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Canadian Forest Service – Great Lakes Forestry Centre

The effects of forest harvesting on water resources

INTRODUCTION

Understanding the long-term effects of forest harvesting on water resources is important in the development of sustainable forest management practices. Scientists have been monitoring many physical and biological variables at the Turkey Lakes Watershed (TLW) study area (approximately 60 km north of Sault Ste. Marie, Ontario), since its establishment in 1979. Such long-term monitoring is essential to our understanding of ecosystem processes and the short- and long-term effects of various disturbances.

The study area was originally set up in response to concerns about the effects of acid rain and was the result of collaboration between three federal departments, namely Natural Resources Canada, Environment Canada and Fisheries and Oceans Canada, with cooperation from the Ontario Ministry of Natural Resources (OMNR). Over the years, TLW has also hosted many university-based researchers. The original and ongoing goal was to focus on understanding the processes controlling ecosystem response to human-caused disturbances. In addition to developing a further understanding of the impacts of acid rain and measuring the response to reductions in acid-causing emissions, the long-term monitoring data can be used to address current and emerging policy questions.

A forest harvesting research trial was undertaken in 1997 in this relatively undisturbed mixed hardwood forest to evaluate the environmental effects of varying logging intensities. The effects on stream flow and water chemistry are outlined in this note.

GREAT LAKES FORESTRY CENTRE (GLFC) RESEARCH

GLFC scientist Fred Beall has been studying many aspects of hydrology at the Turkey Lakes Watershed. In this instance, he has examined the data on stream flow and chemistry that was collected for the 17 years before the harvesting impacts study and the 10 years following it, to assess short- and long-term effects of harvesting practices.

Characteristics of the Turkey Lakes Watershed study area

The study area lies at the northern edge of the Great Lakes–St. Lawrence forest region. The climate of TLW is strongly influenced by its proximity to Lake Superior. The average annual temperature is 4.2 °C (1980-1999) and the area receives approximately 1200 mm of precipitation annually, with one third of that as snow. The average annual temperature has been increasing at nearly 1°C per decade and there is a slight trend to decreasing precipitation. The area is 10.5 km^2 and contains a chain of five lakes and numerous headwater streams. The forest in the TLW is dominated by sugar maple (90%). The site was harvested in the 1950s for high quality yellow birch and is now an uneven aged forest containing trees of variable size and age. Soils in the area are shallow and the topography is rugged. These site conditions result in a forest of relatively low productivity that is also lower in resilience and ability to recover from disturbances compared to similar forests elsewhere. It is possible that harvesting in such areas may result in surface erosion, soil compaction and nutrient removal, which could impede sustained productivity.

Continuous, year-round measurements of stream flow are collected at weirs at the outlet of thirteen small (4 – 66 ha) catchments within TLW. In addition, water samples are collected at the weirs to quantify stream chemistry. Sampling frequency varies according to flow, being as seldom as bi-weekly during winter and summer low flow and as frequent as daily during spring melt high flows. These data have been valuable to a number of research studies and provide useful baseline information. For this reason, it is an ideal location to study the hydrological impacts resulting from a range of harvesting intensities.

The 1997 harvesting impacts study

At TLW, three catchments were harvested at varying levels of intensity and the resulting hydrological effects were measured and compared with uncut catchments. Previous studies, carried out elsewhere dating as far back as 1909 had assessed the impacts of clear-cut harvesting on stream flows and chemistry, but little research has been conducted to assess the effects of less intensive harvesting systems. The objective was to see if the stream responses measured were proportional to harvesting intensity. Previous studies reported increases in annual yield of water flow and low flows (flow of water in a stream during prolonged dry weather), likely due to reduced evapotranspiration, as well as an increase in snow accumulation and melt rates. In these studies, nitrogen, potassium and phosphorus levels in streams increased immediately after harvesting, but responses were generally short-lived.

In this study, the treatments consisted of three levels of basal area removal. The diameter limit harvest, where overstorey trees larger than 20 cm and all other trees larger than 10 cm were removed, resulted in 87% basal area removal. This system of harvesting, essentially a clearcut, while not recommended as a management method for tolerant hardwoods, was carried out to allow for the examination of maximum impacts in terms of nutrient loss and effects on water flow. The shelterwood harvest, which resulted in 38% basal area removal, had the ultimate goal of creating an even-aged forest with a higher yellow birch component. The selection harvest, in which trees were removed individually over a large area to promote the growth of high value trees, resulted in a 31% basal area removal. The selection harvesting system is the typical management method for these uneven-aged hardwood stands in the Algoma region.

RESULTS

Interpretation of the results was complicated by 1997 being the beginning of a period of relatively severe drought at TLW. Consequently, a decrease in many flow parameters was observed in the control streams. Overall, changes in annual and median flows were proportional to harvesting intensity and compared to uncut catchments, the reductions due to the drought were lower in the harvested catchments during the 10 year post-harvest period. Timing of spring melt did not appear to be significantly affected. Roads had a greater effect on flow paths in the catchment than either climate or harvesting.

A wider range of response was observed for nutrient export in the streams measured. Nitrate levels rose sharply in the year after harvesting, particularly at the highest basal area removal, and then declined to levels well below un-harvested levels. The response for dissolved organic compounds and potassium was delayed and more persistent, while others such as phosphorus were unaffected. Where there was a response, it was generally proportional to harvest intensity.

Future Work

GLFC scientists will continue the monitoring activities at the Turkey Lakes Watershed study area to measure recovery from harvesting and to extend the valuable baseline information. Questions that still need to be examined include recovery trajectories and cumulative impacts of harvesting activities in larger watersheds.

CONCLUSION

The effects of harvesting on stream chemistry and water flow appear to be greater at higher levels of harvesting intensity. Other factors such as climate and roads can have significant effects on changes in stream flow, making it difficult to isolate effects from harvesting intensity alone. The results of this study are useful to policy makers and forest managers and have already been helpful to the OMNR in the development of the most recent revisions to Ontario's forest management guidelines. Ongoing monitoring at Turkey Lakes will continue to be valuable to our understanding of ecosystem response to disturbance.

PRINCIPAL COLLABORATORS

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