Tri-Creeks Experimental Watershed

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ABSTRACT

Tri-Creeks Experimental Watershed was initiated to compare the effects of logging and riparian buffers in three sub-basins (Wampus, Deerlick, and Eunice Creeks) and to evaluate the effectiveness of timber harvesting ground rules in protecting fisheries and water resources. The watershed study was terminated in 1985 shortly after the harvest. In 2015, the University of Alberta re-established groundwater monitoring, hydrometric, and meteorological stations in Tri-Creeks Experimental watershed. Future research will utilize the 20-year historic data set and current data to study the effect of forest cover change on the streamflow regime and fish populations. The objective of this paper is to summarize the novel results and available data from 1965–1987 for the Tri-Creeks Experimental Watershed.

RÉSUMÉ

Le bassin versant expérimental de Tri-Creeks a été créé dans le but de comparer les effets de l'exploitation forestière et des bandes riveraines dans trois bassins secondaires (Wampus Creek, Deerlick et Eunice) et d'évaluer l'efficacité des règles d'exploitation sur la protection des ressources halieutiques et de l'eau. L'étude du bassin versant a pris fin en 1985, peu après la récolte du bois. En 2015, l'Université de l'Alberta a remis en fonction les stations hydrométriques et météorologiques du bassin expérimental de Tri-Creeks. Les prochains travaux mettront à profit les données recueillies pendant 20 ans, ainsi que les données actuelles afin d'étudier les effets de l'exploitation forestière sur le régime des débits. Cet article se propose de faire le bilan des résultats récents et des données disponibles pour la période de 1965 à 1987 dans le bassin expérimental de Tri-Creeks.

Introduction

The Tri-Creeks Experimental Watershed (Wampus, Deerlick, and Eunice Creeks; Fig. 1, Table 1) was first conceptualized following a natural resources conference in Edmonton in 1960. It was later initiated in 1965 by the Alberta Department of Lands and Forests under the International Hydrologic Decade as part of the Alberta Watershed Program. The project was planned as a 20-year study to compare the effects of logging and riparian buffers and to evaluate the effectiveness of timber harvesting ground rules in protecting fisheries and water resources (Table 2).

The objectives of the study were to determine the effects of (Nip 1991):

- 1) Clearcutting (CC) on the survival, growth, and reproduction of fish and aquatic invertebrate populations.
- 2) Streamside timber removal on water temperature, streamflow, and suspended sediment.
- 3) CC on the hydrological regime.
- 4) Road construction and CC on suspended sediment concentrations and stream channel siltation.
- 5) CC on the hydrochemical regime.

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Results

Timber harvest

Fifty percent of merchantable timber harvested (39% of Wampus and 40% of Deerlick) resulted in a 7% and 22% increase in seasonal water yield for Wampus Creek and Deerlick Creek, respectively. However, these quantifiable changes could not be attributed to the harvest because the before and after treatment results were not statistically significant (Andres *et al.* 1987).

Other factors that likely contributed to the lack of significant change were:

- Short duration of the post-harvest monitoring (only 2–3 years).

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Fig. 1. Map of the Tri-Creeks Experimental Watershed showing three sub-watersheds: Wampus, Deerlick, and Eunice.

Table 1. Summary of Tri-Creeks watershed and climatic characteristics

	Watershed Location Data
Location (descriptive)	40 km south of Hinton in the foothills of the Rocky Mountains
Location (geographic)	53°09' N 117°15' W
Biogeoclimatic zone(s)	Upper Foothills ecological sub-region
Watershed area	59 km ²
Elevation range	~1250 – 1700 m
Precipitation (mean annual)	855 mm (average range: 770 mm at low elevations and 918 mm at high elevations)
Seasonal water yield (mean)	Wampus: 243 mm Deerlick: 236 mm Eunice: 216 mm
Temperature	Mean annual temperature: 1 °C Mean daily max: -4.8 °C in January 19.9 °C in July

- Forest harvesting occurred over four years.
- Early season data from the snowmelt hydrograph were not collected due to flow data only being collected when sites were accessible and streams were ice-free.

Water Temperature

- A significant increase in mean monthly stream temperature was only detected in Deerlick Creek post-harvest in July and August (no significant change in Wampus Creek; Nip 1991).
- Significant increases in maximum temperatures in both treatment streams; greatest in July and August. Buffer removal in Deerlick Creek magnified the increase in maximum temperature compared to Wampus Creek (Nip 1991).

Suspended Sediment

- Suspended sediment yield was highly variable, but significant increases were observed in both Wampus and Deerlick creeks (12% and 19% higher than predicted following logging, respectively; 26% and 52% higher than predicted in the two years following road construction, respectfully; Nip 1991).

Table 2. Research Design for Tri-Creeks Experimental Watershed

Research Design	
Study type	Paired basin experiment (3 streams in close proximity and large enough to support fish populations)
Treatments	Wampus – ground rules of forest harvest (retention of buffer strips) Deerlick – experimental removal of riparian buffer strips
Controls	Eunice – control watershed
Study duration	1965–1987
Variables measured	Streamflow, groundwater, air and stream temperature, precipitation, suspended sediment, water chemistry, and fish communities

- Although the riparian buffer seemed to reduce the sediment entering the stream, Jablonski (1986) and Wasiliew (1986) reported improper and poor logging, road construction, maintenance, and reclamation practices in both watersheds. Jablonski (1986) suggested that good forest management practices were critical in minimizing sediment entering the stream, rather than the presence or absence of riparian buffers in cutblocks.

Nutrients

- Significant increases in total phosphate loading occurred in Deerlick and Wampus Creeks following logging.
- Significant increase in Kjeldahl nitrogen was observed in Eunice Creek; however, no significant difference was detected in Wampus Creek and no changes were detected in Deerlick Creek following logging.
- Pre-harvest monitoring for a larger number of variables, longer post-harvest monitoring, and better analytical procedures could have produced more meaningful results (Nip 1991).

Fish Community

- Population declines were evident before the commencement of road construction and logging. These general declines appeared not to be associated with any environmental factors or land use; a weak inverse correlation between density and yearly abundance was observed, suggesting that juvenile mortality during the pre-treatment phase was density-dependent (Sterling 1987; Sterling 1990).
- Rainbow trout populations crashed after the 1969 and 1980 floods, but returned rapidly (within five years) to pre-treatment densities (Sterling 1990).
- Fish population trends immediately following logging were uncertain because of limited sampling during the decade following project termination, 1985.
- Fish population surveys were restarted in the mid-1990s. Streams remained closed to fishing and continuing surveys revealed increasing population densities in some study sections in the two decades post-logging. These increases were presumed to be the result of increased pri-

mary and secondary production following forest canopy removal. Current studies reveal variable (fluctuating) population densities generally similar to pre-treatment densities (AFWMIS 2014).

Streamflow/Fish

- Increased streamflow following logging increased the risk of scour and recruitment loss (Sterling 1992).

Temperature/Fish

- No specific relationships were found; however, maximum stream temperature (22 °C) during post-logging in Deerlick Creek (riparian buffers logged) reached near lethal temperatures (23 °C) for rainbow trout during late July and early August. Fish may be able to survive short-term increases by utilizing groundwater inflow areas (Nip 1991).

Settled Sediment/Fish

- Results were masked by flooding in 1969 and 1980.
- Quality of spawning substrates was higher after logging because of bed scour (removal of fine sediments) during flooding (Sterling 1992).
- A 10% increase in the percentage of fine sediment in the spawning substrates resulted in a 50% reduction in fry emergence (Sterling 1992).

Nutrients/Fish

- Fish size significantly increased after logging in Wampus and Deerlick Creeks for fish ages 1–3; it is unknown how long growth effects persisted (Sterling 1990).
- Anecdotal correlation to observed algal blooms in three years post-logging (Sterling 1990).

Management Implications

- Logging and buffer strip removal as in the Tri-Creeks Experimental Watershed resulted in undefined short-term “fish effects”. Nearly 25 years later, in the absence of further landscape change and watershed recovery, populations generally appear healthy, except for Eunice Creek (AFWMIS 2014).
- Harvesting on frozen soils minimized soil erosion and streambank disintegration; however, post-harvest erosion was not minimized due to poor road construction, maintenance, and reclamation practices. Nip (1991) stresses that “forest harvesting practices must continue to minimize or guard against creation of unsuitable conditions for salmonid populations and improve on its practices wherever possible” (pg. 50).

Future Research

The Tri-Creeks Experimental Watershed produced extensive datasets during the initial 20-year study. In addition to the historical datasets, streamflow continued to be monitored by Water Survey of Canada (WSC) in Eunice and Deerlick Creeks until decommissioned in 1992 and 2002, respectively. The WSC hydrometric station is still active on Wampus Creek. These datasets have motivated the re-installation of hydrometric stations in Eunice and Deerlick Creeks, two meteorological stations in Wampus Creek (high and low elevation), and continuous water level monitoring in the

Groundwater Observation Well Network (GOWN) wells within the watersheds during 2015 by the University of Alberta. Additionally, Alberta Fisheries Management is monitoring fish populations at two-year intervals. Future research is focused on understanding the effect of forest cover change (i.e., mountain pine beetle attack) and harvest on the Foothill's streamflow regime and fish populations.

References

AFWMIS. 2014. [Alberta Fisheries and Wildlife Management Information System]. See: <http://aep.alberta.ca/fish-wildlife/fwmis/access-fwmis-data.aspx>

Andres, D., G. Van Der Vinne and G. Sterenberg. 1987. Hydrologic, hydrogeologic, thermal, sediment and channel regimes of the Tri-Creeks Experimental Basin. Alta. Res. Counc. Rep. No. SWE-87/01. Vol. 1. 418 p.

Jablonski, P.D. 1986. Tri-Creeks: Documentation of the timber harvesting operation from a watershed management perspective. Alta. Ener. and Nat. Res., Forest Land Use Branch. *In-house document*.

Nip, A.M.-K. 1991. The Tri-Creeks Experimental Watershed: Changes in hydrology and water quality following forest harvesting

and their impact on salmonid fishes in the Tri-Creeks Basin. Research Branch Technical Report No. 4. Alberta Forestry, Lands and Wildlife. Edmonton.

Sterling, G.L. 1987. An evaluation of spawning habitat and fry escapement of Rainbow Trout (*Salmo gairdneri* Richardson) before logging in the Tri-Creek Watershed of West-Central Alberta. The Tri-Creeks Watershed Study Rep. No. 9. Alta. Ener. and Nat. Res., Fish and Wildlife Div., Edmonton.

Sterling, G.L. 1990. Population dynamics, age and growth of Rainbow Trout (*Oncorhynchus mykiss*) in the Tri-Creek Experimental Watershed of West-Central Alberta; A post-logging evaluation. The Tri-Creeks Watershed Study Rep. No. 10. Alta. For. Lands and Wildl., Alta. Fish and Wildlife Div., Edmonton.

Sterling, G.L. 1992. Fry Emergence Survival of Rainbow Trout, *Oncorhynchus mykiss* (Walbaum), Following Timber Harvest in two Foothill Streams of West-central Alberta. MSc. Thesis. Department of Forest Science, University of Alberta, Edmonton, Alberta. 116 pp.

Wasiliew, W. 1986. Sediment dynamics in an Alberta Foothill stream following clearcut logging. Alta. Forestry and Wildlife, Forest Research Branch. In-house document.