PACIFIC CLIMATE IMPACTS CONSORTIUM

PCIC SCIENCE BRIEF 5: WATER-QUALITY IMPACTS FROM CLIMATE-INDUCED FOREST DIE-OFF

PCIC Science Briefs are a series of brief reports on recent climate science literature relevant to stakeholders in the Pacific and Yukon Region of Canada. Science Briefs contextualize and explain the results and implications of important scientific findings.

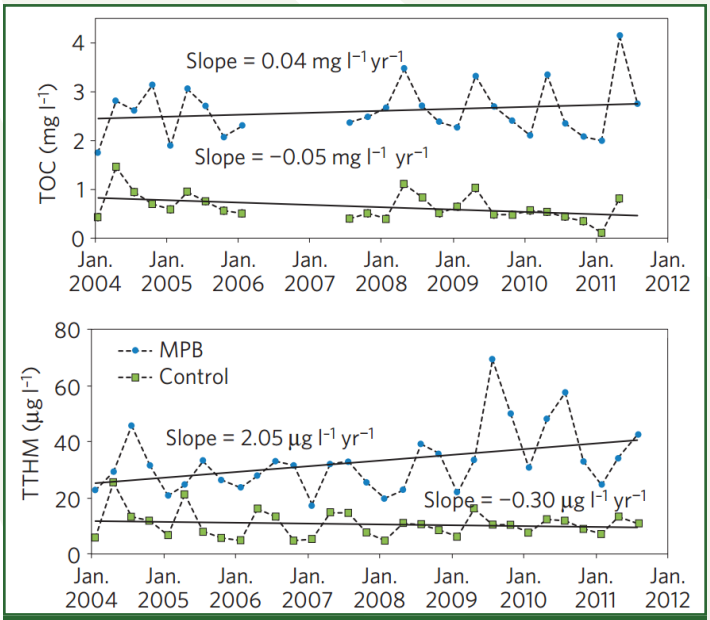
In a recent paper in *Nature Climate Change*, Mikkelson (2013) and colleagues find that municipal water supplies that draw from mountain pine beetle-infested source regions have higher concentrations of both organic carbon and potentially harmful disinfection byproducts[1].

There is an ongoing mountain pine beetle epidemic in the Rocky Mountains. There have been several contributing factors. The prevalence of warmer winters has allowed more beetles to survive each year. Wildfire suppression has caused there to be large expanses of mature pine trees that the beetles prefer. Persistent drought conditions have also weakened some trees, making them more susceptible to beetle infestation.

Mountain pine beetle infestations can cause large-scale tree death. The beetles lay their eggs under the bark of the trees and introduce a blue stain fungus that blocks resin, water and nutrients from flowing in the tree. The beetle larvae also feed on the tree, further damaging it and preventing the flow of water and nutrients.

Large-scale tree death can increase organic matter decay, change the flow of groundwater, increase erosion and increase the leaching of organic matter to surface water. When this organic material is mixed with chlorinated disinfection agents as part of the processing of water in municipal water supplies, the chemical reactions that result can form harmful disinfection byproducts.

Mikkelson (2013) et al. examined water quality data from nine treatment plants in Colorado for total organic carbon concentrations and disinfection byproducts, including five haloacetic acids and total trihalomethane[2] concentrations. Of the nine treatment plants considered in the study, five were processing water from watersheds impacted by mountain pine beetles. Four were processing water from control areas with mountain pine beetle infestation levels that were a quarter of the



Seasonal shifts and trends in total organic carbon (TOC) and total trihalomethanes (TTHM) from Mikkelson et al. (2013). Top: quarterly averages of TOC concentrations in water taken from watersheds in mountain pine bark beetle infested areas (blue circles) and control areas (green squares). **Bottom:** quarterly averages of TTHM concentrations in water taken from watersheds in mountain pine bark beetle infested areas (blue circles) and control areas (green squares).

1. Disinfection byproducts are substances which occur when chlorinated disinfection agents, which are used to kill microbes in drinking water, react with acids and organic matter. Some disinfection byproducts have been associated with adverse health effects.
2. Trihalomethanes result from the reaction of organic matter with chlorine or bromine. They are known carcinogens.

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infestation levels in the impacted areas.

In the areas of Colorado from which the data was taken, mountain pine beetle infestation began between 2004 and 2005. The authors found that concentrations of total organic carbon and disinfectant byproducts were higher in the water from mountain pine beetle-infested areas. In beetle-infested watersheds, the disinfectant byproducts were present in concentrations that were ten times as high as the concentrations in control watersheds. They also found that total trihalomethane concentrations have increased since 2004 in watersheds with mountain pine beetle infestations. and that total organic carbon concentrations have increased since 2007 in those same watersheds. (It can take between three to five years for the needles from infested trees to fall to the forest floor.) Total trihalomethane concentrations were higher in the summer than during the spring, when runoff and total organic carbon are at their maximum. This is thought to be due to the fact that two different types of acid, humic and fulvic, formed from the biodegradation of organic matter, tend to be present in higher concentrations in the later-stage runoff and can cause higher trihalomethane concentrations even with lower levels of organic carbon.

Normally, changes in total organic carbon concentrations in watersheds are associated with increases in precipitation and temperature. However, the authors argue that changes in organic carbon over the period considered cannot be explained in this way, because there were no increasing trends in either precipitation or temperature in these regions over the period considered. Over the whole period (see figure on first page), both total organic carbon and total trihalomethane showed increasing trends in the areas with beetle infestations and decreasing trends in the control areas.

Given the current epidemic of mountain pine beetle infestation in British Columbia's forests, the evidence of water-quality impacts in beetle-infested watersheds presented in this recent paper could be relevant for stakeholders and our province.

Methodology

Mikkelson et al. used quarterly data from the water treatment facilities and publicly available water-quality data from the Colorado Department of Public Health and Environment. ArcGIS was used to determine the number of trees killed by mountain pine beetles in each watershed.

The authors then used statistical analysis to examine how the mean total organic carbon, total trihalomethane and haloacetic acid concentrations in watershed regions with mountain pine beetle infestations compared to control regions. Statistical analysis was also used to determine if the trends in concentrations were significant and how many years after the infestation for Total organic carbon levels to increase.

Mikkelson, K.M, E.R.V. Dickenson, R.M. Maxwell, J.E. McCray and J.O. Sharp, 2013: Water-quality impacts from climate-induced forest die-off. *Nature Climate Change*, 3, 218–222.