# Harvest induced temperature changes on headwater streams: How much protection is enough?

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## Introduction

Headwater streams can account for 65-75 percent of the cumulative length of all stream and river channels in a watershed (Leopold et al 1964). Nevertheless, small headwater streams have often escaped both scientific research and regulatory scrutiny. Little is known about how timber harvesting affects headwater stream temperature. In Maine, streams draining watersheds of less than 300 acres have no buffer or shade requirements under state law (Maine Department of Conservation 1999). Our study was conducted to better understand small headwater streams and their sensitivity to temperature changes following commercial timber harvest.

## Methods

**Design:** Before and after controlled experiment

**Experimental Units:** 15 headwater streams draining watersheds with mature closed-canopy cover forest (>85%) at least 15 m tall forest were located in the industrial forests of western Maine.

**Experimental Treatments:** In the fall/winter of 2001, 200m x 300m blocks of forest on both sides of the study streams were harvested to the following specifications:

**0m buffer**: clearcut harvest zone (<6.8m$^2$/hectare residual basal area) without retention buffers
**11m buffer**: clearcut harvest zone with 11m buffers on both sides of stream
**23m treatment**: clearcut harvest zone with 23m buffers on both sides of stream
**Partial Harvest**: selectively cut harvest zone (> 13.7 m$^2$/hectare residual basal area) without specified buffers
**Control**: no harvest

**Data Collection:** Hourly temperature readings were recorded using dataloggers (OnSet Optic StowAway temperature loggers, Onset, Inc., Bourne, MA) between June 15 and August 15 before harvest activity (2001) and two years post-harvest (2002 and 2003) (See Figure 1).

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## Results

•Canopy closure was greatly reduced (> 70%) in 0m treatment group, slightly reduced (<10%) in 11m, no change in other treatment groups (Figure 2).

•Mean weekly maximum temperature increased between 1.4ºC and 4.4ºC in 0m treatment group following the harvest and between 1-1.4ºC in the 11m treatment group. No change greater than 0.5ºC was observed in 23m buffer, partial harvest, or control treatment groups (Table 1).

•Hourly temperature recordings show increases in temperature and diurnal fluctuation in 0m and 11m buffer treatments (Figure 3).

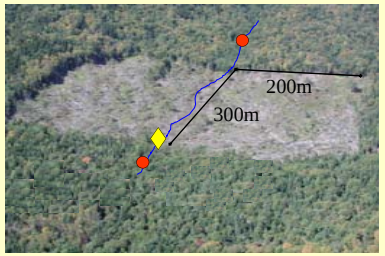


Figure 1 Study Layout

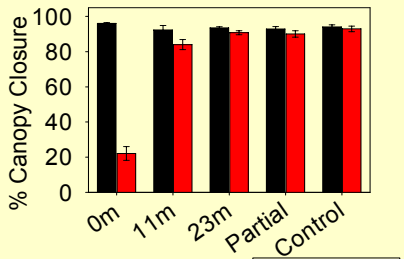


Figure 2 Average canopy closure per treatment group before and after timber harvest.

**Table 1**
**Mean Weekly Maximum Temperature (ºC)**
**June 15-August 15, 2001-2003**

| Treatment | Stream | Pre-Harvest (2001) | Post-Harvest yr. 1 (2002) | Post-Harvest yr. 2 (2003) |
|---|---|---|---|---|
| 0m buffer | Kibby | 13.0 | 17.1 | 17.4 |
| | PP1 | 14.2 | 15.6 | 17.3 |
| | Sk1 | 13.0 | 15.2 | 15.6 |
| 11m buffer | Bald Mt. | 15.6 | 16.9 | 16.8 |
| | Caratunk | 14.8 | 15.8 | 16.2 |
| | Sk2 | 11.9 | no data | 13.0 |
| 23m buffer | MG2 | 6.1 | 6.4 | 6.4 |
| | Roxbury | 14.7 | 14.5 | 15.1 |
| | Sand | 14.2 | 14.1 | 14.3 |
| Partial Harvest | MG1 | 12.9 | 12.8 | 12.9 |
| | PP2 | 14.1 | 14.2 | 15.1 |
| | UpCup | 13.5 | 13.5 | 13.6 |
| Control | Appleton | 12.4 | 12.5 | 12.7 |
| | Bryant | 14.0 | 13.6 | 13.8 |
| | Dud | 14.1 | 13.7 | 13.8 |

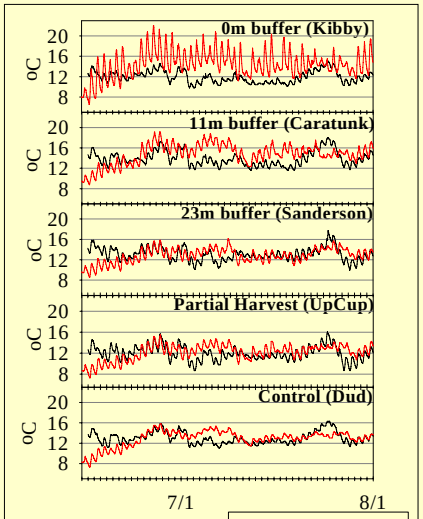


Figure 3
Hourly Water Temperature
6/15-8/1 2001 & 2003

## Discussion

•Water temperature and diurnal fluctuations increased, especially in 0m treatment group. Mean weekly maximum water temperatures did not exceed 17.4ºC, well below the document thermal stress levels for brook trout of 24ºC (EPA 1986).

•The greatest temperature increase occurred in a stream with a southeasterly aspect. Post harvest increases in stream temperature are driven by increased solar radiation reaching the stream channel (Brown and Krygier 1970).

## Conclusions

•Complete canopy removal on 300m sections of headwater streams can raise mean weekly maximum temperatures by as much as 4.4ºC. Observed temperature increases did not exceed thermal requirements for brook trout.

•Streams on south and southeasterly aspects receive intense solar radiation and may require special management consideration.

•This study suggests headwater streams do not require buffers to maintain the temperature requirements for brook trout. However, this conclusion is limited to streams with ≤ 300m of canopy removal and does not consider thermal requirements of macroinvertebrates and amphibians, which are not well understood.

## References

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