2017 April 20

POSITION PAPER

on

SMOKE AND CARBON EMISSIONS

FROM FORESTRY SLASH BURNING

Voices for Good Air
(a network affiliate of
Clean Air Now)

Executive Summary

Logging slash is the woody and leafy material left when sawlogs or pulpwood are harvested from forests and plantations. In British Columbia, most of this material is left in the cutblocks, where, under the Wildfire Act and Wildfire Regulation, it must subsequently be disposed of. One of the permitted methods of disposal is burning; and in fact the method preferred by most logging operators is burning. Across the province, enormous quantities of logging slash are burnt each year. The slash fires produce smoke plumes which drift across populated areas and they emit immense volumes of carbon dioxide and other greenhouse gases.

This document lays out the position of Voices for Good Air, an affiliate of the Clean Air Now network of citizen activist groups, on smoke and carbon emissions from forestry slash burning in British Columbia. ***First***, the paper describes and critiques the four reasons most commonly given for why forestry waste is burned, namely Reduction of wildfire; Minimization of unproductive land base; Low cost (vs. some alternatives); and Aesthetics and tree planter safety. ***Second,*** it provides ten well-founded reasons why logging slash should not be burned. Two of those reasons are most powerful: (1) the known and strongly suspected effects of wood smoke on human health; and (2) the urgent need for humanity to make rapid progress in reversing the emission of greenhouse gases into the atmosphere during the next two decades if it is to avoid the worst impacts of global warming. ***Third,*** the paper identifies five alternatives to burning logging slash: Conversion to biochar; Burial; Piling but not burning, and In situ scattering; Manufacturing into pellets, panelboard, and so on; and Combinations of methods. All of these alternative methods are scientifically defensible.

Next, the Position Paper proposes an interim measure to address the societal problem of slash burning. That measure is a Moratorium on burning.

In conclusion, the Position Paper argues that the only satisfactory solution to the vast harms forestry slash burning imposes on British Columbians and the world is a Complete or nearly complete ban on burning. However, if a complete ban on forestry slash burning proves to be too draconian or politically impossible to institute, then the paper suggests A Partial solution: A carbon tax on wood destined for burning as slash.

TABLE OF CONTENTS

POSITION PAPER on SMOKE and CARBON EMISSIONS

from FORESTRY SLASH BURNING

Introduction

*The **Position Paper on Smoke and Carbon Emissions from Forestry Slash Burning** presented here is the outcome of research, deliberation, and writing by an informal circle of concerned citizens resident in the Bulkley Valley. The circle includes a civil engineer, a lawyer, a medical doctor, an air charter business owner-operator, and a retired environmental planning professor, among others, though it is not limited to participants with professional qualifications. Where especially appropriate, individual members of the group have applied their particular expertise to sections of the Position Paper demanding specialized knowledge, such as the field production of biochar, the relationship between wood smoke and human health, the effects of slash smoke on charter flight operations, and the consequences of slash burning for mountain community planning and regional economic development. Otherwise, the Paper is everywhere co-authored.*

** ** **

This document lays out an argument for a complete or nearly complete ban on the burning of logging slash, or, alternatively, for wood burnt as slash to be included under the B.C. Carbon Tax. A ban on burning requires changes to the Wildfire Act and the Wildfire Regulation, for which the Minister Responsible is the Minister of Forests, Lands and Natural Resource Operations. The B.C. Carbon Tax is a responsibility of the B.C. Minister of Finance but because it must be consistent with the Pan-Canadian Carbon Pricing scheme, in future it will reflect elements yet to be determined in discussions between the Canadian provinces and the federal Minister and Department of Environment.

Under present legislation and regulation, the burning of logging slash – waste wood discarded in the cutblocks -- produces enormous volumes of ***greenhouse gases*** and ***smoke***. The greenhouse gases of course contribute to global warming, which has become perhaps the greatest environmental crisis in human history. The smoke hangs over the British Columbia interior intermittently for months and imposes at least seven sorts of harms, discussed in greater detail below.

Although the B.C. Wildfire Act and Wildfire Regulation do not require burning of slash, they condone it and in practice encourage it. They require that slash be disposed of, and for logging operators burning is usually the cheapest method of disposal. The main reason for ridding timber lands of slash, according to B.C. government documents, is that it lowers the probability of wildfire. Forestry research papers also assert that over long periods of time, slash can cover an appreciable portion of the land base, lessening forest productivity.

Following paragraphs lay out and evaluate reasons cited for burning logging slash, reasons for not burning slash, alternatives to burning slash, the idea of a moratorium on burning slash, the idea of a complete ban on burning slash, and the idea of extending the B.C. Carbon Tax to wood burnt as logging slash. The conclusion of the paper is that the harms done by burning slash far

outweigh the benefits from burning and *burning should therefore cease to be an acceptable method of disposing of logging slash.*

1. Reasons for burning slash

Burning to dispose of slash and other wood residue is done almost everywhere in British Columbia but also in Ontario, Alberta, and other Canadian provinces as well as elsewhere in the world. The practice seems to have originated in the United States, probably as far back as the 1960s. See John M. Pierovich and Richard C. Smith, *Choosing Forest Residues Management Alternatives* (1973); United States Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. It is not clear that burning to reduce wildfire hazard was ever soundly based on research. Rationales for burning, rather than scientifically based reasons, include reduction of wildfire, minimization of unproductive land base, and low cost. Early U.S. publications also mention aesthetics.

Current logging practice in the Skeena Region's interior forests, and elsewhere, is now largely full-tree skidding or forwarding to roadside. This practice results in a reduction of in-block landings and associated soil compaction, thus freeing up more plantable spots. It also reduces logging slash on the block, which in turn makes the planting of trees easier. In addition, many operations have shifted to "cut-to-length," leaving merchantable tree bole sections behind if they do not match the size of the logging truck bunk or the quality or species requirements of the sawmill. As a result, additional slash must be disposed of if it is not simply left on site at the stump.

Reduction of wildfire

Few recent studies question the effectiveness of slash burning for the purpose of reducing wildfire. However, John L. Campbell, Mark E. Harmon, and Stephen R. Mitchell included slash burning in their study "Can fuel-reduction treatments really increase forest carbon storage in the western U.S. by reducing future fire emissions?" (2012; *Frontiers in Ecology and the Environment 10*(2): 83-90). According to their abstract, "Our review reveals high C losses associated with fuel treatment…and a low likelihood that treated forests will be exposed to fire." (The "treated forests" refer to forests under which foresters have conducted prescribed burning of deadfall and brush.) They say the effect slash burning has in reducing wildfire hazard is temporary. Similarly, J.L. Campbell and A.A. Ager (2013; "Forest wildfire, fuel reduction treatments, and landscape carbon stocks: A sensitivity analysis." *Journal of Environmental Management 121:* 124-132) find that concentrated and frequently repeated fuel reduction treatments have a strong effect on forest wildfire; but they are talking about understory and deadfall burning, not the burning of slash.

It is not certain that *clearcuts* in which slash has not been removed or burnt have a higher susceptibility to fire spread than do *forests* "treated" by prescribed understory burning. Another source of uncertainty is how the disposition of slash across a landscape would influence the contribution of slash fuels to fire spread. However, forestry science takes it as axiomatic that the more "fuel" in a landscape, the more prone that landscape will be to wildfire.

P.M Fernandes and H. S. Botelo (2003; "A review of prescribed burning effectiveness in fire hazard reduction," *International Journal of Wildland Fire 12*: 117-128) observe that (118) "The efficiency of prescribed fire in reducing wildfire hazard is frequently mentioned as a matter of fact, but the basic premise is seldom questioned." These authors note that according to research other than their own, "it is sufficient to have fuels reduced on 75-80% of a given area," or even 50% to 90%, to reduce wildfire hazard appreciably (119). If slash were piled but not burned, the area covered by slash fuels would be far less than these figures. Finally, these same authors say (123) that "The operational effectiveness of prescribed fire inferred from case studies is largely anecdotal, and most of the examples of success that are available refer to recently (up to 4 years) treated areas. … Analysis of hazard reduction effectiveness based on well-documented case studies of wildfire behaviour, severity and suppression difficulty as modified by burned areas is thus limited in the conclusions that can be drawn."

In their magisterial 2016 article "Greenhouse gas emission effect of suspending slash pile burning in Ontario's managed forests" (*The Forestry Chronicle 92*(3): 345-356), Michael T. Ter-Mikaelian, Stephen J. Colombo, and Jiaxin Chen state that (354): "…ascertaining the increased fire risk posed by unburned slash piles would require a detection of statistically significant difference in the long-term average characteristics of fire regimes between similar forest landscapes with contrasting treatment of slash piles (burn vs. no burn). In the absence of such tests, attributing a fraction of GHG emissions from wildfires to unburned slash piles would be impossible…."

In short, burning slash to reduce wildfire hazard appears to be entirely unsupported by substantial case history or experimental research evidence.

Even though burning slash to reduce wildfire hazard is not well supported by scientific research, in British Columbia it is being done on a scale so large it is hard to comprehend. By way of comparison, the number of slash piles burnt annually in B.C. (nominally about 400,000) is one-third *larger* than the number of all the single detached houses in Vancouver (just over 300,000). (See Statistics Canada figures at:
http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/famil124g-eng.htm.)

Worse still, while annual slash fires in B.C. burn the residue of logging from about 200,000 ha, ostensibly to lower the incidence of wildfire, the amount of forest lost to wildfire in 2016 (admittedly a year with less wildfire than usual) was 100,187 ha. In other words, burning logging slash after harvesting the commercial timber has roughly *twice* the aggregate burning effect on B.C. forests that forest fires do.

The "aggregate effect" is in fact to reduce to ash not just piles of useless wood, as one might at first suppose, but a large fraction of all the aboveground biomass of what was pre-harvest forest. The ratio of slash to all aboveground biomass before sawlogs are cut and hauled away is not easily ascertained from the scientific literature, and of course slash ratios vary a great deal according to stand characteristics. Available literature suggests, though, that slash just from stems included in the Annual Allowable Cut (AAC) may equate to over 40% of the volume of the volume of the standing trees (see Alf Kivari, Wenli Xu, and Sam Otukol, *Volume to Biomass*

Conversion for British Columbia Forests (Draft), Revised January 2011 (Forest Analysis and Inventory Branch, B.C. Ministry of Forests and Range: https://www.for.gov.bc.ca/hts/vridata/standards/news/volume_to_biomass_conversion_report.pdf)
Slash from live but immature trees, trees of noncommercial species, bushes, biologically important deadfall, and so on, would all go into the fires too.

Minimization of unproductive land base

Another explanation sometimes offered for slash burning is that it lessens the impact an accumulation of slash on the ground would have on forest productivity. In their modelling study, Ter-Mikaelian et al. (2016; see above), state that (352): "A valid question is whether the area covered with unburned slash piles should be counted as a loss of productive forest area. Logically, the presence of slash piles reduces area available for regeneration and this affects stem density in regenerating forest. For example, an average slash pile in northwestern Ontario…covers over 100 m^2 and thus constitutes a physical barrier to either natural regeneration or planting. However, surrounding regenerating trees may benefit from increased availability of nutrients, light, and water due to the artificial gap created by a slash pile, and their growth may compensate for the reduced initial stem density, perhaps eventually resulting in no difference in total biomass between stands with and without unburned slash piles. Based on the latter considerations, Hall…concluded that negative effect of unburned slash piles on the establishment of new stands on Vancouver Island was not a concern." Ter-Mikaelian et al. (2016:352) also observe that "As appears to be the case for all aspects of slash pile burning, empirical observations are scarce."

In regions of British Columbia where timber is valued as sawlogs only, and not pulpwood, the objection may be raised that slash piles would have some negative neighbourhood influence on the desirable characteristics of tree straightness and lack of taper. This influence needs to be quantified, and of course it would vary hugely according to how the slash piles were grouped or scattered in a cutblock.

In short, the concept of burning slash to free up productive forest land has no serious foundation in research. (In fact, some studies have found that the ground where slash piles have been burned is effectively sterilized for years or at least rendered incapable of growing trees at normal rates.)

As noted above, many foresters believe chipping and removing or accelerating the decomposition of fine fuels can go a long way towards reducing the ability of wildfire to spread. On the other hand, large (or "coarse") woody debris, which can magnify the intensity of a fire, is regarded as having less of an effect on the rate at which wildfire spreads. Arguing against removal or burning of large woody debris is the fact that leaving it on site contributes significantly to forest soil productivity over time through slow release of nutrients, reduction of soil bulk density, moisture retention, the affording of habitat for larger animals, microfauna, essential bacteria and fungi, and the provision of nurse logs for tree seedlings and saplings.

The loss of needles or other leaves and fine branches from a cutblock directly results in the loss of nutrients essential to maintaining site productivity. Although most Canadian forests can withstand timber removal over long rotations, the loss of available nutrients is not ideal if a land manager is concerned with growing a new forest quickly. Nitrogen, phosphorus, potassium, magnesium and calcium are five essential elements for plant growth. Depending on the nutrient in question, approximately 10 to 35% of its availability is contained in above-ground vegetation (Forest Ecology Series – Michigan State University Extension, 1998). Available nitrogen in the form of nitrate or ammonia is often in shortest supply in a forest ecosystem. Production of nitrogen is dependent on soil bacteria or lightning. In the attempt to minimize loss of unproductive forest land during timber harvesting via full-tree skidding and yarding, followed by high-intensity slash burning, overall site productivity loss may very well be accentuated instead of reduced.

Low cost (vs. some alternatives)

Burning slash in piles is sometimes said to be the cheapest way of disposing of it. There is no substantial literature on whether or not such is the case. Ning Zeng, in his "Carbon sequestration via wood burial" (published in 2008 in the peer-reviewed journal *Carbon Balance and Management* 3:1, not paginated as in the paper version because online) compares burial of slash against burning and other methods of disposal and concludes that burial costs are comparable.

Jeffrey D. Kline (2004; *Issues in Evaluating the Costs and Benefits of Fuel Treatments in the Nation's Forests;* U.S. Department of Agriculture Forest Service, Pacific Northwest Research Station; Research Note PNW-RN 542) gives estimated average costs per acre for slash reduction burning at $172 U.S. in 1995 dollars. In 2017 this amount might equate to something like $1,000 per hectare in Canadian dollars. Reliable information is needed on current Canadian costs of slash burning reduction, including pre-planning, adherence to venting conditions monitoring, and so on.

Aesthetics and tree planter safety

Aesthetics and tree planter safety are occasionally mentioned as motivations for burning slash. There may be some basis to these rationales. It is possible that to most people slash-covered cutblocks look uglier than slashless cutblocks, and if so, leaving slash unburned might have impacts on tourism, not to mention the public acceptability of clearcutting. At any rate, studies in the research line of Visual Quality Analysis long ago demonstrated that ordinary members of the public dislike the sight of clearcuts because they are known to be unnatural. Even Government of British Columbia research confirms this aspect of Canadian psychology (Research Branch, B.C. Ministry of Forests, 1996, *Clearcutting and Visual Quality – A Public Perception Study – Summary Report* https://www.for.gov.bc.ca/hfd/pubs/Docs/Frr/Frr270.htm). Marginal improvement by removing slash piles is possible, if not likely to be great. Similarly, tree planters may indeed be less prone to injury while working in slashless cutblocks. In either case, the relevant research seems to be lacking. In theory, at least, the less slash in a cutblock, the greater the planting efficiency and the lower the costs of replanting, among which would be costs related to planter safety.

2. Reasons why logging slash should NOT be burned

For an old and non-peer-reviewed but excellent article on reasons why logging slash should not be burned, see Roger Hart, "The questionable practice of slash burning" (*NCAP News,* Fall 1984, 17-21 and Winter 1985, 19-24). The author was then a geochemist in the School of Oceanography at Oregon State University and his article includes much helpful information about the carcinogenic components of slash smoke, the burning of herbicide-treated slash, the chemicals found in slash burn smoke, the effect of slash burns on fish habitat, the effect of slash burns on forest soils, the production of submicron particulates by slash burning, and alternatives to slash burning.

From a contemporary perspective, there are a number of reasons why logging slash should not be burned. Eight are treated below, in no special order.

Inadequacy of science-based rationale for burning

As reviewed under section 1 above, scientific research supporting the need for burning slash is all but non-existent. There are a few modelling studies offering weakly favorable results in the reduction of wildfire hazard but virtually no case studies. This is a totally inadequate foundation for a practice which entails many concrete and serious harms.

Known and probable effects of wood smoke on human health

The main source of rural air pollution is the particles and gases produced by the combustion of wood. Wood smoke is produced and released into B.C. airsheds from multiple cumulative sources. Negative health effects from chronic exposure to residential wood heating exposure are well established. Other sources that contribute to wood smoke exposure include industrial emissions and open burning such as forest industry slash burning, wildfires, prescribed burning, and agricultural burning. There is increasing evidence indicating negative health effects from community exposure to wildfire smoke; some of that evidence is referenced in this Position Paper. Research into the level of community exposure and the health effects of exposure to forest industry slash burning is lacking. It must be remembered throughout this paper that whatever the particular composition and effects of slash smoke alone may be, many rural residents of British Columbia can be subjected to smoke from slash burning and smoke from residential stoves and smoke from forest fires at the same time or in sequence.

Components of wood smoke are known to vary according to fuel load and burning conditions. However, it is reasonable for the public to worry that slash smoke has negative effects on human health similar to those from exposure to wood smoke from other sources. Furthermore, the public has a right to expect, as a matter of good governance, not only that research-based evidence on the health effects of slash smoke will be amassed by the Ministry of Health but that it will be incorporated into the planning and policies of the Ministry of Forests, Lands and Natural Resources Operations (MFLNRO) and Ministry of Environment. Effective collaboration and coordination among these ministries is in the best interest of the health of the public.

Wood smoke exposure

The health effects of wood smoke depend on the level of exposure, the duration of the exposure, and the differing composition of the particulate matter (PM) released. Negative health effects have been documented both from longer-term exposure and also from higher-intensity exposures as short as a few hours in duration. The fine particulate PM 2.5 and ultrafine particulate PM 0.1 matter in wood smoke are associated with negative health effects as described below.

Residential wood smoke tends to result in a lower level of exposure but it is sustained over a longer period of time. Typically exposure to residential wood smoke is cyclical, being greater in the morning and the evening, and it is experienced mainly in the fall and winter. This is considered chronic wood smoke exposure. Wildfire smoke exposure is in general of higher intensity but it is experienced over a shorter period. It is random and sporadic. Short-term exposure of this kind is considered "acute." Exposure to smoke from slash burning may occur repeatedly during a single season and it may be a recurring annual event. See also Sandra Duran, *Evidence Review: Wildfire Smoke and Public Health Risk* (BC Centre for Disease Control, March 31, 2014).

Wildfire wood smoke exposure

It has been estimated that annual premature mortality attributable to **wildfire** smoke on a global scale amounts to 339,000 individuals. (See Johnston F.H., Henderson S.B., Chen Y., Randerson J.T., Marlier M., DeFries, R.S., et al., 2012: Estimated global mortality attributable to smoke from landscape fires; *Environmental Health Perspectives 120*(5): 695.)

The following information is taken from one of a series of Evidence Reviews on Wildfire Smoke completed by Environmental Health Services at the BC Centre for Disease Control in 2014 (Sandra Duran, *Evidence Review: Wildfire Smoke and Public Health Risk;* BC Centre for Disease Control, March 31, 2014):

(i) Components of wildfire smoke

"Flaming combustion and smoldering combustion produce different emissions. Flaming combustion produces fine particulate matter (PM2.5) mainly composed of organic and black carbon. It converts carbon, hydrogen, nitrogen, and sulfur into well-oxidized gases such as Carbon Dioxide (CO_2), Water Vapor (H_2O), Sulfur Dioxide (SO_2), and Nitric Oxides (NO_x). Smoldering is incomplete combustion, which produces more of the toxic emissions. It produces carbon monoxide (CO), volatile organic compounds (VOCs), and polycyclic aromatic hydrocarbons (PAHs) such as benzene and methane, some of which are carcinogenic. Wood smoke can contain mercury as an environmental contaminant. Secondary pollutants can include ozone (O_3)."

(ii) Particulate matter

"The size of particulate matter is important. Fine particulate matter (PM2.5) can penetrate quite deeply into the lower respiratory tract causing local effects by stimulation of immune cells and inflammation." Fine particulates may also be absorbed into the general circulation and cause effects elsewhere in the body. There are reports of effects such as increased levels of coagulation (blood clotting) and of inflammation. PM2.5 is associated with both cardiovascular and lung disease."

(iii) Volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs)

"VOCs and PAHs include hydrocarbons (methane, benzene), halocarbons (chloromethane), and oxygenates (formaldehyde, acetaldehyde). Methane (CH_4) is a greenhouse gas and non-methane hydrocarbons (NMHCs) are precursors to ozone formation. These components are known carcinogens and irritants for skin, eye, nose and throat. Benzene is another component known as a human carcinogen and there are some studies that suggest a link between benzene exposure and childhood cancer."

Citizen concern regarding organic arsenate (MSMA) contained in pesticides

In the Bulkley Valley, concern has been expressed about the potential effects of the organic arsenic, monosodium methanearsonate (MSMA), in the pesticide used against Mountain Pine Beetle. This substance was injected into lodgepole pine trees. In 2002, the Canadian Association of Physicians for the Environment and a local Smithers citizen appealed to the Environmental Appeal Board of Canada about the use of MSMA. The concern was in relation to occupational exposure when treated trees are milled and community exposure when treated trees are burned. The local office of the Ministry of Environment at that time did forbid bark from treated trees from being burned in beehive burners. Since then MSMA has been de-registered by both the U.S. Environmental Protection Agency (EPA) and Health Canada. Its registration is currently under review by the EPA. It is important to clarify or determine whether the remaining treated trees could potentially be a health risk if burned as slash or in a wildfire.

Wildfire smoke and health effects

Dr. Sarah Henderson (Ph.D.) is a Senior Scientist with Environmental Health Services at the BC Centre for Disease Control (BCCDC). She has completed research that includes health effects of wildfire smoke specifically in B.C. This research shows increases in hospital admissions, emergency department visits, increases in asthma symptoms and medication usage, and decreases in pulmonary function during wildfire events. In 2014 the BCCDC produced a series of Evidence Reviews related to Wildfire Smoke. Some are referenced below. How this information can inform public health programs and B.C. forestry practices should be addressed.

The literature shows strong associations (see Elliot 2014, cited below) between wildfire smoke and:

Exacerbations of asthma and chronic obstructive pulmonary (lung) disease
Bronchitis and pneumonia
Overall Mortality
Cardiovascular outcomes
Adverse birth outcomes
Childhood respiratory disease
Anxiety
Localized symptoms such as eye irritation, sore throat, wheezing, and coughing

See C. Elliot, *Guidance for BC Public Health Decision Makers during Wildfire Smoke Events* (2014; BC Centre for Disease Control).

In recent research on wildfire smoke exposure done by the BC Central Disease Control, there was clear evidence of increased mortality due specifically to cardiovascular and respiratory causes. There was also an increase in mortality specifically due to stroke and lower respiratory infection and this was higher in rural areas. Angela Yao presented this information in the following BCCDC media presentation:

http://mediasite.phsa.ca/Mediasite/Play/9bf21888a2d243e18db106b1e5db49fd1d?catalog=8b83c4e8-dc95-40b0-8787-fc2a880b79b3&playFrom=9796&autoStart=true

The Precautionary Principle and the burden of proof

When slash piles are first ignited, their fires are very hot and intense, by design, and consequently the characteristics of the smoke they produce probably overlap with those of hot forest fires. Subsequently, slash fires may smolder for several days, as happens with boreal forest fires. (The Government of British Columbia recognizes the occurrence of slash smoldering when it announces periods when open burning is permitted and issues four-day wind forecasts.) Since one or two hundred large slash piles may be ignited in the same cutblock at the same time, burning on average 25 tonnes of wood apiece (see below), the smoke production and kinds of smoke released may be indistinguishable from those of a forest fire of considerable size.

There is evidence of health effects from chronic exposure to wood smoke from residential wood heating. There is evidence of health effects from non-occupational community exposure to wildfire smoke. So the public policy question which arises in the case of slash smoke is this: Are there reasonable grounds for fearing that exposure to smoke from slash burning could have consequences the same as or similar to those of exposure to other sources of wood smoke? As just reviewed in the previous subsection of this paper, the scientific evidence seems to constitute such grounds. The next question then is this: Is a Canadian provincial government under any moral or legal obligation to do something when one of its policies imposes the risk of serious

harms for the public? As it happens, Canadian provincial governments are indeed under such a moral and legal obligation. It is the Precautionary Principle.

According to the Canadian Environmental Law Association, "The precautionary principle denotes a duty to prevent harm, when it is within our power to do so, *even when all the evidence is not in*. This principle has been codified in several international treaties to which Canada is a signatory" (http://www.cela.ca/collections/pollution/precautionary-principle). The Precautionary Principle of risk management states that if an action or policy has a suspected risk of causing harm to the public, or to the environment, in the absence of scientific consensus that the action or policy is not harmful the burden of proof that it is *not* harmful falls on those taking that action. The Precautionary Principle is an ethical and legal principle in environmental governance that should determine public policy in this circumstance. Because Canada is an adherent to treaties referring to the Precautionary Principle, any Canadian provincial government is under an obligation to apply the Precautionary Principle in its evaluation of policies allowing burning as a legal means of disposing of forestry slash.

Negative impacts on quality of life

Smoke from cigarettes is significantly associated with lower quality of life. According to an article by Fran Lowry, "More smoking equals lower quality of life," (*Medscape Medical News,* 2014 April 22; http://www.medscape.com/viewarticle/823985), "Smoking cigarettes, even for a short time, is associated with a significantly lower quality of life…. A review of 54 studies that assessed QoL in relation to smoking showed that taking up smoking even for a brief duration was associated with lower physical, mental, and social functioning and increased depression." It is true that cigarette smoke is not wood smoke; but the two are surprisingly similar to each other (Pryor, W.A.; 1992: Biological effects of cigarette smoke, wood smoke, and the smoke from plastics: The use of electron spin resonance, in *Free Radical Biology and Medicine 13*(6): 659-76). Consequently it would be surprising if the smoke from slash burning did not contribute to "lower physical, mental, and social functioning and increased depression" in populations subject to it.

Residents can be well aware that their quality of life is lower than it should be. There is a need for research on whether and to what extent rural and wildland populations are aware of slash smoke lowering their quality of life. One contributor to this document observed that "*Even if one does not experience immediate effects from inhaling wood smoke, it is hard to deny the discomfort of breathing it day out in, day during the fall prolonged slash pile burning season."*

Tourists, like other people, can sense that environments they visit are subject to phenomena tending to lower quality of life. See the section below on ***Negative impacts on tourism in general.*** It hardly needs saying is that what they seek is environments self-evidently conducive to a high quality of life.

Negative impacts on community economic development

As the term is used in this section, "amenity migrants" refers to people who move to a place primarily for its high-quality natural or cultural amenities rather than for a particular job or

business opportunity. Amenity migrant households typically generate about two new jobs through the economic multiplier of their spending.

For rural communities in the mountainous landscapes of western North America, amenity migration is one of the greatest factors driving economic development; and for the most part the amenities of interest to prospective in-migrants are natural features such as beautiful mountains, fish-filled rivers, uncut forests, and clean air. There is now a large economic literature on the positive relationships among economic development, amenity migration, and high-quality environments. For an introduction, see Thomas Michael Power, *Environmental Protection and Economic Well-Being: The Economic Pursuit of Quality, 2nd ed.* (Armonk, New York: M.E. Sharpe, 1996). There is also a large economic literature on the equally strong, but undesirable, relationships between economic development and low-quality environments. The classic text is Thomas Michael Power, *Lost Landscapes and Failed Economies: The Search for a Value of Place* (Washington DC: Island Press, 1996). There are scores of peer-reviewed articles on the subject, nearly all tending to support the wisdom of small rural communities' protecting high environmental quality and eschewing the temptation to attract development and jobs at the price of low environmental quality. See for example Patrick Bayer, Nathaniel Keohane, and Christopher Timmins, "Migration and hedonic valuation: The case of air quality" (*Journal of Environmental Economics and Management 58*(1): 1-14, 2009).

During a community forum on air quality during fall 2016, a woman in the audience stated that several years before, she had moved to Smithers as an amenity migrant. She soon discovered that during the winter, primarily because of wood stoves, air quality in Smithers can be very bad. She then moved to an outlying area, where she discovered that the air of the central Bulkley Valley can often be heavy with smoke from slash fires. She is now considering moving out of the region altogether, as, she said, other amenity migrants of her acquaintance have done.

There appears to be no directly relevant planning research literature on the subject, but in the Bulkley Valley many amenity migrants say they choose to reside out of the town of Smithers and often at higher elevations precisely to escape slash and industrial smoke. Certainly census tracts for Smithers and Electoral Area A of the Regional District of Bulkley-Nechako indicate that over time a majority of residents with graduate degrees have chosen to live in the outlying rural areas. From a planning and environmental perspective, driving households away from central settlements into patterns of thinly settled residential development is a bad thing.

Negative impacts on tourism in general

See the section above on ***Negative impacts on quality of life***. Currently the impact of poor air quality on tourism is much in the news in Asia. Atmospheric pollution is blamed for declining numbers of visitors to China and India. (Google "air quality and tourism.") There is a slight peer-reviewed research literature on the relationship between air pollution and tourism; and between smells and tourism. (See Graham Dann and Jens Kristian Steen Jacobsen, "Tourism smellscapes" (*Tourism Geographies: An International Journal of Tourism, Space, Place and Environment 5:* 23-25; https://www.ncbi.nlm.nih.gov/pubmed/1334034.)

Negative impacts on air charter operations and back-country lodges

Except in coastal areas, air charter operations are seasonal, from May until the end of October. More than 80% of such operations are in one way or another connected to tourism. Government (mainly forestry) and First Nations account for the rest.

Air charter companies provide air transportation to remote lodges, flying in all their supplies, such as building supplies, fuel, groceries, employees and clients. Increasingly, individuals or small groups use air charter services for fly-in canoe trips, wilderness trekking, wilderness camping, angling and hunting. Sightseeing trips which include stops at remote lakes are especially popular with elderly people, people with disabilities, and people who just want to get a birds-eye view and take pictures of our magnificent British Columbian backyard.

During the entire slash-burning season, which coincidentally is the most picturesque time of year with all the fall colours, sightseeing flights are few because of the constant haze caused by burning. At that time of year the skies are rarely clear below 10,000 feet.

For all the other clients who use the wilderness for their recreational activities, the flight is a memorable part of their entire journey. Smoky skies do not enhance their experience.

Lodges run on a fixed schedule. Every year, especially in the fall, bad weather leads to delays and sometimes to cancellation of entire groups. Smoke in the atmosphere exacerbates the situation and results in flight cancellations which would not otherwise have occurred.

To put this in the simplest terms, **adding smoke to a bad weather situation (one characterized by low ceiling, fog, or rain or snow) makes the task of charter operators in most cases risky or impossible.** The losses to just one company in the Bulkley Valley, Alpine Lakes Air, amount to at least $10,000 a year. This figure does not include the potential for more sight-seeing trips were the skies clearer than they are.

Burning based on the venting forecasts is of no help at all, because in the case of Alpine Lakes Air, for example, air charter operations are conducted mainly outside the BV airshed.

Smoke travels hundreds of miles and thins out into a haze. If British Columbia had a slash burning moratorium for two or three years, the entire population would be surprised how clear the skies can be.

We all are aware of the importance of the tourism industry. It is sustainable. It does not deplete natural resources.

Waste of a potentially useful and even valuable resource

Simply from a commonsense point of view, it seems unwise to log a forest, then burn half or a third of the wood, bark, and leaves in it, making no productive use of this material. Indeed, for

many people it is simply immoral to engage in or to countenance such waste. Anyone in doubt needs only Google "Is waste immoral?"

The question of just how the burning of slash is wasteful is complicated. Certainly when slash is burned, potentially useful biomass is vaporized, habitat opportunities are reduced, and as yet unknown economic opportunities are foreclosed. Burning slash also encourages the logging of high-elevation forests where the quantities of commercial wood extracted are small in relation to the overall amount of organic matter liquidated and the overall area of natural ecosystems disturbed. On the other hand, many British Columbians would say it is wasteful not to use a natural resource which has commercial value, even if it is at the cost of burning most of the remainder of the biomass in a forest.

Production of enormous volumes of greenhouse gases

Nearly all serious climate scientists agree that humanity must immediately halt growth in greenhouse gas emissions and in the near future begin reversing them. The critical boundary beyond which human-caused climate change becomes irreversible is about 2040, although climate change will be very destructive and costly long before that. In fact, it already is. All kinds of authoritative literature is available on this subject. Here is a quotation from *Scientific American* (EarthTalk, 2015 April 13; https://www.scientificamerican.com/article/have-we-passed-the-point-of-no-return-on-climate-change/):

> Currently the atmospheric concentration of CO_2 (the leading greenhouse gas) is approximately 398.55 parts per million (ppm). According to the National Oceanic and Atmospheric Administration (NOAA), the federal scientific agency tasked with monitoring the health of our oceans and atmosphere, the current average annual rate of increase of 1.92 ppm means we could reach the point of no return by 2042. [After the "point of no return," climate change becomes irreversible no matter what humanity does: Feedback loops drive further change.]
>
> Environmental leaders point out that this doesn't give us much time to turn the tide. Greenpeace, a leading environmental advocacy group, says we have until around 2020 to significantly cut back on greenhouse gas output around the world—to the tune of a five percent annual reduction in emissions overall—if we are to avoid so-called "runaway" climate change.

Forestry is by far the biggest source of greenhouse emissions in British Columbia (see the *British Columbia Greenhouse Gas Inventory Report* for 2014, apparently the most recent data available over the Web: http://www2.gov.bc.ca/gov/content/environment/climate-change/reports-data/provincial-ghg-inventory). Changing the way forestry is done in the province could drastically reduce B.C. emissions almost overnight, and slash burning is the obvious place to start. Ter-Mikaelian, Colombo, and Chen (2016) have examined exactly this strategy for the province of Ontario (Michael T. Ter-Mikaelian, Stephen J. Colombo, and Jiaxin Chen, 2016, Greenhouse gas emission effect of suspending slash pile burning in Ontario's managed forests; *The Forestry Chronicle 92*(3): 345-356.)

According to the *BVLD Airshed Management Plan: A Community Action Plan for Clean Air* (https://www.google.ca/?gws_rd=ssl#q=blvd+airshed+management+plan), p. 27, "Large forest licensees burn between 10,000 and 20,000 piles [of logging debris] in any given year in the BVLD airshed, which represents the vast majority of open burning in the airshed." In 2016, according to an oral presentation by a knowledgeable employee of one of the largest licensees in the BVLD, the figure was in fact about 20,000 piles. It seems there are no figures for the number of piles burnt by smaller operators.

In an email message dated 2016 December 1, the manager of the Wetzin'Kwa Community Forest, near Smithers, estimated that in Wetzin'Kwa operations the amount of slash and other waste wood burned as 10-20 cubic metres of "processing waste" per hectare of WCF cutblock, plus 10-50 cubic metres of dead and dry, heavily checked material, plus an unknown amount of "non-utilization material like tops, branches, rot, etc." Very roughly, then, the total volume for these three kinds of waste wood and slash would be 30 to 100 cubic metres per hectare. Another local authority has estimated the average figure for wood in slash piles at 100 cubic metres per hectare, typically distributed into two piles.

The average oven-dry weight of wood and bark for lodgepole pine is 26 lb./cf for white spruce 26 lb/cf, and for subalpine fir 24 lb/cf (Patrick D. Miles and W. Brad Smith, 2009, *Specific Gravity and Other Properties of Wood and Bark for 156 Tree Species Found in North America;* Research Note NRS-38; Newtown Square PA: U.S. Department of Agriculture, Forest Service, Northern Research Station; https://www.nrs.fs.fed.us/pubs/rn/rn_nrs38.pdf.) "Cf" is "cubic feet." A cubic metre equates to about 3.28 x 3.28 x 3.28 ft. or 35.3 cubic feet. By this calculation, the dry wood of the most common tree species in the Bulkley Valley-Lakes District forestry region therefore weighs about 26 x 35.3 = 918 lb. to the cubic metre or 417 kg per cubic metre (918/2.2).

There is serious reason to believe that these "eyeball" estimates of slash generated by logging in the Bulkley Valley are gross underestimates, however. Harry E. Schimke and Ronald H. Dougherty, in *Disposal of Logging Slash, Thinnings, and Brush by Burying* (Berkeley, CA: U.S. Forest Service, Pacific Southwest Forest & Range Experiment Station, Research Note PSW-111 https://www.fs.fed.us/psw/publications/documents/psw_rp083/psw_rp083.pdf, in a study of high-elevation clearcuts in the Stanislaus National Forest in central California, actually **weighed** all the "slash," cull logs, and brush left on two one-acre plots after logging. (All three sorts of waste are incorporated into B.C. slash piles.) They obtained totals of 39 tons per acre on one plot, and 43 tons per acre on the other plot. Converted to metric, with one British ton equalling 0.907 metric tonne and one acre equalling 0.405 hectare, the figures for the first plot are 39 x 0.907 = 35.4 tonnes multiplied by 1/.405 or 2.47 = 87.4 tonnes per hectare. For the second plot they are 43 x 0.907 = 39 tonnes x 2.47 = 96.3 tonnes per hectare. The average of the two measurements is 91.85 tonnes per hectare.

Similarly, Bengt Nilsson, Daniel Nilsson, and Thomas Thornqvist, in "Distributions and losses of logging residues at clear-felled areas during extraction for bioenergy" (*Forests 6:* 4212-4227, 2015) reckoned the logging residue drawn into windrows in their Swedish study plot at 39 tonnes/ha drymass, with an additional 30% (or about 13 tonnes/ha) left between the windrows.

That works out to about 50 dry tonnes per hectare for what British Columbians would call "slash." Furthermore, old-growth timber is regarded as producing more slash than second- or third-growth, and harvesting of northern B.C. cutblocks, at least, typically involves hitherto uncut forest.

The B.C. *Provincial Logging Residue & Waste Measurement Procedures Manual* (2011, on the Web) does not have a section on measuring waste wood in slash piles. In the absence of audited measurements or peer-reviewed studies of slash in British Columbia, **this paper takes the wood waste burned in slash piles in B.C. to have a nominal dry weight of 50 tonnes per hectare.**

At a presentation he gave to members of CAN on 2017 February 10 in Smithers, the same one at which he stated that the number of slash piles burned in the Bulkley Valley-Lakes District Smoke Management Area (BVLD) in 2016 was 4,000 (Bulkley Valley) plus 16,000 (Lakes), an authoritative forestry company employee said the number of slash piles per hectare is conventionally set at 2. (The actual numbers vary, but that is understood as a convenient average figure.) **Hence the wood burned in a single "nominal" slash pile would be 25 tonnes.**

At a rate of 25 tonnes per slash pile, the amount of slash burned per year in the Bulkley Valley Timber Supply Area would be 4,000 x 25 tonnes = 100,000 tonnes. For the Lakes District it would be 16,000 x 25 = 400,000 tonnes. For the BVLD as a whole the total would be 500,000 tonnes. For the entire province of British Columbia, the figure would approximate to the area the *State of British Columbia's Forests* (p. 3) says has been typical for harvesting public and private forest land combined since the 1990s, 200,000 ha per annum, times 50 tonnes = 10,000,000 tonnes, or 10 megatonnes. (Currently, in British Columbia as a whole, the rate of harvesting is about 0.4% annually of the area available for harvesting (*State of British Columbia's Forests,* 2010 ed.; http://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/reporting/environmental-reporting-bc/previous-reports-indicators).

How much carbon dioxide does burning wood release? As a first approximation, by combining with atmospheric oxygen, 1 kg of wood burned produces 1.9 kg of CO_2. Correspondingly, 1 tonne of wood burned produces 1900 kg or nearly 2 tonnes of CO_2. (See https://www.transitionculture.org/2008/05/19/is-burning-wood-really-a-long-term-energy-descent-strategy/, quoting from the quasi-technical journal *Agroforestry News*.) For detail and comparison with other fuels, see http://www.volker-quaschning.de/datserv/CO2-spez/index_e.php. Wood burning also releases large quantities of greenhouse gases much more potent than carbon dioxide.

For the BVLD Smoke Management Area, then, the amount of carbon dioxide emissions from the burning of slash is roughly 500,000 tonnes x 1.9 = 950,000 tonnes per year. For the whole province, the emissions are 10,000,000 tonnes x 1.9 = about 19,000,000 tonnes or 19 megatonnes per year. By coincidence, according to the B.C. Greenhouse Gas Inventory tables in *British Columbia Greenhouse Gas Inventory Report* for 2014, the most recent edition available over the Web (http://www2.gov.bc.ca/gov/content/environment/climate-change/reports-data/provincial-ghg-inventory)

…this figure is about five times the emissions for Residential Energy consumption for the whole province (3.9 megatonnes). It is also approximately five times the figure for Light-Duty Gasoline Vehicles. It is roughly one-third the size of the Total CO_2 emissions *reported* for British Columbia in 2014 (62.7 megatonnes). (Forestry, agricultural, and certain other "LULUC" Sector emissions are NOT reported in the 2014 B.C. **totals** on the Web, for reasons discussed elsewhere in this document. See the section headed "The current exclusion of burning of slash wood from the B.C. Carbon Tax.")

Finally, it is worth noting that burning just one slash pile containing the reported average of 25 cubic metres of wood will produce nearly 50 metric tonnes (50,000 kg) of carbon dioxide (to say nothing of other greenhouse gases such as methane and nitrogen oxides). By comparison, a B.C. driver who fills up his or her tank with about 40 litres of gasoline every two weeks will release much less than 2,000 kg or 2 tonnes of carbon dioxide (40 x 26 x 2) into the atmosphere in a year. Now consider that the B.C. Carbon Tax has reduced carbon emissions in the province by somewhere between 5% and 15%, as described elsewhere in this document. If the B.C. Carbon Tax has changed B.C. driver behaviour in the direction of reducing gas consumption by 10%, then the improvement in B.C. driver behaviour is saving about 200 kg of carbon dioxide per year (2,000 x 1/10). So burning one slash pile negates the beneficial effect of the Carbon Tax on approximately 250 B.C. drivers driving for a year (50,000 kg slash burnt divided by 200 kg saved = 250 drivers).

3. Potential alternatives to burning slash

Conversion to biochar

Biochar, which is charcoal produced by the incomplete combustion of organic materials, sequesters carbon for centuries and perhaps even millennia. By far the best exposition of what biochar might mean in the context of commercial use of slash and other residual wood in British Columbia is: De Ruiter, Geoff, Steve Helle, and Michael Rutherford, *Industrial and Market Development of Biochar in British Columbia (*Victoria: Pacific Institute for Climate Solutions, University of Victoria, 2014);
https://pics.uvic.ca/sites/default/files/uploads/publications/Biochar%20Paper%20Feb%202014%5B1%5D.pdf

For research on use of biochar production in carbon offsetting, see
https://www.researchgate.net/profile/John_Gaunt/publication/5263646_Energy_Balance_and_Emissions_Associated_with_Biochar_Sequestration_and_Pyrolysis_Bioenergy_Production/links/552fb4410cf27acb0de61d73.pdf

Producing biochar from logging slash – An introduction from an engineering perspective

Biochar is made from various species of wood and is composed of virtually all carbon. There are innumerable forms of carbon. Biochar is produced by heating wood to temperatures just high

enough to drive off all water and hydrogen. This method produces a material with billions of very tiny air pockets that allow for the absorption and retention of water and is an ideal housing for the microorganisms that make soil fertile. This product can enhance the soil for anything from food growers to more successful reforestation.

The second reason for turning wood waste into biochar is that this form of carbon is stable for up to thousands of years, even out in severe weather. This keeps the carbon in the ground rather than in the air, where it contributes to global heating. Trees left in the woods start to deteriorate soon and give off CO_2. The time it takes for all wood to deteriorate to the point at which all carbon is given back to the atmosphere varies greatly. Detailed information is found on the World Wide Web at:
http://sciencenordic.com/how-long-tree-rots-away.

Biochar is made all over the world. However, the amounts are often small and for gardeners. Large forest biochar operations are not common in North America. The whole challenge is to find the simplest method of production that is safe and relatively inexpensive.

Companies in the U.S. have developed ways of burning large amounts of wood waste virtually smokelessly. Some of these methods are even approved by the EPA in terms of emissions. One of these methods is accomplished by an air curtain burner: http://www.airburners.com/ . If the curtain is stopped at the most opportune time, before the resulting charcoal burns and turns to ash, and the coals are doused with water, we have produced biochar.

The burners range up to 30 feet long. They are somewhat bulky to move around in the woods, so an option is to incorporate only an air curtain machine and dig a hole in the ground to be the container for burning. The only downside is that the char may not be clean enough for certain markets, especially when produced in a rocky hole If no market is available, the char can immediately be spread on the forest floor for enhanced reforestation.

A test pit with an air curtain burner could demonstrate how easy it would be to produce biochar in forestry operations in northwest British Columbia.

How could conversion of slash contribute to the smokeless sequestration of carbon in BVLD airshed? The equation below summarizes the potential carbon capture if all the slash piles were utilized for biochar production (however, we must recognize some production of CO_2 in the process that is presently not accounted for in the equation):

(20,000 slash piles x 50 m3/pile x 35.3 ft3/m3 x 26 lb/fts wood wt. x 0.5 (50% of wood is carbon) x 0.4536 lb/kg) divided by 1000 kg/metric tonne = 208,157 tonnes of carbon.

Studies have shown that piles of wood left untouched will start to emit CO_2 right away and in about 30 years will have about 20% of the carbon left. The slow rate of change gives us a few years of "breathing" room. However, if we keep making slash at the same rate for 30 years, subject to natural decay, with the old piles continuing to emit CO_2, we are likely no further ahead in carbon sequestration. This is the beauty of biochar, a product that stores carbon for centuries.

We need to balance the cost of making biochar against the future cost of the emissions. The cost of making char can also be mitigated by using it to enhance the fertility of soil. As our more immediate desire is for a substantial reduction of smoke from burning slash, there is a second reason for reducing slash to biochar, so long as the method of production is smokeless. (See www.airburners.com). We just need to weigh costs against benefits.

(A reviewer notes that although biochar reduces smoke and carbon dioxide, it does produce volatile organic compounds and polycyclic aromatic hydrocarbons.)

Burial

In the 1950s, 1960s, and 1970s the U.S. Department of Agriculture Forestry Research Stations published several reports on studies of burying logging residue on site. The reports concluded that the procedure was advantageous in all the respects studied. Of course at that time there was no awareness of the opportunities burial of slash might present as a means of sequestering carbon.

Perhaps the most interesting of these reports is "Disposal of logging slash, thinnings, and brush by burying," by Harry E. Schimke and Ronald H. Dougherty (Berkeley, CA: Pacific Southwest Forest & Range Experiment Station, 1972; Forest Service, Pacific Southwest Forest & Range Experiment Station, Research Note PSW-111; https://www.fs.fed.us/psw/publications/documents/psw_rp083/psw_rp083.pdf).
Schimke and Dougherty list four objections to burying slash and seven advantages, not including the middle-term sequestration of carbon dioxide. In their abstract, they state that "This method of slash disposal shows promise and has some distinct advantages over disposal by chipping and burning."

In the current era of concern about global warming, the use of burial of slash to sequester carbon for periods of several decades is most directly addressed in an article by Ning Zeng, "Carbon sequestration via wood burial," published in 2008 in the peer-reviewed journal *Carbon Balance and Management* (3:1, not paginated as in the paper version because online). Zeng considers a number of aspects of burial of forestry waste wood and concludes that it minimizes carbon dioxide emissions from deforestation, extends the lifetime of the carbon sink associated with reforestation, reduces fire danger, and is less expensive than some alternative uses of slash. In his abstract, he states that "The technique is low tech, distributed, easy to monitor, safe, and reversible."

Piling but not burning; and in situ scattering

Little or no peer-reviewed research is readily available to the public on the half-life of carbon sequestered in dead trees in British Columbia. In U.S. states with similar kinds of forests and climates, however, extrapolation of research suggests that rates of decay of residual wood must generally be very slow. According to E. Matthew Hansen (2014:482), "The lack of favorable aboveground conditions for decay [in Mountain Pine Beetle-killed stands of lodgepole pine] is evident among reported decomposition rates for snags. Harvey…reported…[less than] 1%

volume loss 11 years after death by MPG in Oregon and in Wyoming, Fahey…found no significant decline in specific gravity of 5- to 12-year-old snags compared with living trees, whereas 20-year-old snags retain…[about] 95% of original specific gravity. The decomposition rate increases after snags fall and contact the ground…. Rates continue to remain low, however, in absolute terms. In Oregon, Busse…reported a … [half-life of about 26 years], whereas Fahey reported a… [half-life of about 43 years] for a Wyoming forest. In Colorado, most lodgepole pine bole volume remained intact after multiple decades on the ground, including one bole dated as dying 139 years before being measured…." [Hansen, E. Matthew. 2014. Forest development and carbon dynamics after mountain pine beetle outbreaks. *Forest Science 60*(3): 476-488. http://www.usu.edu/beetle/documents2/2014Hansen_Forest%20Dev%20and%20Carbon.pdf]

If the lengthy half-lives described by Hansen are reflective of the rates of decay of British Columbian lodgepole pine, then piling logging slash tipi style and simply leaving it sit would sequester most of the carbon in the wood for several decades at least – potentially past the critical point for global warming. Even scattering large woody debris in the cutblocks might sequester half the carbon for twenty or thirty years on average. Admittedly, piles cover ground which might otherwise be growing trees (see Michael T. Ter-Mikaelian, Stephen J. Colombo, and Jiaxin Chen, 2016, Greenhouse gas emission effect of suspending slash pile burning in Ontario's managed forests; *The Forestry Chronicle 92*(3): 345-356), and over very long periods of time the amount of ground covered may become considerable from an operational point of view. Scattering slash in situ can make replanting more hazardous and less efficient. As discussed elsewhere in this document, slash left scattered in cutblocks is alleged to increase the risk of wildfire and fire damage to seedlings.

One objection sometimes made to piling but not burning slash is that the piles would be subject to vandalism and arson. Whether this concern should be taken seriously or not ought to be easily ascertained by consultation with district forestry offices. Virtually all slash piles sit drying for periods of a year or more before being burnt prescriptively, yet vandalism and arson seem to be rare. If systematic inquiries were to reveal that vandalism and arson are in fact occurring with significant frequency, then perhaps slash could be piled according to distribution patterns rendering it less susceptible to the spread of maliciously set fires.

Simply scattering slash on the ground would greatly speed up decomposition. The Intergovernmental Panel on Climate Change (IPCC) document 3.5.4.2 *How Much Carbon Can Be Sequestered by Global Afforestation and Reforestation?* says that in its consideration "One-third of the biomass stock at harvest is assumed to be left on the site as slash, litter, and dead roots. This material is assumed to decay at a constant rate in 15 years (boreal)…" (http://www.ipcc.ch/ipccreports/sres/land_use/index.php?idp=151). Where this assumption comes from is a mystery. Possibly the study sites were at very low elevations in the southernmost reaches of the vast boreal forests of Eurasia. In the Bulkley Valley even rooted stumps from trees cut forty or more years before often remain substantially intact.

Habitat conservation and wildlife biologists in British Columbia have been promoting a policy of distributing slash piles along cutblock edges with tree boles projecting out of the snowpack to facilitate marten access to the subnivean cavities where they can hunt voles and mice, which favour slash piles. In addition, mixing soil with slash piles greatly facilitates the use of slash

structure by bears for winter denning habitat within a decade. In fact, there are many wildlife habitat advantages when slash piles are configured correctly and positioned strategically.

Manufacturing into pellets, panelboard, etc.

It is often supposed that turning wood residue into manufactured products should be an important means of reducing the amount of slash burnt. On the face of it, so long as carbon emissions are a factor in the rational use of Canadian forests, the case for manufacturing must be made by those who advocate public subsidization for this method of disposal.

Wood pellets are burned for heating or power generation purposes within a few years of the death of the source tree from Mountain Pine Beetle attack or logging for the stem. In either case, all the carbon in the wood is liberated into the atmosphere. For at least the next eighty or one hundred years, in central and northern British Columbia, the quantity of CO_2 added to the atmosphere via pelletizing is greater than what can possibly be incorporated into the wood of a new tree on the same site. The production of wood pellets also depends on hauling the waste wood to a plant, shredding it into sawdust, compacting it, drying it, transporting it to markets, and so on. Where new trees can be grown on short cycles, as in the southeastern United States, pellet production might conceivably be carbon neutral in some circumstances, although it still imposes staggering ecological costs (Roger Drouin, 2015 January 22, "Wood pellets: Green energy or new source of CO_2 emissions?" (http://link.springer.com/article/10.1007/s10342-009-0283-5)

On the surface of it, at any rate, the manufacturing of slash into wood pellets in interior British Columbia is not compatible with Canadian plans to lower greenhouse gas emissions in the near future. From a hundred-year perspective, of course, pellet production and consumption might approach carbon neutrality, inasmuch as the carbon dioxide from which the wood is grown and the carbon dioxide which burning emits from the wood are equal. However, it is also true that in the long run, considering that humanity has only about two decades to prevent runaway greenhouse warming, using B.C. slash for pelletizing is far from carbon neutral. Indeed, in the space of two decades it may appreciably contribute to the death of coral reefs everywhere in tropical and subtropical oceans and possibly even saltwater phytoplankton collapse on account of lethal rises in temperature and ocean acidification. Biologists point out that most mass extinctions on Earth have been initiated through the collapse of ocean phytoplankton, the basis of oceanic food chains.

Manufactured structural lumber such as panelboard does sequester carbon for longer periods, but not for as long as one would imagine. See M.E. Harmon, J.M Harmon, W.K. Ferrell, and David Brooks, 1996, "Modeling carbon stores in Oregon and Washington forest products: 1900-1992" (*Climatic Change 33*(4): 521-550); http://link.springer.com/article/10.1007/BF00141703). According to the abstract for this article:

"Pools examined were long- and short-term structures, paper supplies, mulch, open dumps, and landfills. The analysis indicated that of the 1,692 Tg of carbon harvested during the selected period, only 396 Tg, or 23%, is currently stored. ["Tg" is a thousand kilotonnes.] Long-term structures and landfills contain the largest fraction of that store, holding 74% and 20%,

respectively. Landfills currently have the highest rates of accumulation, but total landfill stores are relatively low because they have been used only in the last 40 years. Most carbon release has occurred during manufacturing, 45% to 60% lost to the atmosphere, depending upon the year. Sensitivity analyses of the effects of recycling, landfill decomposition, and replacement rates of long-term structures indicate that changing these parameters by a factor of two changes the estimated fraction of total carbon stored less than 2%."

Ingolf Profft, Martina Mund, Georg-Ernst Weber, Eberhard Weller, and Ernst-Detlef Schulze, in their 2009 peer-reviewed article "Forest management and carbon sequestration in wood products" (*European Journal of Forest Reseearch 128:*4: 399-413), arrive at similar conclusions. "About 47% of annual timber harvest went into short-lived wood products with a mean residence time (MRT)…[less than] 25 years. … The average MRT of carbon in harvested wood products was 20 years."

Of course, wood products do not just sequester carbon; they are useful, and in some cases even essential.

Certain kinds of manufacturing of wood products can be very damaging to human health and the general environment. Consequently proposals to dispose of slash by feeding it into manufacturing of wood products must be carefully evaluated on a one-by-one basis, not least in how individual proposals would relate to particular settings. In the Bulkley Valley, for example, many careful observers believe particle board manufacturing even in its current form is very undesirable.

Combinations of methods

Presumably, the optimum manner of disposing of slash would be to combine methods: use the largest and soundest pieces for manufacturing, convert as much of what remains as economically feasible to biochar, tipi some non-commercial poles for slow decay, spread some large woody debris for biological reasons, and bury the rest.

4. An Interim Measure: A Moratorium on burning

A moratorium is a temporary prohibition on some activity. In the case of slash smoke, an argument can be made that if the provincial government were to declare a moratorium on slash burning, it would have the following advantages. First, it would provide immediate relief for the hundreds of thousands of British Columbians whose lungs are subjected to slash smoke frequently for several months each year. Second, if the moratorium were imposed for a period of, say, three years, it would provide the data necessary to test the idea – currently it is not even a hypothesis – that burning slash significantly reduces the incidence of forest fires. Third, it would give logging operators the time to adapt their methods of slash disposal from burning to the alternatives described elsewhere in this position paper, or to others. Fourth, except possibly for a few small companies which provide slash burning services and some persons hired on an occasional basis, a moratorium would have little effect on employment.

It is hard to see what other harms a three-year moratorium on slash burning might impose. The objection that slash would accumulate during the moratorium is probably correct; but it is of no force. As noted in section 3 above, one of the best means of disposing of slash may very well be to pile it in the usual fashion but then not to burn. By the time the wood in the pile has fully decayed and released its greenhouse gases, humanity will either have brought its global emissions back within safe limits or it will not have done so. In either case, three years of slow emissions and minor additions to wildfire hazard and minor subtractions from the productive commercial forest land base do not compare with the harms burning would do during the same period.

The article by Ter-Mikaelian, Colombo, and Chen (2016), "Greenhouse gas emission effect of suspending slash pile burning in Ontario's forests," referred to elsewhere in this document, analyzes the consequences of a "suspension," effectively what this paper calls a "ban," of slash burning over four periods, 2016-25, 2016-50, 2016-75, and 2016-2100. Their conclusions are favorable to the imposition of a suspension.

5. The Ultimate Solution: A complete or nearly complete ban on burning

On the whole, unless this paper has overlooked some really important consideration, the reasons why British Columbia should not permit the burning of logging slash overwhelmingly outweigh the reasons for allowing it. In summary, here are the reasons given for why slash SHOULD BE or IS burned, along with the basic critiques of those reasons.

First, the belief is widespread that burning slash reduces wildfire hazard. However, there is apparently no convincing body of scientific research establishing that burning slash actually does reduce wildfire hazard more than briefly. Peer-reviewed journal articles state that although modelling studies offer some support for the idea, case studies, at least on appropriate scales, are all but entirely lacking.

Second, research foresters consider that burning slash is necessary to minimize the gradual conversion of land to unproductive – treeless – status. In the course of long periods of time, on the order of a hundred years, models show slash as covering a significant proportion of the commercial forest land base (on the assumption that slash will decay very slowly). This rationale, however, is easily countered by the observation that there are several ways of removing slash from the landscape other than burning; and global warming must be successfully addressed in the next two or three decades, not in a century.

Third, industry and government foresters often claim that burning slash is the best way to remove it from the land base because it is the cheapest. In opposition to this claim is the fact that over time a number of peer-reviewed research reports have concluded that burying slash is no more expensive than burning; that other methods of disposing of slash, such as leaving poles standing, might actually be cheaper than burning; and that combined conversion to biochar and in situ scattering look very promising but have not been rigorously examined as alternatives.

Fourth, somewhat half-heartedly, the assertions are sometimes made that slash should be burnt because it renders clearcuts more attractive and it is conducive to tree-planter safety. The counterarguments to these rationales are that psychological research has revealed that clearcuts are unattractive to many members of the public because they know they are unnatural, so grooming them by removing slash is unlikely to change aesthetic judgments very much; and as for tree-planter safety, there are alternative methods of removing slash and hence the problem.

Now, here again are the reasons why slash should NOT be burned.

First, as in the critique of the first reason given for burning slash, there is little or no scientific justification for it; and if there is no scientific reason for doing it, it is irrational to continue the practice.

Second, scientific research on wood smoke of various kinds indicates that wood smoke has negative effects on human health, both with high-intensity acute exposure and when exposure is of lower intensity but is chronic. The health effects of the recurrent acute exposure to slash smoke exposure are unknown not because of conflicting or confusing or faint results from research but because the subject is understudied. So far as careful inquiry has been able to determine, the Government of British Columbia has not directed significant, or perhaps any, research effort to determining what slash smoke does to the millions of residents who are regularly exposed to it because of legal burning under the Wildfire Regulation.

Third, in circumstances in which serious health effects from some artificial input into the environment are reasonably suspected, if not yet proven, the Precautionary Principle imposes an ethical duty on responsible governments to shut down the sources of that input. Canada is an adherent to the Precautionary Principle. As a corollary, under the Precautionary Principle, for suspected agents of serious environmental harm, the burden of proof is on governments and industry to demonstrate they are safe. An impartial scientist would certainly regard smoke from burning slash as appropriately subject to the Precautionary Principle and at a minimum, an environmental input for which the burden of proof of safety ought to be on governments and industry.

Fourth, smoke from slash fires is a disamenity -- a feature of place which lowers environmental quality -- and disamenities undermine the ability of mountain communities to attract amenity migrants. Research economists and regional planning academics have found ample evidence that amenity migration is of major importance to the prosperity of such communities. Burning slash incidentally forecloses opportunities for jobs and economic activity generated by amenity migrants.

Fifth, tourists dislike air pollution. Although published research on the effects of slash smoke on tourism are lacking, research is available on the tendency of pollution to drive tourists away from destinations they would otherwise visit.

Sixth, air charter companies report that slash smoke interferes with their operations frequently and over large areas every year. When their airplanes are unable to fly, the companies lose

money. When their airplanes are unable to fly clients out to fishing, hunting, and hiking destinations, high-priced lodges and guiding services also lose money.

Seventh, most British Columbians are morally offended at the thought that huge amounts of slash wood are burned as a consequence of the harvesting of comparatively small amounts of commercial timber. Indignation at waste seems to arise from deep in Canadian cultural history.

Eighth, the burning of slash releases truly colossal quantities of greenhouse gases into the atmosphere, helping to bring on global warming. In the opinion of highly qualified scientific experts, global warming promises to become catastrophic within a generation. To authorize emissions on the scale of those produced by the burning of logging slash in British Columbia, and for no persuasively good reasons, is inexcusable.

In short, it would seem the appropriate policy measure for the Government of British Columbia is to impose a complete or nearly complete ban on the burning of logging slash.

Legally, a ban on slash burning might involve nothing more complicated than a minor amendment to the Wildfire Act, or an Order in Council, excluding burning as an acceptable means of disposing of slash under the Wildfire Regulation. In practice, a ban would probably have to follow a planned phase-in allowing logging operators to adapt to new ways of carrying on their business.

6. A Partial Solution: A carbon tax on burning

Governments seldom like to adopt measures they regard as draconian. Banning slash burning altogether could strike both provincial Members of the Legislative Assembly and electorates as indeed excessively absolute. They might prefer to leave logging operators with the option to burn slash provided that the burners absorb at least one of the two main social costs of burning, namely the exemption of wood burnt as slash from the provisions of the B.C. Carbon Tax.

The current exemption of burning of slash wood from the B.C. Carbon Tax

The B.C. Carbon Tax is described and explained in the Ministry of Finance document "Carbon Tax: Overview of the Revenue-Neutral Carbon Tax," available at http://www.fin.gov.bc.ca/tbs/tp/climate/carbon_tax.htm. An excellent assessment of it is provided by:

Murray, Brian C., and Nicholas Rivers. 2015. British Columbia's Revenue-Neutral Carbon Tax: A review of the latest "grand experiment" in environmental policy. Working Paper N1 WP15-04. Nicholas Institute for Environmental Policy Solutions (Duke University) and the Institute of the Environment (University of Ottawa); https://nicholasinstitute.duke.edu/sites/default/files/publications/ni_wp_15-04_full.pdf

The B.C. Carbon Tax applies to a wide range of fuels but not wood destined for burning. See the Ministry of Finance Tax Bulletin "Tax Rates on Fuels: Motor Fuel Tax Act and Carbon Tax

Act," revised August 2016 (http://www.fin.gov.bc.ca/tbs/tp/climate/carbon_tax.htm) for current rates. Rates on coal, another dirty fuel, vary between $53.31/tonne and $62.31/tonne. For peat, the rate is $30.66/tonne. If wood destined for burning in slash piles and as waste were taxed at the same rate as peat, the 20,000 slash piles burnt annually in the BVLD airshed management region would attract a carbon tax of about $29,127,000 per year (30.66 x 20,000 x 25 x 1.9). If the carbon tax were applied to slash burnt throughout British Columbia, the receipts would amount to about $582,540,000 per year (400,000 slash piles x 25 x 1.9 x 30.66). (In both cases, these figures are based on the calculations in the subsection above headed "Production of enormous volumes of greenhouse gases.") Because burning wood emits substantial volumes of greenhouse gases besides carbon dioxide, the tax rate might be considerably higher. By the year 2022, under the Pan-Canadian Agreement on Clean Growth and Climate Change, the B.C. Carbon Tax will rise by 67% over its current rate, from $30 per tonne of carbon dioxide equivalent to $50.

Why does the Government of British Columbia exclude wood destined for burning from the Carbon Tax? After all, carbon dioxide and other greenhouse gases contribute to global warming no matter what their source. One reason is no doubt political: In British Columbia, the logging industry is a sacred cow, and any government measures which are perceived to affect its economic health are sure to ignite a furor.

A reason for a *temporary* exclusion of wood burning from the Carbon Tax is that Under the Kyoto Protocol and Marrakech Accords, "land use, land-use change and forestry" (LULUCF) greenhouse gas (GHG) emissions are inventoried in a way different from emissions from other sectors of national economies and they are **not** included in national totals of GHG emissions. LULUCF seems to have been a problem area at the time the Kyoto Protocol was first adopted (December 1997), at the time Canada ratified it (December 2002), and at the time it came into force (February 2005). As examples of the difficulties in accounting for LULUCF emissions, consider that different countries have hugely varying amounts of forested land, a fact calling into question the fairness of measurements of LULUCF emissions, especially between neighboring countries such as those of the European Union; or that forestry emissions may vary widely from year to year. Even in the European Union, which has a voluntary but intensely serious program of reducing GHG emissions, LULUCF emissions are omitted from national totals. So Canada and B.C. are not out of step in this regard.

A technical but very useful explanation for why forestry (and agricultural) GHG emissions are not included in total emissions inventories in the European Union, and by extension in Canada, is included within the document *Policy options for including LULUCF in the EU reduction commitment and policy instruments for increasing GHG mitigation efforts in the LULUCF and agriculture sectors*, available at: https://ec.europa.eu/clima/sites/clima/files/forests/lulucf/docs/synthesis_report_en.pdf.

With the conclusion of the Paris Climate Change Agreement, however, "GHG emissions and carbon sequestration for Land Use, Land Use Change and Forestry (LULUCF) will be included in the CC policy for 2030." ("CC" is an abbreviation for "Commission Communication on Paris Agreement.) The year 2030 is a target date for national reductions in GHG emissions: "the EU has committed itself to a further reduction of EU Greenhouse Gas (GHG) emissions) by *at least*

40% by 2030 in comparison with 1990, and by 80-95% by 2050.") (See *So, what does the Paris Agreement mean for European agriculture?* …at http://www.farm-europe.eu/blog-en/so-what-does-the-paris-agreement-mean-for-european-agriculture/.) For more information on how the European Union will inventory GHG emissions in the near future, see the article "Including LULUCF in the EU's 2030 climate policy target:" http://capreform.eu/including-lulucf-in-the-eus-2030-climate-policy-target/.

Changes in how LULUCF emissions are calculated are imminent in Europe and even in Canada. According to the Climate Action Tracker (http://climateactiontracker.org/countries/canada.html), "Canada is developing a methodology to calculate LULUCF emissions and removals due to human activity—excluding the impacts of natural disturbances in the managed forests."

A special revenue-neutral form of application of the B.C. Carbon Tax to slash

While B.C. politics would perhaps rule out a simple application of the B.C. Carbon Tax to the burning of slash, a provision in the applicable Ministry of Finance legislation and regulation might render it acceptable to the public and make it hard for the forestry industry to reject. In theory, the B.C. Carbon Tax is *revenue-neutral*: all revenues from the B.C. Carbon Tax are supposed to be returned by the government to the public and business as reduced general taxes, instead of being treated as an additional source of income. What CAN advocates is that all revenues from application of the B.C. Carbon Tax should at least initially be returned to logging operators that dispose of slash by carefully defined methods other than burning. (See the section of this document with the heading *Potential Alternatives to Burning Slash.)* A transfer of Carbon Tax revenues along these lines would mean slash burners would incur a penalty of approximately 100 tonnes carbon dioxide equivalent per hectare times $30.66 = $3,066/hectare for the burning they do; operators that dispose of their slash by other methods would receive the prorated equivalent in cheques from the Ministry of Finance. Initially, because the number of burners would presumably be greater than the number of non-burners, the non-burners would be at a great competitive advantage over burners. Gradually the number of burners should diminish to very few, reducing the competitive advantage; but by that time, one expects, very few burners will remain.

A reviewer notes that since the annual allowable cut in the Bulkley Timber Supply Area equates to about 3,250 ha, at $30.66 x 100 tonnes $C0_2$ /ha x 3,250, burners in the TSA would be incurring a penalty of around $10,000,000/yr. This amount of money would be a substantial incentive to shift to alternative methods of disposing of slash (or to resist any new policy on burning slash).

Public carbon offsetting for non-burning slash disposal

For a helpful description of the thinking behind carbon offsetting, see Deo et al. (2012), cited below.

Since the inception of the B.C. Carbon Tax, the Government of British Columbia has maintained programs for public-sector organizations to offset their irreducible carbon dioxide emissions by funding the lowering of carbon emissions from unrelated bodies. See

http://www2.gov.bc.ca/gov/content/environment/climate-change/policy-legislation-programs/carbon-neutral-government. It is well within the authority and scope of the Government to encourage or even require public-sector organizations seeking carbon offsets to purchase them from logging operators who have found ways of disposing of their slash which sequester carbon for periods of forty or fifty years.

Private carbon offsetting for non-burning slash disposal

At present, private carbon offsetting seems to be under something of a cloud. Nevertheless, it too could direct funding towards logging operators who dispose of their slash in non-burning, long-sequestration methods. For details on private carbon offsetting, though on private rather than Crown lands and on sorts of carbon husbandry other than displacing slash burning, see Balbinder Deo, Han Donker, and Michael Schultz (2012), "Carbon credits on private lands in British Columbia" (*Low Carbon Economy 3*(4): 144-153; http://file.scirp.org/pdf/LCE_2013010211110989.pdf). Deo et al. usefully describe the thinking behind carbon offsetting:

> A carbon credit is created when one metric tonne of carbon dioxide or its equivalent is prevented from entering the atmosphere or neutralized from the atmosphere. The underlying basis of measurement of carbon credits is the amount of carbon that is prevented and/or neutralized by taking on the projects designed to reduce the emissions of, or provide for the sequestration of Carbon Dioxide (CO_2) from the atmosphere versus the status quo. The amount of carbon prevented or neutralized is certified and turned into financial instruments called carbon credits that are purchased, sold or transferred in a carbon market in terms of units of metric tonnes of carbon dioxide equivalent (MtCO2e).

Deo et al. (2012) state that "Afforestation and reforestation (A/R) are the two primary types of forest projects that constitute a planned set of forestry management or land-use change activities designed to remove, reduce or prevent carbon dioxide emissions by conserving and/or increasing forest carbon stocks. Afforestation is defined as the planting of trees on land that historically has not supported forests; reforestation is the replanting of forests on land that was previously forested…. Through participation in afforestation and reforestation projects, landowners have the ability to generate carbon credits that they can make available for sale in markets." Disposing of slash does not fit very well into A/R.

7. Conclusion

In conclusion, it appears that reasons for ending the burning of logging slash (known harms wood smoke imposes on human health as well as a legal and moral imperative for Canadian governments to exercise The Precautionary Principle; and massive greenhouse gas emissions) greatly outweigh any well-founded reasons for continuing the practice of burning (cost advantages of burning versus alternative methods of disposal). If burning were banned altogether, several alternative means of disposing of slash would be available (burial, conversion to biochar, scattering, some sorts of manufacturing). If testing of the concept of banning burning

were required, a three- or five-year moratorium would provide a low-cost, high-benefit, large-scale experiment. If something less absolute than a complete ban is perceived as desirable, then extension of the B.C. Carbon Tax to wood burnt as slash, especially in a revenue-neutral form where tax revenues gathered from burners are transferred to non-burners, would act as a powerful incentive for logging operators to shift to preferable methods of slash disposal. Some of those methods could generate thousands of new jobs across the forest lands of the province.

Unless something is seriously wrong with the argument of this paper, the Government of British Columbia should act swiftly to end the burning of logging slash by amending the Wildfire Act and the Wildfire Regulation, or by issuing an Order in Council imposing a moratorium on the practice. A more gradual approach to achieving much the same result, although at a cost to human health, would be for the Government to revise the B.C. Carbon Tax Regulation in such a way as to cover wood burnt as slash.

+ + +

Principal contributors to this Position Paper were Hans Duerichen, P.Eng; Daphne Hart, MD; Wendel Imhof, owner-operator of Alpine Lakes Air; and Raymond Chipeniuk, Ph.D. (Regional Planning and Resource Development). An additional six persons participated in discussions about content and by writing particular sections and passages.

For further information, contact

Dr. Raymond Chipeniuk
250-847-5758
chipeniuk@xplornet.com