GREATER FUNDY ECOSYSTEM RESEARCH PROJECT

UNB Faculty of Forestry and Environmental Management

State of the Greater Fundy Ecosystem

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Case Study

Effects of Clearcutting and Road Building on Stream Ecology in the Vicinity of Fundy National Park

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This study was designed to investigate effects of forestry-related environmental stressors on the structure and function of stream ecosystems in the Greater Fundy Ecosystem (GFE). Sixteen streams were selected for sampling. Twelve of these streams drained clearcut areas located just outside of Fundy National Park. The clearcuts ranged in age from 4-20 years old, and had been regenerated as conifer plantations. The other four streams drained reference watersheds covered with mature mixed forest within Fundy NP. Each stream was sampled for bottom substrate, water temperature, nutrient concentrations, riparian vegetation, sedimentation, channel morphology, and benthic invertebrates

The choice of study streams represented a time series (or chronosequence), allowing study of the medium- and short-term effects of clearcutting using different-aged cutovers, instead of monitoring particular streams before, during, and after clearcutting. This approach assumes that changes caused by clearcutting and road-building would be detectable despite location-related differences amongst the 16 streams and their watersheds. Spatial influences were minimized by selecting study streams as close to each other as possible, thereby reducing the effects of differences in climate, geology, geomorphology, and forest type.

GOALS

The objectives of this study were:

1) To determine how rapidly streams in clearcut and reforested sites in the GFE recovered biotic regulation of nutrient and sediment export, water temperature, and allochthonous inputs of biomass.

2) To assess the effects of clearcutting and plantation establishment on the habitat of Brook Trout.

3) To contribute to the development and evaluation of guidelines for riparian buffer strips, road

construction, culvert design, and alternative harvesting and management practices.

METHODS

Stream water temperature in individual streams was continuously measured using five Hobo recording thermographs, or periodically using 11 maximum/minimum thermometers. Temperature recorders were placed in each stream from the beginning of June to the middle of November, 1993.

Nutrient concentrations were measured in water samples collected from each stream in early July, early August, and early September. The samples were analyzed for total nitrogen, phosphate, potassium, chloride, magnesium, calcium, sodium, pH, alkalinity, and specific conductance.

Sedimentation was measured using three 500 ml nalgene bottles, dug into the sampling riffle of each stream, such that the mouth was flush with the streambed. The contents were dried and sieved into two categories, fines and larger, and then weighed.

The composition of surface substrates was visually estimated using quadrats placed in three positions along 12 transects across each stream. Within each quadrat, estimates were made of the most dominant and second-most dominant substrate.

Channel measurements were made by securing a measuring tape above and across each stream. The distance from the measuring tape to the streambed was recorded at 20-cm intervals from the edge of the bank-full streambank.

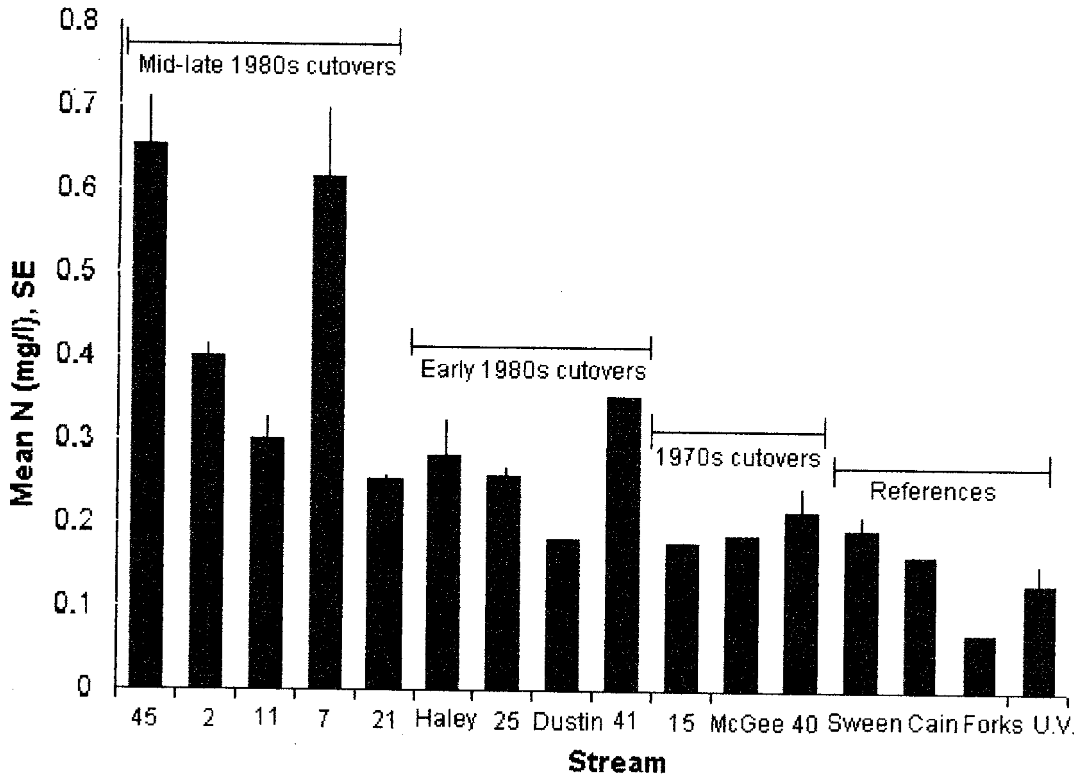
Riparian vegetation was sampled using the point-centred quarter method. The nearest shrubs, trees, and snags to each point were measured. Calculations of dominance, density, frequency, and importance value were made for all shrub and tree species.

Data were analyzed, where appropriate, using regressions, t-tests, Pearson correlations, principal components analysis, discriminant function analysis, correspondence analysis, and canonical correspondence analysis.

RESULTS

Biotic regulation of nutrient exports appeared to recover progressively with time since cutting. The smallest concentrations of dissolved substances were recorded, in general, in the reference streams, and the greatest concentrations occurred in streams draining the most recent clearcuts (Figure 1).

Figure 1.



The thermal regimes of streams draining recent clearcuts were more like the thermal regimes of the reference streams than those of streams draining 1970s clearcuts (Table 1). This is because legislation introduced in the early 1980s required that streams be protected from clearcutting by buffer strips. Before this, buffer strips were rarely left along streams. Consequently, in 1993, streams draining 1970s clearcuts still had higher maximum temperatures and greater diurnal fluctuations than did streams clearcut during the 1980s.

Table 1.
Thermograph data (in degrees Celcius) for streams #11, #15, Sweeney, and Upper Vault. Shown are the maximum summer temperature, the proportion of days the temperature range exceeded 4 degrees Celcius and the proportion of days the maximum exceeded 17 degrees Celcius.

STREAM	# 11	#15	Sweeney	Upper Vault
Maximum Summer Temp.	18.4	23.8	15.3	15.6
Days Range >4°C (%)	2	55	0	3
Days Temp. >17°C (%)	5	34	0	0

The presence of buffer strips along streams draining recent clearcuts ensured a rapid recovery of allochthonous inputs of biomass. Principal components analysis demonstrated that the vegetation along three reference streams was similar to the vegetation along streams draining more recent clearcuts with relatively wide buffer strips. These streams were characterized by low shrub densities, high in-stream moss cover, and higher-than-average tree and snag densities. By contrast, vegetation along streams cutover in the 1970s and early 1980s indicated that these streams will experience long-term impoverishment of large-dimension woody debris. Shrub density was high, and the most common shrub-sized species were Speckled Alder and Balsam Fir.

Streams draining recent clearcuts were moderately well protected by buffer strips, but in the PCA, they differed from the reference streams in their associations with nutrients, sedimentation, and surface bedrock. The recovery of stream ecosystems was slower for streams left unprotected by trees.

Forest cutting and road building caused some degradation of trout habitat. The high temperatures in six cutover streams were sufficient to cause physiological stress, and on three cutover streams, enough to cause mortality. The dissolved oxygen concentrations in at least two cutover streams may have adversely affected swimming performance and growth rates. Selection and clear-cutting in the riparian zones of six streams have depleted the long-term supply of inputs of large woody debris. This will eventually degrade Trout habitat by decreasing the number of pools, amount of cover, and retention of fine sediments.

IMPLICATIONS FOR MANAGEMENT

We propose the following recommendations for the protection of stream habitat in the GFE:

1. Manage stands of timber to supply longer-term inputs of large woody debris (LWD) to streams. This should preclude selective harvesting of large trees in buffer zones, an activity that would be permitted under the proposed Watercourse Buffer Zone Guidelines for Crown Forestry Activities in New Brunwick.

2. Leave a minimum 5-m buffer strip along the full length of the stream, including feeder streams and springs.

3. Where past logging activities have removed riparian vegetation, it may be useful to add digger logs to stream channels as a mitigation.

4. When possible, cuts should be partial or selective, instead of clearcutting an entire watershed.

5. Plan roads to avoid as many stream crossings as possible.

6. Where streams must be crossed, always build adequately-sized culverts or bridges.

7. Logging roads should either be maintained to prevent erosion, or removed.

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Further Reading:

O'Brien, M. 1995. Various effects of forest harvesting and management on stream ecosystems in the vicinity of Fundy National Park, New Brunswick. M.Sc. Thesis. Dalhousie University. Halifax, NS.