info@fpinnovations.ca
web.fpinnovations.ca

Hügelkultur as a debris management technique in forest fuel reduction treatments

Decomposition of woody debris in hugels: A literature search

PROJECT NUMBER: 301014884

Steven Hvenegaard, Wildfire Operations

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Disposal of woody debris and vegetative matter from forest fuel reduction treatments is a challenge and alternatives to conventional methods of pile burning and chipping are being considered. The construction of hugels is proposed as a debris management technique that would configure debris on site in a less flammable state. Flammability of piled debris (hugels) and the productivity of hugel construction are key considerations in assessing the viability of this debris disposal method.

Another consideration in assessing hügelkultur as a long-term debris management strategy is the decomposition of hugels and the evolving flammability of hugels. Research literature does not speak directly to the changing flammability of piled debris (and more specifically hugels), but this literature search attempts to locate material relevant to decomposition of woody debris in a hugelkultur environment.

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APPROVER CONTACT INFORMATION
Michael Benson
Manager, Wildfire Operations

REVIEWERS
Greg Baxter, Wildfire Operations

AUTHOR CONTACT INFORMATION
Steven Hvenegaard
Researcher, Wildfire Operations
steven.hvenegaard@fpinnovations.ca
(780) 740-3310

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1 BACKGROUND

Forest fuel treatments in the wildland-urban interface typically require the strategic removal of large volumes of vegetative fuel and woody debris to achieve the objectives and measurable fuel reduction targets defined in a fuel treatment prescription. The final disposal of removed fuel is often achieved through a pile and burn tactic.

Chipping or mulching are becoming more commonly applied techniques to convert fuel treatment residue to a less combustible state but these are not universally appropriate or acceptable practices.

While a pile burning tactic can typically be achieved safely during winter months with snow cover, several negative consequences occur when using this approach. In winter months, when the potential for escaped fire is low, poor atmospheric venting conditions often limit smoke dispersion and air quality can be compromised. With any debris burning operation, green house gas emissions are a concern.

2 INTRODUCTION

Disposal of woody debris and vegetative matter from fuel treatments is a challenge and alternatives to conventional methods of pile burning and chipping are being considered. Hügelkultur is proposed as a debris management technique that would configure woody debris, branches, and other vegetative residue on site in a less flammable state (hugels). Objectives and desirable long-term outcomes of a hügelkultur technique are to:

1. Reduce the regrowth of flammable fine fuels in zones of created hugels. A patchwork of surface fuels created by hugels can interrupt the horizontal continuity of fine fuels such as grasses and shrubs that occurs in conventional fuel reduction treatments.
2. Create rings of beneficial habitat around each hugel that encourage or “push” the forest structure towards more fire-resistant broadleaf species.
3. Reduce the labour and equipment expense of the original fuel treatment.
4. Reduce the long-term maintenance requirements in a fuel reduction treatment.

‘Hügelkultur – “mound-culture” pioneered by an Austrian ecological farmer Sepp Holzer – aerobically decomposes woody debris into humus over years to decades’ (Bennett 2020). This technique has been recently applied in innovative agricultural settings to store excess woody debris and allow it to slowly rot in a fuel matrix including branches, logs, and finer mulches, which are typically covered with either soil or more mulch and then seeded or planted.

Hügelkulturs (hugels) are not composts. Composts are rich in nutrients and bacteria, so decompose in a matter of weeks or months and quickly off-gas a large proportion of their carbon. By contrast, nutrient-poor hugels decompose slowly over many years, and more carbon remains sequestered for much longer. Other benefits of hugels include habitat creation, and humus development for increased water retention and slow nutrient release.

The City of Rossland has contracted FPInnovations Wildfire Operations group to develop research protocols that explore the viability of applying hügelkultur as a debris management technique in forest fuel reduction treatments. As part of this research project, two companion reports have been prepared to present research designs to:

- evaluate the flammabilty of hugels constructed as part of a fuel treatment operation and
- evaluate the productivity of fuel treatment operations that incorporate hugel construction.

3 RESEARCH QUESTION

3.1 Decomposition and Evolving Flammability of Hugels

Living Lands Agroecology has built a variety of hugels since 2010 and has worked with the City of Rossland since 2018 to trial large-scale hugels to dispose of residents' woody wastes. Scientific research is sparse and hugeling to treat fuel wood to mitigate the risks of wildfire is largely unexplored. (Bennett 2020)

The current practice of constructing hugels using vegetative debris from forest fuel treatments in Rossland, BC has been conducted in controlled spaces where trenching is possible, and soil is available to cover the woody debris. This warm and moist environment with contact to mineral soil provides optimum conditions for decomposition of woody debris.

This research project proposes hügelkultur as a debris management technique to construct hugels within a forest fuel treatment area using the residual branches and stems generated through the treatment operations. A broader application of hügelkultur as a debris management technique is envisioned to store harvest residue that would otherwise be burned on site.

Initial trials in building hugels have demonstrated that storage of fuel treatment residue is a viable debris management technique that promotes a long-term decomposition of woody debris into valuable soil matter. The research hypothesis for this project suggests that constructing hugels in forest fuel treatments or harvest sites can promote decomposition of material and that hügelkultur will be a viable carbon storage strategy and debris management technique in these environments.

4 OBJECTIVES

This search is conducted to identify literature that investigates decomposition and flammability of woody debris and masticated fuel which may help to inform and support the application of hügelkultur as a debris disposal method.

5 FINDINGS

5.1 Principles of Decomposition

Title	Coarse Woody Debris decomposition - principles, rates, and models
Authors	John Parminter
Date	2002
Web access	https://www.for.gov.bc.ca/hre/pubs/docs/nivma.pdf
Data collection methodology	Literature review and presentation to: Northern Interior Vegetation Management Association (NIVMA) and Northern Silviculture Committee (NSC) Winter Workshop: Optimizing wildlife trees and coarse woody debris retention at the stand and landscape level. January 22 - 24, 2002. Prince George, B.C.
Keywords	Decomposition, natural disturbance
Ecosystems	British Columbia

Abstract or relevant findings

Coarse Woody Debris:

- forms part of the dead wood cycle,
- is primarily created by tree death, and
- persists for some time

Natural disturbances (including insects and diseases) can add much CWD, and forest harvesting activities can remove much CWD. The comprehensive study of CWD decay requires a long time period and so our knowledge is limited. As new stands develop:

- competition mortality, small-scale disturbances, and other forms of tree death add CWD to the ecosystem.

CWD decay is due to five processes

- respiration
  - microbes transform bound carbon into CO^2
  - fungi break down components
    - white rot fungi break down cellulose and lignin
    - brown rot fungi break down only cellulose
- biological transformation
  - microbes and invertebrates metabolise organic matter
- leaching of water percolates through CWD and dissolves soluble materials
- fragmentation, collapse and settling
  - physical due to breakage during or after falling to the ground or impact from new CWD arrivals, shrinkage/swelling and freeze/thaw cycles forming cracks, machinery traffic
  - biological due to microbes, fungi, bark beetles, wood borers, other invertebrates, vertebrates (birds, mammals), invading plant roots
- weathering
  - disintegration by atmospheric elements

Title	**Decay**
Authors	Paul E. Aho
Date	1974
Web access	https://www.fs.fed.us/pnw/pubs/pnw_gtr024.pdf
Data collection methodology	Literature collection titled Environmental Effects of Forest Residues Management in the Pacific Northwest
Keywords	Environmental effects; forest residues - - brush, slash; forest residue treatment - -mechanical, prescribed burning; silviculture; coniferae; Pacific Northwest; recommended research; fuel management.
Ecosystems	Pacific

Abstract or relevant findings
Conditions affecting infection and subsequent development of insects and fungi will determine the rate of residue deterioration. In addition to a food base, decay fungi require adequate temperatures, moisture, and oxygen to grow. When these conditions are optimal, deterioration occurs at its maximum rate. Several physical and environmental factors including soil type, elevation, slope aspect and percent, and degree of shading significantly influence temperature, moisture, and oxygen contents of forest residues. Relationships are often complex and difficult to measure under natural conditions. Therefore, much information in the literature is observational and sometimes conflicting. However, there is a body of information concerning deterioration of residues that is consistent enough that broad generalizations can be made for most tree species. Temperature and moisture are the most important factors governing decay rate of forest residues. In general, residues in clearcuts deteriorate slower than those in partial harvest cuts or in thinned young stands. In the summer, because of greater amounts of sunlight, slight rainfall, and low relative humidities, residues in clearcuts may become too dry to decay. Charred wood seems to be highly resistant to decay and protects sound wood, which it surrounds, from fungal infection. Eventually checks develop in charred surfaces through which decay fungi attack the wood beneath. Deterioration of forest residues even under the most favorable conditions is a long - term process. For instance, in clearcuts in the Douglas - fir type, only 70 percent of small (less than 1 inch (2.5 cm) branch volume and 60 percent of large (larger than 1 inch (2.5 cm)) branch volume was decayed 16 to 20 years after logging.

5.2 Modelling Decomposition and Mass Loss in Woody Debris

Title	**Modelling above- and below-ground mass loss and N dynamics in wooden dowels (LIDET) placed across North and Central America biomes at the decadal time scale**
Authors	Amanda C. Smith, Jagtar S. Bhatti, Chen Hua, Mark E. Harmon, Paul A. Arp
Date	2010
Web access	https://cfs.nrcan.gc.ca/publications?id=31988
Data collection methodology	Decomposition modelling; Nitrogen dynamics; Long-term Intersite Decomposition Experiment (LIDET)
Keywords	Mass, Nitrogen, Wooden dowels, Tropical Temperate, Boreal forests, Grasslands, Wetlands, Tundra
Ecosystems	Broad variance from tundra to warm semi-desert to humid tropical forest

Abstract or relevant finding
Wooden dowels were placed at 27 locations across North and Central America, involving tropical, temperate, and boreal forests, grasslands, wetlands, and the tundra. The dowel, inserted vertically into the soil with one half remaining exposed to the air, revealed fast mass and N losses under warm to humid conditions, and slow losses under wet as well as cold to dry conditions. The model formulation, referred to as the Wood Decomposition Model, or WDM, related nitrogen losses to (i) mean annual precipitation, mean monthly January and July air temperatures, and (ii) mean annual actual evapotranspiration (AET) at each location.

Title	**Decomposition of logging residues in Douglas-fir, western hemlock, Pacific silver fir, and ponderosa pine ecosystems**
Authors	Heather E. Erickson, R. L. Edmonds, and C. E. Peterson
Date	1985
Web access	https://cdnsciencepub.com/doi/10.1139/x85-147
Data collection methodology	Specific gravity (density) was used to calculate decay rates. Four different-aged harvest units were chosen within each ecosystem. Each had similar aspect (south), slope, original stand composition, and soil. Within each ecosystem, the only residues sampled were of the same species as the name of that ecosystem.
Keywords	Decomposition; logging residues
Ecosystems	Douglas-fir; western hemlock; Pacific silver fir; ponderosa pine

Abstract or relevant findings

In all four ecosystems, dry season moisture contents were lower in smaller-diameter residues.

Moisture levels associated with small-diameter residues were too low for significant decomposition to occur during the dry summer period and probably contributed to the slow annual decay rates.

Residues located above the soil surface decomposed significantly slower than residues on the soil surface only in the Douglas-fir ecosystem.

Dry season residue moisture, rather than initial lignin concentration, appeared to be the dominant factor determining residue decomposition rates on exposed harvested areas.

Key findings –

Low residue moisture levels during the dry season, rather than residue chemistry (i.e. lignin concentration), appeared to be the dominant factor controlling decomposition rates in harvested areas of four different coniferous ecosystems.

Small-diameter residues decomposed slower than large-diameter residues, especially in Douglas-fir and western hemlock ecosystems.

Title	**Decomposition rates and nutrient dynamics in small-diameter woody litter in four ecosystems in Washington, U.S.A.**
Authors	Robert L. Edmonds
Date	1986
Web access	https://cdnsciencepub.com/doi/pdf/10.1139/x87-084
Data collection methodology	Cone and twig decomposition were determined using the nylon mesh bag technique. Wood discs were cut from branches of trees and initial dry weights for each disc was determined. Samples were removed 11, 24, 36, 48 and 63 months after initial placement. Mass loss at each sampling period was calculated an decomposition constants were determined.
Keywords	Decomposition; nutrients; woody litter
Ecosystems	Douglas-fir, western hemlock, red alder, Pacific silver fir

Abstract or relevant findings
Decomposition rates for cones were slower than those for twigs while branches had the slowest decomposition rates. In general, western hemlock fine woody litter decomposed faster than that of Douglas-fir and Pacific silver fir. Douglas-fir and western hemlock branches in this study decomposed faster than similar diameter branches of the same species in clear-cuts in Washington.

Title	**Dynamics of Coarse Woody Debris in North American Forests: A Literature Review**
Authors	Gregory Zimmerman
Date	2004
Web access	https://www.ncasi.org/wp-content/uploads/2019/02/tb877.pdf
Data collection methodology	Literature Review
Keywords	coarse woody debris; decay classes; decomposition; decay rates
Ecosystems	North American ecosites

Abstract or relevant findings
Section 4.4 on page 23 – Decay Rates in US Pacific Northwest and British Columbia Forests Decay rates in the Pacific Northwest and British Columbia vary widely among tree species and sites. Diameter affected decomposition rates of Douglas fir logs in a controlled study in a northwest Washington forest. Large diameter logs decayed faster than small diameter logs (79.5% of original mass remaining after 10 years for large diameter logs versus 92.3% for small diameter logs). Differences in decomposition rates across geographic regions and within regions show that temperature and moisture are important controls of decomposition rates. Log diameter affects decomposition both through the surface area to volume relationship and water content. On drier sites, the lower moisture content may be more important than the larger relative surface area. Species differences in size and log constituents, including proportion of bark, heartwood, and sapwood, and wood chemistry, also influence decomposition partly by controlling rate of insect incursion.

5.3 Decomposition and Flammability of Woody Debris and Masticated Fuels

Title	**A regional assessment of the ecological effects of chipping and mastication fuels reduction and forest restoration treatments**
Authors	Mike Battaglia; Charles Rhoades; Monique E. Rocca; Michael G. Ryan
Date	2009
Web access	https://www.fs.usda.gov/treesearch/pubs/59181
Data collection	Fuel loading Carbon storage Fire behaviour assessment
Keywords	Mastication; Ecological effects; Decomposition rates; Carbon balance
Ecosystems	Pinyon-juniper; Ponderosa Pine; Mixed conifer; Lodgepole Pine

Abstract or relevant findings
The mechanical treatment added a substantial amount of 1-hr and 10-hr woody fuel (<2.54 cm in diameter) to the forest floor which resulted in a range of depths within each. The treatments provided a relatively large input of nitrogen (N) to the forest floor, but because of the high carbon (C) to N ratio of the added material (e.g. C:N of 125-175), the woody mulch is resistant to microbial decay and the added N is largely unavailable to plants. Slow mulch decomposition in arid and cold western forests may extend the consequences of this management treatment on plant germination, soil nutrient availability, and plant productivity for many years. We found that mastication had few short-term negative effects on plant communities and soil processes, but that responses to the treatment cannot be generalized across western conifer ecosystems. In some ecosystems, mulch additions had no significant impact on stand-level soil N availability, herbaceous cover, or tree seedling regeneration; in others, mastication decreased soil N availability and tree seedling regeneration and increased herbaceous cover. The depth of the added mulch also had consequences on plant cover and soil N availability. Specifically, above a thickness of 7.5 cm, mulching depressed herbaceous plant cover and soil N nutrition in lodgepole pine and pinyon-juniper ecosystems. Though the initial impacts of mastication were subtle, our findings indicate that responses will vary among ecosystems and justify further research to elucidate ecosystem-specific processes and long-term consequences of these treatments.

Title	**Long-term fuel and vegetation responses to mechanical mastication in northern California and southern Oregon**
Authors	Warren P. Reed
Date	2015
Web access	https://www.frames.gov/catalog/24832
Data collection methodology	Field sampling with laboratory analysis
Keywords	Mechanical mastication; fire behaviour; vegetative recolonization
Ecosystems	Dry conifer in Northern California and Southern Oregon

Abstract or relevant findings
While mastication reduces potential fire intensity, these compacted fuels are flammable and capable of causing tree mortality and other negative ecological consequences when they burn in prescribed fires or wildfires. A current knowledge gap is quantitative information about the rate at which masticated fuels decompose and the rate at which vegetation re-establishes within sites previously masticated. Using 25 sites across northern California and southern Oregon, this thesis examines how masticated fuels change over time. Results from this study demonstrate that the majority of mass lost from masticated fuel beds occurred in the 1 and 10-hour woody fuel classes. Because surface fire behavior is driven by these fine fuels, these findings are valuable to the planning and retreatment of masticated fuels treatments and the corresponding fire suppression efforts in masticated sites. In combination with masticated wood surface fuels, shrubs and small trees play an important role in fire behavior, acting as ladder fuels that exacerbate surface fire behavior and threaten to ignite residual trees. A lack of understanding of how woody vegetation recovers following masticated fuel treatments gives rise to questions and challenges regarding treatment longevity. In this study, species with the ability to resprout tended to recover more quickly than obligate seeding species.

Title	**Moisture content and ignition probability in chip fuelbeds along BC Hydro's Northwest Transmission Line right-of-way**
Authors	Steven Hvenegaard
Date	2014
Web access	https://wildfire.fpinnovations.ca/120/NTLROW2014_v11.pdf
Data collection methodology	Moisture sampling; igntion tests; fuel load sampling
Keywords	Chipped debris; mulch; moisture content; flammability
Ecosystems	British Columbia Northwest

Abstract or relevant findings
Fuel moisture determines the amount of fuel available for combustion and is a critical factor that influences ignition and fire behaviour. For other, more common, forest fuel environments, the Canadian Forest Fire Danger Rating System allows wildfire managers to make reliable estimates of relative fuel moisture conditions, which in turn allows them to predict and plan for potential fire behaviour. However, moisture retention in a fuelbed of wood chips is different from the fuelbeds of other forest fuel environments and predicting fire behaviour using standard fuel models may not be reliable. Like other fine surface fuels, the moisture content of chipped fuels 0–5 cm deep responds rapidly to rainfall and to changes in temperature and relative humidity. It also changes diurnally, with the lowest moisture content occurring at the peak of the burning day when temperature is highest and relative humidity is lowest. A drought will have a significant drying effect on surface fuels. The fine fuels in the deeper layers seem to act as a reservoir, accumulating moisture from fall, winter, and spring precipitation. In addition, debris at the surface acts as an insulating layer that limits heating of lower layers, limits airflow, and limits migration of moisture to the atmosphere. The average moisture content at the 10 cm, 15 cm, and 20 cm layers was 137%, 174%, and 159%, respectively. The moisture profiles from this study suggest that chipped debris in the uppermost surface fuel layer (0 to 2 cm) dries quicker and becomes more readily available for ignition than the surface fuels in other forest types. If ignition occurs, the chipped fuel in the top 5 cm is dry enough to sustain ignition and support moderate intensity fire behaviour. The moisture content at 5 to 10 cm is sufficient to support smouldering and creeping surface fire. Flaming combustion is not likely in chipped fuels deeper than 10 cm.

Title	**Coarse Woody Debris: Managing Benefits and Fire Hazard in the Recovering Forest**
Authors	James K. Brown Elizabeth D. Reinhardt Kylie A. Kramer
Date	2003
Web access	https://www.fs.fed.us/rm/pubs/rmrs_gtr105.pdf
Data collection methodology	We examined the knowledge of the ecology of CWD, its contribution to potential fire behavior, historical stand structures and large fuel accumulations, and potential reburn severity as a basis for identifying optimum quantities of CWD.
Keywords	fuel, salvage, snags, reburn, Fire and Fuels Extension to the Forest Vegetation Simulator
Ecosystems	Recommendations for coarse woody debris loadings in two inland west ecosystems are presented - 1) Warm, dry forest types and 2) cool and lower subalpine forest types (page 7)

Abstract or relevant findings
Management of coarse woody debris following fire requires consideration of its positive and negative values. The ecological benefits of coarse woody debris and fire hazard considerations are summarized. This paper presents recommendations for desired ranges of coarse woody debris. Example simulations illustrate changes in debris over time and with varying management. This paper addresses coarse woody debris management following large wildfires that result in dead standing and, eventually, dead and down coarse woody debris. Even though post-fire woody debris accumulations are the focus in this report, the same fundamentals of woody debris loading, fire hazard and fire severity can be applied to other disturbances or fuel treatments. Page 7 – Optimum Coarse Woody Debris – provides some general guidelines for coarse woody debris loading based on fire hazard, soil heating, productivity, wildlife and historical criteria.

5.4 Research Programs Studying Decomposition and Flammability of Woody Debris

5.4.1 MASTIDON – MASTIcated Fuelbed Decomposition Operational Network

Title	**Physical and Chemical Characteristics of Surface Fuels in Masticated Mixed-Conifer Stands of the U.S. Rocky Mountains**
Authors	Robert E. Keane, Pamela G. Sikkink, Theresa B. Jain
Date	2018
Web access	https://www.fs.fed.us/rm/pubs_series/rmrs/gtr/rmrs_gtr370.pdf
Data collection methodology	Field sampling Laboratory measurements and flammability testing
Keywords	mastication, ponderosa pine, fuel treatment, wildland fuel properties, fuel layers, fuel particles
Ecosystems	Northern Rocky Mountains – warm, dry mixed-ponderosa pine sites

Abstract or relevant findings
Relatively little is known about how structural, physical, and chemical characteristics of masticated fuel particles change over time and how these changes affect fuelbed moisture dynamics and fire behavior. Our analysis found few changes in most of the measured masticated fuelbed properties over the 10 years represented in our sample. Woody fuel decomposition was expected to alter important physical characteristics, such as particle density, surface area, and bulk density, and the critical chemical properties, primarily nitrogen, lignin, and cellulose + hemicellulose fractions, of masticated fuels (Keane 2015), yet we found few significant changes. There are probably several reasons that we found little change in fuel properties over a decade. First, most of the sites sampled (11 of 15) were warm, dry mixed-ponderosa pine sites with low precipitation and high temperatures where decomposition was slow. Previous studies in woody fuel decomposition indicated that these warm, dry sites had the lowest decomposition rates of most sites in the Northern Rocky Mountains.

5.4.2 The Canadian Intersite Decomposition Experiment (CIDET)

Title	**The Canadian Intersite Decomposition Experiment (CIDET)**
Authors	J.A. Trofymow and the CIDET Working Group
Date	1998
Web access	https://d1ied5g1xfgpx8.cloudfront.net/pdfs/5030.pdf
Data collection methodology	The study was established in 1992 and involved the preparation of almost 11 000 litter bags containing samples of sets of 12 standard litter types.
Keywords	
Ecosystems	21 study sites across Canada

Abstract or relevant findings
The objectives of the study were: a) to investigate the long-term rates of litter decomposition and nutrient mineralization over a broad range of forested ecoclimatic regions in Canada; b) to study the relationship between decomposition rates, substrate quality and climate; c) to assess the relative importance of site factors and microclimate on decomposition rates; d) to assess the influence of site moisture regimes on decomposition rates; and e) to test specific hypotheses on the observed pattern of litter decomposition. While this study focuses specifically on decomposition of litter, the method using litter bags has been also used for studying decomposition of mulch in a boreal ecosite at the Pelican Mountain FireSmart Vegetation Management research site. The data collection method of using is also used by the Long-term Intersite Decomposition Experiment Team - https://andrewsforest.oregonstate.edu/sites/default/files/lter/pubs/webdocs/reports/lidet/lidet_meth/lidet.htm Decomposition processes and data collection methods for measuring decomposition are detailed in: Harmon, Mark E.; Nadelhoffer, Knute J.; Blair, John M. 1999. Measuring decomposition, nutrient turnover, and stores in plant litter. In: Robertson, G. Philip; Coleman, David C.; Bledsoe, Caroline S.; Sollins, Phillip, eds. Standard soil methods for long-term ecological research. New York, NY: Oxford University Press: 202-240. https://andrewsforest.oregonstate.edu/publications/2713

5.5 Fibre Utilization/Carbon Storage

Title	**Oriented Pile Flammability Burn Trial October 2020: Collaborations with Mosaic Forest Management and British Columbia Wildfire Service**
Authors	Stu Spencer, Steve Hvenegaard, Brandon MacKinnon
Date	2021
Web access	https://wildfire.fpinnovations.ca/196/TR2021N8.PDF
Data collection methodology	Experimental fire
Keywords	Fibre utilization, flammability, coarse woody debris
Ecosystems	Douglas-fir harvest residue piled in oriented piles

Abstract or relevant findings
The clean air initiative led by the British Columbia Ministry of Environment seeks to develop innovative methods to improve community air quality by utilizing harvest residues and minimizing the volume of fibre burned at roadside. Retaining processed tops as roadside oriented piles is proposed as an alternative to burning debris. These burn trials have demonstrated that in this unique arrangement of fuels and interaction of site-specific variables, particular areas of the piles will be more vulnerable to ignition sources which can lead to sustained burning and high intensity fire behaviour. In addition to the low fuel moisture conditions, other fuel properties, such as the close proximity of piles, high volume of fine fuels (branches and needles) and orientation of piles to road all contributed to enhanced burning at this site.

Title	**Forestry and Carbon in BC**
Authors	Dr. Jim Pojar
Date	2019
Web access	https://skeenawatershed.com/resource_files/Pojar-ForestsAndCarboninBC-2019.pdf
Data collection methodology	Literature review
Keywords	Carbon storage; forest management; fibre utilization; green house gas emission
Ecosystems	British Columbia

Abstract or relevant findings
Recommendations and Potential Solutions - Page 12 Reduce drastically the amount of slash burning. • Reduce logging debris (slash) in cutblocks. We need better utilization but the trend over the past decade appears—in west central BC anyway—to have been towards greater waste, more highgrading, more 'cut-to-length' at the roadside (leaving tree bole sections behind if they don't fit the logging truck bunk or meet the quality or species expectations of the sawmill). • Perhaps make biochar (charcoal produced by the incomplete combustion of organic materials) from the slash and use it to amend the soil and store carbon for centuries or millenia. Biochar is great stuff but its production requires money and energy and gives off its own cocktail of emissions. • Pile but don't burn the slash. Stopping the burning of slash piles can substantially reduce GHG emissions. Although the increased area occupied by unburnt slash reduces the area available for growing trees, and slash piles are said to increase the risk of wildfire. • "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.

Title	**Evaluation of two techniques for the utilization of logging residues: Organic mulch for abandoned road revegetation and accelerated decomposition in small, chipped piles**
Authors	K. Bradley
Date	1997
Web access	https://scholarworks.umt.edu/cgi/viewcontent.cgi?article=3283&context=etd
Data collection methodology	All treatments received 5 kg of local soil as a source of native microbial decay organisms to enhance decomposition. Piles were watered immediately after formation and manually turned the following June in order to accelerate decomposition for purposes of study. Temperatures were measured every month to monitor for initiation of meso- or thermophilic decomposition.
Keywords	Douglas-fir
Ecosystems	

Abstract or relevant findings
A second experiment served as a preliminary investigation into whether treatment of slash with composting techniques can significantly enhance its rate of decomposition. Douglas-fir undergrowth from a commercial thinning was separated into stemwood and foliage/fine wood, chipped, piled, mixed with local soil, and left to decompose. Treatments included: a) equal parts stem and foliage, b) 2 parts stem and 1 part foliage, c) 2 parts stem and 1 part foliage + cow manure, and d) unchipped slash. After 13 months, all chipped treatments appeared much more decomposed due to conservation of moisture and increased surface area for fungal colonization. Decomposed slash was comparable to mineral soil as a growth medium in terms of germination rates and biomass yields in a greenhouse experiment.

6 REFERENCES

Battaglia, M., Rhoades, C., Rocca, M. E., & Ryan, M. G. (2009). A regional assessment of the ecological effects of chipping and mastication fuels reduction and forest restoration treatments.

Bennett, A. (2020). (unpublished). Hugels for Fire Hazards. Project summary, proposal, and action plan.

Bradley, K. (1997). Evaluation of two techniques for the utilization of logging residues| Organic mulch for abandoned road revegetation and accelerated decomposition in small chipped piles.

Brown, James K.; Reinhardt, Elizabeth D.; Kramer, Kylie A. 2003. Coarse woody debris: managing benefits and fire hazard in the recovering forest. Gen. Tech. Rep. RMRSGTR-105. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 16 p.

Cramer, O. P. (1974) Environmental effects of forest residues management in the Pacific Northwest: a state-of-knowledge compendium. Gen. Tech. Rep. PNW-GTR-024. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 543 p

Edmonds, R. L. (1987). Decomposition rates and nutrient dynamics in small-diameter woody litter in four forest ecosystems in Washington, USA. *Canadian Journal of Forest Research*, *17*(6), 499-509.

Erickson, H. E., Edmonds, R. L., & Peterson, C. E. (1985). Decomposition of logging residues in Douglas-fir, western hemlock, Pacific silver fir, and ponderosa pine ecosystems. *Canadian Journal of Forest Research*, *15*(5), 914-921.

Hvenegaard, S. (2014). Moisture content and ignition probability in chip fuelbeds along BC Hydro's Northwest Transmission Line right-of-way. FPInnovations Technical Report.

Keane, R. E., Sikkink, P. G., & Jain, T. B. (2018). Physical and chemical characteristics of surface fuels in masticated mixed-conifer stands of the US Rocky Mountains. *Gen. Tech. Rep. RMRS-GTR-370. Fort Collins, CO: US Department of Agriculture, Forest Service, Rocky Mountain Research Station. 56 p.*, *370*.

Parminter, J. (2002). Coarse Woody Debris decomposition - principles, rates, and models. Presentation to: Northern Interior Vegetation Management Association (NIVMA) and Northern Silviculture Committee (NSC) Winter Workshop: Optimizing wildlife trees and coarse woody debris retention at the stand and landscape level. January 22 - 24, 2002. Prince George, B.C.

Pojar, J. (2019). Forestry and Carbon in BC. Report prepared for: SkeenaWild Conservation Trust, Terrace, BC and Skeena Watershed Conservation Coalition, Hazelton, BC.

Reed, W. P. (2015). *Long-term fuel and vegetation responses to mechanical mastication in northern California and southern Oregon* (Doctoral dissertation, Virginia Tech).

Smith, A. C., Bhatti, J. S., Chen, H., Harmon, M. E., & Arp, P. A. (2011). Modelling above-and below-ground mass loss and N dynamics in wooden dowels (LIDET) placed across North and Central America biomes at the decadal time scale. *Ecological modelling*, *222*(14), 2276-2290.

Spencer, S., Hvenegaard, S., & MacKinnon, B. (2021). Oriented pile flammability burn trial October 2020: Collaborations with Mosaic Forest Management and British Columbia Wildfire Service. FPInnovations Technical Report No. 8.

Trofymow, J. A., & CIDET Working Group. (1998). *The Canadian Intersite Decomposition ExperimenT (CIDET): project and site establishment report* (Vol. 378).

Zimmerman, G. (2004). *Dynamics of coarse woody debris in North American forests: A literature review*. National Council for Air and Stream Improvement.

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info@fpinnovations.ca
web.fpinnovations.ca

OUR OFFICES

Pointe-Claire
570 Saint-Jean Blvd.
Pointe-Claire, QC
Canada H9R 3J9
(514) 630-4100

Vancouver
2665 East Mall
Vancouver, BC
Canada V6T 1Z4
(604) 224-3221

Québec
1055 rue du P.E.P.S.
Québec, QC
Canada G1V 4C7
(418) 659-2647