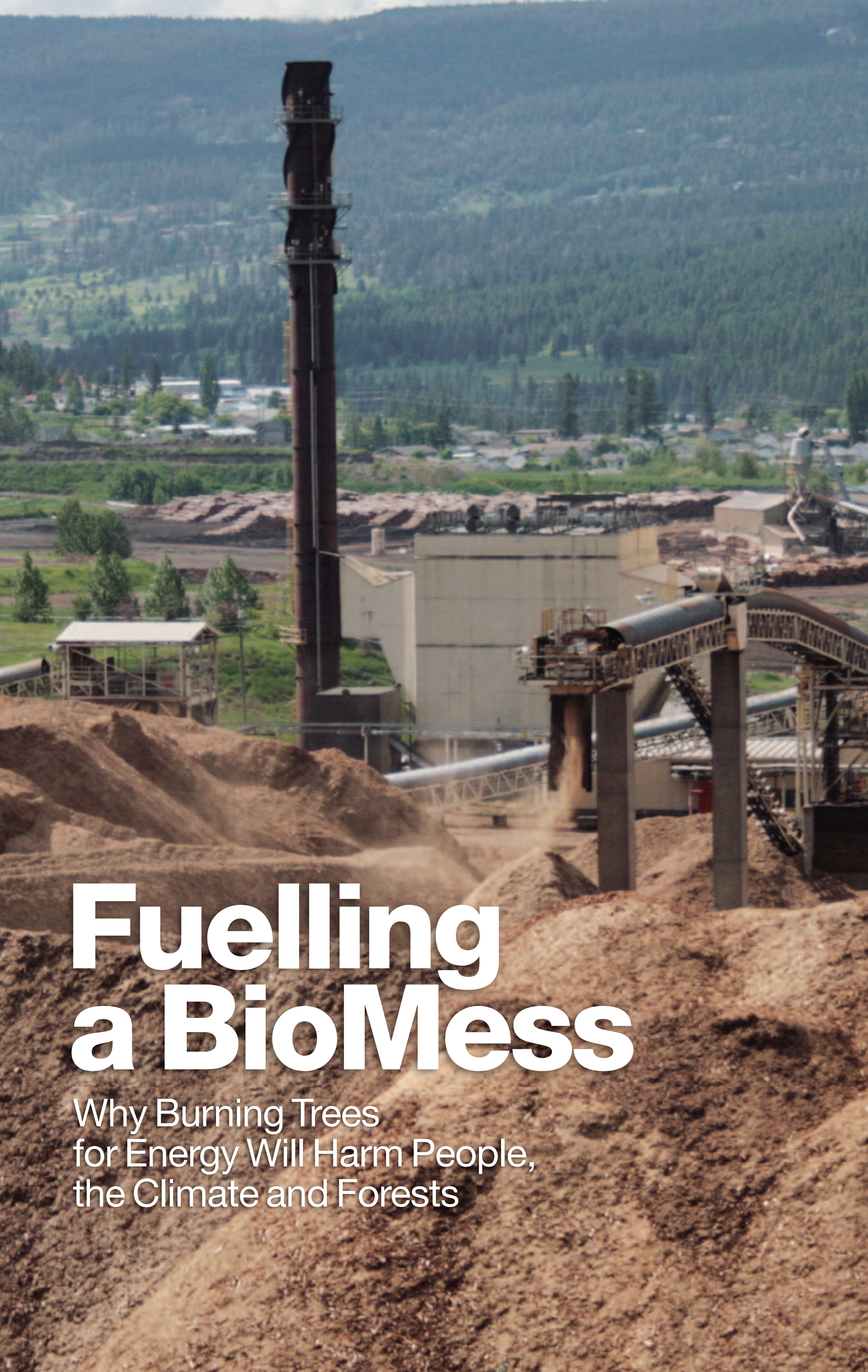

Fuelling a BioMess

Why Burning Trees for Energy Will Harm People, the Climate and Forests

www.greenpeace.ca

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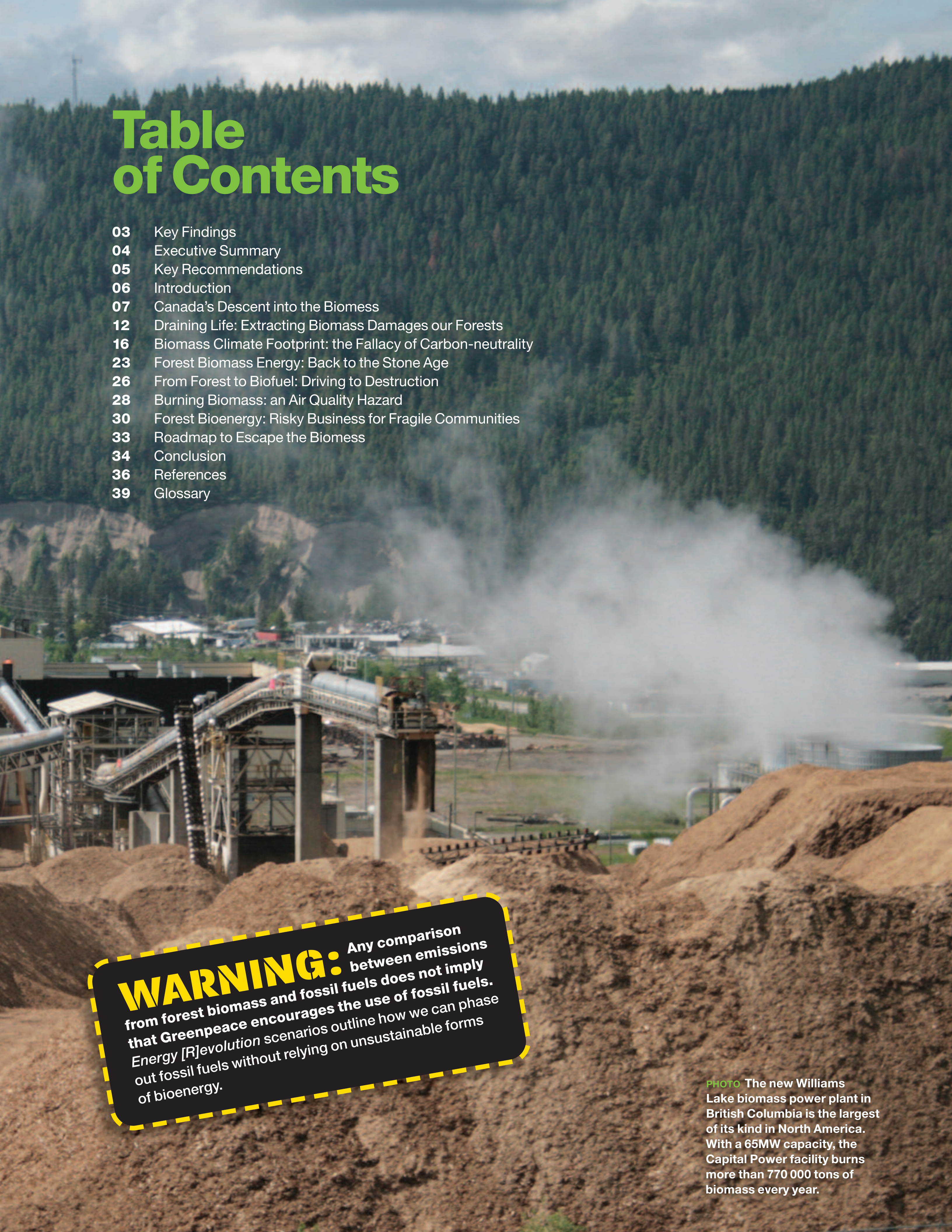


WARNING: Any comparison between emissions from forest biomass and fossil fuels does not imply that Greenpeace encourages the use of fossil fuels. *Energy [R]evolution* scenarios outline how we can phase out fossil fuels without relying on unsustainable forms of bioenergy.

PHOTO The new Williams Lake biomass power plant in British Columbia is the largest of its kind in North America. With a 65MW capacity, the Capital Power facility burns more than 770 000 tons of biomass every year.

Key Findings

PROVINCIAL BIOMASS POLICIES LEAD CANADA INTO A BIOMESS

- **Provinces have recently** opened public forests to large scale extraction of forest biomass for energy production, with neither public consultations nor adequate environmental guidelines.
- **Biomass extraction policies** include logging intact areas of forest, cutting whole trees, removing woody debris, and cutting trees in recently burned and diseased areas.
- **The amount of wood** and other tree parts cut from Canadian public forests could more than double under new provincial policies.
- **The destructive practices** that are encouraged by the forest bioenergy boom threaten the health of forest ecosystems across the country.

FALSE CLAIMS OF CARBON NEUTRALITY CONCEAL CLIMATE IMPACTS

- **Burning natural forest biomass** – whether for electricity, heat or biofuels – is not carbon-neutral as governments and companies claim. Burning trees contributes to climate change for decades, as shown by the most up-to-date science, until replacement trees fully grow back.
- **Compared to current coal-fired electricity plants** in North America, current woody biomass power plants can emit at the smokestack up to 150% more climate disrupting CO_2, 400%more lung irritating carbon monoxide, and 200% more asthma causing particulate matter to produce the same amount of energy. The CO_2 emited will harm climate for decades before being captured by regrowing trees.
- **The latest science** shows that burning biofuels derived from standing trees in southern Ontario's forests will emit more CO_2 emissions than using gasoline for well over a century.
- **Burning boreal biomass** contributes to climate change through a long carbon payback time due to the slow regrowth of forests and the fragility of existing carbon stocks.
- **Federal and provincial governments fail** to account properly the CO_2 emissions from forest bioenergy production by using the simplistic assumption of carbon neutrality. In truth, CO_2 emissions from biomass burning - about 40 megatons annually in Canada – are roughly the equivalent of Canada's 2009 light-duty vehicules emissions.

SIGNIFICANT FOREST BIOENERGY PRODUCTION WILL LEAD TO AN ENVIRONMENTAL FIASCO

- **In 2008, only 3.4% of Canada's** total primary energy production came from burning wood in power plants and heating systems, but this required an amount of woody biomass equivalent to all the wood cut in Manitoba, Ontario, Québec and New Brunswick for the same year (47 million m^3).
- **If it ran at 100% capacity,** a small 30MW biomass power plant would burn more than 470 000 tonnes of wood annually, an amount equivalent to clearcutting 10 soccer fields of Canadian forest everyday.
- **Providing 15% of Canada's** electricity production from forest biomass would require burning more than the equivalent of all the trees that were cut nationwide in 2008 (147 million m^3).
- **More than 560,000 trees** would need to be cut every single day to provide the biofuel (E85) needed to run all of Canada's cars. Annually, this would mean doubling the amount of wood extracted from Canadian forests.
- **Wood pellet exports** from Canadian forests to Europe were around 1.2 million tonnes in 2010, a 700% increase in less than 8 years. Canadian pellet production capacity is expected to increase ten-fold by 2020.

FOREST BIOENERGY NEEDS TO STAY SMALL-SCALE

- **Large forest bioenergy operations** are unprofitable without significant government subsidies and provide as much as 80% fewer jobs than "traditional" forestry.
- **Using mill waste and residue,** such as sawdust and non-commercial wood chips, to replace fossil fuels for local, small-scale heating systems is the most efficient use of woody biomass.

Executive Summary

The global bioenergy boom is driven by a surge of interest in biological materials – or biomass – to produce heat, electricity and fuels. In a world of declining fossil fuel deposits and rising fuel prices, industries and governments are hastily switching back to an ancient source of energy: trees. In Canada, forest bioenergy once referred to a sensible, small-scale and local solution to produce heat and power by using mill and pulp residues at the plant. This is no longer the case.

Now, the sector is rapidly developing into large-scale, industrial use of natural forests for energy. This is due to new government biomass extraction policies and subsidies. Without public hearings, exhaustive science or adequate environmental standards in place, provincial governments have allocated large volumes of biomass from publicly owned forests to be burnt, thereby radically changing the way forests are used in Canada. This is turning to ash sustainable job opportunities, threatening the greening of the forest sector and the value-added product trend that has been emerging in recent years.

The premise on which the forest bioenergy industry is based – i.e. that woody biomass is infinitely available and that burning it is clean and carbon neutral – does not stand up to scientific scrutiny and needs to be revisited. Exploiting forests for energy increases carbon emissions and contributes to climate change for decades, even centuries, before proving to be better than fossil fuels. The Canadian government has failed to report those emissions. Accounting properly for the climate footprint of forest bioenergy is crucial if governments really want to tackle climate change and meet greenhouse gas reduction targets by 2020 and 2050. Large-scale combustion of wood is also a health hazard due to significant toxic emissions of fine particulates, carbon monoxide and heavy metals.

Because enormous amounts of forest biomass are needed to produce small amounts of energy, drastic ecological impacts on forest health and biodiversity are expected if the “green gold rush” continues along its current trajectory. This report shows that forest biomass cannot and should not replace fossil fuels on a large-scale. Electricity production from forest biomass is inefficient, while transforming trees into biofuels for transportation will mean impacting vast areas of forests.

There is an urgent need for provincial policy makers to reassess the perceived environmental benefits of forest-based bioenergy and its role within Canada’s energy portfolio. In a series of recommendations, Greenpeace aims to set the forest bioenergy sector back on track by highlighting the importance of focusing on industrial leftovers rather than relying directly on forests. This report can help policymakers realign forest bioenergy development in Canada and elsewhere before plunging the forest industry into a new environmental controversy.

Key Recommendations

PROVINCIAL GOVERNMENTS SHOULD:

- **Suspend the approval** of new bioenergy proposals and conduct a review of existing projects, their wood allocations, and their impacts on communities, climate and forests;
- **Prohibit whole-tree harvesting** and exclude standing trees from what is currently defined as "biomass;" whether commercial, non-commercial, burned or diseased, standing trees should not be used for energy;
- **Prohibit sourcing** from intact forests and forests with high carbon stocks or high biodiversity values;
- **Abandon the illusion** of carbon-neutrality, perform full and independent life cycle analyses of forest bioenergy projects to avoid underestimating carbon output and track carbon emissions every year to take into account the "carbon payback time" of bioenergy projects;
- **Preclude low-efficiency** electricity-only production from forest biomass and require that waste heat of biomass electric plants be utilized locally;
- **Given the limited potential role for bioenergy,** scale up energy alternatives like efficiency programs and wind, solar and geothermal energy;
- **Ban any cellulosic biofuel production** coming directly from natural forest biomass;
- **Support the production** of higher value wood products from public forests to optimize job creation, minimize resource extraction and develop sustainable solutions for forest-based communities.

Introduction

In an attempt to escape from our addiction to fossil fuels, policy-makers have begun to look to new sources of energy. In the past decade, a laundry list of living matter – trees, logging slash, agricultural crops, grasses, peat, algae, etc., otherwise known as biomass – has been targeted as potential alternative sources for the generation of heat and electricity, as well as feedstock for the production of biofuels. In a vast country like Canada, where forests cover more than 41 per cent of the landbase[1], a multibillion dollar forest biomass for energy – or "bioenergy" – industry is emerging[2]. The use of forest biomass for heat and power is already widespread in Canada, the United States and the European Union. Biofuels from wood – i.e. cellulosic ethanol or second generation biofuel – still face technological limitations and high costs. With new technologies and investments, however, forest biofuels might become a major player in the years to come.

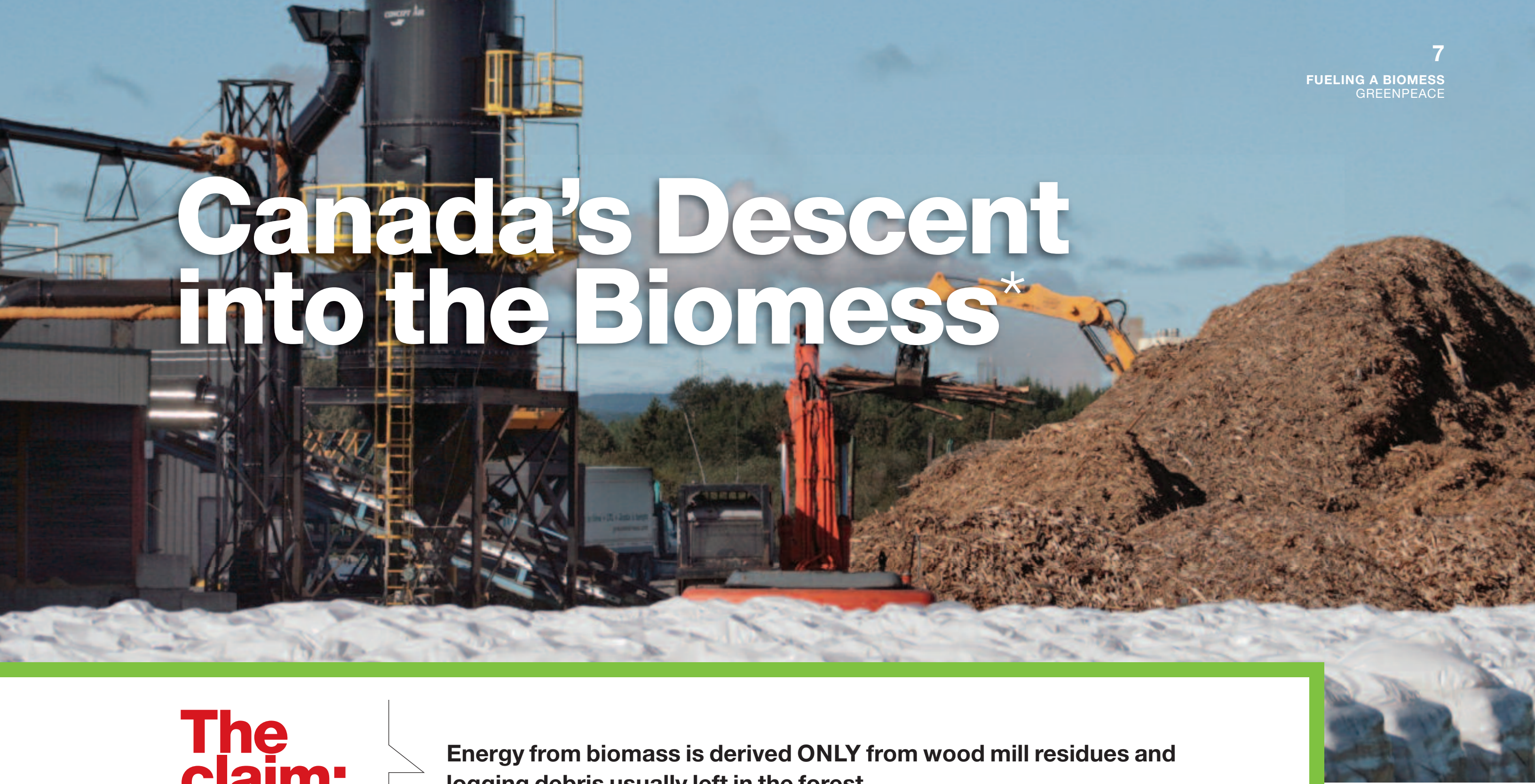
Greenpeace and the forest bioenergy boom

Greenpeace, like many environmental groups around the globe, has long recognized the role that certain types of biomass can play in the renewable energy portfolio. However, in its *Energy [R]evolution* reports, Greenpeace shows that, worldwide, only specific sources of biomass can be beneficial for the environment and only following strong environmental guidelines[3]. In the case of forest biomass, processing residues from sawmill, pulp & paper plants and discarded wood products are the only feedstocks used in the *Energy [R]evolution* scenarios. The ongoing trend to source directly from natural forests is not supported. We believe that the bioenergy sector is damaging its future acceptance by not acknowledging the upfront "carbon debt"generated by burning trees for energy, and other significant environmental side-effects such as biodiversity loss and air pollution.

Why a green gold rush?

Many factors drive the rush towards producing bioenergy from forests:

- Increased oil prices and fewer easily accessible oil deposits;
- Attempts by the forest industry to diversify its products and markets;
- A push for development of second generation biofuels from cellulose;
- Substantial subsidies from governments;
- Loopholes in the bioenergy regulations, policies and carbon accounting framework;
- Well orchestrated greenwashing campaigns by governments and industry.



Canada's Descent into the Biomess*

The claim:

Energy from biomass is derived ONLY from wood mill residues and logging debris usually left in the forest.

The reality:

Canadian provinces are diving into a "biomess" by opening the door to large scale clearcuts, salvage logging and highly damaging extraction practices that could double the forest industry's footprint on already damaged forest ecosystems. Whole trees and large areas of forest are being cut to provide wood that is burnt for energy.

*"The objectives of this policy are […] to improve the utilization of forest resources by encouraging the use of forest biofibre for the production of energy […] Forest biofibre includes tree tops, **cull trees or portions of trees, individual and stands of unmerchantable and unmarketable trees, and trees that may be salvaged as a result of a natural disturbance.**"*

ONTARIO'S MINISTRY OF NATURAL RESOURCES, 2008[7]

PHOTO **This pellet plant in Quebec uses full trees for combustion. Pellet producers across Canada use up to 70% raw material from forests for their pellet production.**

Traditionally, forest biomass has been used by the forest products industry itself, where mill and pulp plant leftovers (bark, saw dust, wood chips, pulp black liquor, etc.) are burned for heat or electricity production at the plant or sometimes sold to the electricity grid[8]. However, the current slump in the forest industry sector has resulted in a sharp decline in mill residue production. The competition between biomass manufacturers continues to increase along with escalating demands for additional sources of forest biomass for energy. In an attempt to diversify the forest industry product portfolio, many Canadian provinces have established new biomass sourcing policies in public forests[7-15].

Without the benefit of public hearings or environmental impact assessments, new regulations in provinces such as British Columbia, Ontario, Québec and Nova Scotia have prematurely opened the door for forest biomass extraction for energy. This switch from wood-manufacturing based to forest-based energy production represents a drastic shift in the way forests are used in Canada and is rapidly evolving into a destructive, industrial-scale practice.

* The term "biomess" is increasingly being used in the environmental movement and the scientific community. It was originally introduced in Mitch Lansky's book *Beyond the Beauty Strip: Saving What's Left of Our Forests* in 1992[4] and has since been used in many publications[2,5-6].

THE FOREST SECTOR HAS TRADITIONALLY USED INDUSTRIAL LEFTOVERS TO PRODUCE ENERGY (HEAT AND/OR POWER) LOCALLY, BUT THIS IS CHANGING RAPIDLY

WOODY BIOMASS

FOREST BIOMASS MADE AVAILABLE BY NEW EXTRACTION POLICIES IN SOME CANADIAN PROVINCES COMPARED TO ANNUAL CONVENTIONAL HARVEST AND THEIR POTENTIAL CUMULATIVE FOOTPRINT

Province	"Traditional" Wood harvested in 2008-2009 (m^3/y)[1]	Biomass made available by new harvesting policies (m^3/y)	Potential biomass extraction compared to "traditional" logging (%)	Cumulative potential area footprint* (ha/y)
Ontario[10]	12 039 000	11 000 000**	89	177 000
Québec[13]	23 718 000	16 800 000***	71	176 000
British Columbia[14]	61 805 000	52 000 000****	85	231 000
Nova Scotia[16]	4 883 000	6 500 000	135	52 000
Alberta[15]	19 736 000	9 500 000	49	84 000

* Areas impacted by logging per province in 2008 are reported in the State of Canada's Forest report[1]. This estimated area footprint supposes that only 50% of biomass extraction will impact areas other than those already impacted, while the other 50% will be extracted from the same areas where logging is already occurring thus having no additional area footprint. In non-traditional areas (non-commercial stands, burned areas, etc.), a higher average of 300 m^3/ha is used rather than the pan-Canadian average of 202 m^3/ha[1] since branches and tree tops are also extracted.

BIOMASS HARVESTING POLICIES ACROSS CANADA HAVE OPENED THE DOOR TO EXTRACTING ALMOST EVERYTHING THAT GROWS IN THE FOREST

WOODY DEBRIS

NON-HARVESTED COMMERCIAL WHOLE TREES (BACKLOG)

NON-COMMERCIAL WHOLE TREES

BURNED OR DISEASED TREES

AREAS SUSCEPTIBLE TO NATURAL DISTURBANCES

TREES CUT IN PRE-COMMERCIAL THINNING

** See: New Competition for Wood Supply in Ontario. In June 2011, more than 4 million cubic meters were directly (pellets, biofuel) or indirectly (power plant, CHP) allocated for bioenergy projects.

*** Excluding all volumes from salvage logging in burned or diseased areas.

**** Including 20,500,000 m^3 annually from Mountain pine beetle infested areas over 20 years.

Exporting the biomess

In 2010, Canada, with 33 pellet production plants across the country, was the fourth largest wood pellet producer after the US, Germany and Sweden, and the second largest exporter[8]. Exports of wood pellets from Canadian forests to the Netherlands, the UK and Belgium were around 1.2 million tonnes in 2010, of which up to 70% came directly from raw forest material[8]. Exports to Europe have undergone a 700% increase in less than 8 years. Canadian pellet production capacity is expected to increase ten-fold by 2020[8]. This bioenergy boom continues, even though a recent Life Cycle Analysis of these exports[18] shows that 40% of the pellets' energy content is expended during transformation and transportation before reaching its destination in coal co-firing plants across Europe. New power plants are springing up, while others are being converted from coal to pellets. For example, the Tilbury plant (UK-RWE npower) will be converted to burn wood pellets and according to an independent estimate, will burn nearly 7 million tonnes of per year [19]. The company RWE have suggested that less than 2 million tonnes per year would be burnt[212], but under any circumstances, they will become one of the world's largest pellet power plant, importing wood pellets from Canada's forests and elsewhere.

PHOTO This coal power plant in the Netherlands is co-firing coal with biomass from Canada.

Ontario's switch to burning forests for energy

In 2009, the Ontario government put forward a Staged Competition for Crown Wood Supply to implement the "forest biofibre directive." 11 million cubic meters were made available, ⅔ of which would come from unharvested, commercial, full trees in low wood market years[9-10], meaning that trees that would have previously been selected for pulp, paper or lumber production will be cut for bioenergy production. When coupled with ongoing logging, extracting these volumes of wood and other biomass would impact about 177,000 hectares of forest every year, or an average of 683 soccer fields per day*. The main goal of the forest biofibre directive, published in 2008, was to "encourage the use of forest biofibre to reduce Ontario's dependence on fossil fuels and reduce energy costs through the development of bioenergy and biofuel projects"[7]. 131 Canadian and International companies proposed 143 facilities (55% for wood pellets)[21]. By June 2011, more than 4 million cubic meters were allocated to projects directly (pellets, biofuels from forest biomass) or indirectly (power plant, CHP from industrial leftovers) producing bioenergy[22]. Among the main allocations for bioenergy was 280,000 cubic meters of whole trees to be chipped and pelletised annually by Atikokan Renewable Fuels Inc. Atikokan Renewable Fuels will potentially feed the new Atikokan biomass power plant, announced in November 2010 to be retrofitted from burning coal to burning pure forest biomass[23]. The 210 MW power plant will burn approximately 1,250,000 tonnes of wood annually (if running half time). Other projects include 620,000 cubic meters from whole trees for a pellet plant in Thunder Bay and 1,150,000 cubic meters of wood for cellulosic biofuel in the Sault Ste-Marie area[22].

* An average soccer field is 7140m² or 0,714 hectares

PHOTO **Naturally disturbed areas like burned forests have become a focus for biomass promoters due to new provincial biomass extraction policies.**

"Forest biomass available in Québec is divided into two types, where 55% are full standing trees (either not marketable ***or not harvested*** *by the forest industry) and 45% are tree tops and branches".*

MINISTÈRE DES RESSOURCES NATURELLES ET DE LA FAUNE DU QUÉBEC, 2009[12]

Although most promoters of bioenergy, including government agencies, insist that forest bioenergy draws on forest "waste", forest biomass is sourced from virtually *everything* in the forest (with the exception of tree stumps) that is not used to make a piece of paper, a 2 X 4 or other traditional forest products.

THE GREEN GOLD RUSH

To ensure that biomass industry stakeholders would invest in this risky new sector, governments have had to guarantee a stable supply in a time when mill residues are decreasing due to a market slump in the traditional forestry sector. By opening the door to harvesting non-merchantable trees (eg. diseased trees, species with lower economic value, trees with uneven shapes, etc.) and other new feedstocks, the amount of biomass made available has soared to unprecedented levels. With volumes allocated to biomass almost equivalent or even higher than "traditional" wood harvested in 2008-2009, new biomass harvesting policies could double the industrial footprint in forest ecosystems. To date, no province has cut the maximum volumes, mostly due to lack of facilities and remaining economic obstacles[8].

Because this is a financially risky and new sector, low-cost, low-quality and damaging practices are already out-competing small-scale and more sustainable operations. As argued by Gordon Murray, executive director for the Wood Pellet Association of Canada, profitability for pellet plants is best for facilities of 500 000 tonnes and over, where these large plants increasingly use whole trees as feedstock[17]. In Nova Scotia, logging is underway **specifically** for the purpose of supplying biomass for bioenergy. In B.C., demand for large quantities of biomass is driving the push to increase "salvage logging" in pine beetle infected forests. In Ontario and Québec, "whole tree harvesting" is underway, wherein the entire tree, including top, limbs and leaves, are removed.

The solutions:

PROVINCIAL GOVERNMENTS SHOULD:

- **Change the definition of forest biomass by removing reference to any standing tree (whether currently commercially valuable or not) in provincial biomass policies;**
- **Suspend the approval of new bionenergy projects and conduct a review of existing projects, their wood allocations, and perform environmental impact assessments on the cumulative industrial footprint (biomass and logging) on ecosystems, communities and the climate before any new approval;**
- **Hold province-wide public hearings on the use of public forests for energy;**
- **Develop province-wide and ecosystem-specific standards, guidelines and criteria based on environmental impact assessments.**

"With forestry industries in distress, and mill closures rampant, the provinces now see bioenergy as a viable socio-economic alternative to traditional forest products."

BRADLEY, 2010[8]

Draining Life: Extracting Biomass Damages our Forests

The claim: **Forest bioenergy is sustainable because it uses only forest "waste".**

The reality: **There is no such thing as "waste" in a forest. Woody biomass is key to maintaining soil fertility, forest productivity and biodiversity. Its large-scale extraction completely undermines the "renewability" of this resource and degrades the health of the forest ecosystem.**

"[…] this is a time for government policy-makers to take the precautionary path in allocating our forest biomass […]."

HESSELINK, 2010[25]

"Currently, neither provincial governments nor certification schemes offer strong standards for sustainable forest fuel production and harvesting."

LATTIMORE ET AL. 2010[27]

PHOTO **Whole-tree harvesting, where the entire tree is cut and brought to the roadside and branched, is the most expedient forestry practice for biomass extraction, but also the most damaging for our forests.**

Every year in Canada, more than 1,000,000 hectares of forest are logged, and up to 30,000,000 hectares are subject to fire or experience damage from insect outbreaks[24]. What impact will large-scale biomass extraction and increased logging have on the health of these public forests? Many forest ecologists and environmentalists have pointed out the key role that forests play in regulating hydrological cycles, preserving biodiversity, and sequestering carbon. An increase in demand for wood to produce bioenergy, in addition to the already existing demand for wood and paper products, poses a threat to forests in Canada and elsewhere[25-27].

FERTILIZER FOR OUR FOREST

Soil is key to forest productivity, nutrient cycling, forest regeneration and ecosystem stability - and biomass is, in turn, key to soil fertility[28-29]. While the bioenergy industry touts the use of "waste biomass," in fact, nature does not "waste" anything. In natural forests, tree branches and leaves or needles contain most of the essential minerals like potassium, magnesium and calcium and elements like nitrogen and phosphorus which are recycled back into soils upon decay[29-30]. Large woody debris is the main source of organic carbon for soils[31-33]. Studies show that every year in Canada's western forests, up to 90% of all nitrogen and phosphorus in top soils comes from leaves, needles and small branches[30, 34]. To ensure forest productivity and re-growth after disturbance, it is essential to maintain the flow of nutrients and organic matter within the ecosystem[28-29, 34]. This is not possible when large amounts of biomass – and the nutrients therein – are removed.

Scientific literature confirms the negative impact of forest harvesting on soil chemistry, physical roperties, nutrient cycling, forest productivity, and regeneration[31, 35-55]. For example, Paré and colleagues (2002) show that whole-tree harvesting (WTH), a practice greatly favoured by new biomass extraction practices (see box below), leads to increased nutrient losses: from 250% to 700% more than what is lost by stem-only harvesting where branches and tree tops are left on site[29].

Stupack and colleagues (2007) demonstrate that nutrient losses with WTH are in the order of 6-7 fold compared to stem-only harvesting[56]. Zummo and Friedman (2011) illustrate that intact forests contain up to 50% more surface soil carbon and 45% more soil nitrogen than clearcut areas[55]. Eriksson and Hallsby (1992) suggest that increased use of logging residues for energy could lead to lower carbon storage in forest litter and soils[57].

Other studies show that removing biomass from a forest will reduce its capacity to buffer acidity from acid rain and could lead in many cases to a decrease in productivity[27, 59-60]. As a result of past and present acid rain and logging, more than half of eastern Canada's forests already have critically acidic soils leading to decreased forest health[61]. The new biomass gold rush, coupled with traditional logging, could aggravate this phenomenon to an extent that further weakens the "renewability" argument for this source of energy. Extreme caution must be taken to ensure forest health.

MATRIX FOR FOREST LIFE

Woody biomass is an essential foundation for all forest life[63-64]. Whether as standing dead trees, coarse woody debris or living trees and shrubs, this biomass hosts and feeds the web of life by supporting bacterial, fungal, insect, bird and mammal populations[38, 40-41, 51, 65-70]. For example, in Scandinavia alone, more than 5,000 species rely directly on downed woody debris[71]. In the Canadian Boreal Forest, as in the Mixed Wood and Temperate Forests of southern Canada, this same strong connection between biomass and biodiversity shapes forest ecosystems. Its extraction has direct impacts on a wide range of wildlife.

Biomass removal, coupled with traditional logging, has direct and cumulative effects on wildlife habitat,

EFFECTS OF INCREASED WOODY BIOMASS REMOVAL

Direct effect	Indirect effects
Nutrient loss in wood removal	Wildlife habitat changes
Soil disturbance and compaction	Erosion } *altered nutrient cycles*
Regeneration of new stands	Leaching } *altered nutrient cycles*
Exposures of soil and litter	
Fire hazard – Air pollution	

From Van Hook et al., 1982[58]

Current biomass harvesting policies encourage bad forestry practices

New biomass policies in provinces like Québec and Ontario encourage whole-tree harvesting (WTH), a technique that has been criticized by the scientific community for decades because of the ecological damage it causes through impacts on nutrient cycling[25, 29, 53, 60]. Because it is cheaper, faster and more convenient to cut an entire tree, remove its branches at the roadside, use the stem for lumber and the rest (top, branches) for bioenergy, the biomass boom encourages this destructive technique[25]. As a consequence, bioenergy operations using post-logging wood debris removal methods are greatly disadvantaged compared to WTH harvesters[25]. Burned and diseased areas, such as pine beetle ravaged British Columbia or spruce budworm infestations in eastern Canada, are also increasingly becoming targets for biomass extraction despite the fact that these fragile forests need time to recover from natural disturbances[62].

PHOTO This clearcut with biomass extraction, SFI certified and operated in Nova Scotia by Northern Pulp Inc. in 2009, shows how combining logging and bioenergy can have devastating effects on the forest.

PHOTO **Logging slash is key to maintaining soil fertility and buffering acidity from acid rain.**

"Extraction of dead wood as forest fuels will decrease the amounts of dead wood in the landscape. Because dead and decaying wood has been identified as a key factor in explaining why many forest species are threatened, extraction of forest fuels may increase the threat."

JONSELL, 2008[63]

species richness and ecosystem resilience[25, 68, 72-76]. Traditional logging is already having severe impacts on certain species due to fragmentation and changes in forest structure and composition[77-94]. The removal of coarse woody debris, non-commercial trees or logging slash only increases pressure on biodiversity[64, 76, 95].

BIOMASS EXTRACTION THRESHOLD

Considering these impacts, a looming question in scientific literature is "how much biomass can be removed from a forest without impacting its productivity and biodiversity?" The almost unequivocal answer is: "it depends." Indeed, this issue is very site-specific, depending on soil fertility and fragility, biodiversity, forest stand, slope, past disturbances, harvesting techniques, etc. Where most national and international scans of biomass availability recognize that at least 50% should be left on site to ensure sustainability[96-98], research shows that some sites cannot sustainably withstand any biomass extraction at all[27, 52, 58, 60, 99-101].

These studies show that forests with shallow, sandy, poorly drained, low nutrient or very acidic soils and areas with acidic precipitations are highly sensitive to biomass removal. For these forests, the precautionary principle should drive decision-making[25]. Setting a limit of – at most – 25% removal of post-logging woody debris is necessary if forest bioenergy is to be plausibly considered green or sustainable. Since many forest ecosystems cannot tolerate any biomass removal the threasholds should be site specific.

The demand for biomass further threatens intact forests

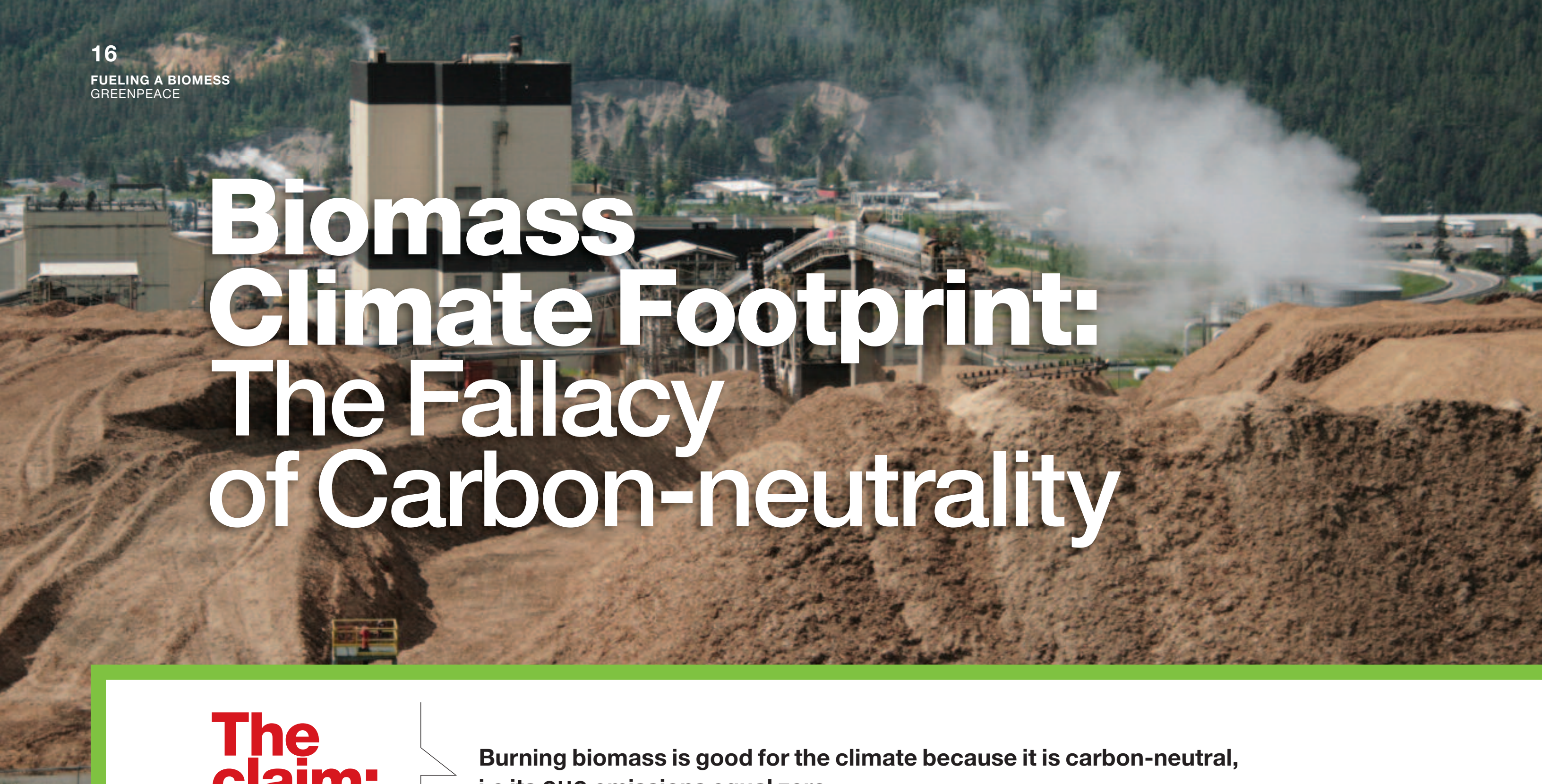
Canadian intact forests are becoming increasingly scarce and play a vital role in the preservation of biodiversity and the maintenance of climatic equilibrium[102-104]. They contain the most species-rich and carbon-dense ecosystems, and are best equipped to resist climate change[105-109]. Moreover, virgin forests are home to endangered species, such as the woodland caribou, and are of inestimable cultural value. Logging operations are moving rapidly northward, and the last remaining intact forests are vanishing at an increasing rate[110]. The biomass boom, driven by dangerously lenient extraction policies and subsidies, will increase pressure on these forests. Although biomass sourcing might not occur in remote, intact areas, policies such as those found in Ontario (see "Ontario's switch" box), will drive logging operations farther north into the last remaining intact forests to ensure supply for lumber and pulp.

The solutions:

PROVINCIAL GOVERNMENTS SHOULD:

- **Ban whole-tree harvesting (WTH);**
- **Never allow more than 25% removal of logging residues, and recognise that a lower percentage or even no removal is necessary in most cases to protect soil fertility and biodiversity;**
- **Exclude standing trees from what is being defined as "biomass": whether commercial, non-commercial, burned or diseased, standing trees should not be used for energy;**
- **Prohibit sourcing from intact forests;**
- **Prohibit sourcing biomass from forests with shallow, sandy, poorly drained, low nutrient, or acidic soils or from areas with high acidic precipitations and/or high slope;**
- **Prohibit sourcing leaves and needles, in order to avoid leaching and soil fertility depletion;**
- **Adapt management plans on a case-by-case basis to provide adequate environmental guidance;**
- **Where biomass extraction is allowed, encourage biomass collection to occur when soils are frozen, to avoid compaction and ensure that leaves stay on site.**

Science for guidance: [25, 27, 29, 48, 52-53, 58-61, 72, 99-101, 111-114]



Biomass Climate Footprint: The Fallacy of Carbon-neutrality

The claim:

Burning biomass is good for the climate because it is carbon-neutral, i.e its GHG emissions equal zero.

The reality:

Forest biomass burning emits heavy loads of CO_2 to the atmosphere while industrial biomass extraction from forests disrupts the ecosystem carbon stocks. Forest bioenergy can only achieve climate benefits after several decades, even centuries, depending on the source of biomass and the type of energy it produces.

"[…] bioenergy production is not efficient in decreasing emissions to the atmosphere in the near future."

REPO ET AL. 2011[118]

"Many international treaties, domestic laws and bills account for bioenergy incorrectly by treating all bioenergy as causing a 100% reduction in emissions regardless of the source of the biomass. They perpetuate this error by exempting carbon dioxide from bioenergy from national emissions limits or from domestic requirements to hold allowances for energy emissions."

SCHLESINGER ET AL., 2010[122]

PHOTO **Average smokestack emissions for small-sized biomass power plants in Canada is about 269,000 tonnes of CO_2 annually, the equivalent of adding 67,500 cars to Canadian roads.**

Burning wood emits a lot of carbon dioxide – typically every tonne of wood (45% moisture content) emits 1 tonne of CO_2 when burned[115]. In the US, some biomass facilities have been shown to emit up to 150% more CO_2 than they would if they were burning coal and up to 400% times more CO_2 than if they were burning natural gas for the same amount of electricity produced*[115-117].

Even in Combined Heat and Power plants (CHP), where biomass generated heat displaces that derived from fossil fuel, the carbon emissions can be as much as 200% greater than when electricity and heat are produced from natural gas[115]. Note that these figures come from measured smokestacks emissions and that they can differ greatly with more efficient technologies. A report produced by the IPCC shows that new technological pathways could improve significantly the overall carbon footprint of bioenergy projects[210].

* Of course, these comparisons are only presented as a reference point and do not imply that coal or natural gas are better solutions to the climate crisis. However, while phasing out coal is a priority, replacing it with biomass can't be presented as a better climate solution due to higher CO_2 emissions per unit of energy. Greenpeace advocates drastic phasing out of all fossil fuels in its *Energy [R]evolution* scenarios.

According to Canadian biomass facilities themselves, the average smokestack emissions for small-sized power plants (15-30MW) is about 269,000 tonnes of CO_2 per plant annually[119], the equivalent of adding 67,500 cars to Canadian roads. However, governments and biomass advocates argue that burning wood is "carbon-neutral" because the trees will grow back and eventually re-capture the carbon emitted during combustion. Some also argue that the carbon stored in biomass would have been emitted anyway through decomposition. Therefore, federal and provincial governments fail to account properly the CO_2 emissions from forest bioenergy production by using the simplistic assumption of carbon neutrality. These emissions are not added to the total emissions in the National GHG Inventory, but rather calculated only in a side memo*[120]. This implies that emissions in the magnitude of 40 megatonnes per year[120], or the equivalent of all emissions from light-duty vehicules in Canada , are being ignored by our governments.

This "carbon-neutral" assumption is considered by many scientists as a serious carbon accounting error and a growing body of literature recognizes the inaccuracy of this cornerstone and the need to address its many shortcomings[6, 55, 112, 118, 123-130] because:

1. Carbon payback time: As underlined by the IPCC, it takes many decades, even centuries, before forests regenerate and recapture the CO_2 that is released immediately upon combustion [113, 118, 129, 131-132, 210];
2. The unintended emissions from harvesting forest biomass (erosion, accelerated decomposition, etc.) further deplete forest carbon stocks, while nutrient and carbon loss slows regeneration[55, 113, 132-133];

* The memo notes that "amounts of biomass used as fuel are included in the national energy consumption but the corresponding CO_2 emissions are not included in the national total as it is assumed that the biomass is produced in a sustainable manner".

** CO_2 emissions from gasoline and diesel cars in 2008 was 41Mt[121]

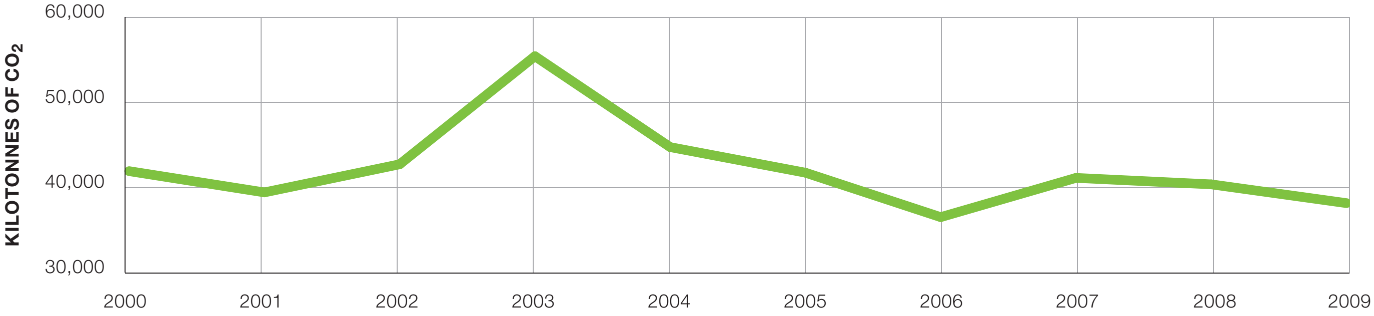
PHOTO **While carbon emissions from burning forest biomass are very high and will take decades before being recaptured by growing forests, governments still ignore these emissions and promote the illusion of carbon-neutrality.**

AVERAGE SMOKESTACK CO_2 EMISSIONS FOR DIFFERENT TECHNOLOGIES AND FUELS IN THE US

	Forest Biomass[115]	Coal[3, 115]	Natural gas[3, 115]
Electric-only power plant (kg CO_2/MWh)	1464	744-991	354-374
Combined heat and power (Kg CO_2/MMBtu)	129	–	66.1
Thermal plant (Kg CO_2/MMBtu)	129	–	62.4

Emissions from forest soil disruption and the whole life-cycle processes are not included.

GREENHOUSE GAS EMISSIONS FROM BIOMASS COMBUSTION[120] AS ACCOUNTED FOR IN THE NATIONAL INVENTORY BUT NOT REPORTED IN CANADA'S TOTAL EMISSIONS



"[…] now that we know that electricity from biomass harvested from New England forests is not 'carbon neutral' in a timeframe that makes sense given our legal mandate to cut greenhouse gas emissions, we need to re-evaluate our incentives for biomass."

MASSACHUSETTS SECRETARY OF ENERGY AND ENVIRONMENTAL AFFAIRS IAN BOWLES[142]

Factors determining the climate footprint of biomass burning

As noted by the IPCC, different forest bioenergy scenarios can lead to very different impacts on the climate[210]. These impacts can be measured through a full life cycle analysis (LCA), from cradle to grave. Generally, what will determine the actual carbon footprint of burning biomass depends on:

- Which biomass is used (industrial leftovers, logging debris, full trees, etc.);
- What would have happened to that biomass if not burned for energy;
- What type of energy it supplies/replaces;
- How efficient the energy production system is;
- What other better options exist, including conservation and efficiency and/or other pathways to produce/supply that energy; and
- How fast and to what extent the forest can re-grow after harvest, including regeneration of soils.

There is an urgent need to reassess the output potential of bioenergy and its overall climate footprint. Conducting a thorough assessment entails, at a minimum, running a full carbon balance analysis in comparison to other energy options.

3. Carbon in forest biomass stays in intact forests for decades, even when decomposing. Much of it is recycled in the soil, enabling the next generation of trees to better capture carbon from the air, while the rest is released very slowly[118, 134-135];
4. Large amounts of energy are needed to extract, transform, dry and transport biomass, thus adding to the overall climate footprint of woody bioenergy[130, 136-139].

URGENT NEED TO READJUST POLICIES ACCORDING TO SCIENTIFIC EVIDENCE

As pointed out by Johnson (2009), harvesting entire forests for fuel without accounting for any emissions defies common sense and ignores a large body of existing scientific literature[123]. Even in the 1990s, many articles described specific methods and frameworks for accounting carbon in forest bioenergy[112-113, 124, 131-132, 140-141]. One of the key methods is to track the forest carbon stock variations, which are currently entirely neglected based on the assumption that they are carbon neutral. New research shows how to include forest carbon stocks in accounting schemes[115, 118, 123, 125, 127, 129]. Leadership from governmental agencies to stop using the carbon-neutral assumption is urgently needed.

Canadian provinces should look to the State of Massachusetts, which gave a mandate to the Manomet Center for Conservation Sciences in 2009 to develop a biomass carbon footprint analysis and evaluate potential carbon policies. After discovering that carbon emissions from burning biomass for electricity would be worse than continuing to burn coal for several decades[128], the State proposed new regulations that will restrict the eligibility of biomass energy facilities for renewable energy credits[142].

Current Canadian CO_2 tracking rules for biomass ignore the "carbon payback time" and the "carbon debt" of bioenergy projects, benefiting polluters and encouraging disruption of forest carbon stocks. To tackle climate change, humankind does not have decades or centuries to spare. Immediate emission

"[…] For forests with large standing biomass and low productivity the most effective strategy (to minimize increases in atmospheric CO_2) is to protect the existing forest."

MARLAND AND MARLAND, 1992[113]

"Removal of woody biomass to be used as fuel cannot be claimed as carbon neutral, despite active regeneration of harvested forests. Changes in land associated with harvest, especially increased soil respiration, must be incorporated into carbon budget calculations".

ZUMMO AND FRIEDMAN, 2011[55]

PHOTO **The Boreal is one of the largest terrestrial carbon stocks in the world. Most of this carbon is stored in its sensitive soils.**

reductions are the key, and postponing reductions while waiting for trees to grow back is an irresponsible way to address the current climate crisis.

BOREAL BIOMASS: THE WORST CASE SCENARIO

Boreal forests already play an invaluable role in tackling climate change globally by capturing and storing enormous amounts of carbon[102]. Biomass extracted from this carbon storehouse is one of the worst biomass feedstocks on the planet due to:

- The low productivity and slow regrowth of the Boreal Forest resulting from the cold climate and long snow cover[143];
- The fact that the Boreal Forest is one of the largest terrestrial carbon stocks in the world and most of this carbon is stored in its sensitive soils[102, 144];
- The Boreal Forest's low decomposition rates[118, 145];
- The fact that traditional logging already has a large environmental footprint in the Boreal Forest, with most harvesting taking place in intact forest landscapes[102, 146].

Extracting biomass in the Boreal Forest, whether through the collection of woody debris left after logging or the removal of standing trees, will deplete forest carbon stocks[55, 133, 147-149] and dramatically accelerate carbon flow to the atmosphere when burned[118]. Such carbon would have otherwise stayed in the forest for centuries instead of being released immediately.

Salvage logging fast tracks carbon release in B.C.

British Columbia was the first Canadian province to dive into the biomess by allowing large-scale, full-tree harvesting in mountain pine beetle (*Dendroctonus ponderosae*) ravaged forests. These ecosystems, impacted by one of the largest insect outbreaks in Canada's recent history, itself due to a changing climate[155], are being cleared through salvage logging, primarily for pellet exports to the EU[8]. The provincial government estimates that more than 20 million m^3 of beetle-killed biomass will be available annually for harvest until 2020[14]. Kurz et al. (2008) suggest that more than 50 million tonnes of carbon will be taken out of B.C.'s forest through salvage logging, further depleting already impacted carbon stocks[155]. Knowing that most impacted forests will be used for bioenergy and its carbon will be released very quickly to the atmosphere through burning instead of decaying slowlyin the forest, large-scale salvage logging in B.C. might be good for the pellet business but will be disastrous for our climate and forests.

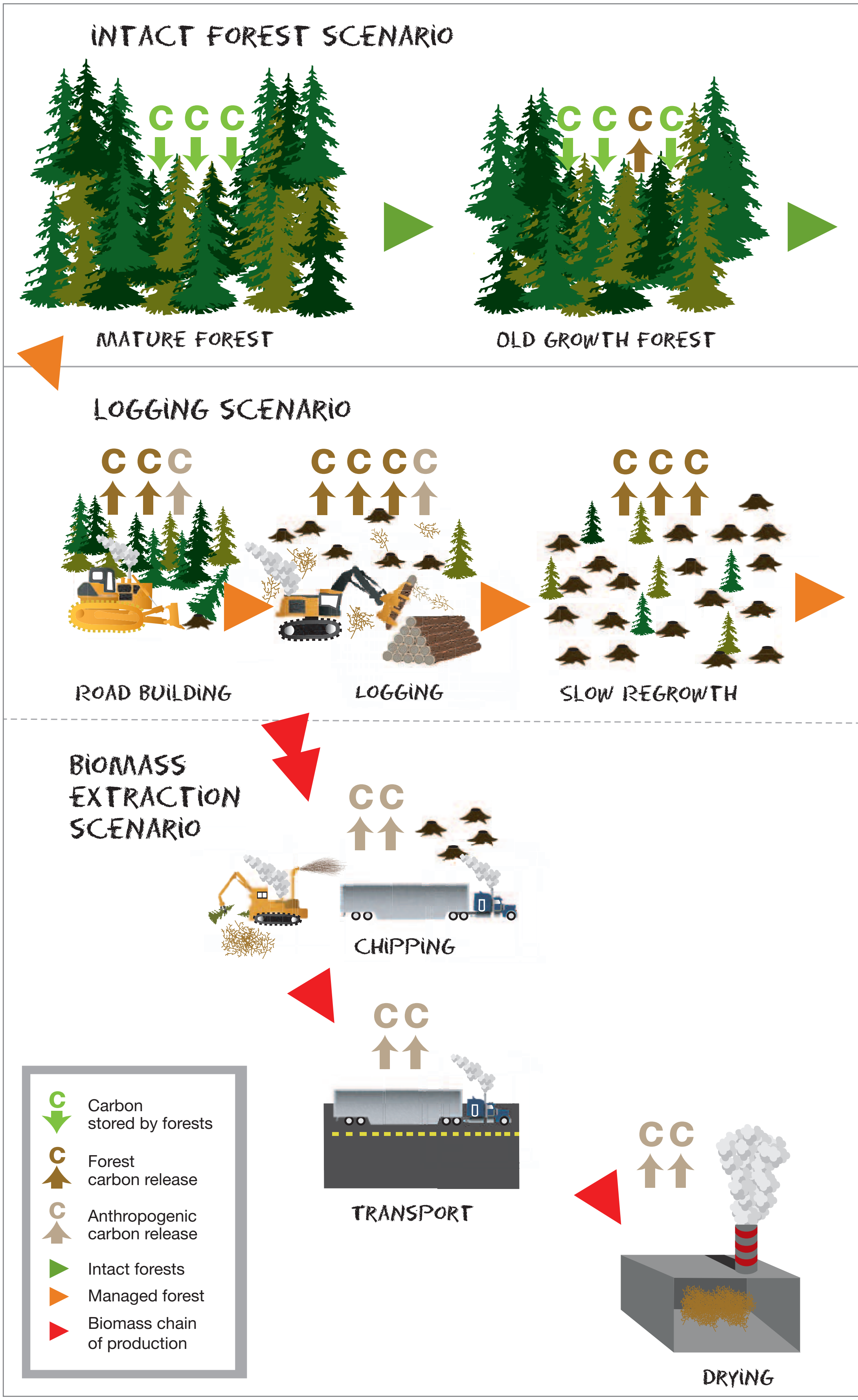
TIME CONTRAST RELATED TO BOREAL BIOMASS AND ITS COMBUSTION

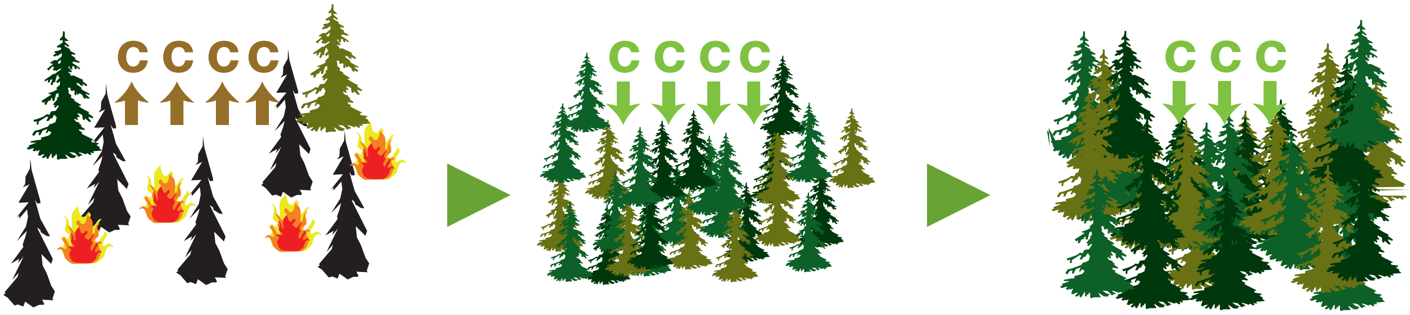
Time needed to burn one tonne of biomass in an average 30MW boiler[150*]	1min15sec
Time for a boreal black spruce to grow to harvestable level after disturbance[151]	70-125 years
Time for boreal forest carbon stock to be rebalanced after disturbance[147, 152-153]	>150-200 years
Time for a branch (1-5cm) to decompose entirely in the boreal forest[118]	>100 years
Time for a tree trunk to decompose entirely in the boreal forest[118, 154]	>120 years

* Assuming 24h production at 90% capacity

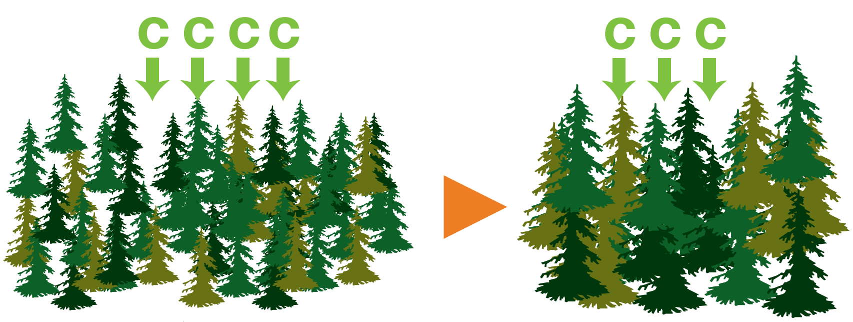
LIFE CYCLE EMISSIONS FROM WOODY BIOMASS FOR ELECTRICITY PRODUCTION

Here is an illustration of the key steps required to extract biomass from a hypothetical boreal forest ecosystem. The illustration depicts the resulting carbon flows to the atmosphere and compares the effects to an intact forest. Biogenic carbon is released to the atmosphere through soil disruption, accelerated decomposition and combustion of biomass, while every step of this cycle implies additional anthropogenic carbon release. Other steps like scarification of forest soil after logging lead to even greater carbon losses. While natural boreal forests tend to accumulate carbon over time, managed forests have diminished carbon stocks. Biomass extraction aggravates carbon loss. Carbon emitted through combustion will be recaptured by forest regrowth only decades, even centuries, after burning, thus contributing to climate change.



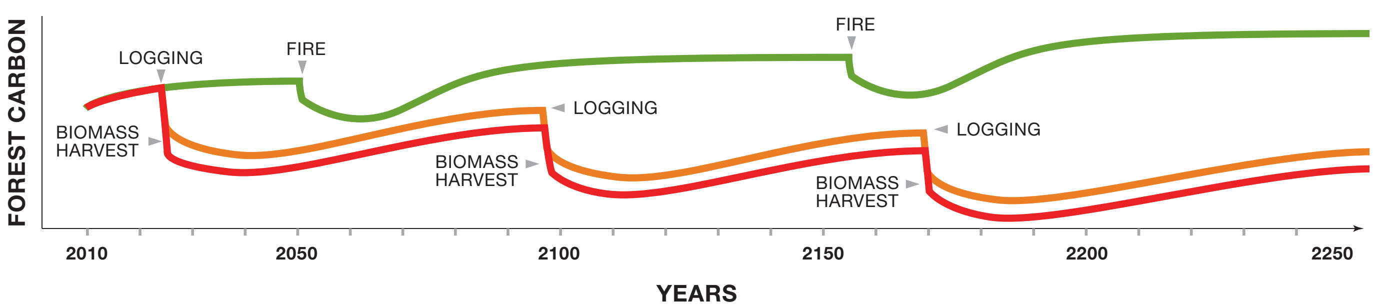


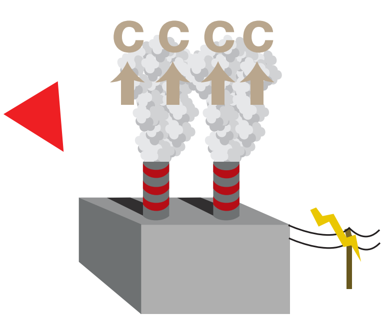
WILD FIRE — YOUNG FOREST — MATURE FOREST



YOUNG FOREST — MATURE FOREST

TIMELINE FOR EACH SCENARIOS





COMBUSTION

More than a century before burning biomass stops harming climate in Ontario

One recent study from southern Ontario – one of the most productive forests in Canada – shows how far from carbon-neutral burning trees is[129]. The study found that carbon emissions from the combustion of tree biomass pellets in a power plant will be greater than they would have been using coal, even when overlooking carbon released by disrupting forest ecosystems. The estimated time required to recapture the carbon released from pellet combustion would be up to 38 years, and full carbon recapture would not be attained for up to a century[129]. This lag time between the emissions of carbon and the recapture of that carbon in new tree growth is referred to as a "carbon debt." When tree biomass is used to produce cellulosic ethanol, the carbon debt incurred may not be offset by new growth for well over a century.

"In temperate forests, the harvest cycle can range from 60 to 100 or more years due to the relatively slow growth of forest species. It could therefore take a century for carbon stocks to be replaced […]"

MCKECKNIE ET AL., 2011[129]

The solutions:

PROVINCIAL AND FEDERAL GOVERNMENTS MUST:

- **Protect forests, particularly those with large carbon stocks like intact areas of the Boreal Forest, rather than seeking energy from them. Trees and forest ecosystems are one of the best tools to tackle climate change;**
- **Perform full and independent life cycle and forest carbon balance analyses of bioenergy projects to avoid underestimated carbon accounting;**
- **Track CO_2 emissions every year to ensure that real short-term climate impacts and long-term benefits are properly accounted for;**
- **Prioritize local use of woody biomass against exports to make sure that Canadian biomass contributes first to scaling up cuts in domestic emissions;**
- **Avoid sourcing biomass from forests with large carbon stocks and low growth rates, like the Boreal Forest;**
- **Exclude standing trees: whether commercial, non-commercial, burned, diseased or from forest thinning, standing trees should not be cut for energy because they provide much better carbon storage or capture options alive;**
- **Lengthen rotations between logging operations to ensure full forest re-growth and carbon capture.**

Science for guidance: [6, 55, 113, 115, 118, 122-123, 125-129, 131-132, 140, 156-162]

Forest Biomass Energy: Back to the Stone Age

The claim: **Biomass is infinitely available and represents one of the best alternatives to fossil fuels.**

The reality: **Given the limited amount of forest biomass that can sustainably and effectively be used to provide low-carbon energy, governments need to scale up other energy options like energy conservation, wind, solar and geothermal energy.**

AVERAGE ANNUAL CONSUMPTION OF WOODY BIOMASS PER MW IN ELECTRIC POWER PLANTS (25% EFFICIENCY)[150].

Power plant capacity	80%	90%	100%
Annual green tonnes biomass (50% humidity)/MW	11,860	13,342	14,676
Annual dry tonnes biomass/MW	5,930	6,671	7,338

PHOTO **To produce the highest quality energy (electricity) with biomass consumes massive amounts of wood that will increasingly come from our forests. Switching existing coal power plants to biomass or adding biomass co-firing to coal power plants should be discouraged.**

Forest biomass is more than half water[163], thus it needs to be dried before combustion or it will burn inefficiently. Because it contains small amounts of energy, very large volumes of biomass are needed to meet energy needs[164-165]. For example, to produce electricity from forest biomass, a 30 MW power plant that runs full time burns more than 50 tonnes of biomass every hour, or about 477,000 tonnes annually*. When transferred into surface area, more than 2,695 hectares of forest** (or 3,774 soccer fields) must be clearcut every year to provide enough energy for a power plant of this size. This large amount is needed because only 20 to 25% of the energy contained in wood can be transformed into electricity in large boilers, meaning that for every 100 trees burned, the energy content of 75 trees is lost to heat and pollution[6, 166-167]. Note that better efficiency can be reached with new technologies implemented, for example, in European facilities.

Better efficiency (up to 85-90%) is also reached in Combined Heat-and-Power (CHP) facilities, where

* A 30MW plant running full time produces 263 GWh of electricity annually. At 25% efficiency, 477,000 tonnes of green wood (55% moisture content – 8 GJ/t or 0,0022GWh/ton) will be needed to produce that amount of electricity.

** Forest with average standing biomass of 300m^3/ha.

energy lost as heat can be captured and used for other purposes in the surrounding area[128, 210]. Even though the vast majority of the newly allocated volumes by provincial governments go to electricity production and CHP[8], the most efficient way to use woody energy is for heating purposes (district heating, residential and commercial pellet heaters, etc.)[168]. However, recent life cycle analyses show that the process of pelletizing biomass (from mill residues) consumes the equivalent of 25% of the energy content of the pellet itself[18]. This percentage is expected to increase substantially if additional energy is required to source biomass from the forest instead of relying directly on mill residues.

PHOTO Despite the fact that this 20MW power plant claims to be a Combined Heat-and-Power facility, the St-Felicien cogeneration plant does not distribute its heat to surrounding installations and wastes about 75% of the potential energy to heat and pollutants.

LARGE-SCALE ELECTRICITY PRODUCTION FROM BIOMASS DEFIES COMMON SENSE

In 2008, Canada's energy production (electricity and heat) from woody biomass was 154,700 GWh, a small fraction (3.4%) of total Canadian primary energy production[170-171]. To produce that energy with dry wood (0% humidity – 18 MJ/Kg or 0,00495GWh/t), 31,250,000 tonnes of dry wood were needed or 62,500,000 tonnes of green wood (50% humidity) for a system 100% efficient. Efficiency in existing electric-only facilities is currently around 25%, while CHP current facilities are around 75% efficient. In a very conservative scenario with 70% efficiency, the amount of wood needed to produce 3.4% of Canada's primary energy in 2008 was 43,750,000 tonnes, or 51,600,000 m^3 of green wood*. As a comparison, this amount of woody biomass is equivalent to all the wood harvested in Manitoba, Ontario, Québec, New Brunswick and Nova-Scotia for the same year (51 million m^3 [1]). However, the Canadian government does not publish the official amount of wood burnt for energy annually. We impose a 5 million m^3 margin of error as a safety measure for those calculations, or the amount of wood extracted in Nova Scotia in 2008 (4.9 million m^3).

A 30 MV biomass power plant burns the equivalent of 10 soccer fields of clearcut EVERY DAY.

Every 1% increase in Canada's electricity production** from burning biomass in electricity facilities like the new NewPage power plant in Nova Scotia*** would lead to burning 9,814,000 m^3 more wood every year****. In 2004, the European Biomass Association suggested that OECD countries reach 15% of electric production from forest biomass by 2020[176]. If this target was reached in Canada using only forest-based biomass, more than 147 million cubic meters of wood would need to be burned annually, more than the amount harvested by "traditional" logging throughout Canada in 2008[1]. To produce the highest quality energy (electricity) with biomass consumes massive amounts of wood that will increasingly come from our forests. Switching existing coal power plants to biomass or adding biomass co-firing to coal power plants should be discouraged. Further, subsidies may divert from better energy alternatives that need stronger support by governments (efficiency programs, wind power, solar and geothermal energy, etc.). Burning forests for electricity production is just not a credible energy solution.

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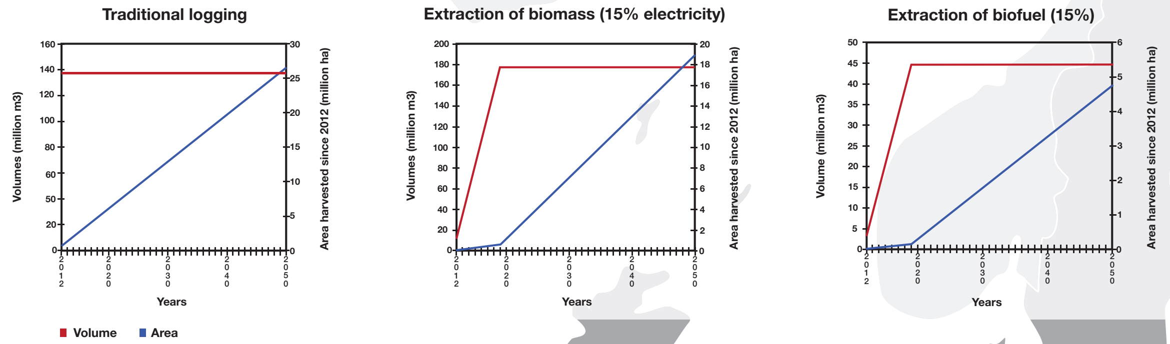
* The ratio for 1 ton of wood (55% moisture content) is around 1,18 m^3 solid[172].

** Estimated to be 617 470 GWh in 2007[173].

*** Estimated to produce 400 GWh and burn 650 000 tonnes of stemwood annually[174-175].

**** With a very conservative scenario of 30% efficiency for electric-only facility, the amount of oven dried wood (0,00495GWh/t) needed to produce 6175 GWh is 1,247,000 tonnes of dry wood, or 2,495,000 tonnes of green wood (50% moisture content). With a ratio of 30% efficiency, 8,316,000 tonnes of green wood are needed, or 9,814,000 m^3 solid.



Cumulative footprint of Canadian logging and 15% forest bioenergy scenario from 2012 to 2050

In a scenario where biomass extraction from natural forest would be used to produce 15% of the Canadian electricity production and to replace 15% of gasoline consumption by cellulosic ethanol (E85), a forest (300 m^3/ha) the size of France would need to be clearcut from 2012 to 2050 to provide that amount of energy. Cellulosic ethanol and electricity production from forest biomass would increase gradually in the first decade, from less than 1% today to 15% in 2020, and then be maintained at 15% until 2050. This scenario includes stable "traditional" logging at levels recorded in Canada in 2008 (around 700,000 ha/yr).

The solutions:

PROVINCIAL LEGISLATION SHOULD:

- Preclude low-efficiency electricity-only production from forest biomass and require that waste heat of biomass electric plants be utilized locally;
- Avoid "fuel switch" from existing power plants to forest biomass and discourage coal co-firing with biomass;
- Scale up investments in better energy alternatives like efficiency programs and wind, solar and geothermal energy;
- Utilize locally industrial leftovers at mills and pulp & paper plants for heat and power generation (CHP) or for small-scale, local district heating systems to replace fossil fuels.

From Forest to Biofuel: Driving to Destruction

The claim: **Producing biofuels from trees for transportation is a green and sustainable solution.**

The reality: **Producing biofuel from natural forests is a wasteful process that consumes massive amounts of trees, inefficiently extracts its energy and could lead to disastrous impacts on ecosystems.**

"[…](forest) ethanol production for gasoline displacement […] is not an effective use of forest biomass for GHG reductions."

MCKECHNIE ET AL. 2011[129]

PHOTO **To quench Canadian's thirst for gasoline with cellulosic ethanol (E85) from forests, Canada would need to double the amount of wood extracted from public land.**

In 2006, the Government of Canada committed to reaching a content of 5% bioethanol (1.4 billion liters) in all gasoline for ground transportation by 2010 and 2% of biodiesel for heating and transport by 2012[177]. Initially, targeted feedstocks were from food crops, mainly corn and wheat. With soaring prices and a global food crisis – provoked by this agrofuel boom[178] – forests and plantations have become an increasingly attractive feedstock for the biofuel industry[2]. Moreover, cellulosic biofuels have become a very appealing product for a logging industry in need of new markets[179].

However, at the moment, producing jet fuel or other liquid transportation biofuel out of forest biomass faces major technological and financial limitations[184]. Once technology has improved enough to make it profitable (inevitably with the support of large tax payer funded subsidies), enormous volumes of wood will be needed to drive the shift from fossil fuels to forest-based fuels. With an average of 172 liters of cellulosic biofuel produced from an average spruce tree*, more than 560,000 trees would need to be cut every day to provide enough fuel (E85 or 85% Ethanol) for all the cars in Canada[171]. In Ontario, cutting about 4,5 million m^3 of whole trees would

* One tonne of wood produces 365L of cellulosic biofuel[98].

provide a little less than 3% of the province's annual gasoline consumption[129]. Transformation of forest biomass to cellulosic biofuel is the least efficient way to use energy stored in wood. Studies show that the harvest, transportation, and processing of wood for cellulosic ethanol requires 57% of the energy contained in the ethanol itself[185]. Moreover, the energy efficiency of cellulosic ethanol production processes varies from around 40-50%[186].

While many claim that the forest biofuel boom would rely solely on "waste"[97-98], less than 10% of the annual gasoline consumption could be shifted to cellulosic ethanol if all the mill residues available in Canada were transformed into biofuel*. In Canada, it is clear that any profitable wood-based biofuel venture will have to draw its biomass straight from forests[8, 97-98]. This is already clearly the case for the Rentech jet fuel project in Ontario (see box above). To quench Canadians thirst for fuel with 85% cellulosic ethanol in their cars (E85 biofuel), we would need to double the amount of wood extracted from our forests**, a scenario that would obviously have drastic consequences for Canadian forest ecosystems.

Instead of replacing liquid hydrocarbon (oil) with liquid biomass (ethanol), Greenpeace's *Energy [R]evolution* proposes reducing the overall demand for liquid fuel consumption by tapping into the large potential for improving the efficiency of the transport sector (shifting freight from road to rail, expanding public transit and through regulations that promote much lighter, smaller and more efficient passenger vehicles) and by accelerating the transition to electric vehicles powered by renewable energy (non-combustion renewables).

* Mill residue production in Canada for 2009 was 10,9 million tonnes[8], whereas gasoline consumption in 2008 was 41,8 billion litres[171] and a tonne of woody biomass provides about 365 litres of cellulosic ethanol[98].

** Canadian harvest levels for 2008[24].

Flying on Ontario's forests

Ontario's biggest single wood volume allocated during the recent Competition for new Wood Supply went to Rentech Inc., a US based company, to produce 85 million litres of jet fuel, 43 million litres of naphtha gas and 40MW of electricity in White River close to Sault Ste-Marie[180]. Although it was presented in the news as a "green forest waste" burning project[181], the fuel and electricity will be produced by using 1,146,000 m^3/y of commercial and non-commercial trees coming directly from Ontario's public forests[10]. Seeking a $200 million subsidy from the federal NextGen Biofuel Fund[182], Rentech would sell the jet fuel at Pearson International Airport, providing approximately 4% of the 2 billion litres of jet fuel consumed there annually[183].

VOLUMES OF WOOD AND NUMBER OF TREES NEEDED FOR PRODUCTION OF CELLULOSIC ETHANOL (BLEND CONTAINING 85% ETHANOL)

Average yield of cellulosic ethanol from woody biomass[98]	365L/t
Production of cellulosic ethanol from one average black spruce*	172 L
Canadian Annual gasoline consumption in 2008[171]	41,8 billion L
Number of trees to provide 1% of Canada's gasoline consumption in cellulosic ethanol (E85)	2,064,047 trees or 2,977,074 m^3
Volume of wood to provide 100% of Canada's gasoline consumption in cellulosic ethanol (E85)	206 million trees or twice the total wood harvest in 2008[24]

* An average 15 meter tall spruce tree with 30 cm diameter at breast-height weighs about 0,47 tonnes[172].

The solutions:

PROVINCIAL AND FEDERAL LEGISLATION SHOULD:

- **Ban any cellulosic biofuel production coming directly from natural forest biomass;**
- **Not subsidize cellulosic biofuels, even if coming from mill leftovers.**

BIOFUEL INDUSTRY SHOULD:

- **Not invest in or source from forest-based biofuels;**
- **Seek supply from industrial leftovers without any support from governments.**

Burning Biomass: an Air Quality Hazard

The claim: Biomass is a clean source of energy.

The reality: Burning biomass is far from clean since it emits massive amounts of toxic pollutants like lead, carbon monoxide, nitrogen oxides and particulate matter.

"The Lung Association urges that the legislation not promote the combustion of biomass. Burning biomass could lead to significant increases in emissions of nitrogen oxides, particulate matter and sulfur dioxide and have severe impacts on the health of children, older adults, and people with lung diseases"

AMERICAN LUNG ASSOCIATION, 2009[195]

PHOTO **Burning forest biomass releases high amounts of of toxic elements into surrounding environments.**

It has long been recognized that burning wood for energy releases toxic substances which have negative impacts on human health and contribute to smog episodes, climate change and acid rain[211]. While technology has improved considerably, including the use of sophisticated air filters and high burning temperatures, there is still concern over the health impacts of burning woody biomass[188]. Wood smoke contains at least five known human carcinogens and at least 26 chemicals which are categorized as hazardous air pollutants[189].

Burning wood in industrial boilers emits on average 4 times more toxic, lung irritating carbon monoxide (CO) than coal and 92 times more than oil[190]. Biomass combustion emits 10 times more fine particles than natural gas, up to 4 times more than oil and twice as much as coal[191]. Even though sulfur emissions from biomass are lower than coal, they are still 100 times higher than natural gas[191]. Large biomass boilers are known to release heavy metals including lead, mercury, manganese and cadmium and other highly toxic molecules like dioxin and furane[119].

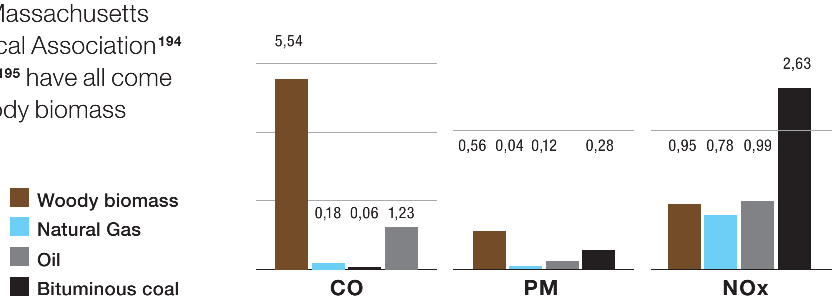
Inhalation of particulate matter, especially PM 2.5 – the most damaging for people's health – leads to allergic responses and asthma[189]. Evidence that long-term exposure to low doses of these toxic substances

TONNES OF TOXIC POLLUTANTS RELEASED IN 2009 BY 10 BIOMASS POWER PLANTS IN CANADA COMPARED TO OTHER POWER PLANTS AS REPORTED TO THE NPRI[119].

Facility/Company	City	Capacity (MW)	CO (t)	NOx (t)	PM10 (t)	PM2.5 (t)	Lead (kg)	Cadmium (kg)	Manganese (t)
Capital Power	Williams Lake, BC	65	241	492	3.7	3.3	89	7.6	n.a.
TransAlta Generation partnership	Grande Praire, AB	25	563	285	50	43	53	n.a.	n.a.
Whitecourt Power Partnership	Whitecourt, AB	24	761	232	4.5	2.6	n.a.	n.a.	n.a.
Northland Power	Kirkland Lake, ON	20	562	1905	76	41	38	20	0.16
Northland Power	Cochrane, ON	13	330	260	12	11	n.a.	n.a.	n.a.
Capital Power	Calstock, ON	35	547	200	36	32	63	59	22
St. Felicien Cogeneration Project	St-Felicien, QC	21	1606	87	13	6.5	n.a.	5.3	n.a.
Boralex Senneterre	Senneterre, QC	34	525	426	22	8.3	73	6.2	2.4
Boralex Dolbeau	Mistassini QC	24	457	220	23	20	n.a.	3.7	1.4
Brooklyn Power Corporation	Brooklyn, NS	30	255	309	115	52	204	13	2.4
Average from biomass facilities		**29**	**585**	**442**	**36**	**22**	**87**	**16.4**	**5.7**
TransCanada Energy (co-gen gas)	Redwater, AB	40	42	102	2.9	2.9	n.a.	n.a.	n.a.
Imperial Oil (gas)	Sarnia, ON	440	391	360	18	0.15	0.30	0.125	n.a.
Axor (wind)	Matane, QC	100	0	0	0	0	0	0	0

poses grave health risks such as lung disease is mounting[189, 192]. Because of the health implications from exposure to air pollutants the Massachusetts Medical Society[193], the Florida Medical Association[194] and the American Lung Association[195] have all come out against industrial burning of woody biomass for energy.

TOXIC EMISSIONS FROM ELECTRIC FACILITIES IN KG/MWH[190-191]



The solutions:

PROVINCIAL AND FEDERAL LEGISLATION MUST:

- **Follow recommendations from the American Lung Association and avoid large-scale forest biomass combustion;**
- **Ensure that CHP facilities have the highest standards for efficiency and air quality control;**
- **Ensure that only wood pellets from industrial leftovers are used for heating systems and enforce the "Washington Fireplace Standard" for any residential heating installation. This Standard is stricter than the EPA standard and limits fine particulate emissions.**

Forest Bioenergy: Risky Business for Fragile Communities

The claim: **Forest bioenergy and the bio-economy will save the failing Canadian forest sector.**

The reality: **Biomass production is a low value-added, risky business in today's market. It depends heavily on government subsidies, while offering few opportunities for forest communities.**

"It is clear that producing pellets from residuals is economically feasible; however, the ability of this sector to absorb feedstocks other than processing residuals is unclear."

STENNES AND MCBEATH, 2006[196]

"Most bioenergy investments would not be undertaken if there wasn't some form of government support."

DON ROBERTS, CIBC WORLD MARKETS[200]

The rapid expansion of forest-based bioenergy production has been driven, in large part, by government subsidies and incentives. Even with help from governments, there are significant barriers to the long-term profitability of forest-based biomass operations. With mill residue shortages, bioenergy facilities are sourcing materials from logging slash and standing trees, which is more expensive to procure[8].

To ensure profitability for pellet or electricity production from biomass, economies of scale are emerging as plant sizes increase[17]. As suggested by Kumar and colleagues (2003), the optimal profitability for a biomass power plant is reached with large 900 MW facilities burning only whole forests[198]. Using logging residues has proven to be too expensive because large areas are needed to provide enough energy[198].

According to Don Roberts at CIBC World Markets, *"one of the negatives of bioenergy is that we've got this pretty high variable cost – the cost of delivered biomass – and that is a problem."*[199] The variable cost of Canadian biomass is mostly due to feedstock being spread out over a wide geographic area, the considerable expense of delivering biomass to international markets and fluctuating freight prices for shipping overseas[8, 196].

PHOTO **Biomass from public forests is often given away across Canada to stimulate the bioenergy boom.**

While forest-based biomass has seen a dramatic rise in recent years, the market is unstable and forest-based biomass so far has only been profitable under very specific market conditions. These factors, combined with the high costs associated with accessing harvest residues and harvesting trees and declining mill residues, make forest-based bioenergy a risky business venture to say the least.

FORESTS INTO BOILERS, JOB OPPORTUNITIES INTO ASHES

While many proponents of biomass have framed it as the salvation for the ailing forest sector, biomass production creates fewer jobs than traditional forest products, which also have a higher commercial value[202]. A calculation of new wood allocations in Ontario shows that saw and pulp and paper mills provide an average of 1.5 jobs/1000m^3 while bioenergy operations only provide 0.3 jobs/1000m^3 [203-204].

Because of a decline in market prices and demand for traditional forest products, many forestry experts are advocating increased production of value-added forest products, such as specialty construction materials and engineered wood products, instead of the export of raw materials*. Value-added products can increase the number of jobs per cubic meter of wood threefold over traditional forestry manufacturing thereby creating better employed and more stable communities[206].

The large-scale production of biomass potentially competes directly with forest sector activities that support a higher number of jobs (eg. pulp and paper, plywood industry)[201]. As reported in *Pulp and Paper Canada magazine,* 445 wood-using bioenergy projects have been announced in the US and all of these are competing in some way with the pulp and paper sector for resources[17]. While the expansion of biomass production may create new business opportunities for some parts of the ailing forestry sector, there are socio-economic costs, particularly over the long term, which are borne by communities.

* The forest industry, unions, governments and environmental organizations like Greenpeace have all come to the conclusion that one way to maintain jobs and a healthy forest sector while respecting the environment is by developing 2nd and 3rd transformation of forest products (eg. engineered wood), since these products can play a carbon storage role, increase job opportunities and add value to the product[205]. Burning trees for energy goes against these principles.

JOBS CREATED/MAINTAINED THROUGH ONTARIO'S RECENT WOOD SUPPLY ALLOCATION (SELECTED FACILITIES): TRADITIONAL FOREST SECTOR VS BIOENERGY[204].

Company	Facility	Cubic Metres Allocated	Jobs
Long Lake Forest Products	Sawmill	72,000	105
AbitibiBowater	Sawmill	221,000	210
Nakina Forest Products	Sawmill	40,000	150
Muskoka Timber Mills	Sawmill	101,200	76
Domtar	Pulp & paper	626,000	331
Woodville Pellet Corps.	Pellets	56,500	36
Capital Power Income LP	Power plant	173,000	38
Rentech Inc.	Jet biofuel	1,146,000	83
Atikokan Renewable Fuels	Pellets	179,400	95
K.D. Quality Pellets	Pellets	90,000	16
Average jobs per 1k cubic meter allocated		**Sawmill and Pulp & Paper**	**1.49**
		Biomass	**0.31**

PHOTO **Is burning forests overseas really the way to ensure a sustainable future for forest-based communities?**

The solutions:

PROVINCIAL AND FEDERAL GOVERNMENTS MUST:

- **Support the production of high-value wood products from public forests to optimise job creation, minimize resource extraction and develop sustainable solutions for forest-based communities;**
- **Prioritize job creation in energy conservation programs and the wind, solar and geothermal industries;**
- **Charge stumpage fees for slash removal that are equivalent to those for traditional wood harvest and reinvest these funds into the local communities from which these trees originate.**

CBFA: Part of the solution

The Canadian Boreal Forest Agreement, a conservation and business agreement between 22 logging companies and Greenpeace and 8 other environmental groups provides a forum to develop solutions to forestry and forest conservation issues. Under the CBFA, an opportunity exists to develop a joint approach to best management practices for potential biomass harvest, as well as a full carbon life-cycle analysis of forest products.

PHOTO **Transforming full trees into pellets for combustion deviates from the value-added trend that the forestry sector needs to follow.**

Roadmap to Escape the Biomess

"The complex flows between standing and harvested carbon stocks, and the linkage between harvested biomass and fossil fuel substitution, call for a holistic, system-wide analysis in a life-cycle perspective to evaluate the impacts of forest management and forest product use on carbon balances."

ERIKSSON ET AL., 2007[209]

Canadian governments and industry must do their part to prevent the bioenergy sector from descending into a "biomess" with huge environmental consequences. The scientific literature highlights the sustainable path which policy makers and the forest bioenergy industry should pursue. Moreover, it is the responsibility of governments to consult with the public about how they want their forests to be used.

Some small-scale, local projects that use industrial leftovers from existing mills may be acceptable uses of woody biomass. For example, saw and pulp and paper mills that use waste from their primary operations to provide their own heat are suitable. Projects that replace fossils fuels for use within district heating systems may also provide some benefits.

BEFORE THESE SMALL-SCALE PROJECTS PROCEED, PROVINCIAL GOVERNMENTS MUST:

- **Conduct province-wide public hearings on the use of public forests for energy to ensure that biomass production from crown forests has public support;**
- **Develop real and detailed sustainability guidelines on the extraction and production of biomass;**
- **Ensure that all projects require environmental impact assessments before opening;**
- **Conduct full life cycle and forest carbon balance analyses on biomass projects to ensure that they are indeed climate friendly.**

The forest industry must focus on adding value to their products, which will create more jobs in Canada and help store carbon in forest products (ie – construction materials, engineered wood, furniture and other items that last for decades). Burning trees for energy goes against this trend, undermines the credibility of governments' efforts to fight climate change and poses a real problem for Canadian forests. Thus, large-scale, industrial projects, designed to export energy, must be avoided.

THE FOLLOWING TYPES OF BIOMASS PROJECT MUST CEASE IMMEDIATELY:

- **Projects that source biomass from full-tree harvesting;**
- **Projects that compete with renewable energy options that offer immediate GHG emissions reductions (energy conservation, wind, solar, geothermal);**
- **Projects that are intended for production of new energy, instead of replacing existing fossil fuel production;**
- **Projects that source from intact or natural forests with high biodiversity values;**
- **Projects that source from forests with large carbon stocks and low growth rates like the Boreal Forest.**

Already jurisdictions like the State of Massachusetts have set clear limits to the use of biomass for energy[142]. Others, like Australia, have moved away from classifying biomass from natural ecosystems as being "renewable" to avoid competing with real green energy solutions[208]. It is time that Canadian provinces and the federal government opt for good climate solutions; large-scale forest biomass is not part of that package.

"[…] the most urgent need is for research that assesses which biomass harvesting, processing, transportation and energy conversion methods yield the greatest net GHG benefits compared to similar cradle-to-grave lifecycle assessments for other renewable and fossil fuel sources of energy."

DYMOND ET AL. 2010[207]

Conclusion

Provincial governments are transforming public forests into a major energy source without fully informing the Canadian public. Cutting forests and burning trees for electricity and fuel, coupled with ongoing traditional industrial forest operations, will markedly increase the degradation of these living ecosystems. Forests play a critical role in tackling climate change by capturing and storing carbon. Disrupting their balance jeopardizes this role and also undermines the other ecological functions they provide, such as air and water filtration. Now that provinces have opened public forests – from full trees to burned areas to logging debris – for biomass extraction, the bioenergy boom threatens the very health of Canadian forest ecosystems.

Forest biomass is far from being the clean, green and carbon-neutral source of energy of the future that industry and governments promote. Burning trees and tree parts will in fact harm the climate for many decades. The failure to account for carbon emissions from bioenergy means we neglect massive amounts of carbon flow to the atmosphere. Subsidies and incentives, based on this false accounting, are encouraging tree burning over better climate solutions.

Provinces and countries that rely on bioenergy to meet their 2020 and 2050 GHG reduction targets need to track real emissions. This exercise will show that burning forests for energy moves them away from targets until beyond the 2050 horizon.

Increasing the amount of electricity produced from biomass, while also increasing the use of cellulosic biofuels, and keeping the logging industry afloat, is not feasible. Is this what Canadians want from their forests, which provide a myriad of ecological, recreational, economical, aesthetic, cultural and spiritual functions? Greenpeace believes that most Canadians do not want to loose their forests for climate-damaging energy production. The ecological and health threats are too great and the immediate carbon costs are too high.

It is time for policy makers to take a stand and ensure that Canada does not create a new environmental crisis. Plunging headfirst into industrial bionenergy without a full accounting of carbon, biodiversity and forest productivity costs, will have devastating impacts on the health of the Canadian wilderness, the public, and the global climate.

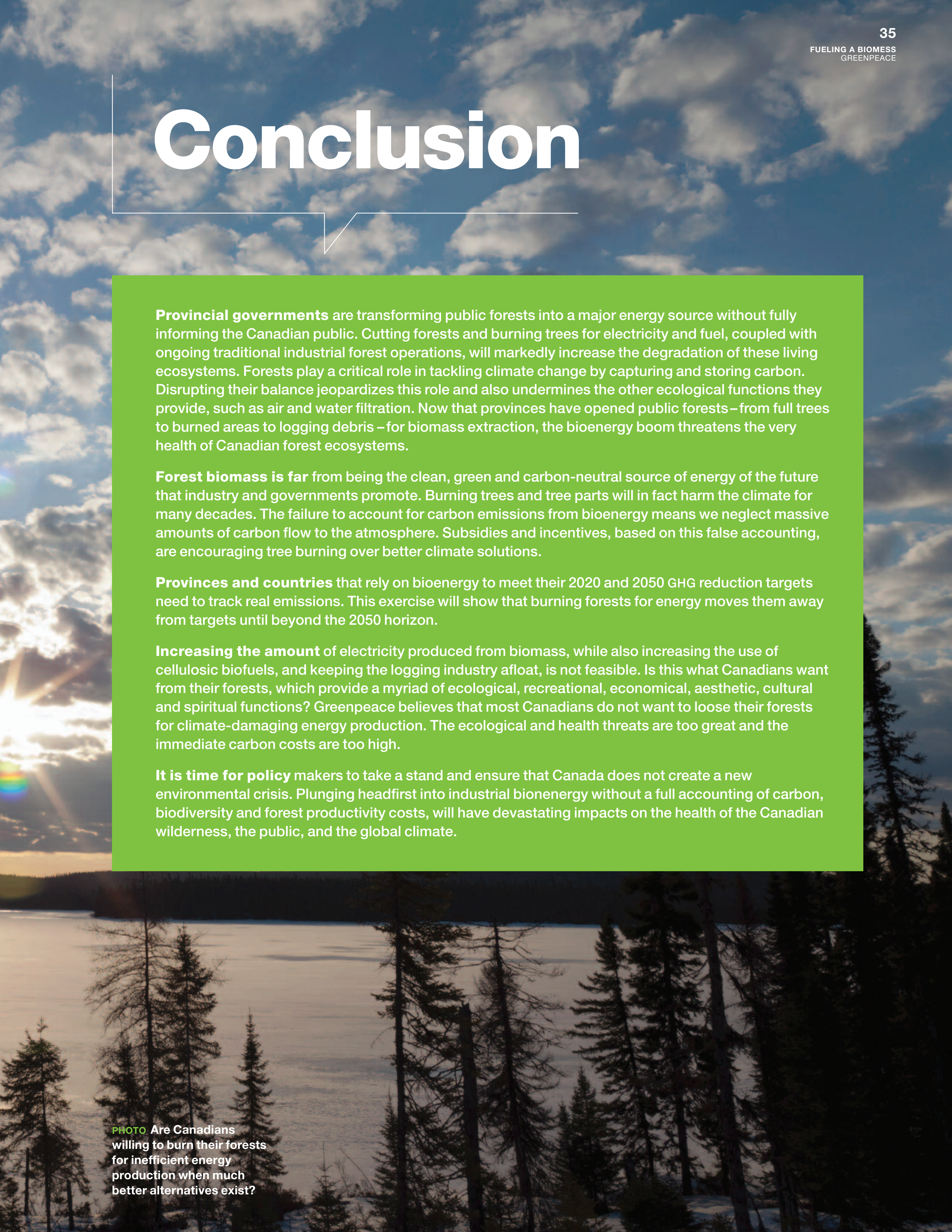


PHOTO Are Canadians willing to burn their forests for inefficient energy production when much better alternatives exist?

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Glossary

BIOENERGY: energy from materials derived from biological sources

BIOFUEL: liquid fuels derived from biomass

BIOGAS: gas produced by the biological breakdown of organic matter

BIOMASS: biological material from living, or recently living, organisms

BLACK LIQUOR: liquor produced from turning wood into paper pulp

CARBON-NEUTRAL AND CARBON-NEUTRALITY: achieving net zero carbon emissions by balancing a measured amount of carbon released with an equivalent amount sequestered

CELLULOSIC ETHANOL: type of biofuel produced from lignocellulose, a structural material that comprises much of the mass of plants (also referred to as second generation biofuel)

COMBINED HEAT AND POWER (CHP): the use of a heat engine or a power station to simultaneously generate both electricity and heat to be harnessed (also referred to as cogeneration)

FOREST OR WOODY BIOMASS: plant material from living, or recently living, trees and shrubs in forests

LOGGING SLASH: coarse and fine woody debris (branches, tree tops, leaves, needles) generated during logging operations and not typically used in sawmills or pulp mills

LULUCF: Greenhouse gas inventory sector that covers emissions and removals of greenhouse gases resulting from direct human-induced Land Use, Land-Use Change and Forestry activities

MILL RESIDUE: residues (sawdust, bark, black liquor, wood chips) produced when converting logs into lumber, plywood and paper

RENEWABLE ENERGY: energy from sources which are naturally replenished

STANDING TREE: any living tree with a diameter greater than 10 cm at breast height

WOOD CHIP: medium-sized material made by chipping larger pieces of wood

WOOD PELLET: type of wood fuel created by compacting sawdust into small, dense and low moisture pieces

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