Effects of landscape disturbance on Alberta's water supplies:
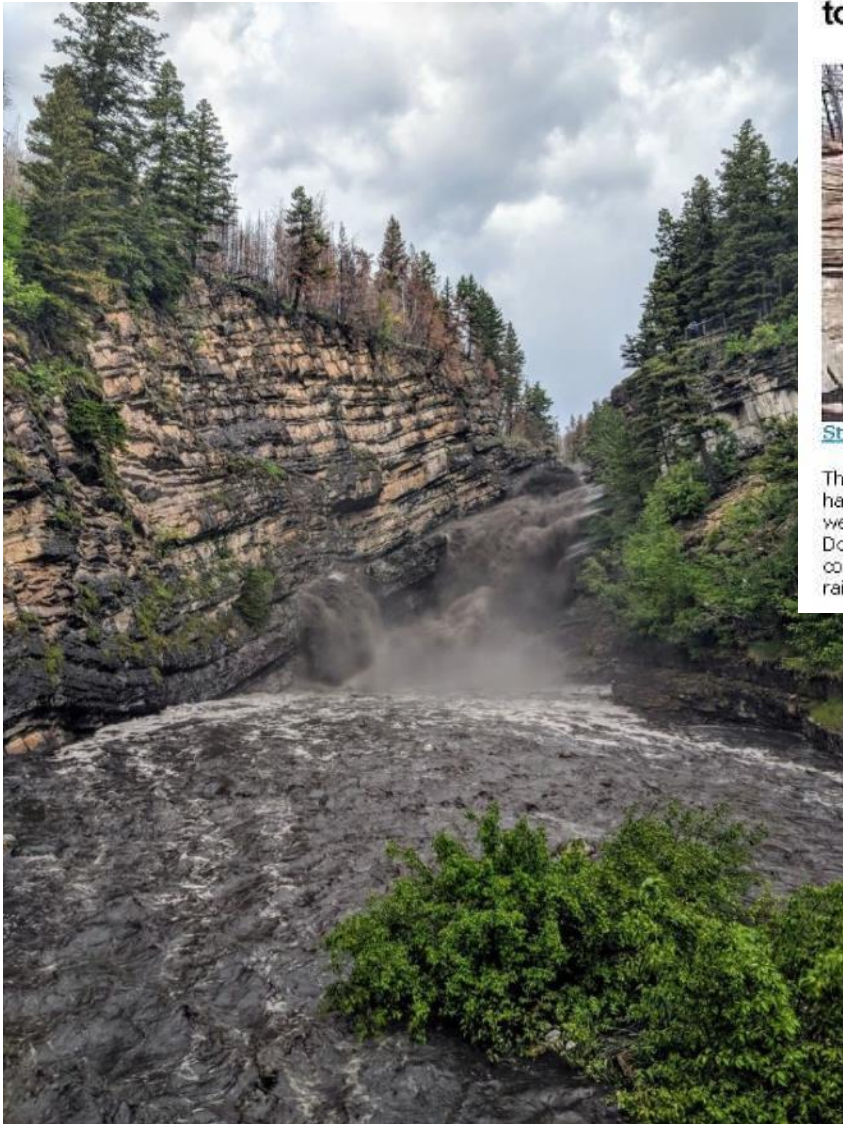## Source water protection and adaptation in a warmer world

Southern Rockies Watershed Project

Monica B. Emelko and Uldis Silins,
Stone M, Anderson A, Cherlet E, Collins C, Cooke C, Dyck M, Emmerton C,
Hawthorn K, Krishnappan B, Martens A, Quideau S, Wagner M, Williams CHS

Red Deer Watershed Alliance
2021 Annual General Meeting
June 15, 2021

Impacts on water & watersheds ?

Firefighters move on to flood control

Steven G. Smith/Tribune

Thomas Tenorio (left) applies a bandage to the blistered hands of James Calabaza in the scorched woodlands west of Los Alamos. The two firefighters from Santo Domingo Pueblo have gone from fighting fire to flood-control efforts, raking the ash-laden forest floor to allow rainwater to ...

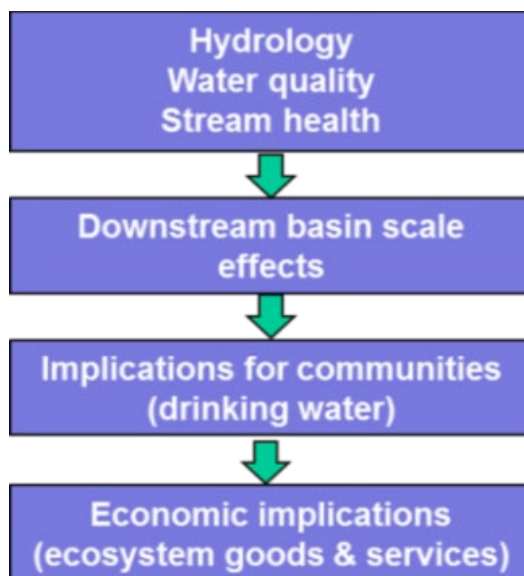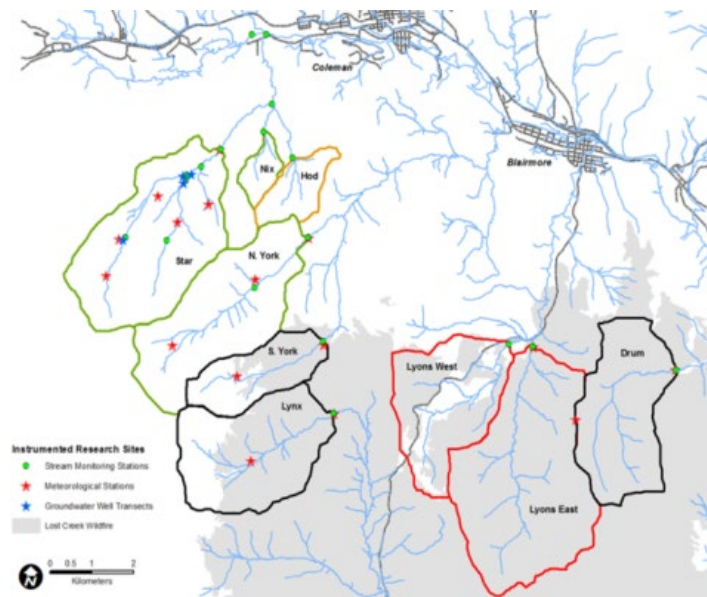TIME   Thousands Evacuated From California Wildfire Areas Amid Flash ...

U.S. • CALIFORNIA

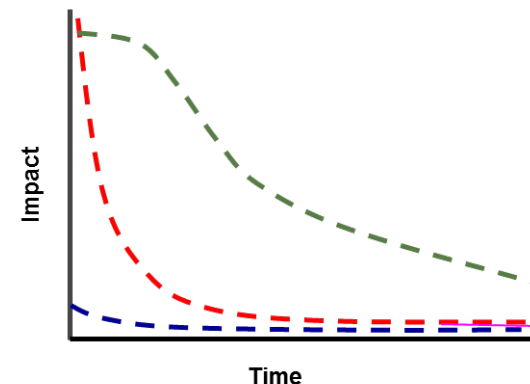**Thousands Evacuated From California Wildfire Areas Amid Flash Flood Fears**

STAY LONGER. SAVE MORE.

- *Ash, fire debris, "emergency" sediment*
- *Catastrophic … but relatively "quick" recovery (1-3 yr.)*

Southern Rockies Watershed Project – *Wildfire/water studies*

2003 Lost Ck. (2004-2014)

- **Scope of impacts to water?**
- **How large?**
- **For how long?**

**Hydrology
Water quality
Stream health**

⬇

Downstream basin scale effects

⬇

**Implications for communities
(drinking water)**

⬇

**Economic implications
(ecosystem goods & services)**
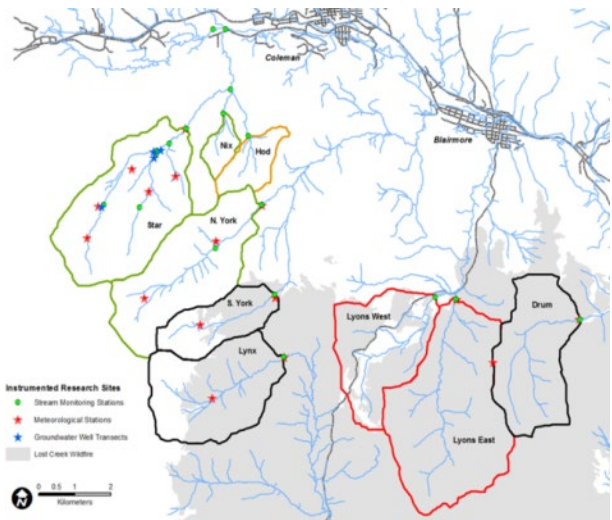

Emerald Awards 2014 Recipient

2014 Council of the Federation -
Excellence in Water Stewardship Award

- *Trans-disciplinary water science / management domains – "source to tap"*
- *Pan-Canadian and international research team*
- *Most comprehensive study of it's kind worldwide – "big data"*

Southern Rockies Watershed Project – *Wildfire/water studies*
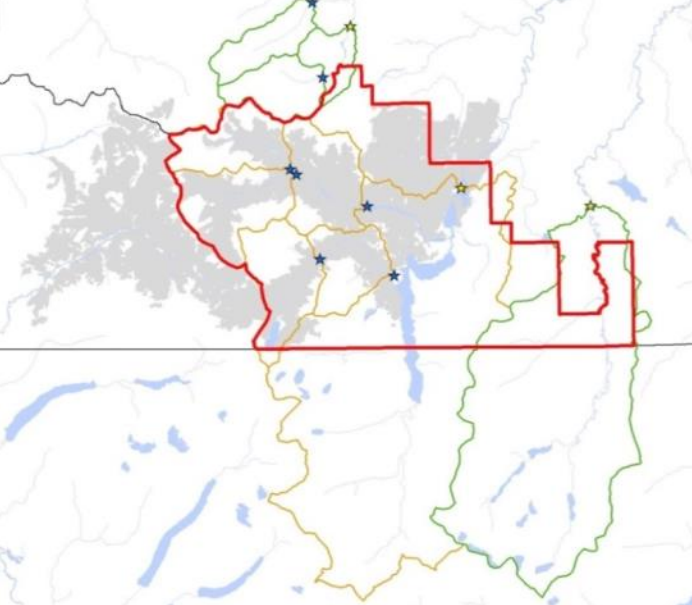
2003 Lost Ck. (2004-2014)

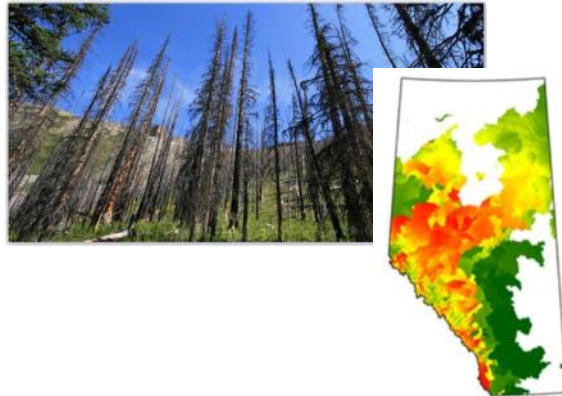## *2016 Horse R. (2016-ongoing)*

2012 Milk River

2017 Kenow Mtn. (2018-ongoing)

Provincial risk analysis

Management of Wildfire Risk to Municipal Waterworks Systems in Alberta

Principal Investigator - Uldis Silins, Professor, University of Alberta, 2012 - 2014
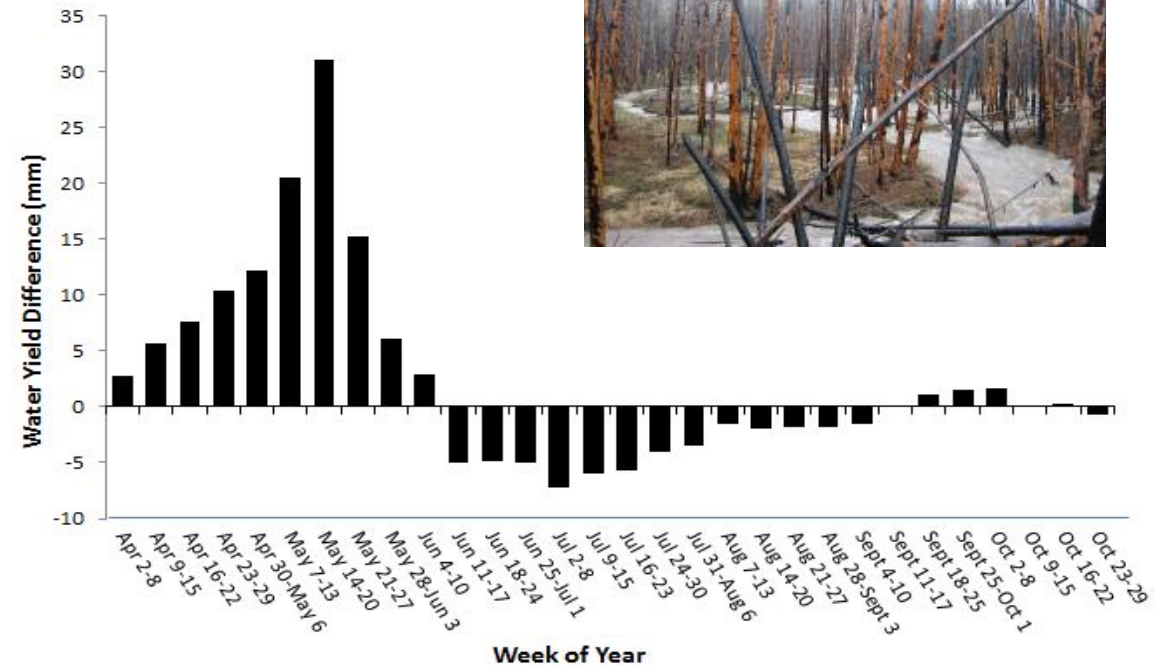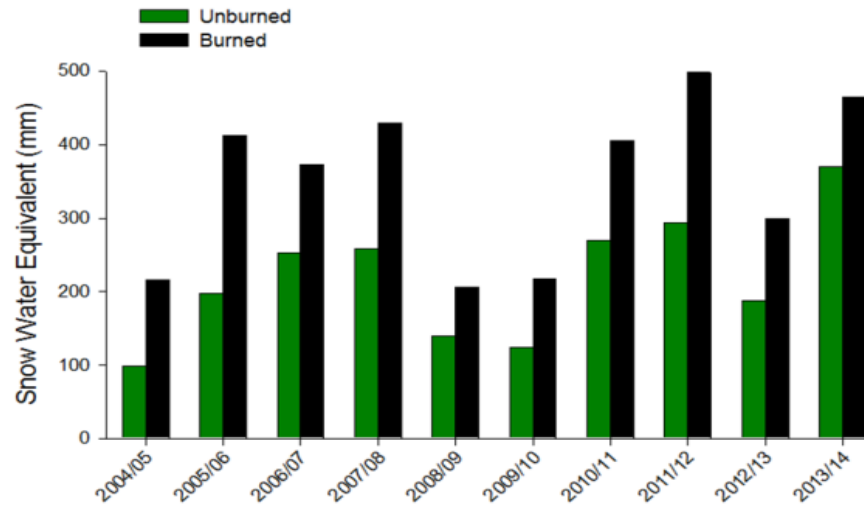

2014 Spreading Creek

2017 Elephant Hill, Thuja Ck. , Little Fort Complex (B.C.)

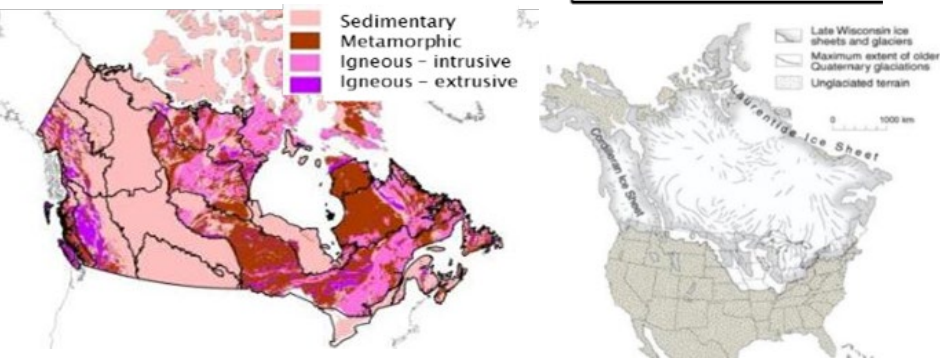# Wildfire effects on water – *Hydrology*

- **More snow melts earlier, more rain**
  - **~ 300 mm ↑ net precipitation (51%)**

- **Minor ↑ in total flow**
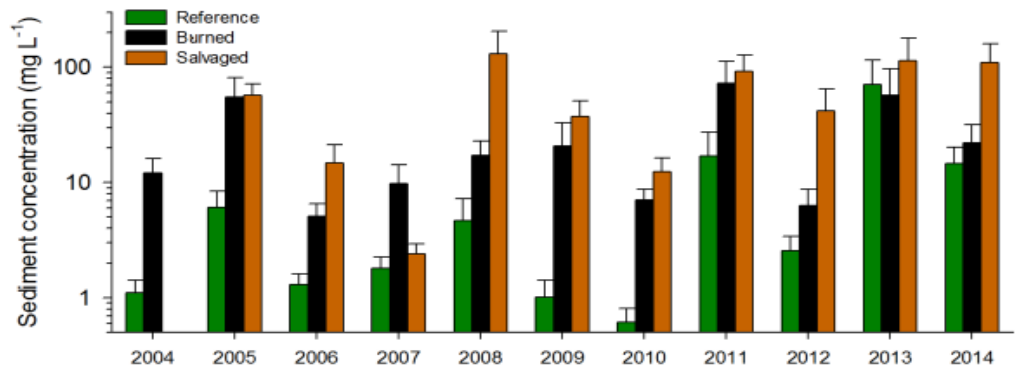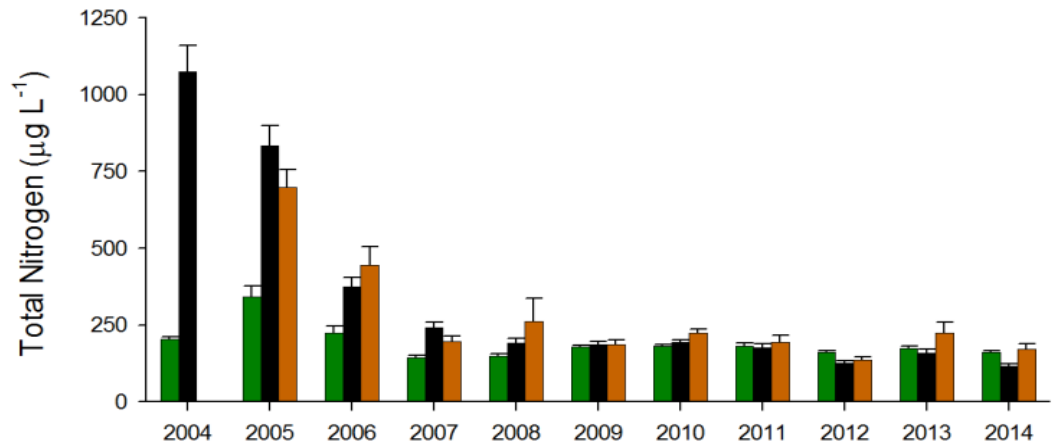- **Earlier melt – change in timing of runoff**
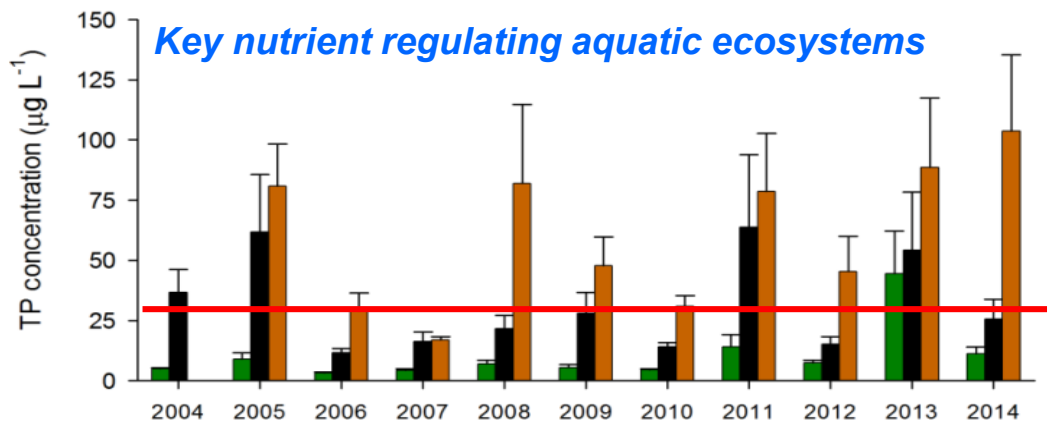
Wildfire effects on water – *Water quality*

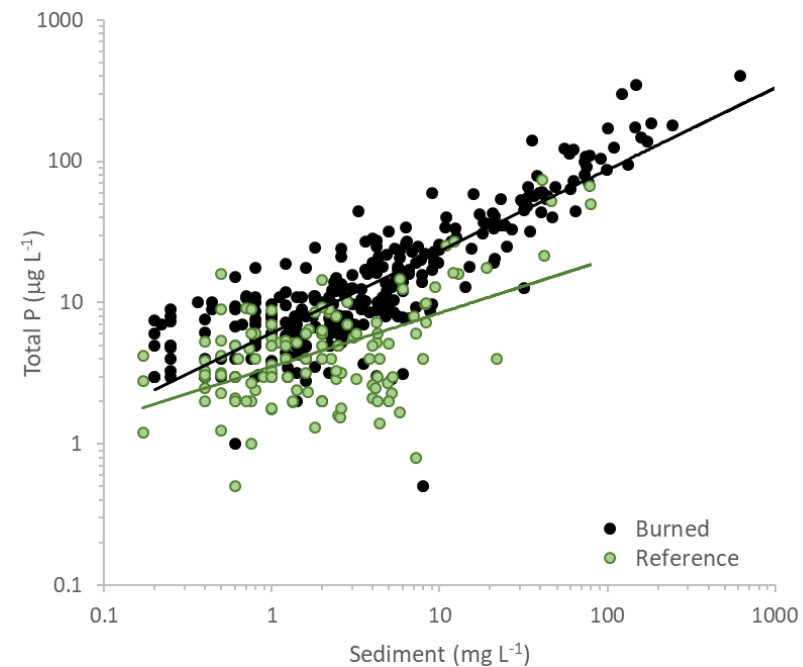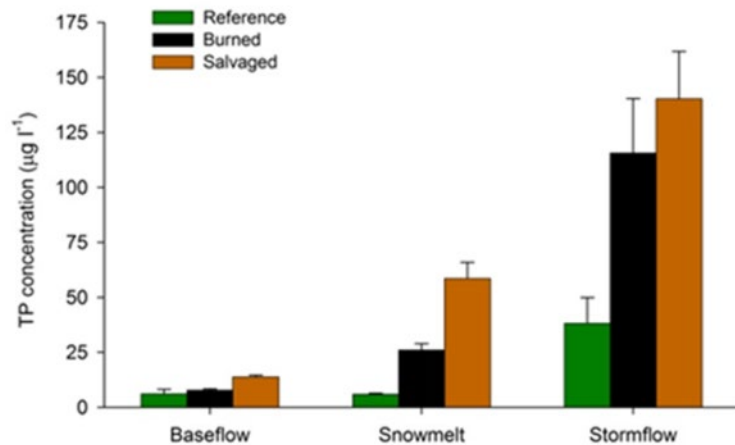- **Broad range of effects**
  - Full suite WQ

- **effects ~ last > decade (sediment / P)**
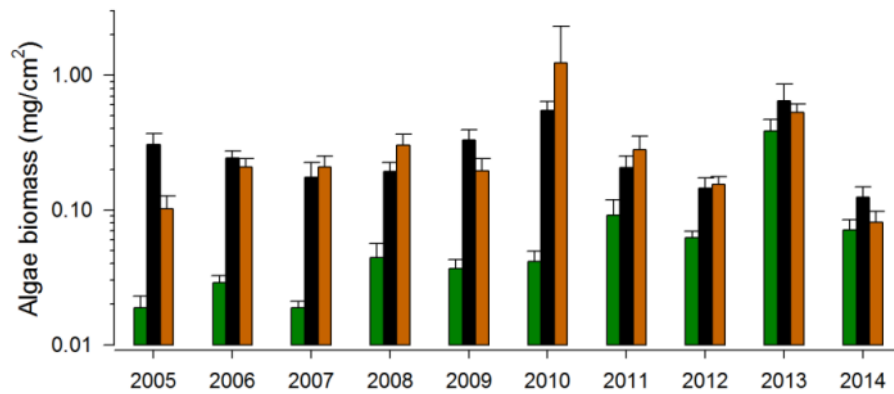 - *Differs from other regions of Canada, USA, Australia, S. Europe, or Asia*

Key nutrient regulating aquatic ecosystems

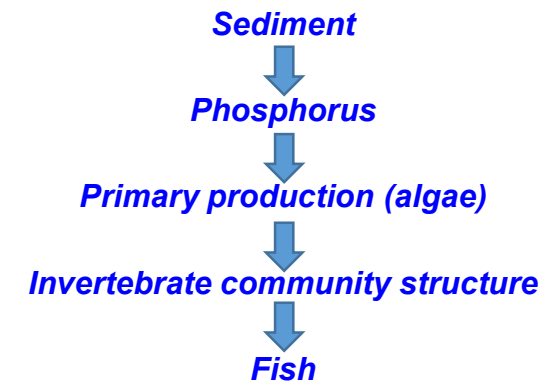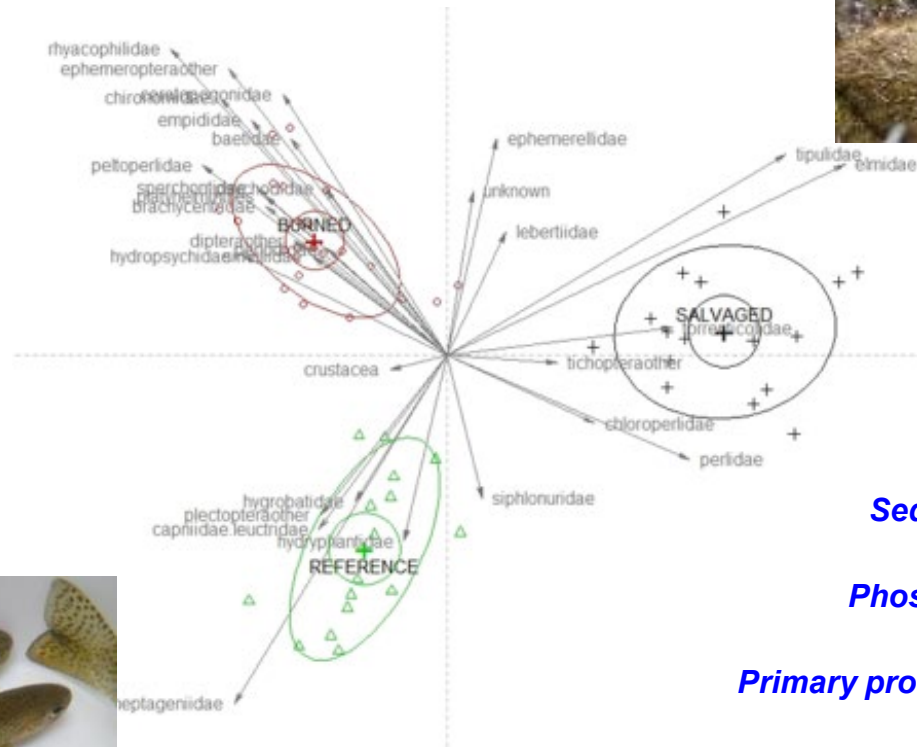# Wildfire effects on water – *Stream health*

Phosphorus <u>strongly</u> associated with sediment

- – *Greater post-fire sediment = greater P*
- – *<u>plus</u> > 2x greater P per unit sediment*
- – *<u>plus</u> fire transforms P - more "bioavailable"*

Wildfire effects on water – *Stream health*

Sediment
↓
Phosphorus
↓
Primary production (algae)
↓
Invertebrate community structure
↓
Fish

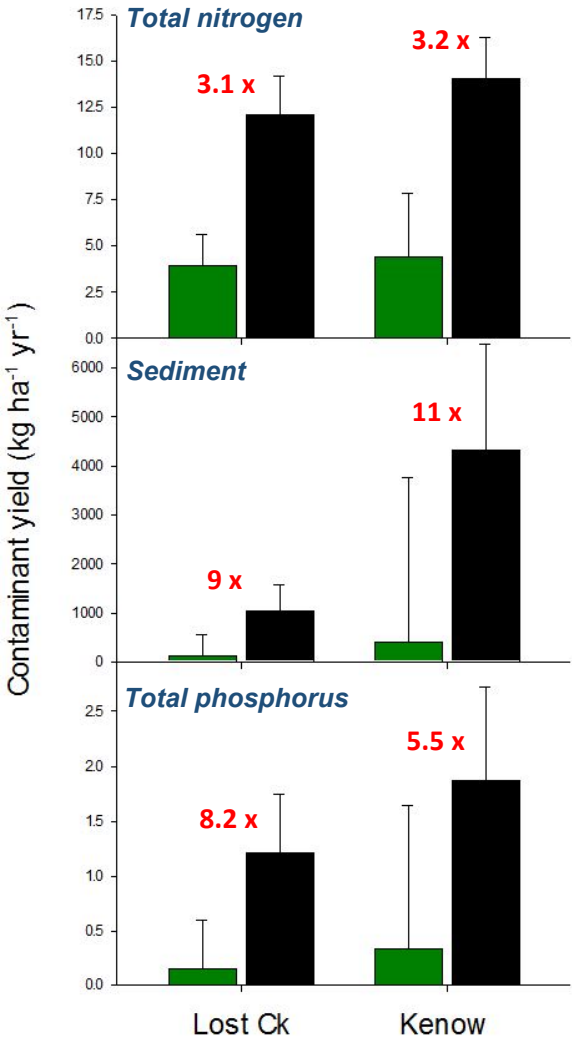# Wildfire effects on water – impacts vary among fires & regions

Kenow Mtn. fire - Déjà vu ?

1st 3 years after fire

Total nitrogen — 3.1 x, 3.2 x

Sediment — 9 x, 11 x

Total phosphorus — 8.2 x, 5.5 x

Contaminant yield (kg ha^{-1} yr^{-1})

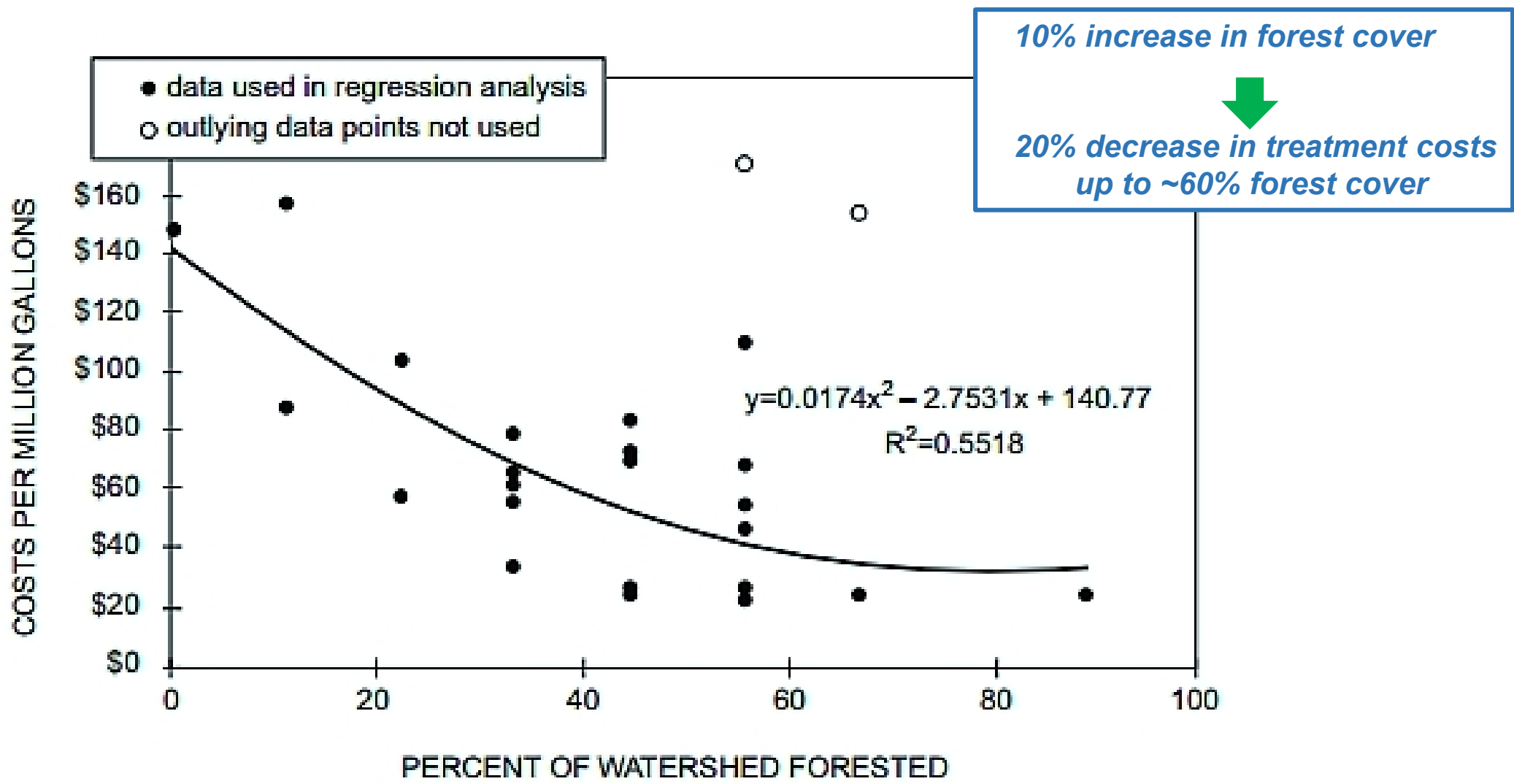Lost Ck   Kenow

Similarities but important differences reflecting key differences in wildfires and source watersheds

Forests, Wildfire & Drinking Water – *Drinking water "treatability"*


Relationship between watershed forest area and drinking water treatment costs. From Ernst (2004): Protecting the Source: Land Conservation and the Future of America's Drinking Water.

Forests, Wildfire & Drinking Water – *Drinking water "treatability"*

Impact on Treatment \ Parameter	Turbidity and SS	TP	DON and TKN	Hg	DOC	Chl.-a
need for solids removal (C/F/S)	✓				✓	✓
↑ coagulant demand	✓				✓	✓
↑ sludge production	✓				✓	✓
↑ oxidant demand	✓		✓		✓	✓
↑ potential DBPs	✓		✓		✓	✓
↑ fluence required for UV			✓		✓	✓
↑ potential microcystins		✓				✓
taste & odor concerns					✓	✓
compliance concerns	✓			✓	✓	✓
↑ operating costs	✓	✓	✓	✓	✓	✓

Emelko et al. (2011)

Drinking Water and Water Security
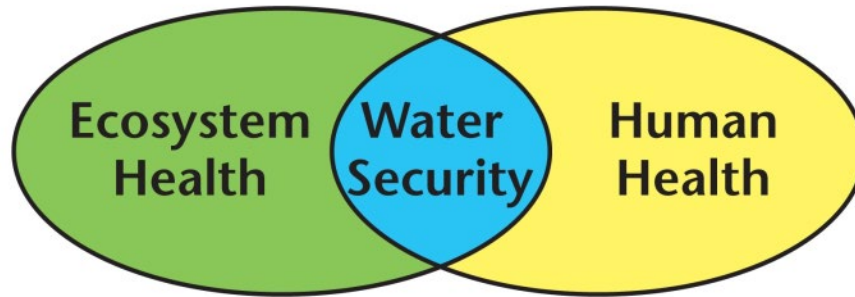
"**Water Security:**
     sustainable access on a watershed basis
     to adequate quantities of water,
     of acceptable quality,
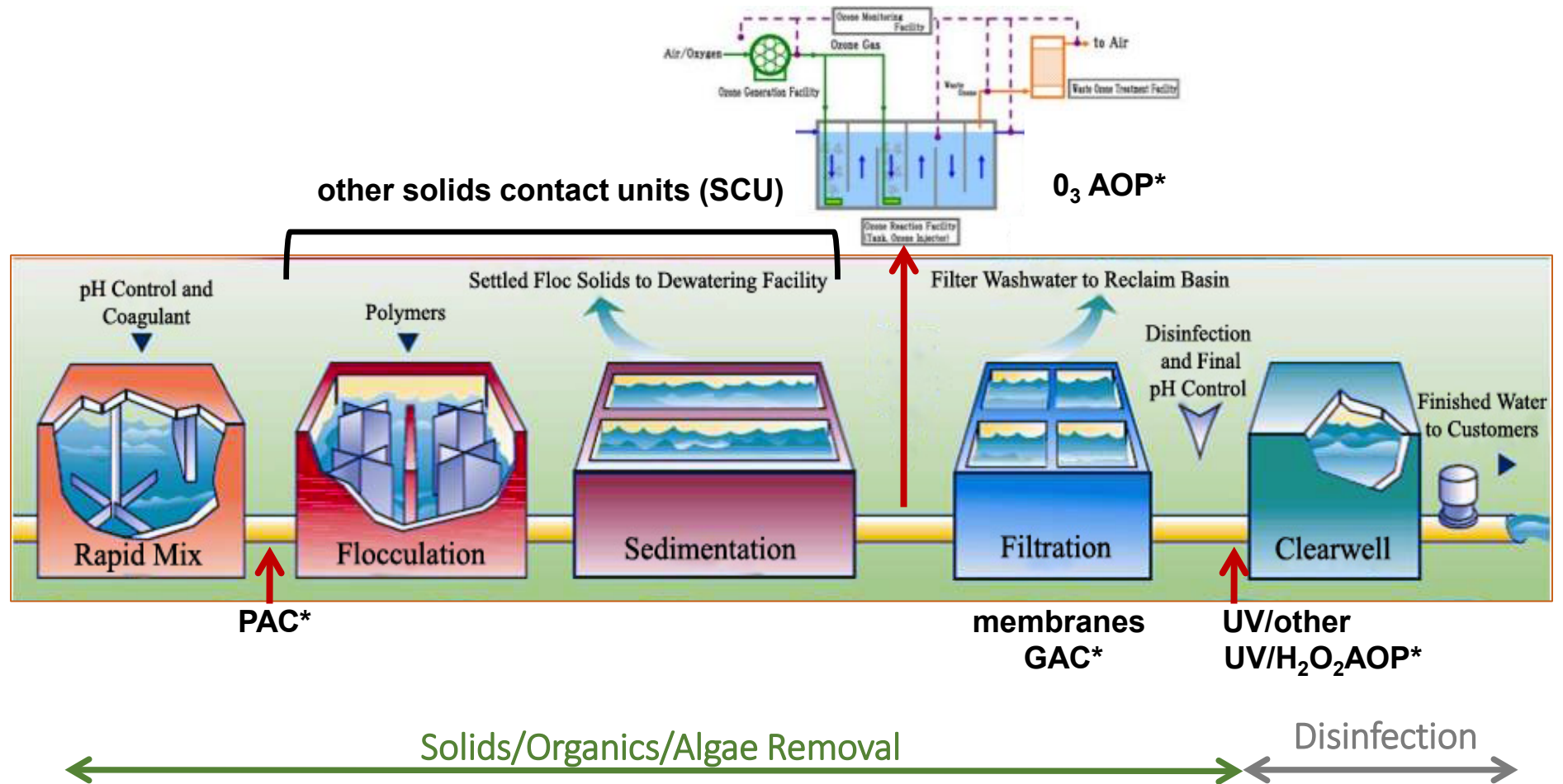   **to ensure human and ecosystem health.**"

Norman et al. (2010)

water security ≠ drinking water security!

Emelko et al. (2011)

Treatment of Surface Water

other solids contact units (SCU)

O_3 AOP*

pH Control and Coagulant

Polymers

Settled Floc Solids to Dewatering Facility

Filter Washwater to Reclaim Basin

Disinfection and Final pH Control

Finished Water to Customers

Rapid Mix

Flocculation

Sedimentation

Filtration

Clearwell

PAC*

membranes
GAC*

UV/other
UV/H_2O_2AOP*

Solids/Organics/Algae Removal

Disinfection

*algal toxin control

Emelko et al. (2021)

Implications of Threats to Source Water Quality

PLOS | ONE

RESEARCH ARTICLE

A Burgeoning Crisis? A Nationwide Assessment of the Geography of Water Affordability in the United States

Elizabeth A. Mack[1]*, Sarah Wrase[2]

1 Department of Geography, Environment & Spatial Sciences, Michigan State University, East Lansing, Michigan, United States of America, 2 Department of Accounting & Information Systems, Eli Broad College of Business, Michigan State University, East Lansing, Michigan, United States of America

* emack@msu.edu

Check for updates

🔓 OPEN ACCESS

Abstract

While basic access to clean water is critical, another important issue is the affordability of water access for people around the globe. Prior international work has highlighted that a large proportion of consumers could not afford water if priced at full cost recovery levels. Given growing concern about affordability issues due to rising water rates, and a comparative lack of work on affordability in the developed world, as compared to the developing world, more work is needed in developed countries to understand the extent of this issue in terms of the number of households and persons impacted. To address this need, this paper assesses

Water Research Foundation

Wildfire Impacts on Water Supplies and the Potential for Mitigation: Workshop Report

Web Report #4529

Subject Area: Water Resources and Environmental Sustainability

- **Water rates have increased 41% since 2010**

- **At this rate, over the next five years,
  ~36% of all households (40.9 million people)
  may not be able to afford water and wastewater services on a full cost recovery basis.**

- **Climate change threats and adaptation needs exacerbate these costs!**

Key Messages Regarding Drinking Water Supply & Treatment

Process	Turbidity	Color	TOC
Conventional	high >20 NTU	high >20 c.u.	high >4 mg/L
Direct/Inline Filtration	low ≤15 NTU	moderate to low ≤20 c.u.	low <4 mg/L
Microfiltration	low ≤10 NTU	moderate to low ≤10 c.u.	low <4 mg/L

- **Microbial risk management is <u>always</u> a top priority.**

- **Parameters of health consequence are <u>NOT</u> the most significant threats to <u>treatability</u> of surface water supplies!**

- **More variable water quality can be a game changer!**

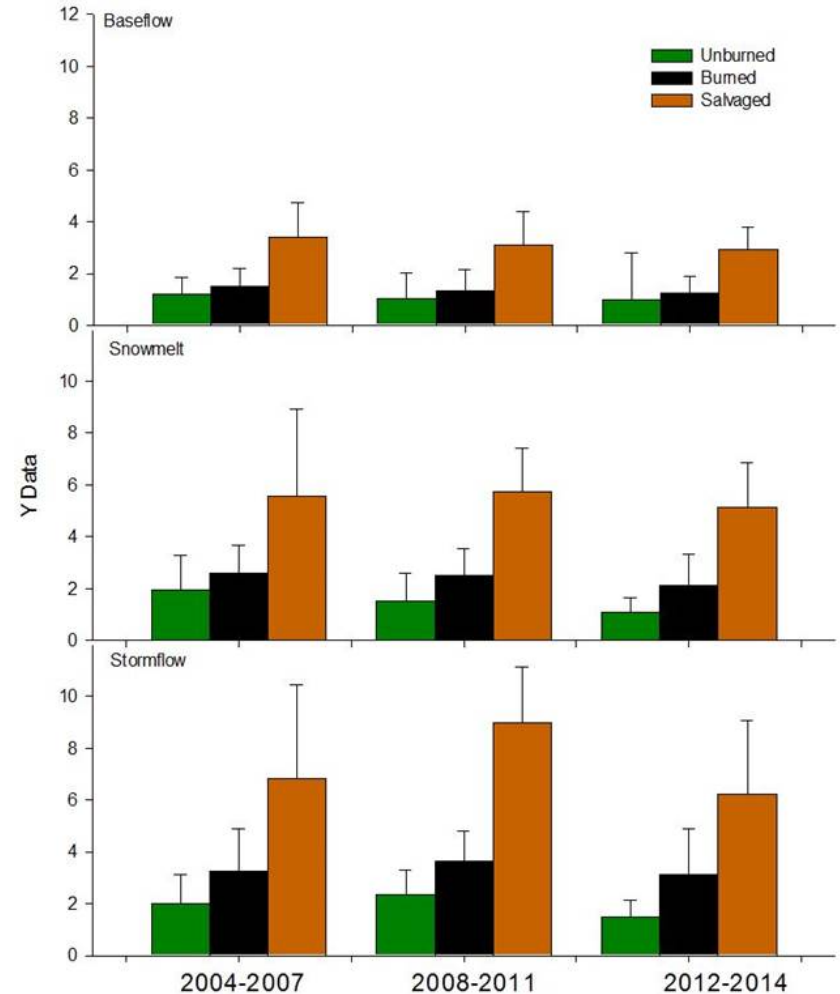# Sediment and turbidity after wildfire – *A potential legacy of impacts*
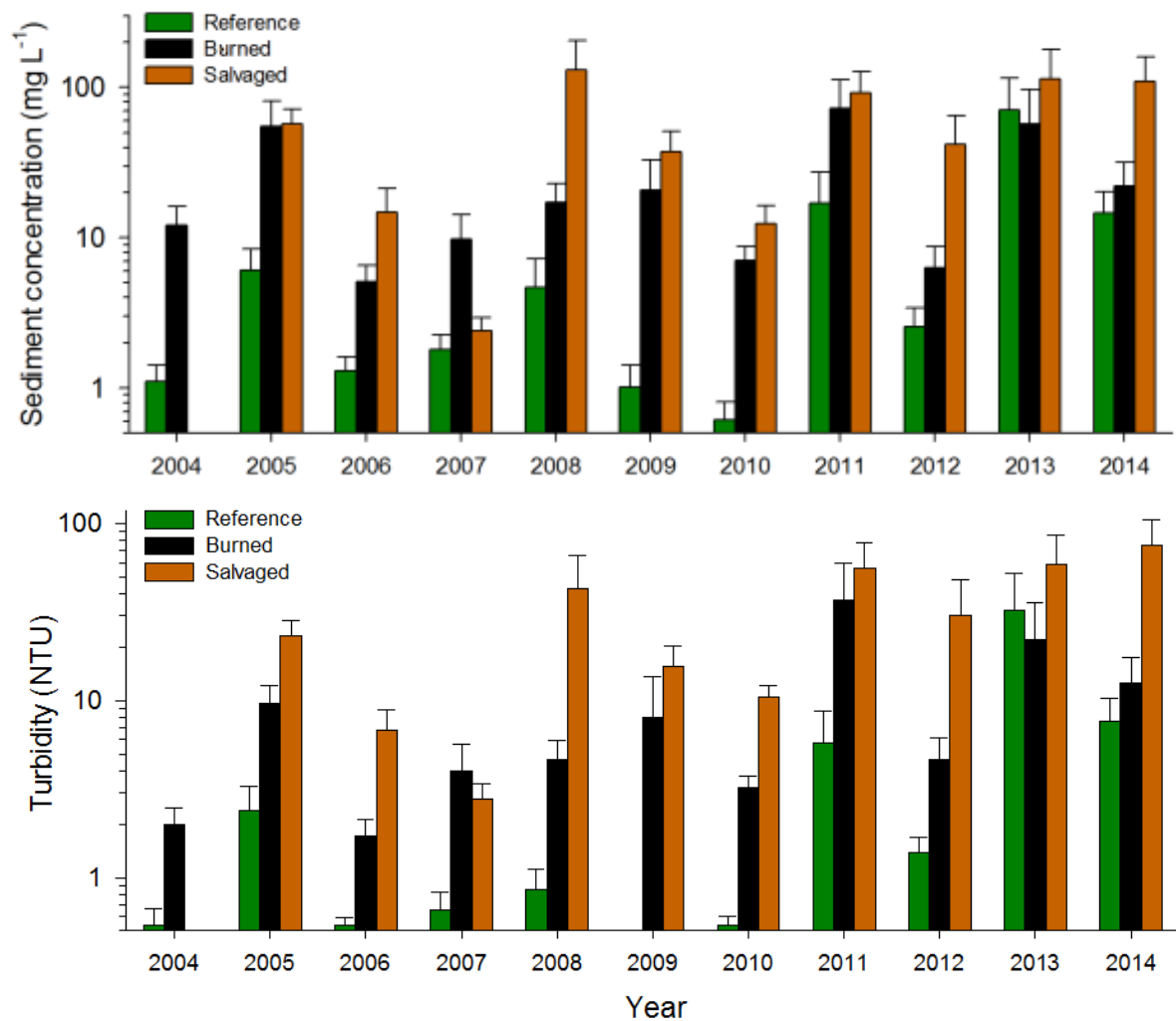
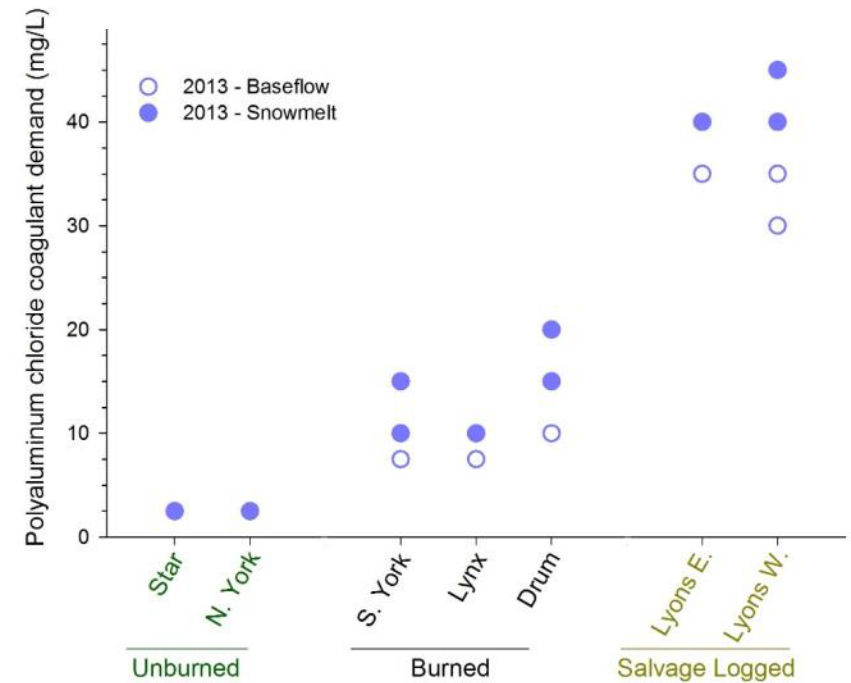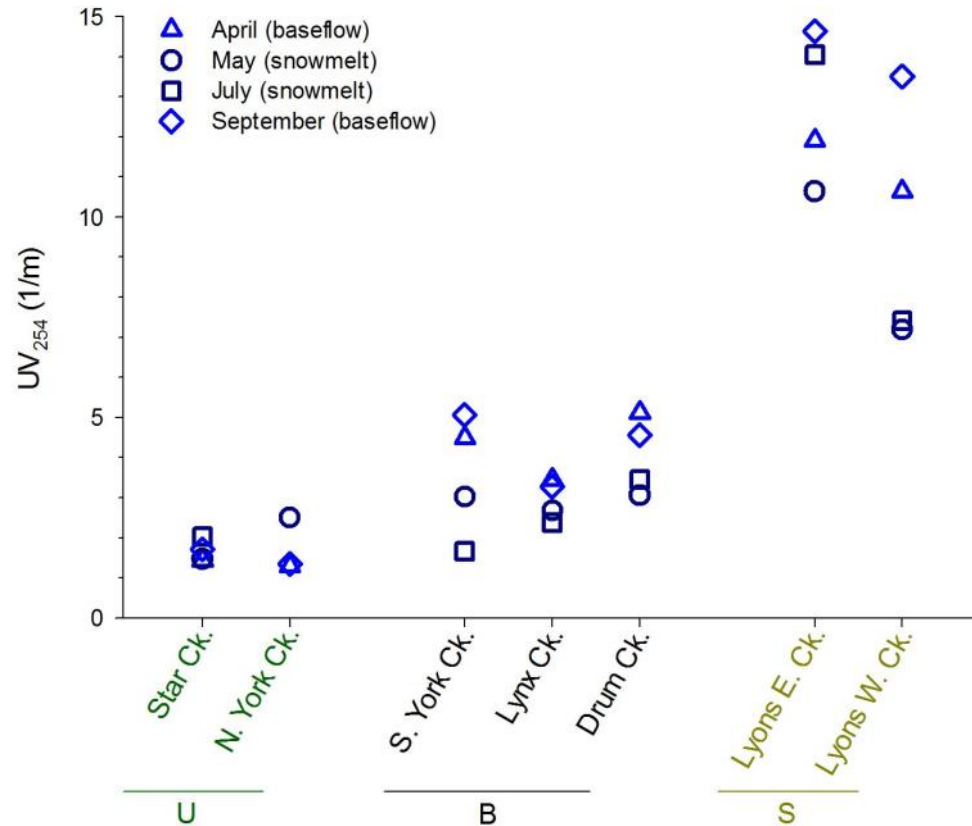# Phosphorus, algae & nitrogen after wildfire – *More legacy impacts*
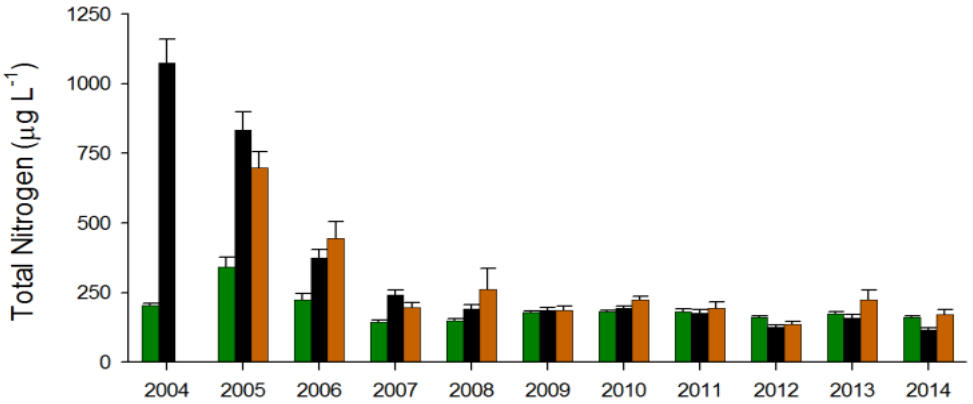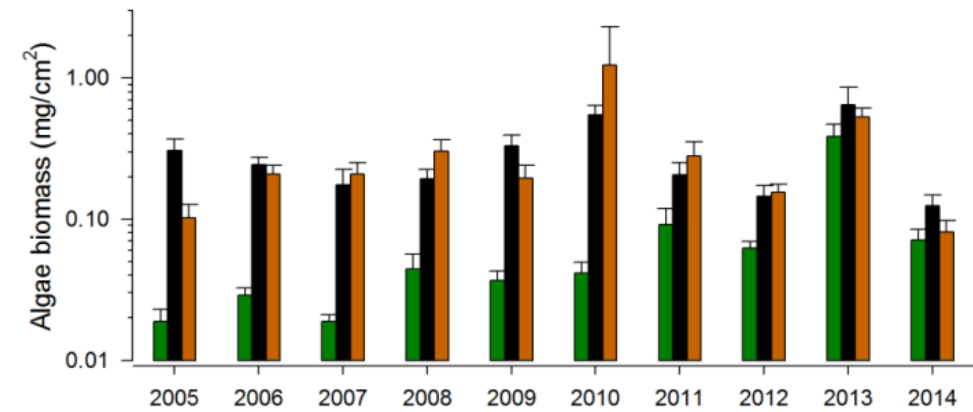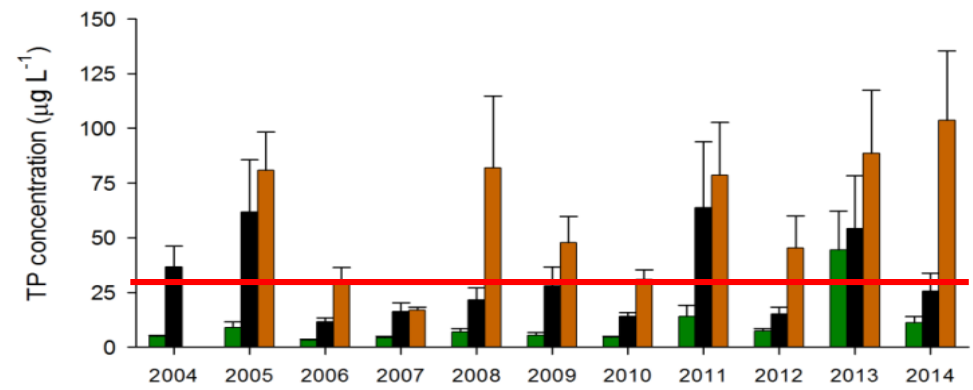
Dissolved organic carbon after wildfire – *More legacy impacts*
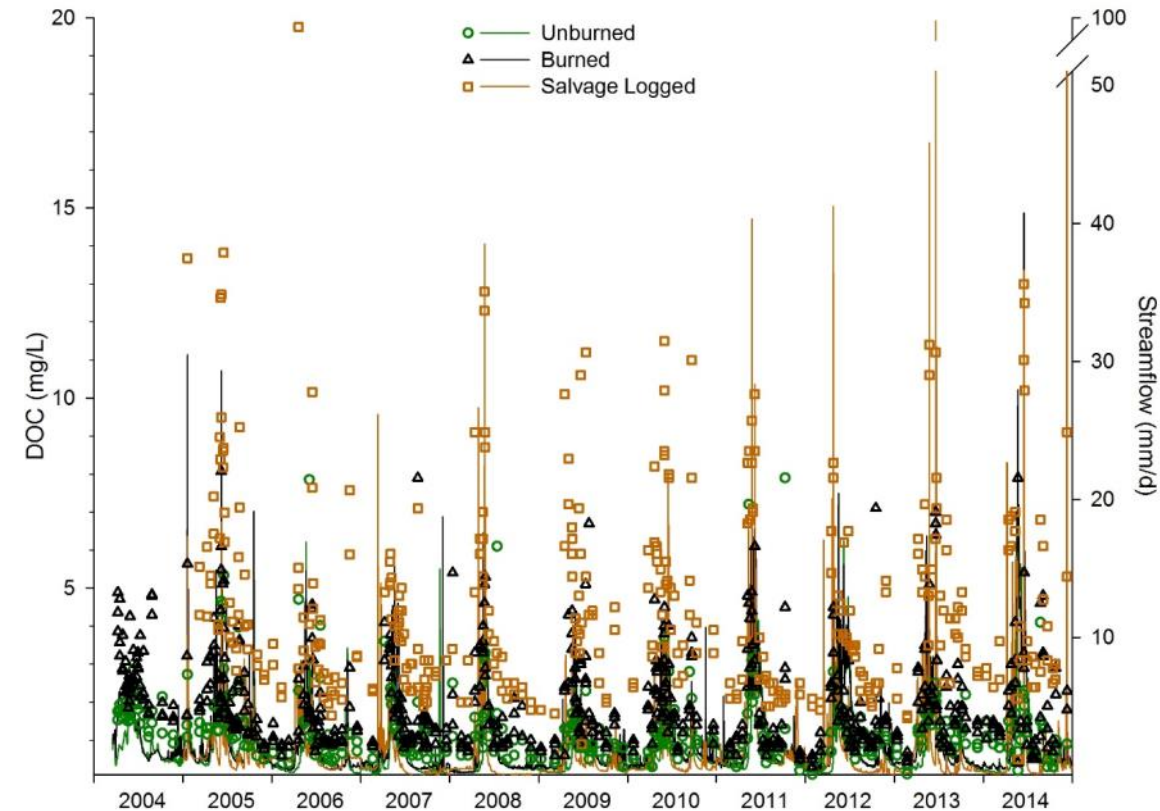
- **Over a decade of continued impact**
- **Treatment impacts = costs… at a minimum!**

Dissolved organic carbon after wildfire – *More legacy impacts*

- **Over a decade of continued impact**

- **Treatment impacts = costs… at a minimum**

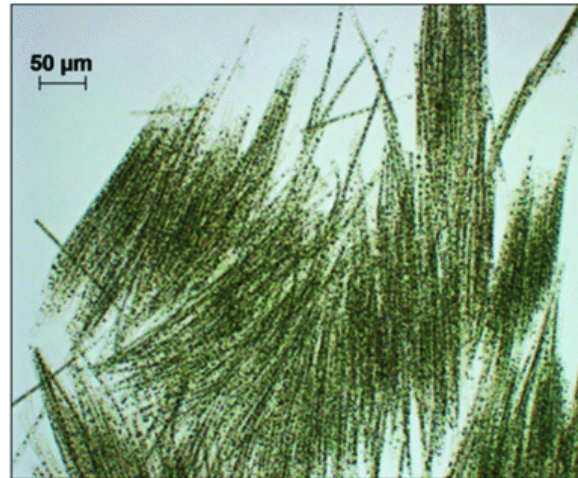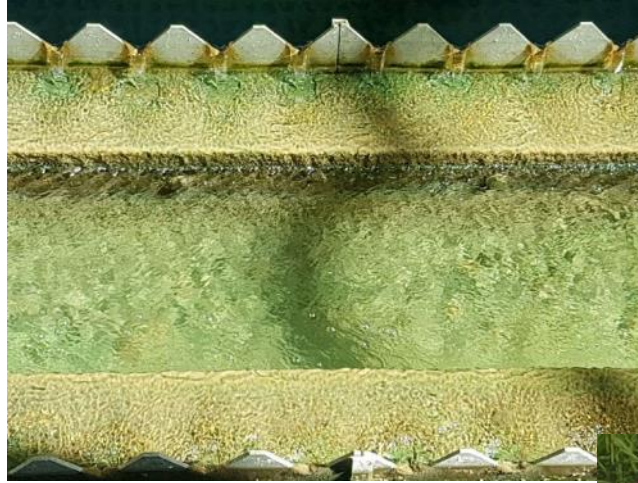# High quality systems are the most threatened...

A tale of two regions… "bookends" within Alberta

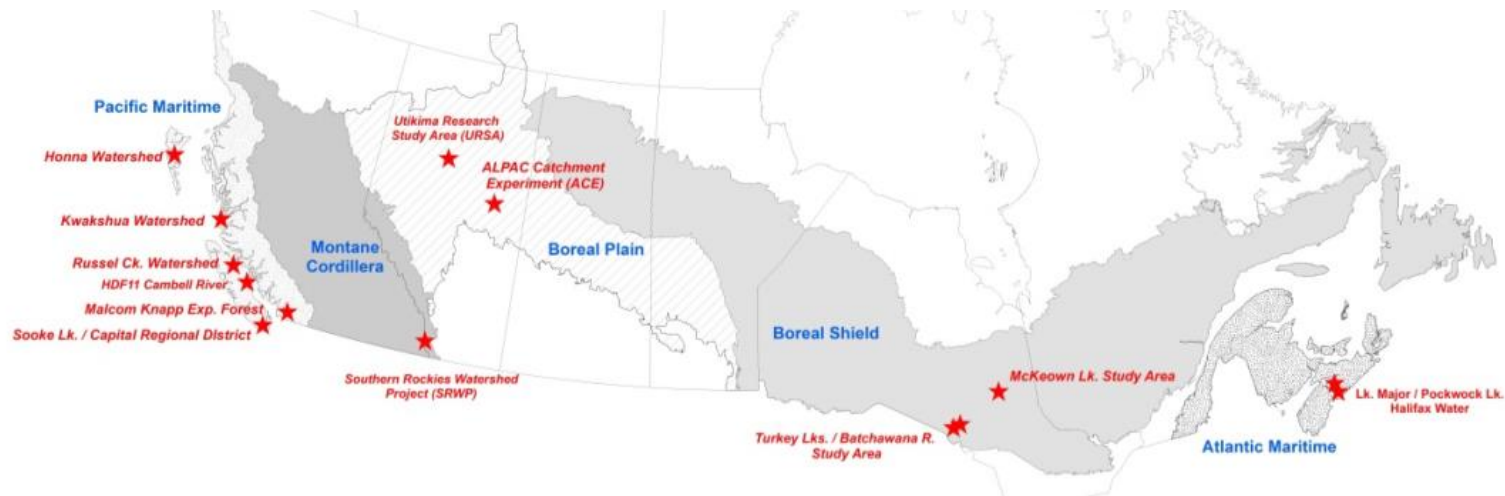# Local hydrology, fine sediment & reservoir management
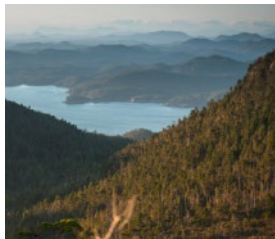
Algal blooms after wildfire

Forested source water protection in a warmer world
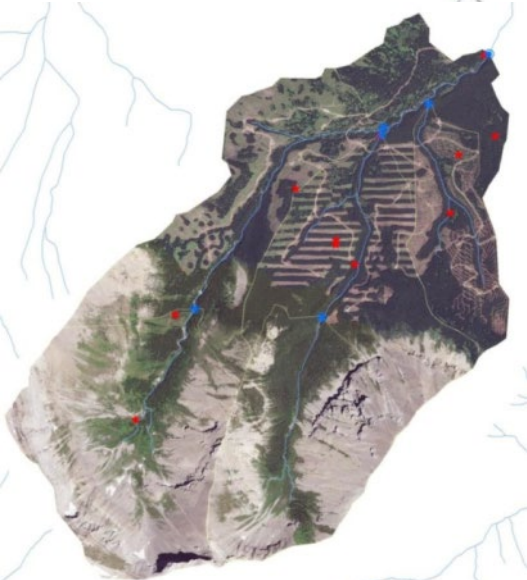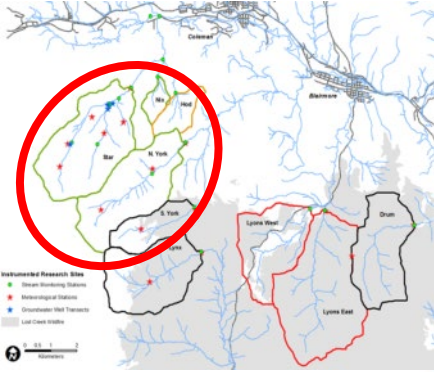
National Forest Source Water Protection Network

Southern Rockies Watershed Project – *Contemporary forest harvest strategies*

- **Three alternative forest harvesting strategies**

- **Powerful fully controlled watershed study (before : after) – rarely possible**
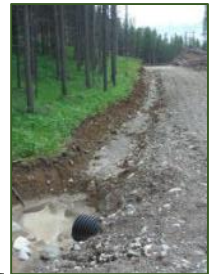
Clear-cut w/retention

Partial-cut

Strip-shelterwood

Suite of BMP's

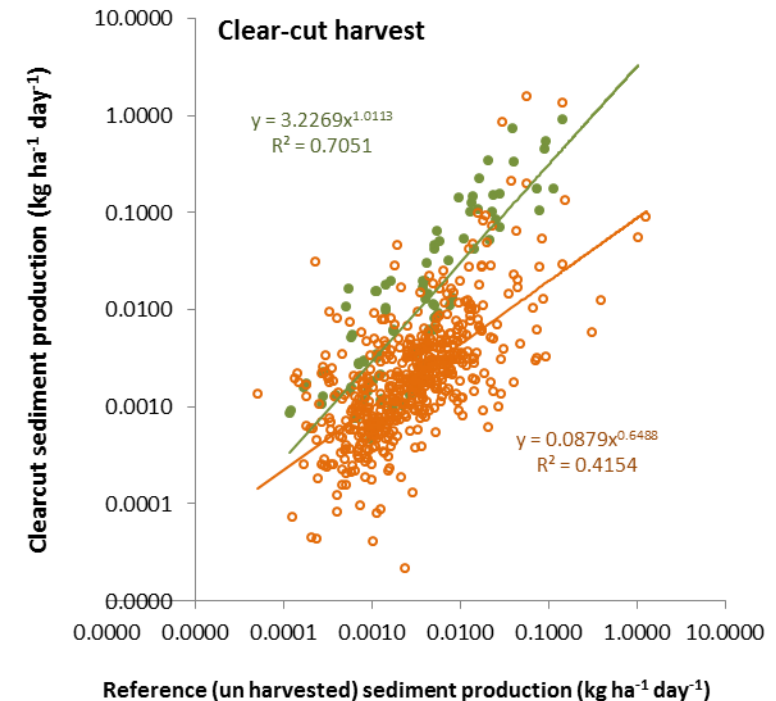# Southern Rockies Watershed Project – *Contemporary forest harvest strategies*

- ***Findings to date – minimal to no detectable effects***
  - *Water quality (sediment, nutrients, others)*
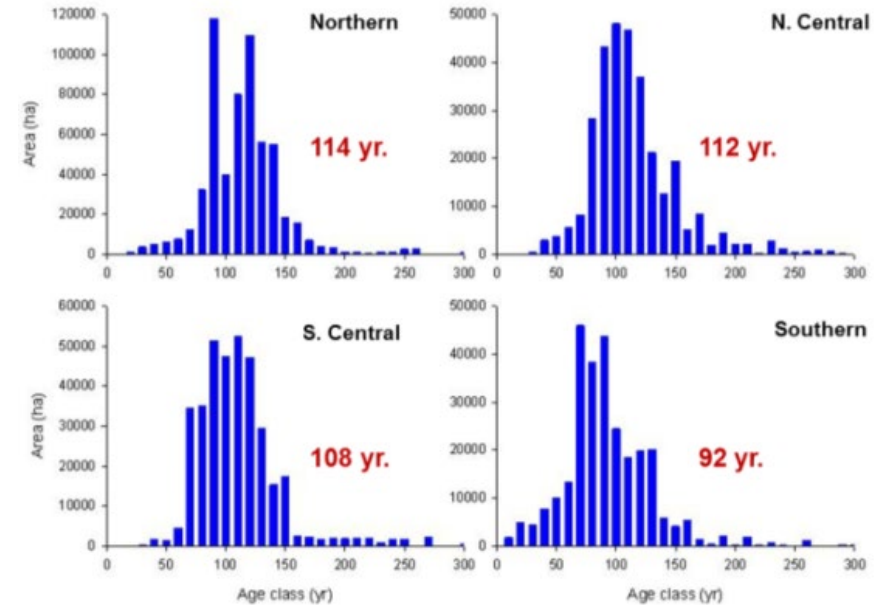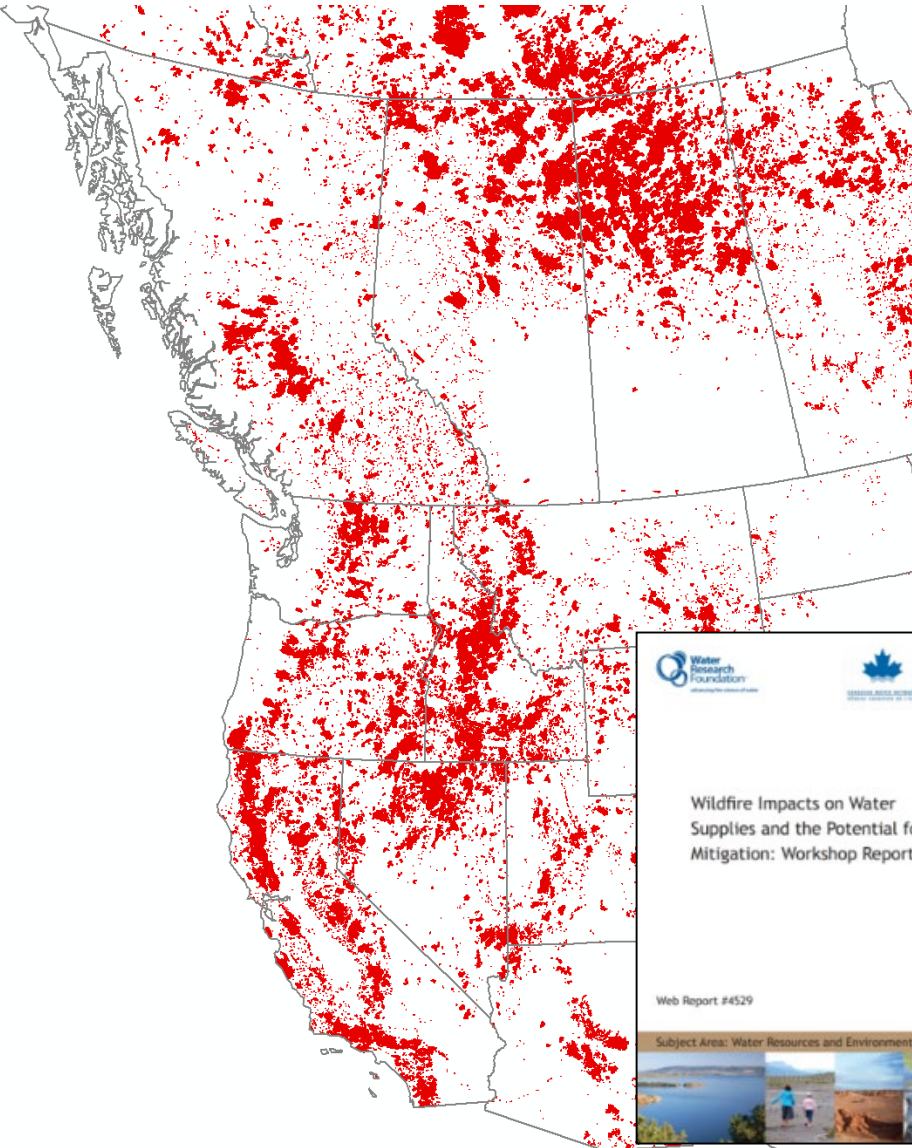 - *Stream ecology*

- **Consistent with more recent studies from other regions**
  - *Impacts much lower than historic studies – consistent with more contemporary studies (BMPs)*
  - *Contemporary forest management is/can be in much closer alignment with water objectives than past practices*
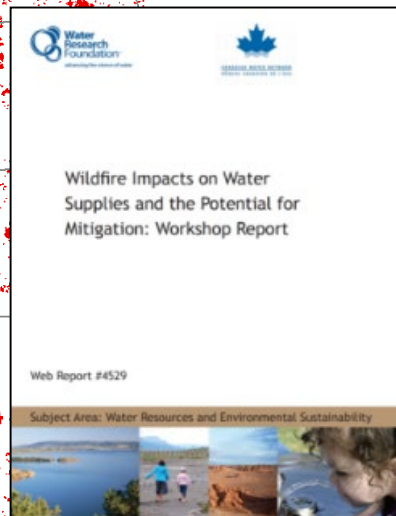

Clear-cut harvest

$y = 3.2269x^{1.0113}$
$R^2 = 0.7051$

$y = 0.0879x^{0.6488}$
$R^2 = 0.4154$

Clearcut sediment production (kg ha^{-1} day^{-1})

Reference (un harvested) sediment production (kg ha^{-1} day^{-1})

Forested Source water protection in a warmer world
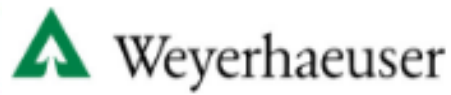
Wildfires since 2020

~ 70 % of this forest region is 95-130 yr. old

- **Wildfire <u>very</u> hard on water**

- **Effective forested source water protection - coordination of both Green and Grey infrastructure strategies**

- **Contemporary forest management is/can be in much closer alignment with water objectives than past practices**

Partnerships

… Thank you