonne $CO_2e$ in 2011 and $30 per tonne $CO_2e$ in 2012. The phasing in of carbon taxes was intended as an incentive to encourage users to change their fuel consumption habits, such as by reducing useage or switching to alternative low or no-carbon sources of fuel. An example of fuel switching in British Columbia is the conversion from using coal to using wood; recent examples of fuel switching can be seen at greenhouses and cement plants. A number of communities are considering using biomass as a fuel for district energy systems. (Note that many pulp mills and sawmills have long since converted to using wood residues for fuel as a way to reduce costs and address waste management requirements.) For more examples of carbon taxes on fuels, see B.C. Ministry of Small Business and Revenue (2008).

### *Zero Net Deforestation Act (2010)*

According to recent studies undertaken by the provincial government, British Columbia is losing about 8000 hectares per year to deforestation (see Figure 1; this measurement assumes an energy consumption rate of 11,100 kWh per home per year).

Since forests are a key contributor in the management of greenhouse gases, and to help retain as much of British Columbia's 60 million hectares of forest land in a forested state, the provincial government passed the *Zero Net Deforestation Act* in spring 2010. The bill is part of the government's effort to reduce greenhouse gas emissions in British Columbia. It sets the path for zero net deforestation by 2015. The Act applies to Crown land, private land, Indian reserves and federal land in the province.

The term "zero net deforestation" refers to an area

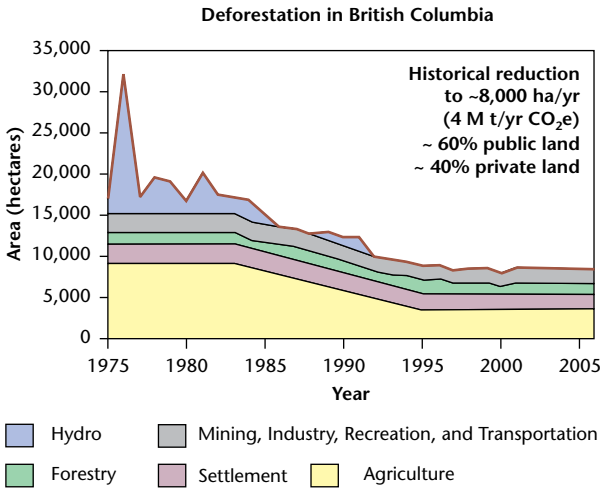



**FIGURE 1.** Deforestation in British Columbia since 1975. In recent years the rate has been 8,000 hectares per year (Niemann 2009, p. 37).

that has had trees removed and re-established to the extent that "the amount of afforestation is not less than the amount of deforestation" (Government of B.C. 2010a, section 1). The Act defines deforestation as "the human-induced removal of trees from an area of forest land to such an extent that the area is no longer forest land, but does not include the removal of trees from any area of forest land that is excluded from this definition by regulation" (section 1). The Act includes the following reporting requirements:

> Beginning with a report on the net deforestation within British Columbia for the 2012 calendar year, and continuing with a report for every subsequent even-numbered calendar year, the minister must, as soon as reasonably practicable for each of those years, make public a report respecting:
>
> (a) the progress that has been made toward achieving the goal of zero net deforestation,
>
> (b) the actions that have been taken by the government to achieve that progress, and
>
> (c) the plans of the government to continue that progress. (Government of B.C. 2010a, section 3).

A draft implementation plan for zero net deforestation was prepared in December 2010 and circulated for public input. The plan is expected to be complete in 2011. The draft plan states that "zero net deforestation can be achieved through a combination of avoiding deforestation, minimizing the area of deforestation, and balancing deforestation by creating areas of new forest" (Government of B.C. 2010b, p. 4). Timber harvesting in British Columbia is not considered deforestation. The plan describes several objectives and outlines guiding principles to meet zero net deforestation, plus approaches that might be used by government and various sectors. It includes a series of proposed actions by sector. The plan also identifies the approximate amount of deforestation by sector (see Figure 2).

The *Zero Net Deforestation Act* and policy is still under development. It is unclear exactly how zero net deforestation will be rolled out by government beyond the policy objectives set out in the draft plan and commitments made in the Act. In particular, specific expectations of private landowners and forest tenure holders are not yet clear by government.

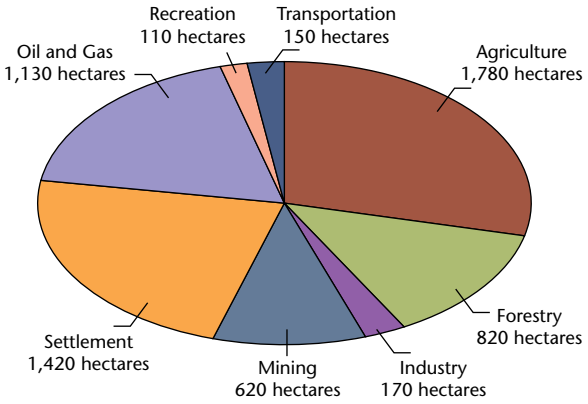



**FIGURE 2.** Area deforested in British Columbia by sector in 2008 (Government of B.C. 2010b, p. 2).

### *Wood First Act (2009)*

The new Wood First policy was implemented by the provincial government in part to help meet climate change objectives while promoting the use of wood as a building product. *The Wood First Act* (2009) mandates that provincially-funded building projects use wood as the primary construction material where possible. For more on the Wood First Initiative, see B.C. Ministry of Jobs, Tourism, and Innovation (2011).

In terms of carbon offsets, most forest carbon offset project protocols now provide for the inclusion of harvested wood products in the calculation of how long carbon is stored. The Protocol for the Creation of Forest Carbon Offsets in British Columbia is consistent with this general direction (Pacific Carbon Trust 2010b; more on this protocol below). This means that the carbon stored in wood building could at some point in the future be included in the calculation of forest carbon stored. Accounting for harvested wood products as a carbon sink is an important step forward for carbon accounting and carbon offset projects.

## Recent B.C. Government Actions

### *Pacific Carbon Trust*

The Pacific Carbon Trust (PCT) is a Crown corporation initiated by the Government of B.C. to purchase carbon offsets for the public sector. The public sector commitment now covers the operations of provincial ministries, school districts, universities, colleges, health authorities, Crown corporations, and other government agencies. In addition to purchasing offsets for government, PCT

has authority to purchase offsets for sale back to private companies.

PCT acquires carbon offsets from projects located in British Columbia. To qualify as an offset, projects must conform to the *Emission Offsets Regulation*, demonstrating a carbon reduction that is "additional" to forest management in a business-as-usual scenario (B.C. Ministry of Environment 2010f; Pacific Carbon Trust 2010a, 2011a). The trust intends to use the new Protocol for the Creation of Forest Carbon Offsets in British Columbia to guide forest-based carbon offset projects, although currently it allows project proponents to consider international forest protocols (e.g., Voluntary Carbon Standard, American Carbon Registry Standard, and California Forest Carbon Credit Standard) and adapt these to local conditions.

The PCT is mandated to source one million tonnes of carbon offsets annually. Of this, one-third is to be comprised of forest-based projects and another one-third is to be comprised of fuel switching projects. This presents new economic opportunities for businesses across multiple streams in the forest sector.

In 2011, PCT will consider the following forest-based carbon offset projects, identified in the new Protocol for the Creation of Forest Carbon Offsets in British Columbia (Pacific Carbon Trust 2010b):

- Afforestation: establish additional forest base;
- Reforestation: planting trees beyond requirements of existing legislation;
- Improved Forest Management: enhanced forest management practices in addition to those required by law; and
- Conservation: permanent removal of land from the harvesting cycle.

In 2010, PCT issued a $3-million call for forest-based offset projects to increase the total stock of carbon sequestered in British Columbia's forests under three activities: afforestation, seed selection, and fertilization. PCT has indicated that the corporation met its forest-based offset target for 2010 (personal communication, David Muter, PCT, November 16, 2010).

In British Columbia, fuel switching–based carbon offset projects represent real opportunity for project developers and producers of wood-based biomass fuels. Forest-based biomass used as a fuel source has been deemed by the B.C. Ministry of Environment to have an emission factor of zero. It is therefore considered carbon neutral and a green energy source. Switching from using fossil fuels to using biomass can result in reduced emissions and could be eligible for carbon offsets. Some of PCT's first carbon offset projects were fuel switching projects using biomass.

Regarding the extent to which biomass is considered carbon neutral, there is ongoing debate about this in some jurisdictions outside of British Columbia, such as the State of Maine. As long as tree biomass production occurs  at least as fast as wood burns or decomposes, the carbon cycle is in balance. For more information on carbon neutral aspects of wood as a fuel, see eXtension (2009).

Wood fuels from sustainably managed forests can be argued to be carbon neutral. However, wood fuels from land clearing to other non–forest land uses may not be considered carbon neutral.

***Forest carbon offset protocols***

The Government of B.C. has developed two forest carbon offset protocols to guide the development of forest-based projects for sale to PCT. The protocols meet requirements under the B.C. E*mission Offsets Regulation* and the *Greenhouse Gas Reduction Targets Act*, and they provide good practice guidance for the design, development, quantification, and verification of projects. Projects are expected to be undertaken on a broad range of forest activities on private and public land (personal communication, David Muter, PCT, November 16, 2010).

The first protocol, the British Columbia Forest Offset Guide, was developed by the Ministry of Forests and Range in 2010. Eligible projects under the offset guide were limited to three types of forest-based carbon offset projects: afforestation, select seed use, and fertilization (B.C. Ministry of Forests, Lands, and Natural Resource Operations 2010). This guide is expected to be replaced by the newer Protocol for the Creation of Forest Carbon Offsets in British Columbia (Lesiuk et al. 2011).

The aforementioned protocol was developed by the Climate Action Secretariat, which has stated that "forest carbon is an increasingly significant component of climate action, and the protocol will ensure that forest carbon offsets developed in British Columbia meet domestic and international quality standards" (B.C. Ministry of Environment 2011, para. 1). Eligible projects include afforestation, reforestation, improved forest management, and conservation (see above under PCT).

Items covered by the protocol include

- identifying GHG sources sinks and pools (SSPs), determining baseline scenarios, identifying project additionality, and making comparisons. See Figure 3 for a summary overview of SSPs for eligible projects.
- quantifying GHG emissions and emission reductions for controlled and related carbon sources, and quantifying leakage.
- managing the risk of reversal—plans covering a 100-year span are required to meet the requirements set under the *Emission Offsets Regulation*.

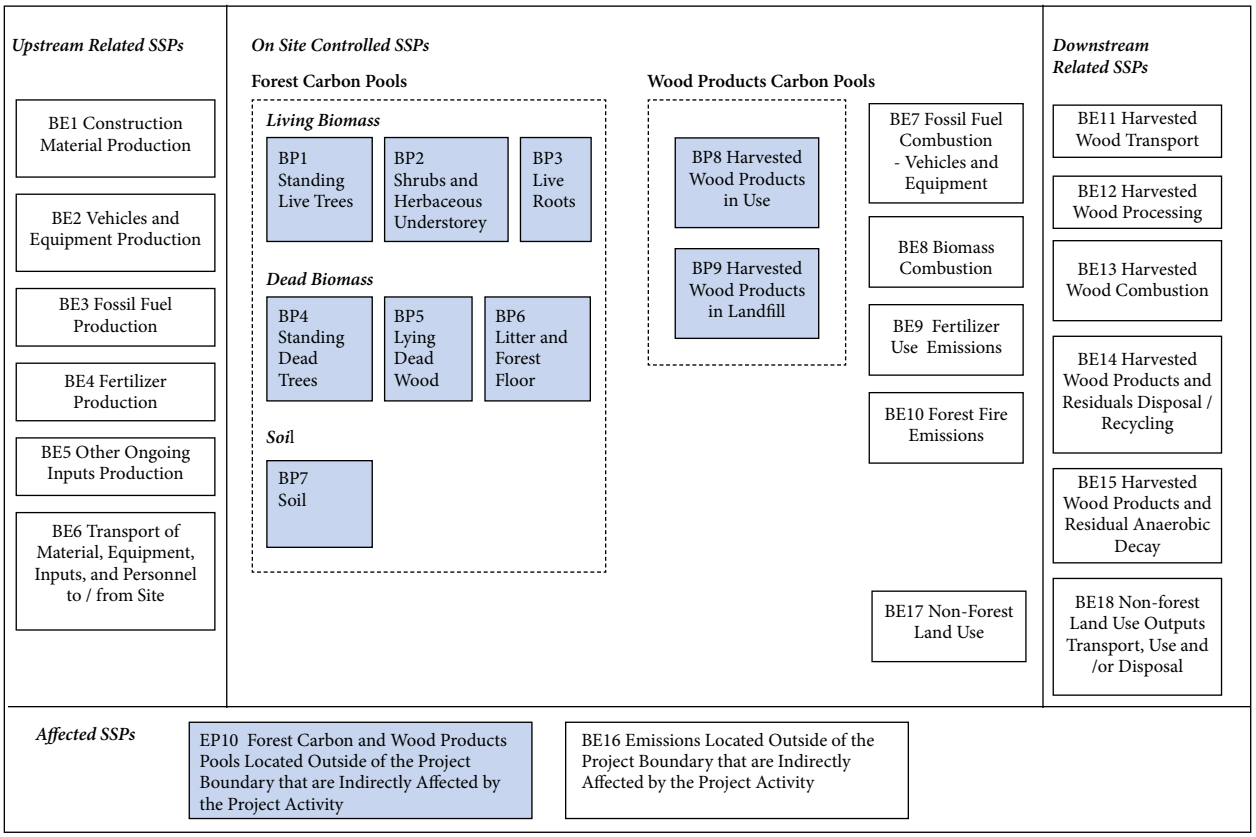
Notably, harvested wood products (HWP) can qualify under this protocol for carbon storage. Research results are presented in the protocol to describe the levels of carbon storage in various forest products and landfills.

Figure 3 provides a summary overview of sources, sinks and pools for eligible projects under the Protocol for the Creation of Forest Carbon Offsets in British Columbia.

***Future Forest Ecosystems Initiative***

The ability of forests to sequester carbon is inextricably linked to their ability to adapt, grow, and recover in a changing climate that features accelerated disturbance. The Future Forest Ecosystems Initiative (FFEI) was designed in 2008 to address climate change. Specifically, it aims to adapt "British Columbia's forest and range management framework so that it continues to maintain and enhance the resilience and productivity of B.C.'s ecosystems as our climate changes" (B.C. Ministry of Forests, Lands, and Natural Resource Operations n.d.) The FFEI laid the scientific foundation for ecosystem resilience and complexity, identified climate scenarios to use for British Columbia, and undertook a suite of projects in the areas of research, modelling, monitoring, policy evaluation, policy change, and extension.

In March 2008, the Ministry of Forests, Lands, and Natural Resource Operations also established the Future Forest Ecosystems Scientific Council (FFESC), to guide research funds supporting the objectives of the FFEI.




Note: Carbon pools are shaded light blue to distinguish them from emission sources.

**FIGURE 3.** Baseline sources sinks and carbon pools for eligible projects under the B.C. Forest Carbon Offset Protocol (B.C. Ministry of Environment 2010g, p. 41).

Projects underway will assist forest managers to assess the vulnerability of British Columbia's forests and range resources to the effects of a changing climate, as well as help develop strategies to adapt to a changing climate. For more information on the Future Forest Ecosystems Initiative and the FFESC, refer to B.C. Ministry of Forests, Lands, and Natural Resource Operations (2011).

***Bioenergy calls for power—Green energy***

BC Hydro's recent bioenergy calls for power projects include a call for Community-based Biomass Power projects and a call for large-scale biomass power projects to "generate clean, green electricity" (B.C. Ministry of Environment 2010h, p. 16). According to a biomass utilization guide prepared for the Province called the Bioenergy Guide 2010, "the Government of British Columbia has committed to ensuring that clean or renewable electricity generation continues to account for at least 90% of total generation in the province, and to require that all new electricity generation facilities will have net zero greenhouse gas emissions" (ENVINT Consulting for BC Bioenergy Network 2011, p. 5).

The Community-based Biomass Power Call is targeted at community-level projects up to five megawatts (MW) in size, while the general Bioenergy Phase 2 Call Request for Proposals (Call) is a competitive call for larger-scale biomass projects. BC Hydro hopes to attract up to 1000 gigawatt hours (GWh) per year of electricity through the Call for Power, enough to provide electrical power for approximately 90,000 homes per year (again, assuming energy consumption of 11,100 kWh per home per year). As part of the Call process, the Ministry of Forests, Mines, and Lands identified areas available to meet the needs of forest-based biomass energy projects, including areas of mountain pine beetle–killed trees.

BC Hydro received proposals for 13 projects from 10 proponents for the Bioenergy Phase 2 Call by the October 28, 2010, proposal submission deadline. The submissions represent more than 400 MW of aggregate capacity and over 3300 GWh per year of firm energy. BC Hydro received proposals in four of the six designated areas: the Smithers/Fort St. James corridor, Northeast British Columbia, Central and Northern Vancouver Island, and the Cariboo-Chilcotin, as well as proposals from non-designated areas (BC Hydro 2010).

## Some Recent National Actions

***CCFM Framework for Forest Management Offset Protocols***

In 2009, the Canadian Council of Forest Ministers (CCFM) commissioned a project to develop a framework for forest management offset protocols in Canada. Provincial premiers had asked the Council in 2008 to prepare a common forest carbon management protocol for all jurisdictions to use. On further review, the CCFM favoured a more generic framework. It argued that a single protocol could not adequately cover the diversity of forest conditions and forest management applications across Canada and apply to multiple offset systems (e.g., federal, British Columbia, Alberta, Western Climate Initiative).

The CCFM document identifies and analyzes key issues that protocol writers and project proponents should consider when drafting a forest management protocol. For more information, see Canadian Council of Forest Ministers, 2009.

***North America Forest Carbon Standard***

In 2009, the Forest Products Association of Canada joined forces with the American Forest Products Association, the Canadian Institute of Forestry, and the Society of American Foresters to develop a North America–wide Forest Carbon Standard. The intent was to develop a forest offset protocol for use in North America that would meet multi-stakeholder process requirements of the American National Standards Institute (ANSI) and the Canadian Standards Association (CSA). Such a proactive step would also meet the requirements of several competing stakeholders, such as industry, non-governmental organizations (NGOs), and governments. Committee membership is made up of a diverse group of 50 forestry organizations, government agencies, NGOs, academics, and professionals from various disciplines. Several forest professionals from British Columbia active in the carbon market contributed volunteer time to develop by committee the draft standard.

In 2010 a forest carbon offset protocol was drafted and circulated. The document set a standard for the measuring, reporting, and verifying of forest carbon emission reduction projects (e.g., offsets) under current and emerging greenhouse gas emission reduction programs in Canada and the United States. For more information on the committee and its work, as well as

the process for seeking consensus, see the Forest Carbon Standards website (2008). The intention is for the forest carbon offset protocol to be usable in either Canada or the United States. The draft standard is currently under revision and industry is not pursuing opportunities to apply it at this time.

Under the standard, the goal of a forest carbon sequestration, or forest-related GHG emission reduction projects, is to remove carbon dioxide from the atmosphere and maintain, increase, and/or retain forest and forest-related carbon stocks without any negative impacts. These negative impacts could include loss of ecosystem function, biodiversity, water and air quality and wildlife habitat.. Other competing standards are discussed in the next section of this report.

## Institutional Requirements for Forest Carbon Offsets in British Columbia

As mentioned, British Columbia is currently designing an emission trading system, and the Province invited comments on the institutional design with a deadline of December 6, 2010. The government also has plans to design a  a registry in British Columbia, where projects can be serialized. In the meantime, project proponents can use one of the American-based registries or the CSA registry, which focuses on compliance with the ISO 14064:2 and 3 (Canadian Standards Association 2009).

There is both voluntary and compliance emission trading market activity. In British Columbia, the voluntary market focus has been twofold: to develop small-scale projects in urban forests in the Lower Mainland and to work with a combination of standards. B.C. developers have primarily used the following standards: VCS Improved Forest Management, Climate Community and Biodiversity, American Carbon Registry, and California Forest Carbon Credit. There is some discussion of utilizing the Carbon Fix Standard. For the compliance markets at the local level, the focus has been on developing strategic carbon plans for jurisdictions such as Nanaimo and Metro Vancouver.

Of course, many critical issues are at stake with regard to the standards—issues that both voluntary and compliance markets are grappling with as they seek to move forward. These issues are focused around baseline identification, leakage, harvested wood products, permanence, liabilities, insurance, additionality, modelling uncertainties, unintended consequences, risks of reversals, and fungibility. Fungibility refers to the equivalence of each unit of a commodity with other units of the same commodity.

No clear policy or regulatory framework yet exists to define carbon ownership, and there is only preliminary thinking on the inevitable issue of who will make the trade-off decisions. When one considers the classic dimensions of a property right (duration, transferability, comprehensiveness, benefits conferred, and exclusivity), it is clear that there are many complex issues to address, especially relating to First Nations land claims and to existing property rights, such as timber tenures of various kinds.

As yet there is still only a very poor understanding of the start-up costs, the transaction costs associated with project development, and the monitoring, validating, and verifying costs associated with ongoing maintenance of a contract. In addition, debate and confusion remain over the pricing of a carbon offset. In British Columbia, the Pacific Carbon Trust is the buyer of carbon offsets for the provincial government. While PCT advertises that it will sell offsets for $25/tonne (Pacific Carbon Trust 2011b, para. 6), which is also the price it charges government, PCT will negotiate a purchase price it is prepared to pay from project developers. Current exchange market prices[1] can be as low as $4 t $CO_2$e, Alberta Energy companies are already using a price of $40 t $CO_2$e for investment planning and the government of Alberta has currently set the price at $15 t $CO_2$e.

These prices may still be low if the aim is to see the widescale adoption of technologies such as carbon capture and storage; here the price needs to be, at a minimum, $90 t $CO_2$e. In fact, many technology solutions will require a price of about $100 t $CO_2$e; otherwise technology projects will have to be  subsidized.

One key institutional issue is how to harmonize the monitoring, reporting, and verifying of forest carbon offset projects with existing government requirements, and with market requirements through schemes such as FSC, SFI, and CSA. Another key issue is the identification of qualified validators and verifiers, especially if one is attempting to develop forest carbon projects for multiple markets.

Finally, again from an institutional policy point of view, British Columbia still requires a better and more comprehensive linkage between its energy and climate

1 Note that the Chicago Climate Exchange halted trading in 2010. See Lavelle (2010).

change policies to strengthen carbon trading markets in the province. Other jurisdictions have demonstrated that it is essential to have a formal institutional linkage between these two areas.

## Market Requirements for Forest Carbon Offsets in British Columbia

Generating investment interest in B.C. forest carbon projects requires a number of key financial market elements, namely a suite of functioning financial instruments, a well-defined financial authority framework, marginal abatement cost curves, silvicultural investment lookup tables, cost-effective delivery to minimize transaction costs, an environment that encourages market liquidity, and a recognition of the market "pull" and institutional investor requirements.

### Financial Instruments

Today many options exist to finance forest and forest carbon markets. The following are the instruments generally considered:

- Equity markets;
- Bond markets—silvicultural bonds;
- Single buyers (e.g., large final emitters);
- Emission trading systems;
- Venture capital; and
- Government financing schemes.

All of these financial mechanisms are currently being used in forest carbon markets. The biggest challenge is to identify their specific requirements, their points of contact, and the transaction costs of completing a project.

### Financial Authority Framework

There are many middlemen in the market exchange, and markets often require their participation despite the high costs. Some of the key middlemen are the environmental brokers who work on the exchanges, the project developers who act as an interface between the buyer and seller, the insurance brokers who insure against risk, and the monitors, verifiers, and validators who ensure quality products. All of these are essential authorities in most market-based systems.

### Marginal Abatement Cost Curves

Markets need a method to clearly prioritize all GHG project types and to know that they are buying a low-cost solution to their problem. In a forest carbon project, the typical direct costs considered are as follows:

- Project planning costs;
- Planting costs;
- Other stand management investment costs;
- Maintenance costs;
- Monitoring, verifying and reporting costs; and
- Other transaction costs.

Potential investors would find it easier to identify investment priorities if forest stands and treatment types throughout the province of British Columbia were ranked based on financial and other criteria,

### Forest Investment Tables

Table 1 shows a ranking of silvicultural projects for three kinds of management activity: genetic improvement of the stock, seed improvement of the stock, afforestation of the land and fertilization for different site indexes (ranging from an SI of 30 to an SI of 15) for all projects less than \$30/tonne $CO_2$e. Since the carbon production costs can be estimated, the silvicultural activity can be ranked by site index. In the case of productive lands (i.e., Site Index of 30 m in 50 years), the carbon production costs are \$.80/tonne $CO_2$e. In contrast, for low-productivity lands (i.e., Site Index of 15 m in 50 years in Prince George) that are fertilized, the production costs are \$29.30/tonne $CO_2$e.

In Table 1, fertilization generates carbon at an acceptable price on the better coastal sites. The optimum fertilization applications interval varies according to species and site index. It is also worth noting that fertilization for carbon offsets differs from fertilization for harvest, as the return on capital could occur much sooner (i.e., especially if paid *ex ante*, and also before harvest if paid *ex post*). The cost of carbon generation through fertilization is sensitive to a rise in energy prices, for the manufacture of fertilizers, their transport to site, and their aerial application are all energy-intensive processes.

Seed improvement appears to be cost-effective for the Campbell River area and the faster-growing sites in the Prince George area. Our simulations assumed a 20% genetic gain, but even higher gains are reported (e.g., 26% for white spruce). Afforestation appears to be viable on the better sites in the Prince George and Campbell River areas.

The use of appropriate information from the carbon markets can assist silviculturists to make investment decisions based not only on timber growth, but also on

**TABLE 1.** Ranking of eligible forest carbon projects by cost (Bull 2010).

| | Location | Activity | Carbon production cost $/tonne $CO_2e$ |
|---|---|---|---|
| <$30 | Campbell River | Genetic improvement SI 30 | 0.8 |
| | Prince George | Seed improvement SI 17.5 | 2.6 |
| | Campbell River | Genetic improvement SI 15 | 2.9 |
| | Campbell River | Afforestation SI 45 | 3.2 |
| | Campbell River | Fertilization SI 30 (10-year interval) | 6.0 |
| | Campbell River | Fertilization SI 30 (20-year interval) | 6.8 |
| | Prince George | Afforestation SI 27.5 | 7.1 |
| | Campbell River | Afforestation SI 30 | 7.2 |
| | Prince George | Afforestation SI 17.5 | 18.1 |
| | Campbell River | Fertilization SI 15 (20-year interval) | 29.3 |

carbon market signals. Although, in the past, silvicultural decision-making have been made with assumptions about forest products prices, integrating carbon prices will create a new ranking of silvicultural priorities.

### Cost-effective Delivery

Transaction costs are a huge challenge for the delivery of forest carbon projects. These costs are often initially hidden and can sometimes outweigh the total value of a project. The costs include project design documentation, stakeholder engagement, communication, validation, verification, reporting, management, and legal expenses.

### Market Liquidity

Market liquidity allows buyers and sellers flexibility in their business relationship in order to meet company targets and regulatory obligations as their respective businesses develop. The internal Canadian market for carbon could be characterized as lacking in liquidity. One of the challenges, for example, is to find a place to register and serialize projects domestically. As a result, many of the current "one-off" forest carbon projects are not registered domestically and are confidential in nature. This creates a number of challenges, not the least of which is establishing a market price for carbon.

The external dimension of market liquidity is the exposure of the jurisdiction to international markets. Some jurisdictions, such as Alberta, have prepared a legal and regulatory framework that prevents their emitters from purchasing offsets outside of their provincial borders; this makes their market rather illiquid. Other jurisdictions, such as New Zealand, are making their emission units fungible with other markets, such as the *European Union Emissions Trading System (*EU ETS). The degree to which a jurisdiction applies "protectionist" measures will have a direct effect on carbon pricing and could well be another significant obstacle in finding global solutions to the problem of greenhouse gas emissions.

### Market Pull and Investor Requirements

Market pull happens when there is an expressed market need; in essence, the buyer defines what is required, not the seller. A significant number of industries see the need for carbon offsets in what is perceived to be an emerging carbon-constrained world. Both the technology and forest products industry are responding at the strategic and technological level, but much remains to be done at the operational scale and in creating the regulatory environment for markets to work efficiently. For more information about carbon pricing in British Columbia, refer to B.C. Ministry of Environment (2010i).

## Managing Forest Carbon

British Columbia's roughly 60 million hectares of forests play an important role as carbon sinks and sources. Approximately 25 million ha are in the timber harvesting land base and another 35 million ha in other forests (Niemann 2009). This section provides an update for forest managers on the status of carbon in British Columbia's forests; some forest carbon research initiatives, the role of forest products in reducing greenhouse gas emissions, forest carbon modelling efforts; and recent insight into First Nations interest in managing for forest carbon. This update provides a useful reference for managers interested in developing forest carbon offset projects for

commercial purposes and forest managers interested in managing forests to balance GHG emissions.

## The Current Status of Carbon in British Columbia's Forests

At the national level, Canada's managed forests were quantified to be a sink for atmospheric $CO_2$ from 1990 to 2008, which represented an uptake of 50 ± 18 million tonnes of carbon per year (Stinson et al. 2011). Net losses of ecosystem carbon occurred during several years due to large fires and widespread bark beetle outbreak.

The B.C. Ministry of Forests, Lands, and Natural Resource Operations (2010) released recent reports related to forest carbon and climate change. A 2009 report indicated that British Columbia's forests were a net source of carbon dioxide and other GHG emissions to the atmosphere (Dymond and Spittlehouse 2009). Contrary to the national level, greenhouse gas emissions from British Columbia's forests increased while sinks decreased from 1990 to 2007. This upward trend in emissions was mostly due to insect attack and wildfires, although an increase in harvesting from 1990 to 2007 also resulted in a greater transfer of carbon from forests to harvested wood products (see Figure 4).

The impact of the mountain pine beetle on carbon stocks in British Columbia has been significant according to recent reports, which show that B.C. forests have been a net source of GHG emissions due the beetle infestation (Niemann 2009; Kurz et al. 2008) (see Figure 5).

It is important to bear in mind that this was a provincial level of analysis and does not reflect what may be occurring in a particular project. The challenge for project developers is to explain the difference between provincial-level analyses and project-level analysis, where management activity will be undertaken at a much smaller scale and will have to deal with all the uncertainties associated with forest land management.

Regarding the impact of harvested timber on carbon stocks, in accordance with international rules, harvested

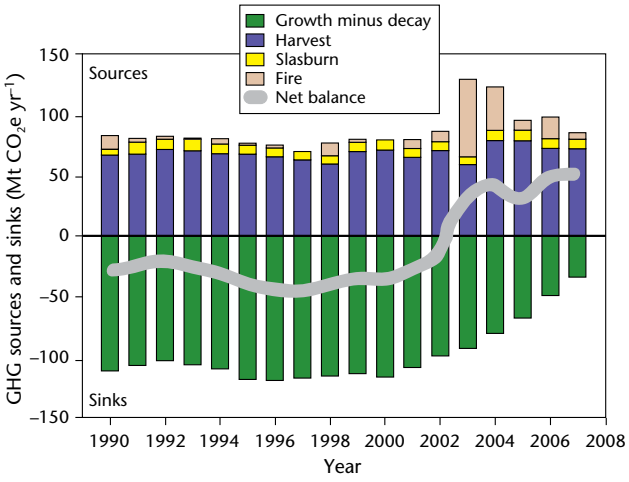



**FIGURE 4.** Greenhouse gas sources and sinks in the forest ecosystem of British Columbia (approximately 64 million ha) (Dymond and Spittlehouse 2009, p. 3).

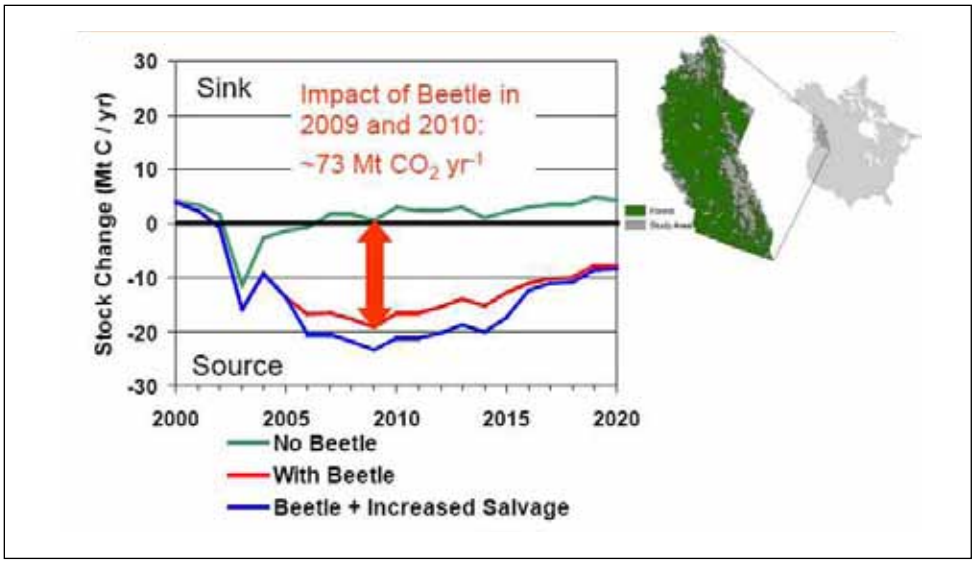



**FIGURE 5.** Impacts of mountain pine beetle (MPB) on carbon stocks in British Columbia (Kurz et al. 2008, p. 989).

timber is reported as a loss of $CO_2e$ to the atmosphere, largely because of lack of agreement on how to account for carbon in harvested wood products and life cycle analysis. In British Columbia, Dymond and Spittlehouse (2009) estimate that "about 40% of the carbon removed from the forest is turned into long-lived forest products like lumber and panels" (p. 3). However, each wood product has a different life expectancy before carbon is released to the atmosphere. The Protocol for the Creation of Forest Carbon Offsets in British Columbia, Version 1.0, provides a table (based on USDA research) of the estimated fraction of carbon remaining "In-Use" and "In Landfill" after 100 years (e.g., softwood lumber has a fraction of carbon in-use of 0.234 and a fraction of carbon in landfill of 0.405) (Lesiuk 2011).

## Recent Research Initiatives into Forest Carbon in British Columbia

The B.C. provincial government has undertaken a number of research projects recently targeted at increasing knowledge around the best practices for forest carbon management and assessing the best opportunities for projects in British Columbia.

### *Forest management regime offset approach*

In 2010, the Ministry of Forests, Mines, and Lands began a project to develop and assess a forest management regime offset approach for British Columbia. The project was fashioned under an industry advisory committee, the Forest Sector Climate Action Steering Committee.

Authors of the study hope to clarify how forestry can participate in carbon projects in British Columbia. Since many foresters are being asked to undertake carbon management, there is a need for guidance on highest-value project opportunities. Research aims to help identify what the public wants and what foresters can do to help their clients take full advantage of the carbon opportunities in British Columbia's forests (personal communication, Kelly McClosky, *Registered Professional Forester* (RPF), Project Manager, October 21, 2010).

With study areas on northern Vancouver Island and in Kamloops, the project has the following objectives:

- identify specific forest management and silvicultural activities within a forest management regime framework that can contribute to enhanced sequestration;
- develop recommendations for a draft forest management regime quantification protocol;
- quantitatively assess the sequestration impact and financial viability of offset projects; and
- quantitatively assess the sensitivity of key financial parameters and protocol elements.

### *Reforestation carbon offset mapping*

The Ministry of Forests, Mines, and Lands Forest Analysis and Inventory Branch (FAIB) has undertaken GIS analysis to highlight potentially high opportunity areas for carbon offsets for reforestation activities. Given the extent and severity of the mountain pine beetle outbreak, FAIB is looking into the potential to generate carbon offsets to help support reforestation activities in the province. The intent of the project is to define at the strategic, or management unit, level areas where these opportunities might be promising for follow-up verification (B.C. Ministry of Forests and Range 2010).

## The Role of Forest Products in Reducing Greenhouse Gas

### *Biomass fuels*

Biomass products are considered an attractive energy option when compared to fossil fuels because of the carbon neutral aspects of biomass. In British Columbia, forest-based biomass fuels are derived from sawmill residue, logging residues, trees killed by the mountain pine beetle, and other residual wood from recycling processes. A recent report by the BC Bioenergy Network estimates that in British Columbia the total sustainable forestry potential for forest-based biomass fuel is more than 28 million dry tonnes/year of available forest-based biomass feedstock (ENVINT Consulting for BC Bioenergy Network 2011). Of this total, harvest residue is the single largest biomass resource in British Columbia, at about 12 million dry tonnes per year. The study indicates that approximately 10,000 to 15,000 dry tonnes per year of wood is required to generate 1 megawatt, so the forests of British Columbia have the potential to supply 1800 to 2800 MW of power per year.[2] This would provide enough power for approximately 1.35 million to 2.1 million homes per year (assuming 1 MW per 750 homes).[3]

2 This calculation is based on the assumption that 10,000 to 15,000 dry tonnes per year of forest-based biomass will generate 1 MW (ENVINT Consulting for BC Bioenergy Network 2011).

3 MW will power 750 to 1000 homes (United States Department of Agriculture 2007).

Biomass can replace fossil fuels such as coal, diesel, and natural gas, reducing GHG emissions if the biomass is sustainably produced. This is a very important consideration for large-scale energy users given the Government of British Columbia's actions to provide incentives for the reduction of GHG emissions with the introduction of the carbon tax, the looming cap-and-trade system for large emitters, and the government's obligations to become carbon neutral by 2012. Such policies and legislation have moved the European Union and countries elsewhere to utilize large volumes of biomass as an energy source.

Biomass fuels continue to be a large exportable commodity from British Columbia, typically in the form of wood pellets and wood briquettes for industrial users and residential users around the world. Industrial buyers, such as power plants in Europe, are typically looking to reduce their GHG emissions with the use of biomass. Transporting biomass, however, often requires burning fossil fuels, which should be considered in the overall calculation of the carbon footprint of utilizing biomass as a fuel; international rules in the carbon offset world are unclear on this.

The latest estimates are that 1.2 million tonnes of pellets alone were produced from British Columbia in 2010, and that British Columbia accounts for 65% of Canadian pellet capacity and production (B.C. Ministry of Forests, Mines, and Lands 2011), most of which is exported. Recently British Columbia has seen the introduction of other densified wood residual products such as wood briquettes for industrial users. Wood pellets and wood briquettes can typically provide 17 to 19 gigajoules per tonne with a low moisture content, as compared to green wood chips or hog fuel at about 9 GJ per tonne and coal at about 25 GJ per tonne.

### *Wood products*

Using wood products that store carbon, instead of building materials that require more fossil fuel to manufacture, can help reduce GHG emissions and save energy. Numerous international scientific studies demonstrate the environmental benefits of wood. A recent life cycle assessment compared the environmental impacts of homes framed with wood, steel, and concrete; it found that the production of steel and concrete-framed homes generated 26% and 31% more greenhouse gas emissions, respectively, than their wood-framed counterparts (B.C. Forestry Climate Change Working Group 2009). The same study found that the production of the steel and concrete homes consumed 17% and 16% more embodied energy and released 14% and 23% more air pollutants, respectively, than a wood-framed home.

An important consideration in comparing building products is life cycle analysis (LCA). LCA allows the impartial comparison of building designs based on measures such as global warming potential. Tools are available online to carry out LCA. For example, the US-based group Athena has developed the EcoCalculator (see Athena Institute 2011), which offers architects, engineers, and others access to instant LCA results for hundreds of common building assemblies, including residential and commercial assemblies.

For more information on benefits to climate change of using wood products, Naturally Wood provides a "Building Green with Wood Toolkit" (Naturally Wood 2011). Naturally Wood is sponsored by Forest Innovation Investment.

## Forest Carbon Modelling Update

The Ministry of Forests, Lands, and Natural Resource Operations has incorporated biomass tonnage and carbon tonnage for forest stand yield estimating into the latest release of the TIPSY4.2. Work is also underway to develop a link to export data from TIPSY to CBM-CFS3, expected in 2011.

The ministry is working on a new version of the TIPSY Economist software for 2011–12 that will incorporate simple carbon dioxide equivalent ($CO_2e$) values as a forest product from a stand. This product will be available for consideration in economic analysis of silviculture activities.

Tools described in the "Market requirements" section above for ranking silviculture investments will assist analysts in assessing silviculture investments in terms of values in carbon offsets.

The Protocol for the Creation of Forest Carbon Offsets in British Columbia identifies forest estate and landscape dynamics models used in British Columbia and suggested for consideration by project proponents, including CBM-CFS3 (Kurz et al. 2009) and FORECAST (Kimmins et al. 1999). CBM-CFS3 is used for national-level and forest management unit–level forest carbon accounting in Canada. FORECAST is more for ecosystem-level analysis. Both of these models have been parameterized using field data from British Columbia forest ecosystems. For more information on recent updates and applications of CBM-CFS3, a recent article

is available in the Ecological Modelling Journal, titled "CBM-CFS3: A model of carbon-dynamics in forestry and land-use change implementing IPCC standards" (Kurz et al. 2009).

### Examples of Forest Carbon Projects in British Columbia

Interest in forest carbon offset projects continues to be high in British Columbia among government, municipalities, forest land owners, private carbon-sector entrepreneurs, First Nations, and other non-governmental organizations (NGOs). Only a few carbon offset projects have been undertaken in British Columbia to date, although the Pacific Carbon Trust has reported negotiations with a number of private interests to purchase "high quality" forest-based carbon offsets. Given the confidential nature of project evaluations and project undertakings, specific projects and entities cannot be named in this report. However, forest-based carbon offset projects in British Columbia typically include afforestation and forest conservation.

Project viability for most parties is not simply contingent on financial viability or on meeting the requirements of a particular protocol. Many proponents consider co-benefits of a carbon project to see whether additional benefits might meet their mandate. Examples of co-benefits include

- Habitat development or habitat conservation
- Riparian restoration
- Parks development
- Forest conservation
- Future timber supply

### First Nations Interests

First Nations have expressed an interest in managing for carbon offsets on treaty lands. The recent Coastal First Nations Reconciliation Protocol provides for, among other things, developing and sharing environmentally credible and marketable forest carbon offsets that could be generated in accordance with requirements of the *Greenhouse Gas Reduction Targets Act* (Government of British Columbia 2008c; see also Government of British Columbia 2009).

## Opportunities and Challenges

Forest-based carbon offset projects continue to provide significant opportunities and challenges. A recent report delivered by the Climate Action Secretariat describes British Columbia's forests as our "natural advantage" to help meet aggressive new GHG reduction targets (B.C. Ministry of Environment 2010h).

### Opportunities

Some key opportunities for managing for forest carbon in British Columbia

- **PCT forest-based projects:** enhancing removals of GHG through forest carbon projects, including afforestation, reforestation, improved forest management, and conservation.
- **PCT fuel switching projects:** moving from fossil fuels in industrial operations to forest-based biomass.
- **Wood products useage:** promoting the use of wood products to reduce British Columbia's overall GHG footprint, both in building products and biomass fuels.
- **Harvested wood products:** accounting for harvested wood products as long-lived wood products as a benefit in carbon offset projects.
- **Co-benefits:** accounting for co-benefits of carbon offset projects, which tend to generate tangible values in addition to atmospheric values. This additional value may be enough to overcome financial obstacles.
- **Joint benefits:** forging ahead with First Nations and the provincial government projects with the aim of producing joint benefits from different management actions.
- **International markets:** exporting surplus credits that are high in quality, can demonstrate many ecological benefits, can be supported by First Nations, and can be integrated with existing vital economic activity, such as the continued harvesting of trees to produce wood products.

### Challenges

Ongoing challenges that influence forest carbon management in British Columbia include the following:

- **Fungibility:** The carbon market being developed, in alignment with legislative or regulatory requirements, may not be fungible with the international

marketplace, where many project developers will have to sell their excess credits. If not fully harmonized, this could lead to great difficulties.

- **Financial:** Proponents of commercial carbon offset projects indicate that projects are financially difficult to undertake given high up-front costs, the long payback periods, and the perceived permanence and leakage requirements. As a principle, cost-effectiveness is critical to the procedures in programs which aim to reduce greenhouse gas emissions and increase carbon stored underground, aboveground. Institutional: The emission trading platform, registries, and banks are not in place to serialize projects, to establish price, to increase efficiencies, and to facilitate over-the-counter trading.
- **Modelling:** Despite good modelling capability, it is difficult to assess the carbon budget and/or flux of forest soils and long-lived harvested wood products. There is uncertainty associated with assessing the impact of climate change adaptation on carbon budgets. Further, to address issues such as leakage, further development is needed of modelling tools in areas such as forest products trade, regional and project supply curves, and carbon flow along the supply chain. Finally, all modelling efforts will require a sustained effort by key agencies to ensure integrated and consistent forest inventory data, forest products trade data, and production/consumption data.
- **Decision support tools:** There is a need for user-friendly decision support software tools to help forest managers assess carbon management options. Use of most current models is beyond the capability of most forest managers.
- **Appropriate forest practices:** There is still a need for clear decision support guides and training to help B.C. forest managers decide on practices to undertake. Research is underway by the Ministry of Forests, Lands, and Natural Resource Operations in 2011 to help identify which forest practices provide the greatest returns. The development of forest investment tables would help in ranking silviculture investments geared toward increasing GHG removals and reducing GHG emissions.

## Acknowledgements

We would like to acknowledge the individuals who contributed material toward the preparation of this report: Ajit Krishnaswamy (FORREX), Tom Niemann and Brian Raymer (B.C. Ministry of Forests, Lands, and Natural Resource Operations), Kelly McCloskey (Wood Is Good), David Muter (Pacific Carbon Trust), Werner Kurz (Canadian Forest Service), and report reviewers. In addition, we would like to thank the many colleagues contacted for information and views.

## References

Athena Institute. 2011. EcoCalculator overview. *http://www.athenasmi.org/tools/ecoCalculator/index.html* (Accessed November 2011).

B.C. Forestry Climate Change Working Group. 2009. Tackle climate change, use wood (Canadian edition). *http://www.naturallywood.com/sites/default/files/Tackle-Climate-Change-Use-Wood.pdf* (Accessed November 2011).

BC Hydro. 2010. Bioenergy Phase 2 Call RFP. *http://www.bchydro.com/planning_regulatory/acquiring_power/bioenergy_call_for_power/2009_Phase_II_BP.html?WT.mc_id=rd_bioenergyphase2call* (Accessed November 16, 2010).

British Columbia Ministry of the Environment. 2010a. Reporting Regulation—Greenhouse Gas Reduction (Cap and Trade) Act. *http://www.env.gov.bc.ca/cas/mitigation/ggrcta/reporting-regulation/index.html* (Accessed November 2011).

_____. 2010b. Emissions Trading Regulation—Consultation paper. *http://www.env.gov.bc.ca/cas/mitigation/ggrcta/pdf/etr-consultation-paper.pdf* (Accessed November 2011).

_____. 2010c. Cap and Trade Offsets Regulation—Consultation paper. *http://www.env.gov.bc.ca/cas/mitigation/ggrcta/pdf/ctor-consultation-paper.pdf* (Accessed November 2011).

_____. 2010d. Greenhouse Gas Reduction (Cap and Trade) Act. *http://www.env.gov.bc.ca/cas/mitigation/ggrcta/* (Accessed November 2011).

_____. 2010e. Emission Offsets Regulation—Consultation paper. *http://www.env.gov.bc.ca/cas/mitigation/ggrta/offsets_reg.html* (Accessed November 2011).

_____. 2010f. Pacific Carbon Trust. *http://www.env.gov.bc.ca/cas/mitigation/pct.html* (Accessed November 2011).

_____ 2010g. Forest Carbon Offset Protocol, Final draft for public review—November 22, 2010. *http://www.env.gov.bc.ca/cas/mitigation/pdfs/FCOP_Final-(22nov2010)-for_public_review.pdf* (Accessed November 2011).

_____. 2010h. British Columbia climate action for the 21st century. *http://www.env.gov.bc.ca/cas/pdfs/climate_action_21st_century.pdf* (Accessed November 2011).

_____. 2010i. Consultation backgrounder—Carbon pricing. *http://www.env.gov.bc.ca/cas/mitigation/ggrcta/pdf/carbon-pricing-bg.pdf* (Accessed November 2011).

_____. 2011. Forest Carbon Offset Protocol. *http://www.env.gov.bc.ca/cas/mitigation/fcop.html* (Accessed November 2011).

British Columbia Ministry of Finance. n.d. How the carbon tax works. *http://www.fin.gov.bc.ca/tbs/tp/climate/A4.htm* (Accessed November 2011).

British Columbia Ministry of Forests and Range. 2010, November 17. Request for Proposals, FS1300 Reforestation Carbon Offset Mapping. Prepared by Graham Hawkins, Forest Analysis and Inventory Branch. File: 1070-20/CS1179A028.

British Columbia Ministry of Forests, Lands, and Natural Resource Operations. 2010. Climate change and forest carbon. *http://www.for.gov.bc.ca/mof/Climate_Change/publications.htm* (Accessed November 2010)

_____. 2011. Future forest ecosystems. Scientific Council of British Columbia. *http://www.for.gov.bc.ca/hfp/future_forests/council/index.htm* (Accessed November 2011).

_____. n.d. Future Forest Ecosystems Initiative. *http://www.for.gov.bc.ca/HFP/future_forests* (Accessed November 2011).

British Columbia Ministry of Forest, Mines, and Lands. 2011. Selection of monthly economic statistics. *http://www.for.gov.bc.ca/ftp/het/external/!publish/web/snapshot/201101.pdf* (Accessed November 2011).

British Columbia Ministry of Jobs, Tourism, and Innovation. 2011. Wood First Initiative: Creating a culture of wood. *http://www.jti.gov.bc.ca/woodfirst/* (Accessed November 2011).

British Columbia Ministry of Small Businesses and Revenue. 2008. Notice: British Columbia Carbon Tax. *http://www.sbr.gov.bc.ca/documents_library/notices/British_Columbia_Carbon_Tax.pdf* (Accessed November 2011).

Bull, G.Q. 2010. Requirements for forest carbon credit financing in British Columbia: An analysis. B.C. Ministry of Forests and Range, Victoria, B.C. *http://farpoint.forestry.ubc.ca/FP/search/Publication_View.aspx?PUB_ID=6896* (Accessed November 2011).

Canadian Council of Forest Ministers. 2009. A framework for forest management offset protocols. *http://www.ccfm.org/pdf/FFMOP_e.pdf* (Accessed November 2011).

Canadian Standards Association (CSA). 2009. Welcome to CSA's GHG registries web site. *http://www.ghgregistries.ca/index_e.cfm* (Accessed November 2011).

Dymond, C.C. and D.L. Spittlehouse. 2009. Forests in a carbon-constrained world. B.C. Ministry of Forests and Range Forest Science Program. Extension Note 92. *http://www.for.gov.bc.ca/hfd/pubs/Docs/En/En92.pdf* (Accessed November 2011).

ENVINT Consulting for BC Bioenergy Network. 2011. An information guide on pursuing biomass energy opportunities and technologies in British Columbia. *http://www.bcbioenergy.com/wp-content/uploads/2011/07/Bioenergy-Guide-2010-final-updated-May-2011.pdf* (Accessed November 2011).

eXtension. 2009. Is burning wood carbon-neutral? *http://www.extension.org/pages/43727/is-burning-wood-carbon-neutral* (Accessed November 2011).

Forest Carbon Standards. 2008. Committee. *http://www.forestcarbonstandards.org/committee.html* (Accessed November 2011).

Government of British Columbia. 2007. Greenhouse Gas Reduction Targets Act. S.B.C. Chap. 42. *http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/00_07042_01* (Accessed November 2011).

_____. 2008a. Greenhouse Gas Reduction (Cap and Trade) Act. S.B.C. Chap. 32. *http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/00_08032_01* (Accessed November 2011).

_____. 2008b. Greenhouse Gas Reduction (Cap and Trade) Act. S.B.C. Regulation, B.C. Regulation 272/2009. *http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/10_272_2009* (Accessed November 2011).

_____. 2008c. Reconciliation—Moving forward. *http://www.newrelationship.gov.bc.ca/agreements_and_leg/reconciliation.html* (Accessed November 2011).

_____. 2009. Reconciliation protocol. *http://www.newrelationship.gov.bc.ca/shared/downloads/cfn_bc_reconciliation_framework.pdf* (Accessed September 2010).

_____. 2010a. Zero Net Deforestation Act. Bill 5—2010. *http://www.leg.bc.ca/39th2nd/1st_read/gov05-1.htm* (Accessed November 2011).

_____. 2010b. Zero net deforestation—Proposed implementation plan. Draft. *http://www.for.gov.bc.ca/ftp/hfp/external/!publish/web/znd/files/ZND-Implementation-Plan.pdf* (Accessed November 2011).

Greig, M. and G. Bull. 2008. Carbon management in British Columbia's forests: Opportunities and challenges. FORREX Series 24. FORREX Forum for Research and Extension in Natural Resources, Kamloops, B.C. *http://www.forrex.org/publications/forrexseries/fs24.pdf* (Accessed November 2011).

Kimmins, J.P., D. Mailly, and B. Seely. 1999. Modelling forest ecosystem net primary production: The hybrid simulation approach used in FORECAST. Ecological Modelling 122: 195–224.

Kurz, W.A., C.C. Dymond, G. Stinson, G.J. Rampley, E.T. Neilson, A.L. Carroll, T. Ebata, and L. Safranyik. 2008. Mountain pine beetle and forest carbon feedback to climate change. Nature 452: 987–990.

Kurz, W.A., C.C. Dymond, T.M. White, G. Stinson, C.H. Shaw, G.J. Rampley, C. Smyth, B.N. Simpson, E.T. Neilson, J.A. Trofymow, J. Metsaranta, and M.J. Apps. 2009. CBM-CFS3: A model of carbon-dynamics in forestry and land-use change implementing IPCC standards. Ecological Modelling 220: 480–504.

Lavelle, M. 2010, November 3. A U.S. cap-and-trade experiment to end. National Geographic Daily News. *http://news.nationalgeographic.com/news/news/energy/2010/11/101103-chicago-climate-exchange-cap-and-trade-election/* (Accessed January 2011).

Lesiuk, T., S. McDonald, D. Peterson, R. Draeseke, and S. Wehr. 2011. Protocol for the Creation of Forest Carbon Offsets in British Columbia (Version 1.0). *http://www.env.gov.bc.ca/cas/mitigation/pdfs/Forest_Carbon_Offset_Protocol_v1_0_Web.pdf* (Accessed November 2011).

Naturally Wood. 2011. Getting started. *http://www.naturallywood.com/design-environment/getting-started* (Accessed November 2011).

Niemann, T. 2009. Port Alberni Bio-Energy and Forest Carbon Discussion Forum July 9, 2009, Ministry of Forests and Range. *http://www.for.gov.bc.ca/ftp/DSI/external/!publish/Port%20Alberni%20Climate%20Change%20and%20Forest%20Carbon/Port%20Alberni%20Climate%20Change%20and%20Forest%20Carbon%20July%2009.pdf (*Accessed November 2011).

Pacific Carbon Trust. 2010a. Offset call brings $3M in forest sector opportunities [News release]. *http://www.pacificcarbontrust.com/LinkClick.aspx?fileticket=A%2BjJHN8rusk%3D&tabid=76* (Accessed November 2011).

_____. 2010b. Protocol for the Creation of Forest Carbon Offsets in British Columbia (Version 1). *http://pacificcarbontrust.com/LinkClick.aspx?fileticket=5OEWsNuAIlI%3D&tabid=81&mid=721* (Accessed November 2011).

_____. 2011a. [Homepage]. *http://www.pacificcarbontrust.com/* (Accessed November 2011).

_____. 2011b. Buy offsets from PCT. *http://www.pacificcarbontrust.com/BuyOffsets/tabid/64/Default.aspx* (Accessed January 2011).

Stinson, G., W.A. Kurz, C.E. Smyth, E.T. Neilson, C.C. Dymond, J.M. Metsaranta, C. Boisvenue, G.J. Rampley, Q. Li, T.M. White, and D. Blain. 2011. An inventory-based analysis of Canada's managed forest carbon dynamics, 1990 to 2008. Global Change Biology 17(6): 2227–2244. *http://cfs.nrcan.gc.ca/pubwarehouse/pdfs/32135.pdf* (Accessed November 2011).

United States Department of Agriculture. 2007. Woody biomass utilization desk guide. *http://www.forestsandrangelands.gov/Woody_Biomass/documents/biomass_deskguide.pdf* (Accessed November 2011).

Western Climate Initiative. 2011. Design for the WCI regional program. *http://westernclimateinitiative.org/the-wci-cap-and-trade-program/program-design* (Accessed November 2011).

**ARTICLE RECEIVED: May 4, 2011**
**ARTICLE ACCEPTED: October 21, 2011**

Production of this article was funded, in part, by the British Columbia Ministry of Forests, Mines and Lands through the Forest Investment Account-Forest Service Science Program.

# Test Your Knowledge . . .

*Carbon management in British Columbia's forests: An update on opportunities and challenges*

**How well can you recall some of the main messages in the preceding Discussion Paper? Test your knowledge by answering the following questions. Answers are at the bottom of the page.**

1. What is Pacific Carbon Trust's Role?
   A) To develop carbon offset projects for sale
   B) To purchase carbon offsets on behalf of the B.C. government for government operations
   C) To sell B.C. carbon offsets to global markets such as the EU

2. What type of carbon offset projects might qualify under the new Protocol for the Creation of Forest Carbon Offsets in British Columbia?
   A) Afforestation and improved forest management
   B) Harvested wood products
   C) Both of the above

3. Insect attacks and wildfires in B.C. from 1990-2007 have caused B.C.'s greenhouse gas emissions to:
   A) Increase while sinks decreased
   B) Decreased while sinks increased
   C) Stay the same, in fact overall improvement in B.C.

## *Answers*

1. B 2. C 3. A