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The Island Lake Biomass Harvest Experiment: Early results



2016
Natural Resources Canada
Canadian Forest Service
Great Lakes Forestry Centre
Information Report GLC – X – 16

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Published by:
Natural Resources Canada
Canadian Forest Service
Great Lakes Forestry Centre
1219 Queen Street East
Sault Ste. Marie, Ont. Canada
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Information Report Number: GLC-X-16
2016

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Cataloguing information for this publication is available from Library and Archives Canada.

The Island Lake Biomass Harvest Experiment: Early results.
(Information Report, GLC-X-16)

Issued also in French under title: “Expérience de récolte de la biomasse à Island Lake : résultats préliminaires“ . L. Boisvert-Marsh, et al. 2016.

Electronic monograph in PDF format.

Includes bibliographical references.

ISBN 978-0-660-06257-0 ISSN 2562-0738 (online)

Cat. no.: Fo123-2/16-2016E-PDF

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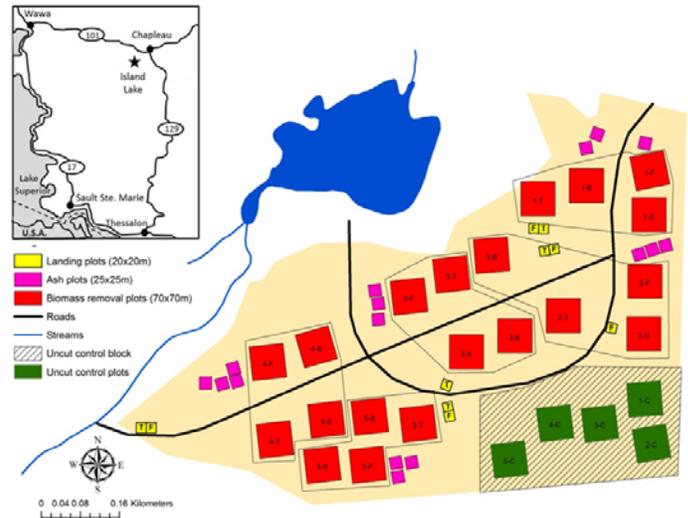
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INTRODUCTION

Forest harvesting residues are a large potential source of feedstock for bioenergy in Canada. However, this same material is a source of nutrients for future forest growth and provides habitat for a wide variety of organisms. There are therefore concerns that increased removals of this material could affect the ecological sustainability of forest sites.

The Island Lake Biomass Harvest Experiment was established to assess the impacts of biomass harvesting intensity on boreal forest biodiversity, soil properties and stand productivity (refer to Frontline Express #80 for more information on the study). Using an integrative, multi-disciplinary approach, researchers are developing a comprehensive understanding of how biomass harvesting intensity affects different groups of organisms, their responses and interactions, and the implications for ecosystem function. A wide range of organisms, including microbes, arthropods and vegetation, are being investigated that are important links in the food-chain and hence linked to nutrient cycling and site productivity. Rather than simply emulating current harvest levels, the experiment is specifically designed to investigate the implications and thresholds associated with a range of disturbance levels and silvicultural options. This is necessary to develop robust indicators that could be used to conserve biodiversity and ensure long term site and ecosystem productivity under various future scenarios. In addition, the effects of wood ash (a by-product of forest use for bioenergy) as a soil amendment are being studied in a similar fashion.

The forest (a 40-year-old second-growth jack pine stand) was harvested in the winter of 2010-2011 using four increasing levels of biomass removal, including: 1) stem-only jack pine sawlog harvest (leaving the crowns of harvested trees and all non-merchantable stems); 2) full-tree biomass harvest, removing the entire above-ground portion of all merchantable and non-merchantable trees; 3) full-tree biomass harvest with stump removal; and 4) removal of all biomass including stumps, downed woody debris and the forest floor. Effects of each treatment were further divided into subplots based on the tree species planted post-harvest (jack pine vs. black spruce) and whether herbicide (vegetation control) was applied or not. Three “natural” forest conditions (young fire-origin, old fire-origin and 40-year-old second growth forest) are also being studied to compare experimental results to reference conditions. Ten additional stem-only and full-tree



Plot layout at the Island Lake Biomass Harvest Experiment area

biomass harvest plots were also established on landings from the original (1960s) harvest where the forest floor and likely some mineral soil had been removed. These plots provide an opportunity to increase our understanding of the potential impact of repeated intensive biomass removals on ecological sustainability.

PROJECT SUMMARY

A group of collaborating researchers from the Canadian Forest Service (Great Lakes Forestry Centre, GLFC), the Ontario Ministry of Natural Resources and Forestry (OMNRF) and several universities are studying various aspects of biodiversity, soil processes and stand productivity response in a total of 14 integrated projects. Following is a brief description and five-year progress report for each project.

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Project Component	Participating Researchers*	Taxa, function or process studied/ measured
Tree productivity		
1. Stand productivity before and after biomass harvesting	Rob Fleming Dave Morris ¹	Tree nutrition (chemical analysis) Tree growth (DBH, height) Total biomass
Soil processes		
2. Impacts of biomass harvesting on soil nutrient availability	Dave Morris ¹ Paul Hazlett	Pre and post-harvest slash amount Stumps and coarse roots Soil characterization (pH, C and nutrients)
3. Impacts of biomass harvesting on carbon balance and soil respiration	Kara Webster	Soil respiration Carbon balance
4. Effects of wood ash addition on nitrogen cycling	Bill Peng ² Neal Scott ² Paul Hazlett	N mineralization and leaching
Microclimate		
5. Change in climate, microclimate and soil environment related to biomass harvesting and global change	Elyn Humphreys ³ Rob Fleming Kara Webster	Air/Soil temperature Relative humidity Soil moisture Wind speed/direction Photosynthetically active radiation Precipitation
Biodiversity		
6. Effects of wood ash addition on nematodes	Paul George ⁴ Zoe Lindo ⁴ Paul Hazlett Lisa Venier	Nematode abundance and characterization
Soil microbial response to: 7. biomass harvesting and 8. wood ash addition	Emily Smenderovac ⁵ Genevieve Noyce ⁵ Nathan Basiliko ⁶ Kara Webster	Soil microbial community
9. Impacts of biomass harvesting on soil invertebrates	Joseph Bowden ⁷ Jan Klimaszewski ⁸ Tim Work ² Dave Morris ¹ Paul Hazlett Lisa Venier	Spider, ground and rove beetle communities
10. Community indices and functional traits of mesofauna for potential as ecological indicators	Laurent Rousseau ⁹ Tanya Handa ⁹ Marco Moretti ¹⁰ Sandrine Salmon ¹¹ Lisa Venier	Soil springtail and mite communities



Island Lake site during (top) and after harvest (middle) , and site regrowth in 2015 (bottom)

Project Component	Participating Researchers*	Taxa, function or process studied/ measured
11. Relationships between deadwood and fly, beetle and fungal saproxylics	Cédric Boué ⁹ Alexis Brodeur ⁹ Charbel Hanna ⁹ Steve Kembel ⁹ Tim Work ² Lisa Venier	Saproxylic flies, beetles and fungi
12. Genomics techniques for measuring soil faunal communities	Jesse Hoage ⁶ Nathan Basiliko ⁶ Terri Porter ¹² Kara Webster Lisa Venier	Genomics techniques for measuring soil faunal communities
13. Change in taxonomic and functional composition of understory vegetation	Idaline Laigle ¹³ Christian Messier ¹⁴ Isabelle Aubin	Understory vegetation community
14. Integrated assessment of vegetation, fauna and soil processes	Idaline Laigle ¹³ Dominique Gravel ¹³ Marco Moretti ¹⁰ Isabelle Aubin and all study researchers	Modeled interactions between organisms Integrative ecosystem response to biomass removals

*NRCan unless otherwise noted. ¹OMNRF, ²Queen's University, ³Carleton University, ⁴Western University, ⁵University of Toronto, ⁶Laurentian University, ⁷Aarhus University, ⁸Laurentian Forestry Centre (CFS), ⁹Université de Québec à Montréal, ¹⁰Swiss Federal Research Institute, ¹¹Muséum National d'Histoire Naturelle, ¹²McMaster University, ¹³Université de Sherbrooke, ¹⁴Université de Québec en Outaouais.

Italics indicate main contact.

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INTERIM RESULTS

1. Stand productivity (Ongoing)

The biomass removal plots on the landings from the previous harvest showed decreased dominant height and basal area when compared to naturally regenerating stands. Seedling survival two growing seasons after establishment was greater than 95% across all treatment types for both tree species. However, annual height growth of planted jack pine was poorer in the two more intense biomass removal treatments while planted black spruce only showed decreased annual height growth in the forest floor removal treatment.

2. Soil nutrient availability changes (Ongoing)

Plots with higher biomass removal (via slash removal) had lower retention levels of carbon and nutrients. In treatments with stump removal, there was little effect on organic and mineral carbon pools. Plots with wood ash addition retained greater reserves of minerals (K, Ca, Mg) as a result of the high concentrations in the ash.

3. Soil respiration and carbon (Ongoing)

Despite reduced soil respiration in vegetation control treatments, net CO₂ effluxes (discharges) were greater in the tree length, full-tree and stumped treatments in August because photosynthesis from understory plants was reduced. There is a need to develop criteria for site-specific biomass retention that takes into account the amount and type of residue required to maintain healthy microbial populations and their critical functional role in nutrient cycling.

4. Effects of wood ash addition on nitrogen cycling (Ongoing)

There were no significant effects of wood ash additions on nitrogen mineralization in the forest floor or upper mineral soil one-year post-application. Plots with wood ash additions also showed no change in nitrogen leaching compared to full-tree biomass harvested plots.

5. Microclimate (Ongoing)

Soil temperature was related to the amount of organic matter and debris left post-harvest, with the forest floor removal treatments having the warmest growing-season temperatures. Interestingly, the forest floor removal and tree-length treatments had higher soil moisture, possibly because vegetation growth was inhibited, thus reducing transpiration losses.

6. Effects of wood ash addition on nematodes (Completed 2014)

Nematode abundance was not a good indicator of soil disturbance. Assessing nematode body size spectra (a trait-based approach) is the recommended approach for assessing soil disturbance and quality, and is an accessible tool for community ecologists.

7. Soil microbial response to intensified harvesting (Completed 2014)

Any level of harvesting resulted in a change in the microbial community but differences between harvest intensities were not apparent. In the short term, there was a change in

metabolic function related to harvesting. By the second year post-harvest, there was also a change in community structure. Comparison with a fire disturbed site showed differences in community composition from both harvested and control plots, indicating that fire disturbance may not be ecologically comparable to harvesting.

8. Soil microbial response to wood ash addition (Completed 2015)

Initial wood ash additions resulted in changes in the native soil microbial community. However, increasing wood ash addition caused only minimal changes, especially compared to the effects of natural forest fires.

9. Effects of harvesting on soil invertebrates (Ongoing)

Forest floor disturbance, especially disc trenching, may be an important factor in driving epigeic (soil surface) communities. Epigeic communities were found to be most sensitive to the most intensive biomass removals (stumping and forest floor removal), but less sensitive to conventional harvesting methods. Rove beetles seem to be good indicators of mature forests.



Field work carried out at Island Lake
Soil respiration (top) and insect collecting (bottom)

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10. Mesofauna as potential ecological indicators (Ongoing)
Community structure and soil functioning seem to change markedly at the whole-tree harvest level, suggesting a threshold of biomass removal.

11. Importance of remaining deadwood for saproxylics (Ongoing)
We are currently studying the importance of below ground deadwood for saproxylic communities (those relying on decaying wood) left over from biomass harvest. We used emergence traps to collect flies and beetles from stumps in harvested sites. In addition, sampled wood from stumps was used to assess wood decay fungal communities. Studying the role of deadwood is important for developing sustainable forest practices because fungi associated with decaying wood are the primary food source for these saproxylic invertebrates.

12. Genomics of soil fauna as potential ecological indicators (Ongoing)
We are currently developing genomics techniques to efficiently measure soil faunal communities in biomass harvested treatments as biodiversity indicators of forest integrity. To date, we have been successful at extracting sufficient DNA directly from soil samples and are awaiting results from sequencing.

13. Understory vegetation (Ongoing)
Two-year results showed differences in functional and specific composition in the forest floor removal and stumped treatments, but not between whole-tree harvest and tree length.

14. Integrated assessment (Ongoing)
We are currently modeling the impacts of increasing biomass removal on the food web and the functional diversity in the different trophic groups. The goal is to identify the key linkages that maintain functioning of the ecosystem. Simultaneous analysis of the different groups of organisms measured in the field shows important variations in the strength of response to disturbance between taxa, suggesting different sensitivity among groups of organisms. This illustrates the need to include several groups of organisms in impact assessments.



Demonstration of soil profile characterisation during site visit



Experimental design of study examining impacts of slash quantities left over after harvest on site recovery

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This comprehensive study currently provides a greater understanding of the short term effects of different biomass harvesting intensities on ecological processes in this forest type. The information will help managers and policy makers in decisions regarding the ecological sustainability of different harvesting and silvicultural scenarios. It also contributes to the development of biological indicators that can be used to determine threshold levels of harvesting. Finally, the Island Lake study, with its integrated approach incorporating a wide range of biodiversity and productivity concerns, draws on and serves as a scientific hub for a range of regional, national and international studies examining the ecological sustainability of harvesting practices. These include the 20-year-old Ontario jack pine and black spruce Long Term Soil Productivity Project installations (18 in total), which are part of a larger international site network, and a new suite of regional studies on the impacts of post-fire salvage logging. As with all of these studies, continued measurement is critical to confirm whether short term trends are maintained and to assess substantive longer-term effects, including biodiversity recovery patterns, soil dynamics, stand development and coarse woody debris recruitment.

PARTICIPATING INSTITUTIONS AND COLLABORATORS

Aarhus University (Denmark), Canadian Ecology Centre, Canadian Forest Service, Canadian Institute for Forestry (SEEK), Carleton University, Centre for Forest Research, FPInnovations, Laurentian University, McMaster University, Modélisation Complexité de la Forêt, Muséum National d'Histoire Naturelle (France), Natural Sciences and Engineering Research Council of Canada, Northeast Science and Information, Northeast Superior Forest Community, Northeast Superior Regional Chiefs Forum, Ontario Ministry of Natural Resources and Forestry, Ontario Power Generation, Quebec Centre for Biodiversity Science, Queen's University, Swiss Federal Research Institute, Tembec, Université de Québec à Montréal, Université de Québec en Outaouais, Université de Québec à Rimouski, Université de Sherbrooke, University of Toronto, Western University



Island Lake research group meeting

Front Row: Mark Primavera, Hedi Kebli, Paul George¹, Stephanie Wilson, Lisa Venier, Isabelle Aubin, Zoe Lindo¹, Emily Smenderovac², Christian Messier³, Vic Wearn⁴

Back Row: Rob Fleming, Ken Lennon⁵, Kara Webster, Dennis Joyce⁵, Bill Peng, Paul Hazlett, Dave Morris¹

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