**Forest Biomass Harvesting for Energy: Recommendations for Nova Scotia**
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## SUMMARY

If biomass from the forest is to be a sustainable energy source, it is imperative that

1. the forest ecosystem, including soil productivity and wildlife habitat, is maintained, and
2. carbon loss from harvested sites, especially from the soil, is minimized.

Burning wood to produce energy is not inherently detrimental, and can in fact provide environmental benefits over the use of fossil fuels. The crucial issue is deciding what is safe to remove from the forest to fuel biomass energy production. The available science is clear that stand-wide whole-tree harvesting (*i.e.*, removing branches, tops and foliage as well as stem wood) and removal of deadwood has significant detrimental impacts on soil nutrients, wildlife habitat and forest carbon storage. The straight-forward way to avoid these threats to forest sustainability is to leave the tops and branches of harvested trees in the forest, along with standing and fallen deadwood.

Existing forestry guidelines and regulations recommend against removing tops, branches and deadwood from the forest due to the threats to forest sustainability. These include the Department of Natural Resource's Code of Forest Practice, Nova Scotia's Wildlife Habitat and Watercourse Protection Regulations, Forest Stewardship Council Standard for Certification in the Maritimes, and the Canadian Standards Association's standard dealing with woodlot certification (Z804-08). Biomass harvesting guidelines developed by the Province must recognize the consequences of whole-tree harvesting and deadwood removal by not allowing their general use in forest harvesting.

## INTRODUCTION

The pressure to develop non-fossil fuel energy sources increases the popularity of burning 'waste' forest biomass, such as branches, tops and otherwise unmarketable trees to produce energy. Indeed, wood has the potential to provide a relatively green, local and potentially carbon-neutral energy source. Wood can be burned to produce electricity, to heat residential and industrial facilities, and to derive products to store and transport energy (such as ethanol or bio-oil). Examples from Europe demonstrate that communities can achieve energy self-sufficiency with the use of small biofuel co-generation power plants.[1] In the Maritimes, fossil fuels may be replaced as existing companies introduce biomass energy into their power supply, as home owners switch to wood-based heating, and as new companies emerge to create wood pellets and other products to supply the growing demand for biofuels.

However, the aggressive harvesting of biomass from forests poses a fundamental threat to the health and productivity of forest ecosystems. Much of the material proposed to be removed from the forest as

biomass (tops, branches, foliage and decayed wood) plays a critical role in soil fertility, soil structure, carbon storage and wildlife habitat. In terms of sustainable forest management, leaving tree tops, branches and foliage (logging slash) in the forest, along with maintaining standing and fallen dead trees, are two of the easiest and most effective actions forest managers can take to promote biodiversity and sustain a healthy, resilient and productive forest.[2] For these reasons, forest certification requirements (such as under the Forest Stewardship Council or the Canadian Standards Association) discourage biomass harvesting. Nova Scotia's Code of Forest Practice, developed by the Department of Natural Resources, discourages biomass harvesting because of its adverse effects on forest productivity and wildlife habitat. Furthermore, Nova Scotia's Wildlife and Watercourse Regulations, which is mandatory on both private and public land, require that standing dead trees and as much large woody debris as possible be left. These standards and regulations exist because of the direct dependence of soil productivity and wildlife habitat on fine and coarse deadwood.

Nova Scotia's native forest, the Acadian Forest, is already highly degraded and depleted. It is classified as one of North America's most endangered forests.[3] Allowing and encouraging a market for forest biomass, unless carefully regulated as recommended in this report, will undoubtedly accelerate the degradation of our forest, reducing both the economic and ecological value of our forests for the next generation. Experience gained from European forests demonstrates the need for a conservative approach to biomass harvesting. For example, in the whole of Europe, species that depend on deadwood make up the largest single group of species at risk.[4] Furthermore, research in Finland found that forest productivity following biomass harvesting dropped by approximately 10%.[5] Soil specialists with the Canadian Forest Service (Peter Salonius and Taumey Mahendrappa, retired) recommend an extremely cautious approach to removing tree tops, branches and deadwood from the forest, suggesting that removing these from the forest inevitably damages forest health, for which future generations will pay.[6]

Biomass harvesting also jeopardizes forest carbon stores by increasing the rate of carbon lost from forest soil.[7] On average, soil tends to store two-thirds of all carbon found in a forest. Biomass harvesting can cause a decline of soil carbon by over one-third at time of harvest, and a recovery time of 60-80 years.[8]

## RECOMMENDATIONS

Given the known negative consequences of removing slash and deadwood from the forest, it is the Province's responsibility to take a strongly cautious approach to biomass harvesting, and to communicate the negative consequences of biomass harvesting to the public, private woodlot owners, and the forestry industry. Note, this position paper, including the following recommendations, does not apply to the traditional harvest of firewood.

1. Whole-tree harvesting (removing the entire tree from the stump up) must not be used on the vast majority of harvesting sites on Crown lands. The Province should introduce similar regulations for private land.
2. The Department of Natural Resources must assume a responsibility to provide educational material to landowners on the detrimental consequences of whole-tree harvesting.

3. The Province must enforce regulations on wood-value optimization to ensure that high-value logs are not chipped.
4. The Province must monitor Crown land to ensure that immature stands are not clearcut for biomass.
5. The Province must enforce the Wildlife Habitat and Watercourse Protection Regulation to leave standing dead trees and as much as possible of the large woody debris on harvested sites.
6. In addition to the above recommendation, the Province must set minimum, measurable, stand-level objectives for numbers of standing dead and dying trees. The best research to date recommends a minimum of 8 snags and 8 potential nest trees greater than 25cm DBH per hectare. Minimum volumes of fallen deadwood (>10cm diameter and 2m length) should be approximately 110 m3/ha in softwood stands, 40 m3/ha in hardwood stands and 60 m3/ha in mixed wood stands. If minimum volumes of coarse woody debris are not present, harvesting must leave sufficient cut trees to meet the minimum levels.[9]
7. The Province must incorporate carbon budgeting in forest management planning on Crown Land; harvesting and silviculture activities must not result in net loss of carbon from the forest. Carbon loss from the soil must be minimized at harvest sites.
8. The Province should promote and assist bio-energy plants that (a) are co-generators (electricity and heat), (b) have appropriate technology to meet best practice air emissions standards, (c) are regionally dispersed, and (d) are tied to local production and consumption of energy.
9. Prior to creating additional capacity or expanded supply of biomass, the Province should ensure maximum efficiency of existing wood product wastes by improving technology at pulp mills and other existing bio-energy producers.
10. The Province must strive to ensure that plantations for bio-fuel be created only on under-utilized agricultural lands, and not at the expense of food production. Sewage sludge (bio-solids) could be considered as a fertilizer for such plantations, provided the sludge is free of heavy metal contamination and other environmental pollutants.
11. The Province must not provide subsidies or other incentives for biomass harvesting or biomass harvesting equipment.
12. The Province should restrict the export of raw biomass, including chips.

## BACKGROUND

### What is Forest Biomass?

The definition of biomass in current discussions in Nova Scotia includes any live or dead tree that is not generally considered to be merchantable under current product specifications. A recent article illustrates the idea that a new market for biomass would introduce a much lower standard on the quality requirement of what can be harvested from the forest (emphasis added):

> *The beauty of the idea [of biomass energy] is its ability to run on the ugly stuff; the bark, the lumber leftovers, the logs of dubious marketing quality, and <u>even the dead trees in the forest</u>. 'Why would New Brunswick want to bring in oil from Venezuela when we have 10 million tonnes of wood rotting in the forest every year?' asks George Jenkins, a research scientist at the Wood Science and Technology Centre with the University of New Brunswick.* [10]

Defining dead trees as 'waste' clearly misses the fact that deadwood plays an invaluable role in forest health, as described in the following paragraphs.

**Potential Impacts of Biomass Harvesting on Forests**

*1. Soil Productivity*

Biomass harvesting that includes removal of tree tops, small branches and foliage tends to decrease soil fertility because these materials contain the majority of a tree's nutrient stores.[11] A study in Nova Scotia shows that whole-tree harvesting (removing the entire above-ground portion of a tree) can remove 99% more nitrogen, 93% more phosphorus, 74% more potassium, 54% more calcium, and 81% more magnesium from the forest than does a conventional clearcut.[12] A similar report from Maine states that whole-tree harvesting removes 100 to 215% more nutrients from the forest than conventional clearcutting.[13] While rich sites can withstand a greater loss of nutrients without loss of fertility, soils in Nova Scotia are young and tend to have small nutrient reserves.[14] On shallow and nutrient-poor soils, several successive harvests of branch and leaf material, even in small amounts, may seriously affect nutrient availability for future growth.[15] Removing biomass during clearcut harvesting also tends to result in increased nutrient loss due to the accelerated decomposition of dead organic material, and increased rate of water run-off (which carries soluble nutrients into water courses). Long-term studies in Finland show approximately 10% declines in tree growth following whole-tree harvesting.

Beyond the direct loss of nutrients, removing deadwood and/or tree tops and branches from the forest also reduces the supply of organic matter to the forest soil. Organic matter builds soil structure, which is important for soil biodiversity, moisture retention, root growth, air flow and erosion resistance, all of which contribute to soil productivity. Due to these risks to soil productivity, numerous forest researchers have drawn attention to the serious consequences of whole-tree harvesting.[16]

The following illustrates some concerns of forest researchers:

> *"…full tree harvest methods have been flagged as problematic on many site types because of the significant removals of calcium, nitrogen and potassium in the small branches with high bark to wood ratios and the attached foliage…. Recent research results from Finland, showing 8 to 12% declines in growth rates of rotations of pine and spruce that follow full tree harvest, indicate that removing nutrient-rich slash from many forest sites would not be sustainable."* [17]
>
> - Taumey Mahendrappa (retired) and Peter Salonius, researcher scientists with the Canadian Forest Service, Atlantic Region

> *"In forests with limited nutrient capital, such as much of the forest landscape in New England, the efficient cycling of nutrients between soil, plant and forest floor is critical to maintaining healthy and productive forests…. New England forests in particular have been subject to heavy acid deposition loads and repeated timber harvest. Continuing losses of base cations [nutrients] due to these disturbances will lead to nutrient deficiencies and imbalances and subsequent declines in forest health and productivity."* [18]
>
> - Northeastern Research Station of the US Department of Agriculture

*2. Carbon Storage*

Biomass in the forest, if not harvested, tends to end up as soil organic matter, which holds two-thirds of all terrestrial stores of carbon.[19] Removing biomass thus reduces this store of carbon in the forest, due both to the removal of harvested trees and to the loss of soil carbon caused by accelerated rates of decomposition that result after a clearcut harvest.[20] A study in Maine, for example, showed that the soil of sites clearcut for a biomass harvest contained 36% less soil carbon than control sites even 17 years after the harvest.[21] Modeling of soil organic matter levels in the Acadian Forest has predicted that soil organic matter decreases for 15 to 30 years after whole-tree harvests and that it would take 60 to 80 years for those levels to recover to the pre-harvest amount.[22]

*3. Biodiversity*

Although deadwood is often regarded as wasted wood, the importance of deadwood to forest health is hard to overstate: deadwood shelters wildlife, provides germination spots for small seeds, regulates water flow, contributes to the nutrient cycle and builds soil. In short, forests need deadwood. At least one-quarter of wildlife species in the Acadian Forest depend on woody debris or dead or dying trees for habitat.[23] From beetles to salamanders to woodpeckers to bears, wildlife relies on deadwood for a place to rest, escape predators and store food. As well, numerous species of insects, fungi, bacteria, mosses, liverworts and lichens find nourishment in deadwood, gradually decomposing the wood as they feed on it.

Experience in Sweden demonstrates the potential harm to biodiversity of biomass harvesting. In 1890, distribution of woody debris in central Sweden was approximately 13 cubic metres per hectare. Intensive logging and the development of bioenergy systems reduced this amount to 0.1 cubic metres per hectare.[24] This dramatic reduction in woody debris was correlated with a rapid decline in biodiversity: some 800 species that depend on deadwood are on the country's Red List of threatened and endangered species. All across Europe, the species that depend on deadwood make up the largest single group of threatened species.[25]

## Additional Considerations

*1. Biomass Harvesting in Context of Current Practices*

Clearcutting accounts for over 90% of all harvesting in Nova Scotia,[26] which is well outside the scale and frequency of ecosystem-based management for Nova Scotia's forests. The dominant natural disturbance pattern in the Acadian Forest is driven by frequent small-scale (gap) disturbances, estimated at an average of 1% of the forest per year.[27] In the Acadian Forest, the frequency of large, stand-replacing disturbances is at least twice the age range of the dominant trees (at least 300-800 years).[28] Adding the removal of tree tops, branches and foliage to the clearcutting that is already taking place would place additional stress on these ecosystems.

*2. Forest Certification and Current Regulations:*

a) Nova Scotia's Wildlife and Watercourse Protection Regulations. These regulations are mandatory on both Crown and private land. Regulation #3 states as follows:

- Standing dead trees, fallen trees and large branches, and rotting logs are important habitat for many species of wildlife, and when decomposing, they are a source of nutrients for the next forests. When harvesting: Leave standing dead trees and as much large woody debris on the harvested areas as possible.

A Department of Natural Resources slide show[29] provides the following explanation of Regulation #3:

> "Coarse Woody Debris: Standing dead trees and large trunks, pieces of trunk and large branches left scattered over the harvested area to provide habitat for small wildlife.
>
> Role of coarse woody debris: cover for small animals; habitat for insects, lichens, mosses; moisture retention and soil improvement; nutrient cycling.
>
> The Regulations require: Leave standing dead trees and unmerchantable portions of tree trunks or branches scattered over the harvest site to the fullest extent possible. Try to match natural patterns."

b) FSC (Forest Stewardship Council) certification.[30] The following criteria from the FSC Maritime Standard restrict biomass operations:

- *Criterion 6.3: Ecological functions and values shall be maintained intact, enhanced or restored, including: (c) Natural cycles that affect the productivity of the forest ecosystem.*
- *Criterion 6.3.1: maintaining stand stucutures*
- *Criterion 6.3.2: In the exceptional cases where clearcutting is used the clearcuts must … leave clumps of live trees and an abundance of scattered standing and downed coarse woody debris.*
- *Criterion 6.3.4: explicit requirement to maintain coarse woody debris*
- *Criterion 6.5: requirement to minimize soil nutrient loss*

An auditor for FSC certifications in the Maritimes (Dr. Matthew Betts) offers "I expect that many auditors would not accept extremely high percentages of timber 'waste' removal."[31]

c) Canadian Standards Association (CSA) Standard Z804-08.[32] The interpretation of Criterion 3, Conservation of soil and water resources, states: "Because most of the nutrients in trees are contained in the leaves, needles, and branches, these tree components should be kept in the woods where the trees are growing, not piled at the roadside."

- *Criterion 7.3.2 (c) Maintenance of soil productivity: "the woodlot owner shall distribute logging debris, tops, and branches throughout the harvest area or use other means to maintain soil and forest productivity."*

d) The Nova Scotia Code of Forest Practice,[33] produced by the Nova Scotia Department of Natural Resources. The Code directly addresses the danger of biomass harvesting, as illustrated by the following passages from the Code:

> "Forest Operations can significantly affect site productivity, which is a function of nutrient and moisture availability. Some timber harvest systems can degrade a forest site through biomass removal, soil compaction, forest floor loss, and soil erosion. These impacts can lead to reduced nutrient pools and impaired moisture regimes."
>
> "Frequent timber harvests have resulted in fewer snags and less coarse woody debris, thus reducing the abundance of many species of vertebrates, micro-organisms and insects, as well as mosses, liverworts and some plants including trees."

Several of the Code's criteria implicitly discourage biomass harvesting:

- *"A forestry operator shall ensure levels of snags and coarse woody debris on all harvested sites are similar to natural patterns to the fullest extent possible."*
- *NS Forest Code 1.6.5: "Timber harvest and biomass removal from a site will remain below rates that would impair long-term site productivity."*
- *NS Forest Code 2.3.2: "Site characteristics responsible for forest productivity; soil fertility, structure and processes, will be maintained."*
- *NS Forest Code 2.3.10: "Sufficient forest biomass to maintain future site productivity will be kept on site."*

The Code of Forest Practice is mandatory on Crown lands, and is encouraged to be followed on private lands.

*3. Need for Appropriate Technology*

Investment in appropriate technology must accompany any bio-fuel development in Nova Scotia. For example, gasification of biofuels reduces air pollution and increases fuel efficiency through collection of the gases produced during the combustion of bio-fuels. These gasses can be used both as a direct heating source and as a product to store and transport energy. Bio-oil is another useful energy product that can be produced during bio-fuel combustion. Utilizing waste sludge from the pulping process at craft pulp mills is another example of how bio-fuel technology can increase energy efficiency and reduce dependence on fossil fuels.[34]

*4. Plantations or Agroforestry?*

Studies of softwood plantations in this region show that plantations tend to negatively impact biodiversity (such as snags, coarse woody debris[35]; birds[36]; amphibians[37]; herbaceous plants[38]; and bryophytes[39]). Plantations also fragment forest landscapes and can negatively impact biodiversity well beyond the boundaries of the planted stand.[40] It is clear that replacing natural forest with plantations of bio-fuel crops would be devastating for biodiversity if done beyond a very minimal portion of the landscape.

However, there is merit in pursuing an agro-forestry model of bio-fuel crops. Planting under-utilized farm fields with fast-growing bio-fuel crops, such as poplar, alder and willow, would have relatively little negative impact on biodiversity.[41] Some of these species can be coppiced, thereby eliminating the need for planting and ensuring a constant presence of roots in the soil to reduce erosion potential. Sewage sludge (bio-solids) could be considered as a fertilizer for such plantations, provided the sludge is free of heavy metal contamination or other environmental pollutants.

## Potential Benefits of a Forest Biomass Fuel Source

*1. Reduced Green House Gasses*

The most significant benefit of burning biomass for energy is its potential as a carbon-neutral energy source, as long as the harvested biomass is replaced by new plant growth that will sequester and store an equal amount of carbon both above and below ground.[42] However, careful planning is required to ensure that both the biomass burned and the additional carbon lost from the forest due to harvesting practices is entered into the carbon equation.

*2. Increased Local Energy*

Utilizing locally available energy sources makes environmental and social sense: it reduces the need to transport fuel vast distances, it gives communities opportunity to have control over local energy production, it provides local employment, and it reduces dependency on foreign fossil fuel.

*3. Reduced Air Pollution*

Bio-fuels produce less air pollutants than fossil fuels. They produce very low or no emissions of sulphur oxides and low emissions of nitrogen oxides.[43] As these pollutants cause acid rain, reducing their abundance has environmental benefits. However, secondary processing of emissions produced by biofuels is necessary. Without secondary processing, the benefits of biofuels could be offset by an increased amount of particulate matter pollution.

## CONCLUSION

Using forest-derived biomass for energy production could lessen Nova Scotia's dependence on fossil fuels, thereby realizing environmental and fuel-security benefits. However, whole-tree harvesting and deadwood removal to general bioenergy feedstock threatens to negate the benefits of forest-derived bioenergy. Specific threats include reduced soil quality through loss of nutrients and organic matter, and loss of wildlife habitat through reduced levels of standing deadwood and coarse woody debris on the forest floor. Increasing carbon released to the atmosphere is also a threat if the complete carbon cycle is not accounted for in the carbon budget of forest biomass. If the health and productivity of our forests is to be safeguarded, the Province of Nova Scotia must

create clear and conservative regulations to severely restrict whole-tree harvesting and deadwood removal.

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*"Currently, 1862 forest species [are on Sweden's Red List of species at risk]…. An examination of their habitat shows that about 60% [of these at risk species] are dependent on old or dead trees."*