



Fire effects on lake ecosystems: Water chemistry and zooplankton community structure

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Introduction

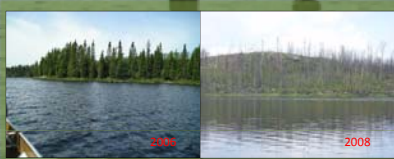
- Lakes are dependent on their catchments for nutrients. Catchment perturbations such as agriculture and forest fires directly affect the influx of nutrients into aquatic ecosystems (Bronmark & Hansson 2005).
- Several studies have demonstrated elevated nutrient levels (phosphorus, nitrogen, and carbon) in lakes with burned catchments (Lamontagne *et al.*, 2000, McEachern *et al.*, 2000).
- Lakes with burned catchments have shown increases in algal biomass (Planas *et al.*, 2000) and decreases in juvenile yellow perch and white sucker populations (Isabelle and Magnan, 2000).
- Researchers found that there were no significant difference in zooplankton diversity, but did find increased phosphorus and nitrogen concentrations in burned lakes relative to reference lakes (Patoine *et al.*, 2000). These negative results are contrary to the current understanding of how nutrients affect zooplankton diversity and community structure (Dodson, 1992).
- This study was undertaken to determine the affects of a forest fire on lake nutrient levels and zooplankton community structure.**

Hypotheses

- Zooplankton community composition in the burned lake will be different after the fire while the reference lake's zooplankton community will be undergoing normal seasonal variation.
- Nutrients in the burned lake will be significantly increased due to the fire relative to the reference lake.

Methods

- Lake Everett (burned lake) was burned in May of 2007 by the Ham Lake Fire.
- Lake Thelma's (unburned lake) catchment has not been burned in the past 85 years.
- Water samples were collected 1 meter below the surface. Samples were taken from the deepest part of each lake. Nutrients included total phosphorus (TP) and total organic carbon (TOC) were analyzed using EPA protocols.
- Zooplankton tows were taken from the deepest part of each lake 1 meter above the bottom.
- Water level was measured as the distance from a benchmark to the surface of the water (Greater Distance = Lower water).**
- Zooplankton samples were split so each subsample contained between 200-400 individuals. Each individual was identified to species in both sub samples.



Picture 1. Pictures of the burned lake (Everett) one year before (2006) and one year after (2008) the Ham Lake Fire of 2007.



Picture 2. Stephen Nikolai conducting a depth tow to collect zooplankton



Picture 3. Stephen Nikolai and the team's trusty canoe "Lizz".

Water Chemistry

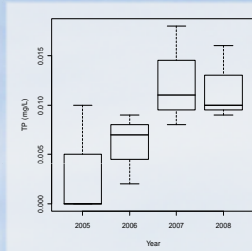


Figure 1. Summer mean total phosphorus concentrations (mg/L) for the burned lake (Everett) for years 2005-2008. ANOVA (p=0.120)

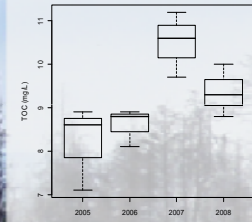


Figure 3. Summer mean total organic carbon concentrations (mg/L) for the burned lake (Everett) for years 2005-2008. ANOVA (p=0.019)*
Tukey HSD
2005-2007 (p=0.018)*
2006-2007 (p=0.047)*

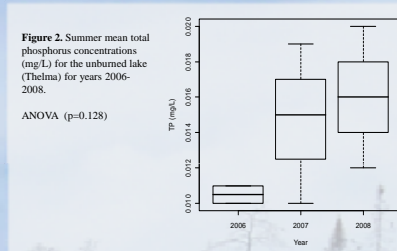


Figure 2. Summer mean total phosphorus concentrations (mg/L) for the unburned lake (Thelma) for years 2006-2008. ANOVA (p=0.128)

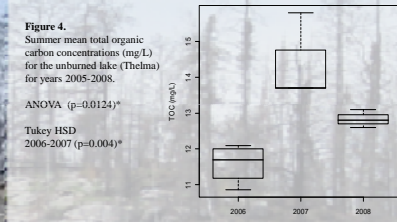


Figure 4. Summer mean total organic carbon concentrations (mg/L) for the unburned lake (Thelma) for years 2005-2008. ANOVA (p=0.0124)*
Tukey HSD
2006-2007 (p=0.004)*

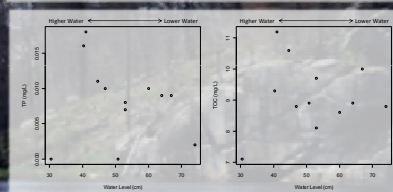


Figure 5. Summer total phosphorus concentrations (TP) (mg/L) and total organic carbon concentrations (TOC) (mg/L) in relation to water level (cm) for the burned lake (Everett). Each point represents data from a specific sample date between 2005 and 2008. No relationship between water level and either nutrient was found.

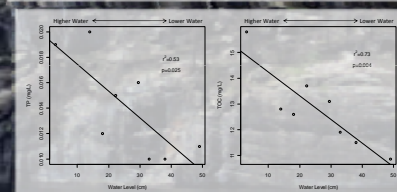


Figure 6. Summer total phosphorus concentrations (TP) (mg/L) and total organic carbon concentrations (TOC) (mg/L) in relation to water level (cm) for the unburned lake (Thelma). Each point represents data from a specific sample date between 2006 and 2008. Significant relationships were found between TP and water level ($r^2=0.55$, $p=0.025$) and TOC and water level ($r^2=0.73$, $p=0.004$)

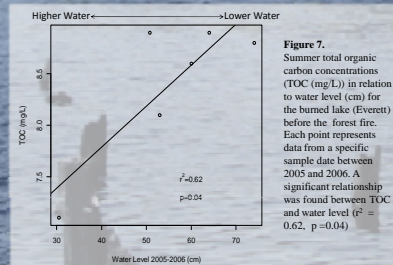


Figure 7. Summer total organic carbon concentrations (TOC) (mg/L) in relation to water level (cm) for the burned lake (Everett) before the forest fire. Each point represents data from a specific sample date between 2005 and 2006. A significant relationship was found between TOC and water level ($r^2=0.62$, $p=0.04$)

Water Chemistry Synthesis

- Total Phosphorus (TP) and Total Organic Carbon (TOC) increased in both lakes in 2007 after the forest fire (Figure 1, Figure 2, Figure 3, Figure 4). However the causation for the increase in nutrients may have been different.
- Thelma (unburned) shows a distinct relationship between water levels and nutrients (Figure 6). As the distance between the water and the benchmark decreases (more water), nutrient levels increase. This can be attributed to Thelma's larger catchment and short residence time. As water enters the lake from the catchment, it picks up nutrients. More water equates to more nutrients and Thelma's water levels were significantly higher in 2007 (p=0.04), accounting for the increased TOC and TP.
- Everett (burned) shows no relationship between water levels and nutrients when all years of data are combined (Figure 5). However, before the forest fire a significant relationship between water level and TOC exists (Figure 7). As water levels increase, TOC decreases. This relationship can be explained by Everett's hydrology. Everett has a water residence time of 14 years and a small catchment. Since very little water is flowing in or out of Everett, we would expect concentrations of nutrients to increase as the distance to the benchmark increases (less water). No relationship after the fire suggests that the hydrology of the catchment changed and the rate of nutrient loading into the lake increased. Water levels were not significantly different after the forest fire.

Literature Cited

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Zooplankton Community

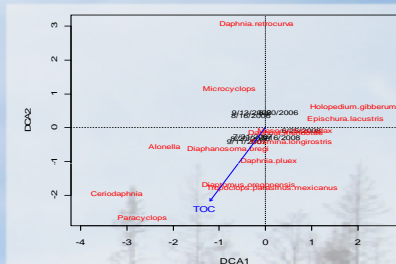


Figure 8. Detrended correspondence analysis (DCA) of zooplankton species (Red), sample date (Black), and environmental variable vectors (Blue) on the burned lake (Everett) for years 2006-2008. TOC was the only significant vector ($r^2=0.87$, $p=0.002$)

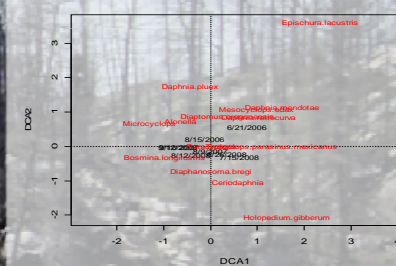


Figure 9. Detrended correspondence analysis (DCA) of zooplankton species (Red), sample date (Black) on the unburned lake (Thelma) for years 2006-2008. No vectors were found to be significant.

Zooplankton Communities Synthesis

- The DCA for Everett (burned lake) shows that the sample dates and species are associated with the year. The year before the burn (2006) and the years after the burn (2007-2008) are clumped above and below the x-axis, respectively. DOC was the only significant vector and pointed to the species and sample dates associated with the increase in DOC after the forest fire (Figure 8). The species found in abundance after the forest fire may have benefited from increased nutrient levels.
- The DCA for Thelma (unburned lake) shows that the sample dates and species are more closely associated with month; samples taken later in a given year on the left and shifting to the right earlier in the year (Figure 9). This suggests that the species are undergoing normal seasonal variation. Also, no environmental vectors were significant suggesting that Thelma's zooplankton community is very resistant to swings in nutrients.

Addressing the Hypotheses

- ✓ We can accept the hypothesis that the burned lake will have a change in zooplankton community structure after the forest fire while the reference lake will be undergoing seasonal variation.
- ✓ We can accept the hypothesis that nutrients in the burned lake will be significantly increased due to the fire while nutrients in the reference lake will not be significantly increased due to the fire.

Importance

- First study to suggest a zooplankton community composition change after a forest fire.
- This research demonstrates how closely tied lakes and their zooplankton inhabitants are to their catchments for nutrients. Also, it appears that the forest succession that takes place on land after a forest fire may also take place in lake ecosystems. This possible occurrence suggests that forest fires are not only essential events for terrestrial ecosystem health, but possibly lake ecosystem health as well.

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