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Canadian Forest Service – Great Lakes Forestry Centre

Stream Bioindicators in Boreal Forests

INTRODUCTION

Healthy aquatic ecosystems are strongly linked to the surrounding terrestrial watersheds. Forested watersheds have long been recognized for their role in regulating surface and groundwater quality and quantity. For example, shade from streamside vegetation helps moderate water temperatures; living and dead forest components help reduce sediment movement into water bodies; and forest watersheds regulate flow rates of streams by affecting spring snowmelt and storm water runoff.

Forested watersheds also influence habitat for biota living in adjacent water bodies A major source of food for aquatic organisms, including fish, is dead or decaying organic matter from the adjacent forest (detritus). This material makes its way into watercourses, where it is decomposed and the nutrients recycled with the aid of aquatic insects, fungi and bacteria. Forest-derived dissolved organic carbon underpins aquatic food webs, provides protection from damaging UV radiation, and reduces the toxicity of metals and other contaminants in aquatic ecosystems. In addition, large pieces of wood from trees that have fallen into streams and lakes provide critical habitat for fish and invertebrates. In these and many other ways, terrestrial and aquatic ecosystems are interdependent, and the interactions between land-based activities and their impacts on water bodies are complex.

Forest management regulations in Canada are evolving in an effort to produce managed landscapes that more closely emulate natural landscapes. In the boreal forest, natural landscape patterns arise from large disturbances such as fire. To ensure that forest management practices sustain watershed functioning, productive capacity, and the land/water linkages described above, policy-makers and regulators need the most up-to-date knowledge about how the impacts of logging in forest watersheds compare to changes following natural disturbances such as fire.

Biological indicators, or bioindicators, are species used to monitor the health of an ecosystem. In forests, they are any biological species or group of species whose function, population, or status can be used to determine forest ecosystem integrity. By monitoring bioindicators, problems can be detected quickly, and mitigation measures put in place to minimize the impacts. As part of a collaborative study, Natural Resources Canada is investing in a field project that compares streams in logged, unlogged and fire-disturbed watersheds in the boreal forest, with the aim of developing bioindicators and having them integrated into forest management decision-making.

GREAT LAKES FORESTRY CENTRE (GLFC) ROLE

GLFC researcher Dave Kreutzweiser, who has spent his career studying the impacts of forestry activities on aquatic ecosystems, is the leader of a collaborative study on Bioindicators of Forest Stream Health. The goal of the study, which began in 2009, is to examine streams and their surrounding habitat to determine key factors that could be used as indicators of ecosystem health. These bioindicators will then be used to monitor the effectiveness of new logging regulations, and to inform the continuing development of forest management policies and practices that emulate natural (fire) disturbance in boreal watersheds. Twenty-eight streams in the White River Forest Management Area in north-central Ontario have been selected for study, 12 from areas logged from 5 to 15 years earlier, 10 from areas undisturbed for at least 60 years, and 6 from areas burned 11 years earlier.

Image 1. Stream sampling.

A leaf pack sampling method (mesh bags containing leaf material) (Image 1) will be used to examine stream invertebrate communities and their ecological function. The technique involves placing known quantities of natural leaf material in mesh bags on stream beds to mimic natural accumulations of leaf material and monitoring their subsequent colonization and decomposition by aquatic invertebrate and microbial communities. The variety and relative abundance of

species found on the leaf packs (a measure of biodiversity) and the rate of decomposition (a measure of ecological function) will be evaluated as potential bioindicators. A similar sampling method has been used to assess the impacts of other land use activities such as agriculture and urbanization on stream health, but this is the first time it has been used in logged watersheds of the boreal forest. Early testing shows it to be a sensitive, efficient and ecologically relevant indicator in this new application.

Leaf litter decomposition rates and associated stream invertebrates are the primary measurements in this study. Stream characteristics and their watershed features are also being compared among the treatments. Organic matter fluxes and other nutrients are being monitored to determine how they are affected by characteristics of the recovering and undisturbed forests. Data loggers to record water level and water temperature in the streams have been installed to assess how stream processes are influenced by water temperature and discharge patterns, especially during peak flow periods. Other stream habitat conditions including sediment accumulation, forest canopy cover, woody debris, and pool frequency will also be measured. Complementary terrestrial conditions being examined include percentage of wetlands, catchment slope and size, characteristics of the streamside vegetation, upland forest features, and time from disturbance (logging and fire). Results will be compared with a partner study that is examining the recovery of watersheds affected by mining activities in the Sudbury region.

The information gathered from this study will be used to develop a model to predict which streamside or watershed characteristics contribute to stream recovery following forest disturbances. In particular, the data gathered will be used to determine how stream habitat conditions and biotic communities compare or differ among logging-disturbed, fire-disturbed and undisturbed boreal forest watersheds. Forest managers and policy-makers can then use this information to improve mitigation strategies for protecting forest watersheds, and for developing forest management regulations based on natural disturbance emulation.

CONCLUSION

This comprehensive study will answer many questions related to the impact of logging and fire disturbances in boreal forest watersheds on aquatic ecosystems. The identification of bioindicators of ecosystem health will provide an effective tool for monitoring sustainable forest management practices. Resulting analyses will influence the development of sound forest management planning and conservation guidelines for forested watersheds, thus helping forest managers improve harvesting and silvicultural practices to maintain watershed integrity and protect water resources.

PRINCIPAL COLLABORATORS

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- Laurentian University
- Domtar Inc.
- Wagner Ontario Forest Management Ltd.
- Trent University
- Forest Science Ecosystem Cooperative
- Cooperative Freshwater Ecology Unit
- Wilfrid Laurier University
- York University
- NSERC
- Vale Inco Limited

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