Fires, Floods, and Bugs:
How Climate Change Impacts Drinking Water Source Quality

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In collaboration with:

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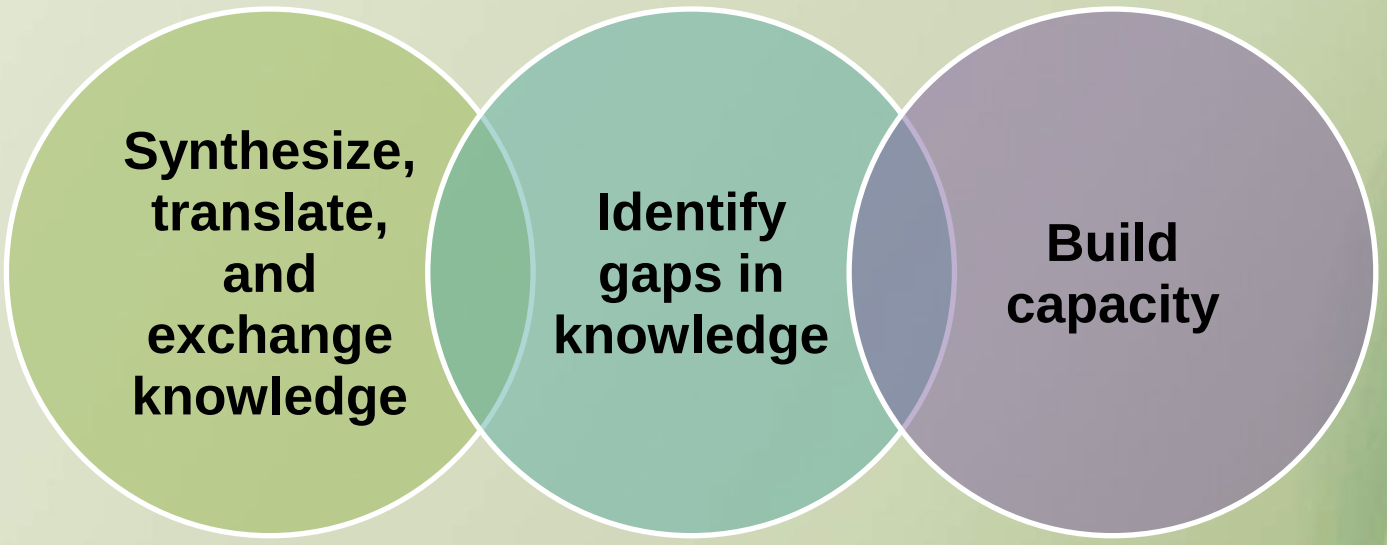
National Collaborating Centre for Environmental Health
Centre de collaboration nationale en santé environnementale

BC Centre for Disease Control
An Agency of the Provincial Health Services Authority

About the NCCEH

- One of six National Collaborating Centres, funded by the Public Health Agency of Canada
- Support and promote evidence-informed decision-making through:



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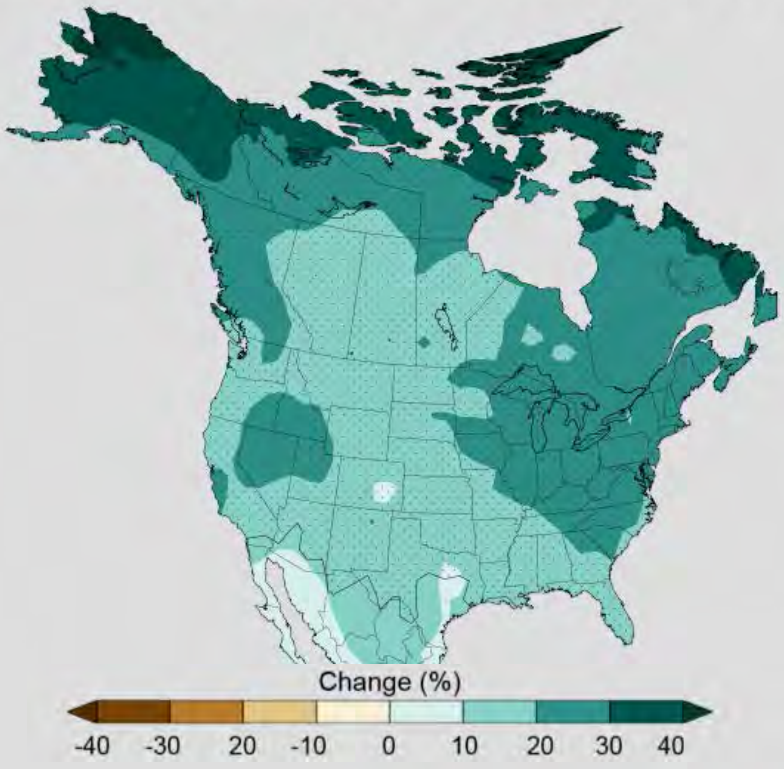
Outline

- High-level view of climate impacts
- Change at the watershed level
- Water quality changes in response to wildfire

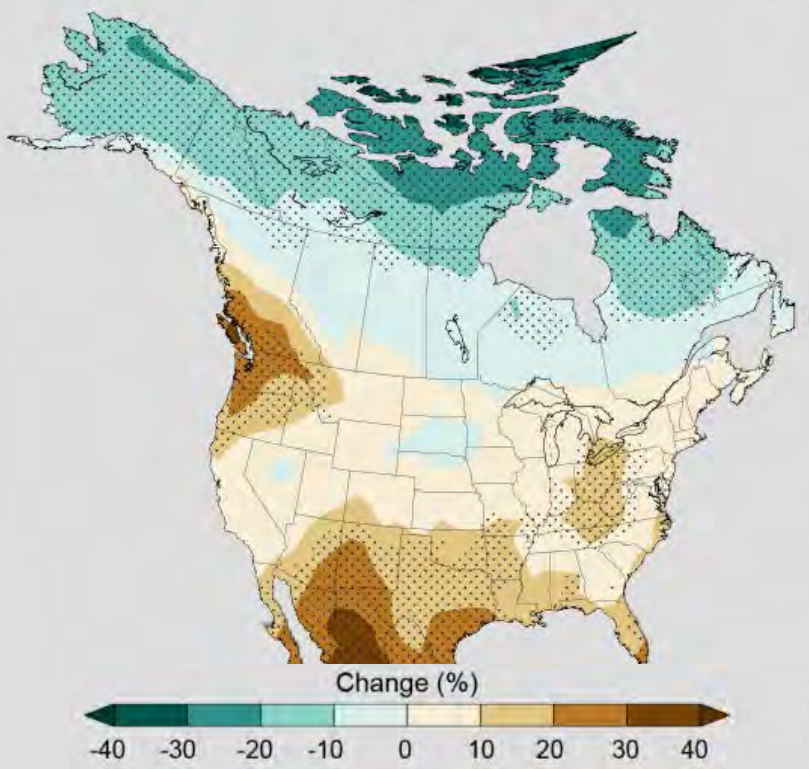
National Climate Assessment (2014)

Annual Max Precipitation



US Global Change Research Program, https://data.globalchange.gov/file/f2ee3d50-89bc-4225-9317-88eec322d87d

Consecutive Dry Days



US Global Change Research Program, https://data.globalchange.gov/file/4ab71794-0f21-446f-bd69-1d1eae63974d

- Under current emissions increases, 2070-2099 vs. 1971-2000.
- More precipitation on fewer days = ↑ **Heavy precipitation events**

Full NCA report available at: http://nca2014.globalchange.gov/report

Climate change in the watershed

- In what ways is climate change expected to impact or stress the normal function of watersheds?

Watershed Processes

Atmospheric Inputs

- Rain/snow
- Inorganics (CO_2, N, S)
- Solar radiation

Biological processes

- Plants & trees use, intercept and/ re-direct water
- Chemical transformations
- Create organic compounds & store carbon

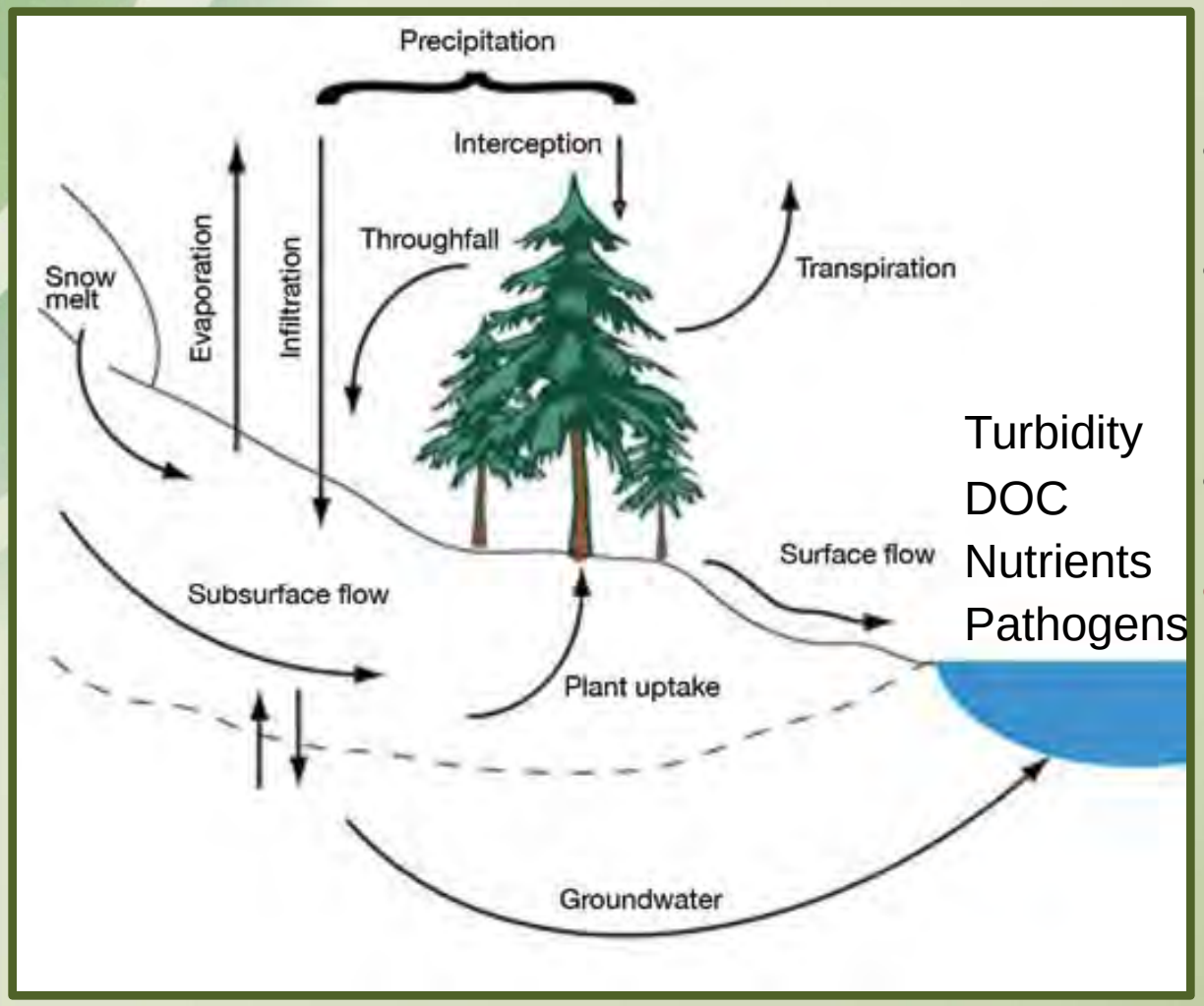
Subterranean processes

- Biogeochemical cycling
- Nutrients (P, N)
- Metals, minerals
- Organic compounds
- Carbon storage
- Water storage

Runoff and streamflow

- Water quantity
- Water quality

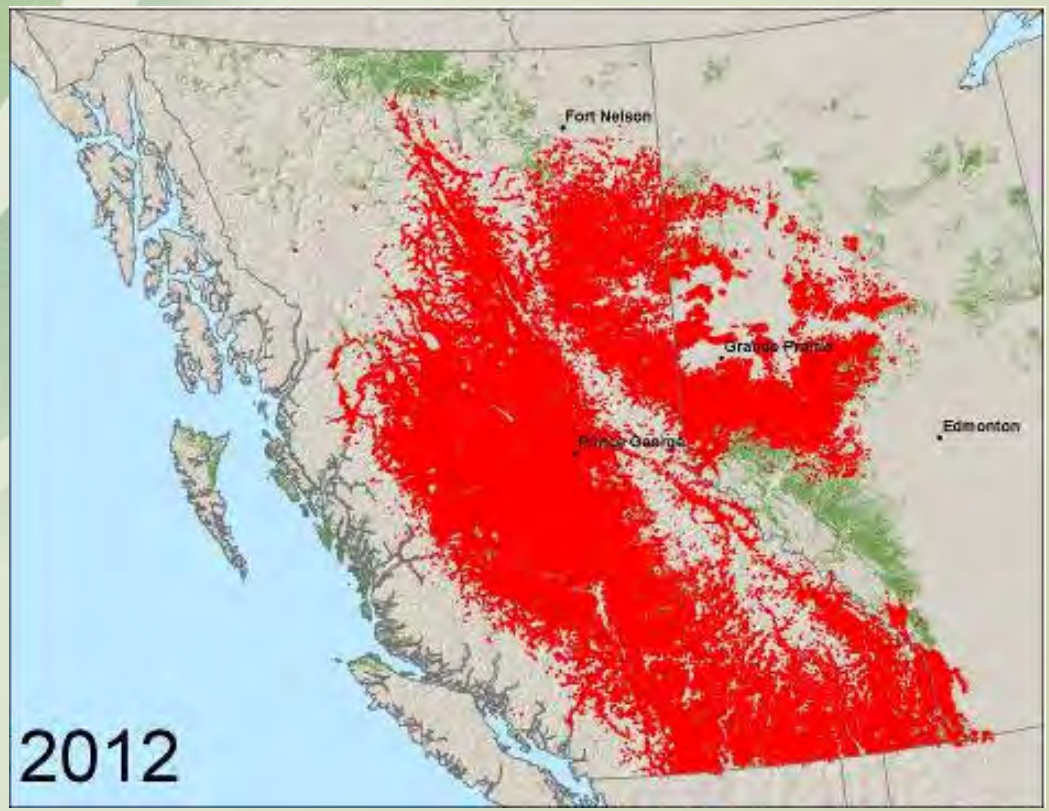
Trees in the Watershed



- Heavy rain
- Heat & Drought
- Pine beetle
- **Fires**

NRCAN, 2008. Towards Adaptation: Case Studies in British Columbia. In: *From Impacts to Adaptation: Canada in a Changing Climate.* FIGURE 11: Forest hydrological cycle (adapted from Hélie et al., 2005).

Pine Beetles and Water Quality



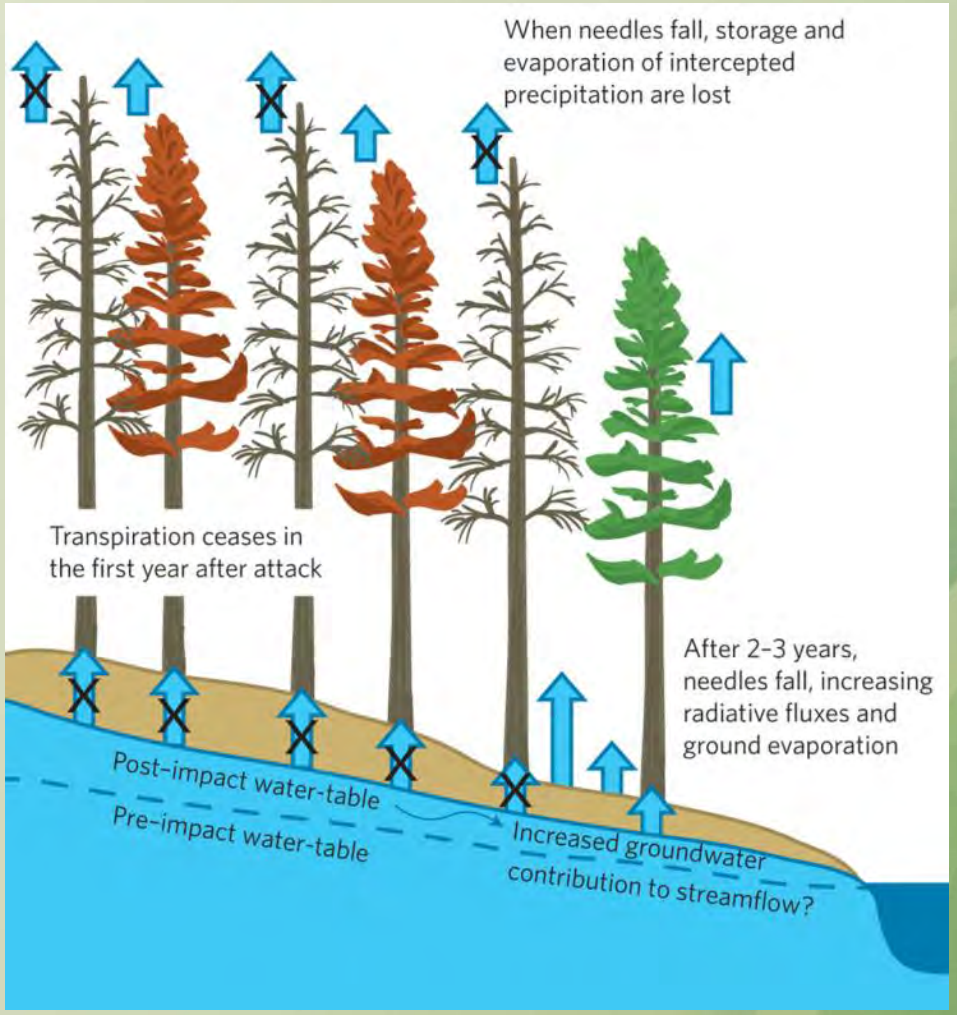
All of Canada's boreal forest is potentially at risk.

NRCAN *2016. Mountain pine beetle (factsheet). Available from: http://www.nrcan.gc.ca/forests/fire-insects-disturbances/top-insects/13397*

Pine Beetles and Water Quality

- Trees die, stop transpiring.
- Leaves more water in the soil.
- But, when needles fall, increase heat at the soil surface, increases evaporation.

- **Net result: ↑ groundwater to streams.**
- **WQ: ↑ N, organic C, metals**
- **Flash flooding**



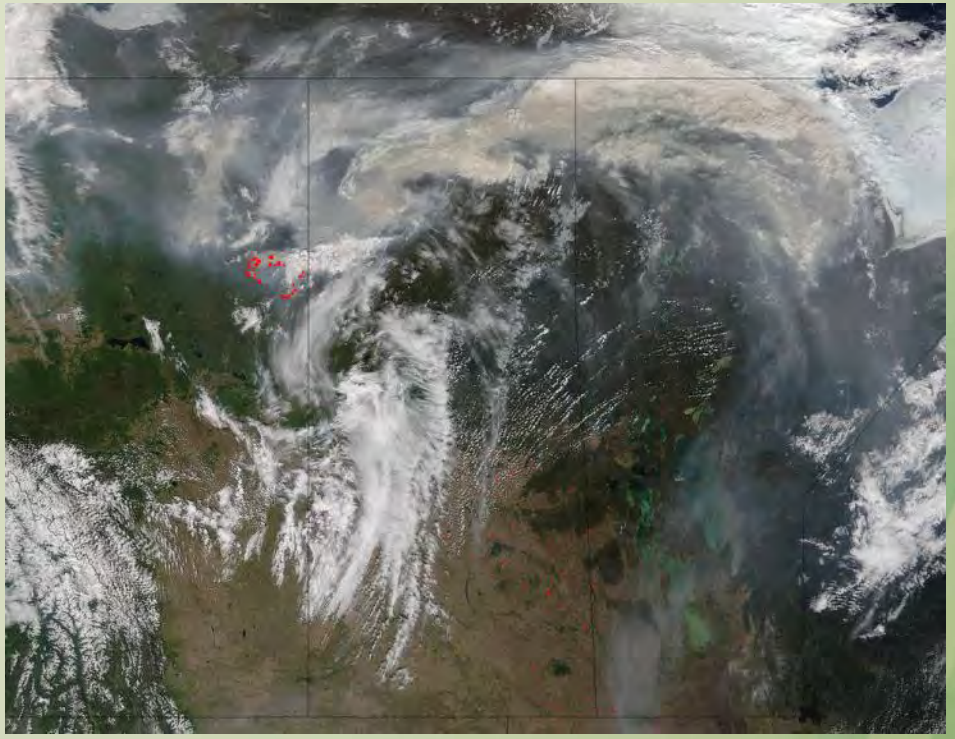
Bearup, L. A., et al. (2014). "Hydrological effects of forest transpiration loss in bark beetle-impacted watersheds." Nature Clim. Change **4**(6): 481-486.

Wildfires and Water Quality

*By **Cameron Strandberg** from Rocky Mountain House, Alberta, Canada (DSC_7139) [CC BY 2.0 (http://creativecommons.org/licenses/by/2.0)], via Wikimedia Commons*

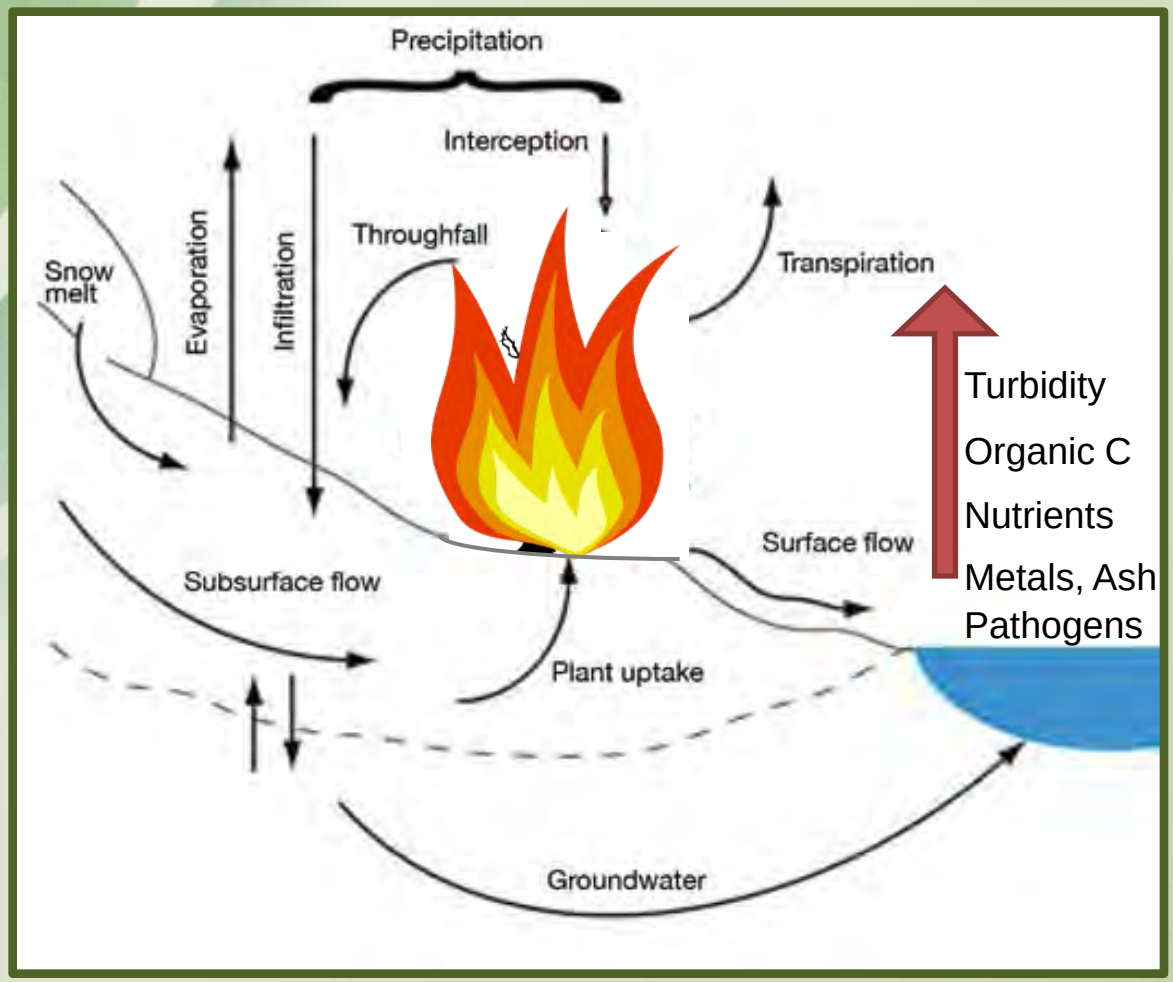
What's new about this???

- Combination of climate and other factors is creating conditions for "mega-fires."
- Mega fires have the ability to impact large watersheds.
- Human drivers: changes in forest harvest practices; watershed conservation and management



NASA/Jeff Schmaltz, MODIS Rapid Response Team. http://www.nasa.gov/feature/goddard/2016/nasa-satellites-image-fort-mcmurray-fires-day-and-night

Wildfires and Water Quality



***NRCAN**, 2008. Towards Adaptation: Case Studies in British Columbia. In: From Impacts to Adaptation: Canada in a Changing Climate. FIGURE 11: Forest hydrological cycle (adapted from Hélie et al., 2005).*

- **Canopy gone, roots present**
- During a storm, more rain hits the ground.
- Soil is warmer and now water repellant – more water runs off
- More runoff, more erosion, more sediment & surface contaminants (ash, metals, pathogens)
- No water being transpired, so more GW, more DOC, more N+P, metals???
- Higher yields and peak flows increase.
- Snow melts faster; streamflow peaks earlier

“Immediate” Effects after Wildfire

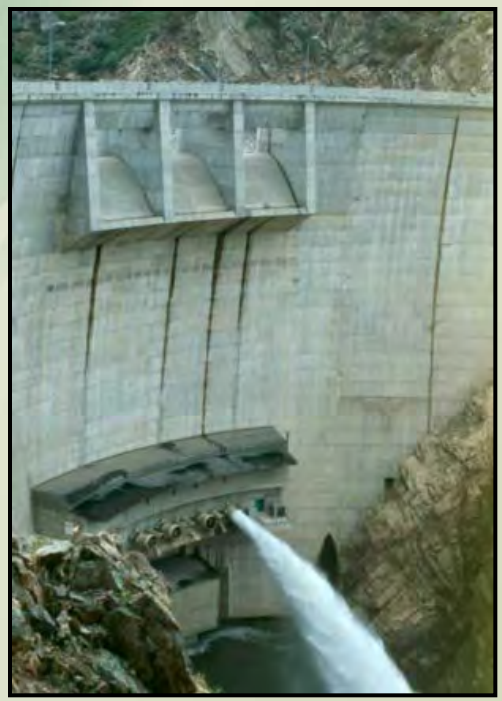
- Significant amounts of ash may be mobilized; typically in conjunction with precipitation events: ≥ 3 years post-fire!
- Depend on geologic setting, antecedent precipitation conditions, wildfire intensity, watershed area burned, etc.

Aspen Wildfire 2003, AZ (D. Martin, USGS)

Drum Creek, Crowsnest Pass, AB in 2005 after the Lost Creek Wildfire 2003 (Southern Rockies Watershed Project)

“Immediate” Effects after Wildfire

- Erosion can be significant in some areas and may include potentially catastrophic debris flows.



Strontia Springs Reservoir (Denver, CO) after the Buffalo Creek Fire 1996
(J. Moody, USGS. Hydrological and erosion responses of burned watersheds. Available at: http://wwwbrr.cr.usgs.gov/projects/Burned_Watersheds/)

“Immediate” Effects after Wildfire

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Colorado Buffalo Creek Fire 1996, flash flood 1997. (*D. Martin, USGS. Hydrological and erosion responses of burned watersheds. Available at: http://wwwbrr.cr.usgs.gov/projects/Burned_Watersheds/)*

Changes in key WQ metrics

- Most significant risks to drinking water supply and treatment are not from "contaminants" associated with "toxic ash."

Impact on Treatment	Parameter					
	Turbidity	TP	DON and TKN	Hg	DOC	Chl.-*a*
Need for solids removal (C/F/S)	✓	✓			✓	✓
↑ Coagulant demand	✓				✓	✓
↑ Sludge production	✓				✓	✓
↑ Oxidant demand	✓		✓		✓	✓
↑ DBPs	✓		✓		✓	✓
↑ Fluence required for UV			✓		✓	✓
↑ microcystins		✓				✓
↑ Taste and odor concerns			✓		✓	✓
Compliance concerns	✓		✓	✓	✓	✓
↑ Operating costs	✓	✓	✓	✓	✓	✓

***Emelko, M.B.**, et al. (2011). "Implications of land disturbance on drinking water treatability in a changing climate: Demonstrating the need for 'source water supply and protection' strategies." Water Research **45**: 461-472.*

Post-fire Regime Change

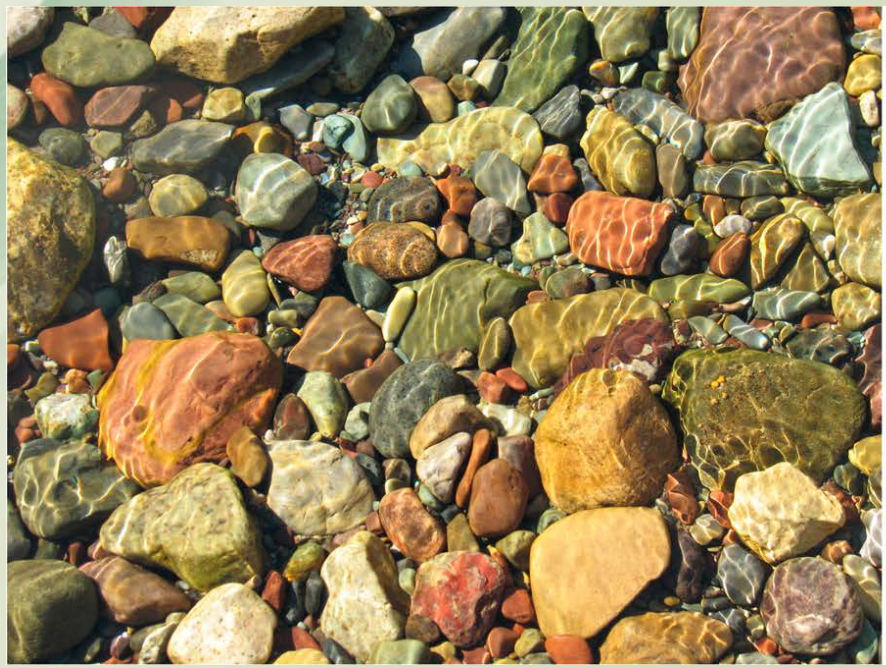
- Increased yield, bigger peak flows, earlier freshet, flash floods, warmer water, altered water quality
- Effects can propagate far downstream and last for years
- Severity may be linked to landform or physiography

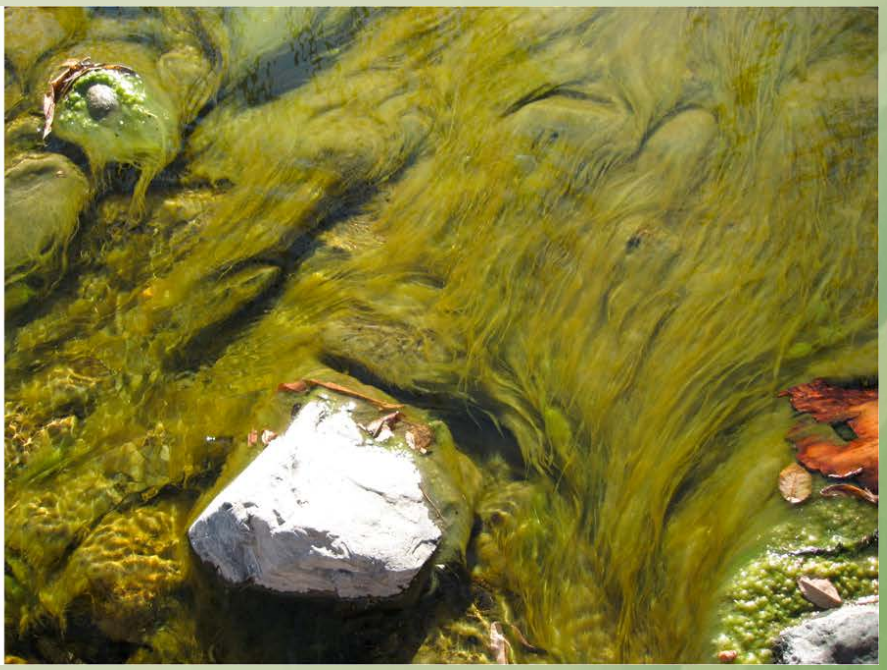
***Bladon, K. D.**, et al. (2014). "Wildfire and the Future of Water Supply." Environmental Science & Technology **48**(16): 8936-8943.*

***Emelko, M.B.**, et al. (2016). "Sediment-phosphorus Dynamics Can Shift Aquatic Ecology and Cause Downstream legacy Effects after Wildfire in Large River Systems." Global Change Biology **22**: 1168-1184.*

Post-fire Regime Change

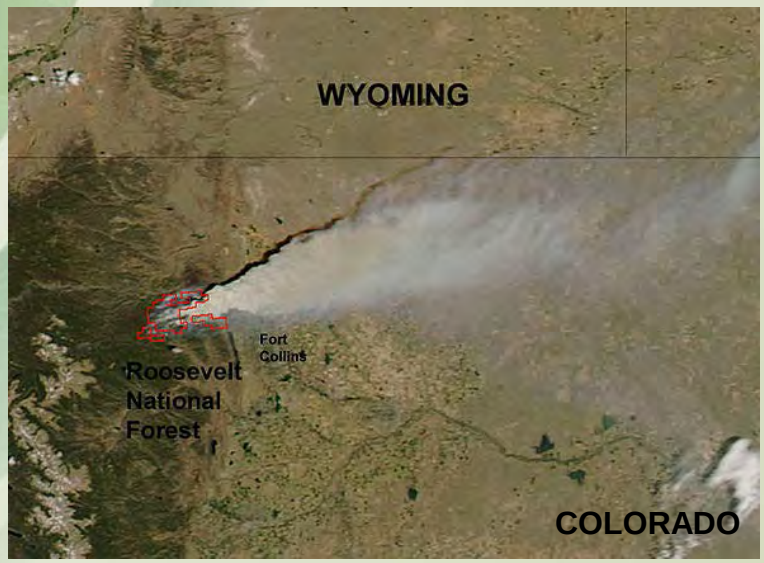
- Nutrient increases (DOC, P, N, K, etc.) can lead to drastic changes in aquatic ecosystem.





***Bladon, K. D.**, et al. (2014). "Wildfire and the Future of Water Supply." Environmental Science & Technology **48**(16): 8936-8943.*

A tale of two watersheds: Colorado vs. Alberta



By Jeff Schmaltz, MODIS Rapid Response Team [Public domain], via Wikimedia Commons

- High Park, 2010
- Immediate: ↑ DOC, stayed elevated
- Turbidity and P↑, but decreased within few years

- Lost Creek Fire, 2003
- Immediate: ↑ DOC, persisted
- Turbidity and P↑, and has also persisted
- Difference = ↑Fine sediment (surface area & transport)

Herald Contributor Photo. Crowsnest Pass Herald July 23, 2013, Vol. 83 (no. 29).

Key Messages

- Climate change affects the hydrological processes at work in watersheds.
- Drivers include changing precipitation patterns, heavy precipitation events, increase heat/drought, the spread of mountain pine beetle, and the climatic and human factors favoring mega-fires
- In addition to effects on water quantity and flow regime, disturbances are expected to negatively impact water quality.
- Effects may persist over the long term, dependent at least in part on the physical characteristics of the watershed.

Thank You

Questions?
Comments?

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