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CANADIAN FOREST SERVICE SCIENCE-POLICY NOTES

Is forest bioenergy good for the environment?

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As countries, industry, and communities seek ways to reduce greenhouse gas (GHG) emissions to address the climate change issue, there is increasing interest in the use of forest biomass for bioenergy to offset energy from fossil fuels. At the same time, there are increasing calls to reduce harvesting and to protect forest lands as carbon reservoirs, also to address the climate change issue. This Note outlines what we know and what we do not know about forest bioenergy. It also outlines some of the complex issues that need to be considered when deciding whether or not it makes sense to use woody biomass for bioenergy.

What is forest bioenergy?

Forest biomass includes all parts of the tree, not only the trunk but also the bark, the branches, the needles or leaves, and even the roots. Biomass can be converted into solid, liquid, or gaseous biofuels that can then be burned for energy or used as fuel substitutes for transportation or industrial processes. Trees are useful for energy because they convert sun energy into biomass through photosynthesis, a process that captures carbon dioxide from the atmosphere.

Most forest biomass being used for bioenergy in Canada is produced from waste or residues from manufacturing processes. Forest bioenergy has become a significant portion of the energy used by the pulp and paper sector (58% in 2007) largely because it makes economic sense to convert into energy what might otherwise be a waste product to be sent to a landfill or disposed of by burning. There are a variety of technologies that can be used to convert biomass to energy. For example, pulp and paper producers burn the liquid waste from the pulping process (called black liquor) for energy in a recovery boiler that also allows them to recycle the chemicals. Pulp and paper producers and lumber producers also burn waste wood (largely bark) for energy, which is used for heat and sometimes for steam to run turbines to produce electricity. Increasingly, however, there is interest in the use of leftover biomass on harvested or disturbed sites for producing bioenergy, such as branches, low-value trees, and residues left on the forest floor after harvest, fires, or insect infestation, or piles of slash left at the roadside. There is also interest in growing or harvesting trees specifically for bioenergy purposes.

Why is there interest in forest bioenergy?

As energy prices have fluctuated, and as concern about climate change has grown, companies and governments have looked increasingly to bioenergy as an economic and environmentally friendly alternative to fossil fuels as well as for energy security. Recent low forest product prices and financial difficulties faced by the forest sector have also led to calls for increased use of forest biomass for production of a range of bioproducts including bioenergy as additions or alternatives to traditional forest products. The transition to a bioeconomy has led to increased interest in higher value bioproducts that can improve the bottom line, such as biochemicals and biomaterials that can substitute for similar products made from fossil fuels and that are often coproduced with bioenergy. There are also opportunities to increase bioenergy production by using new conversion technologies that better capture the energy in forest product residues.

Trembling aspen (*Populus tremuloides* Michx.).

Forest bioenergy as an offset to fossil fuels

Forest biomass is a renewable source of feedstock for energy production. As long as the forest biomass comes from a sustainably managed forest and is replaced (that is, renewed) over time through regrowth, the GHG emissions from the production of bioenergy can be considered to offset—at least to a large extent—fossil fuel emissions. This is because, as part of its biological cycle, carbon is taken up by trees and becomes forest biomass that eventually dies, decays, and releases carbon that is in turn taken back up by renewed forest growth. Converting the biomass to energy effectively captures the carbon energy. Although this conversion does emit carbon dioxide and other GHGs into the atmosphere, it also replaces the use of fossil fuels and their carbon emissions. So using forest biomass provides energy and, at the same time, the forest continues to grow and recapture most of the carbon dioxide emitted by this energy production; however, this recapture takes at least as long as it takes the forest to regrow to the size it was when cut. Because forest bioenergy has a lower energy content than fossil fuels, in the short run it can actually generate higher CO_2 emissions than fossil fuels. But over time there is a net benefit to the atmosphere because the forest is renewable; hence bioenergy is an effective way to reduce net GHG emissions. The time period over which the benefit is realized depends on the type of fossil fuel being replaced, the conversion technology used, forest growth rates, and what the alternative use and life cycle of the wood or residues would have been if not used for bioenergy.

Does it make sense to increase forest bioenergy production?

Forests are used by humans for a range of products and services, from traditional forest products such as lumber for houses and paper for newspaper, to parks and wilderness and other environmental services. The increasing interest in forest bioenergy raises several questions.

We need to consider how much forest biomass can be removed from a site before it adversely affects the environmental sustainability of the site, including its productivity. Forests are a renewable resource, and many rules and regulations are in place to ensure that they are harvested responsibly and then fully regenerated. Historically, only the tree trunks were removed from a site in stem-only harvesting systems—the rest of the biomass would decay over time on the site and replenish the nutrients and soil and provide food and habitat for a diverse range of organisms and animals. All above-ground parts of trees are now often harvested in full-tree harvesting systems, with branches and tops left at the roadside. Optimizing biomass use may lead to increased full-tree harvesting. In Nordic countries, the U.K., and parts of the U.S., however, productivity losses have been found after the intensive removal of forest biomass. Scientists in Canada and elsewhere are now looking at how much biomass in addition to trunks can be removed on an on-going basis on different kinds of sites so that guidelines can be developed for forest managers. Initial results from Canadian research indicate that the amount of additional biomass that can be removed from sites varies, depending on many factors including soil type and depth, and climatic conditions. Researchers are also exploring the feasibility of growing trees in plantations explicitly for wood energy use. As energy prices increase and technology advances, energy plantations and intensive forest biomass removal from harvested sites as sources of biomass for energy are likely to become more economical.

What is the best use of Canada's forest?

Perhaps the more challenging question is, what is the best use of the forest? Should we increase use of the forest to produce more of the traditional forest products (that are often more climate change friendly than alternatives), set it aside to use it to store carbon, use it for more bioenergy to offset fossil fuel use, or some combination thereof? Foresters have always had to make

Is it better to use salvaged wood for bioenergy or to let it decompose in the forest?

It is predicted that more than twice as much dead wood will be produced from Canadian forests killed by fires or insects than from harvesting residue, although not all of this may be readily available. Dead wood left on sites that have been harvested or disturbed by forest fires or insect infestations will decompose, which releases carbon dioxide into the atmosphere. Intuition might suggest that it is better to salvage this dead wood and convert it into bioenergy instead, thus releasing the carbon into the atmosphere rapidly rather than slowly through decomposition; however, this depends on the time frame. Forest-based bioenergy generally has a lower energy content than fossil fuels and emits more GHGs per unit of energy produced than energy generated from fossil fuels (at the time that the fuel is converted into energy.) Salvaged wood used for bioenergy therefore offsets fossil fuel use but results in higher immediate carbon emissions. In the short term, there are therefore fewer emissions if dead wood is left in the forest to decompose slowly. But bioenergy will always result in lower net emissions over a longer time period (which can be decades) because some fossil fuel use has been "permanently" offset by using the biomass that was going to decompose anyway. The break-even point will be sooner if fast-decaying biomass such as harvest residues are used instead of large logs, if biomass is converted into energy at higher efficiencies, and if the technology that is being substituted has a high GHG emission rate per unit of energy produced (for example, heating oil compared with natural gas). The break-even point will also be delayed if advance regeneration is lost in salvage harvesting, and will depend on the amount of regeneration lost and its stage in succession. The practice of burning left-over harvesting residues on-site or at the roadside for waste disposal is a poor use of biomass because the carbon is released immediately, without capturing the energy content to offset fossil fuels.

Regardless of the energy source, a full life-cycle accounting of all carbon emissions and sequestration, from initiation through to final consumption, is required if different energy sources are to be compared for their net effects on atmospheric carbon per unit of energy produced.

decisions that balance the various demands on the forest. These decisions have become increasingly complex as governments decide how best to use public forest lands for the benefit of all, taking into account an increasingly broad array of uses and values. In general, using the by-products of industrial processes for bioenergy purposes (that is, the current situation) makes both economic and environmental sense. But evaluating and then balancing different uses of the forest, including whether to increase the removal of biomass for bioenergy, make for a complicated equation for which there is no one right answer that covers all situations. The answers will depend on society's values, local conditions, and the various economic, social, and environmental impacts of both current and alternative uses of the forest.

Why are wood pellets exported to Europe rather than used in Canada?

Wood pellets are made of ground and compressed wood fiber (usually from sawmill waste) and can be burned in a variety of ways to produce energy. Nearly 85% of Canada's pellet production, which is equivalent to approximately 1.3 million t, is exported (less than 1% of Canada's forest sector exports by value). This is because, in contrast to Canada, many countries in Europe do not have abundant supplies of fossil fuels and are therefore diversifying their energy mix so that they will be less reliant on countries such as Russia from whom they purchase natural gas for power production. Also, residential electricity prices in Europe are commonly double what we pay in Canada, making bioenergy a more competitive source of heat and power. Finally, bioenergy is an important part of the EU strategy for meeting its GHG emission reduction targets, and many member countries have established policies to expand bioenergy use; for example, under EU policy, utilities that incorporate biomass into their fuel supply may obtain carbon credits for producing bioenergy. High energy prices, energy security concerns, and climate change concerns that have led to renewable energy requirements and carbon trading have all contributed to a willingness by European countries to pay much more for wood pellets than the price in Canada.

Wood pellets are used to generate energy from renewable resources.

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