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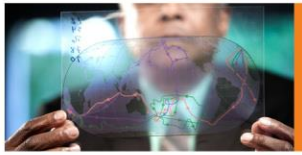


Impacts of Wildfires on Water Quantity and Quality

Chi Ho Sham, Ph.D.,
The Cadmus Group, Inc.

September 27, 2014

Wildfires & Watersheds

- Wildfire is a natural component of healthy forest ecosystems
- Severity and frequency of wildfires in the western U.S. have increased over the past decade
- Wildfires can produce dramatic physical and chemical changes in soils and hillslopes that negatively affect downslope and downstream hydrology and water quality

Wildfires & Watersheds

- Magnitude of changes in soils and hillslopes is dependent on several factors including fire severity, intensity, and duration; topography; and post-fire precipitation amount and intensity

Wildfires & Watersheds

- Post-fire changes
  - Reduced interception
  - Increased rain splash
  - Decreased infiltration
  - Reduced ET
  - Hydrophobic soil
- Post-fire effects
  - Increased total runoff
  - Increased peak flow
  - Increased flooding
  - Increased sediment mobilization

Wildfires & Hydrology

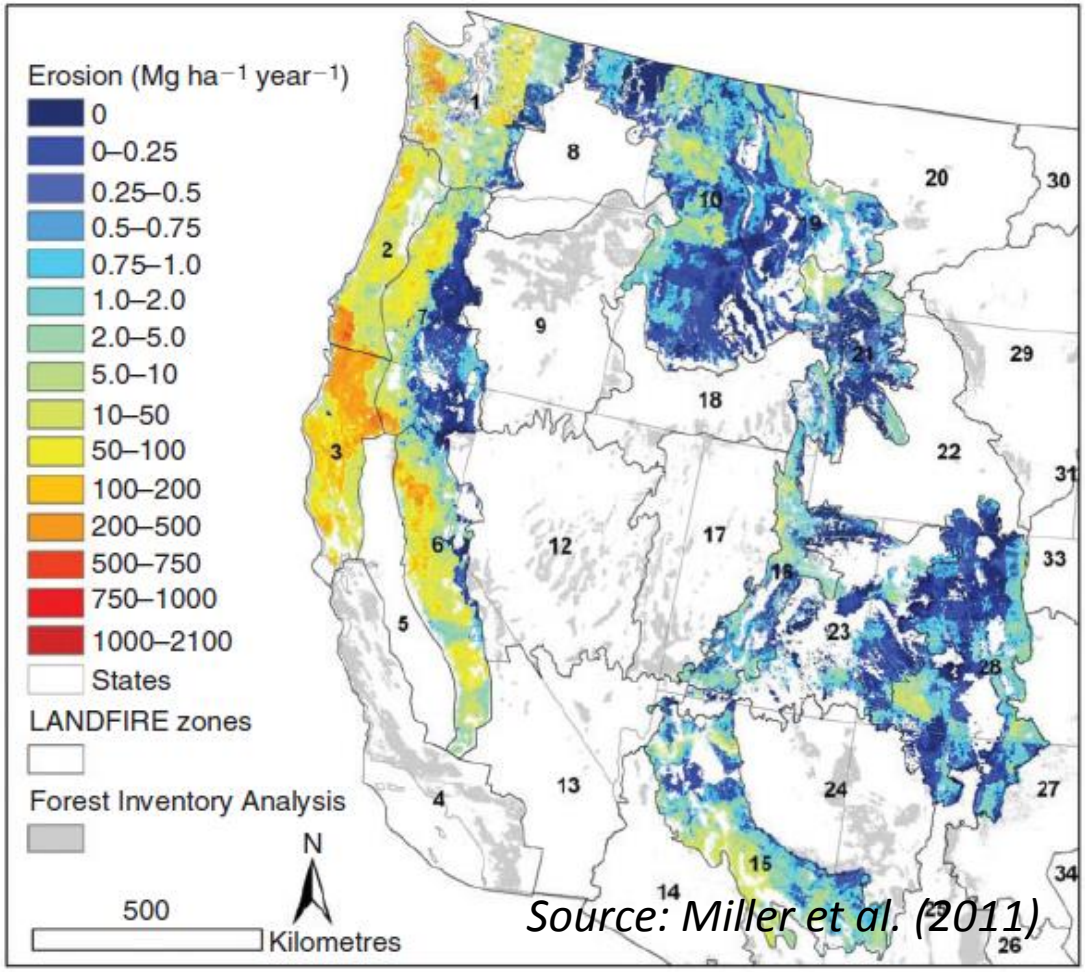
- Total Runoff – higher post-fire annual discharge (Burke et al., 2005) and water yield (Neary et al., 2005)
- Peak Flows – resulting from loss of vegetation and decreased soil infiltration, especially from hydrophobic soils (Neary et al., 2011)
- Sediment Mobilization – consumption of litter exposing soil to rain splash, lower infiltration, and increased overland flow (Ice et al., 2004)

Wildfires & Hydrology

Wildfires & Sediment

- Post-fire sediment transport – up to 20 folds (Moody and Martin, 2001)
- Dependent on geology, soil, topography, vegetation, fire characteristics, weather patterns, and land use practices (Neary et al., 2005)
- Timing, magnitude, and duration of storms immediately after a fire – a key factor (Ryan et al., 2011)

Wildfires & Sediment



Source: Miller et al. (2011)

Predicted post-fire erosion one year after wildfire

Wildfires & Debris Flow

- Debris Flows – triggered by severe fire followed by intense rain (Goode et al., 2012)
- Steep slope, thick sediment and soil, hydrophobic soil, and heavy and prolonged rainfall (USGS, 2005; Cannon, 2001; Neary et al., 2011)
- Less predictable and can occur with little warning

Wildfires & Debris Flow

Campground in Cable Canyon, southern California, where a debris flow on December 25, 2003, killed two people. A wildfire during the previous October burned hillslopes in the area, and heavy rains triggered the deadly debris flows. Photograph by Sue Cannon.

Wildfires & Water Quality

- Nutrients – increase after fires
  - Nitrogen (organic nitrogen, nitrate, and ammonium) increases immediately and peaks in the first or second year, slowly declines as vegetation re-establish (Ranalli, 2004)
  - Phosphorus (dissolved and sediment-associated) concentrations and export are greater (Ranalli, 2004; Gill, 2004)

Wildfires & Water Quality

- Organic Carbon – increase after fires
  - Particulate organic carbon (POC) may increase due to deposit of ash (Smith et al., 2011)
  - Dissolved organic carbon (DOC) may increase as rain and snowmelt percolate through ash (Ranalli, 2004)
  - DOC elevated into third and fourth year (Emelko et al., 2011)

Wildfires & Water Quality

- Other Chemical Constituents – may increase post-fire
  - Ash contains oxides of calcium and magnesium, chloride, carbonates of sodium and potassium, polyphosphates of calcium and magnesium (Ranalli, 2004)
  - Leaching of ash can mobilize cations and chloride (Smith et al., 2011)
  - Mobilization of mercury (Caldwell et al., 2000)

Wildfires & Water Quality

- Suspended Sediments and Turbidity – due to suspension of ash and clay-sized soil particles
  - TSS and turbidity may increase by orders of magnitude post-fire

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Wildfires & Water Quality

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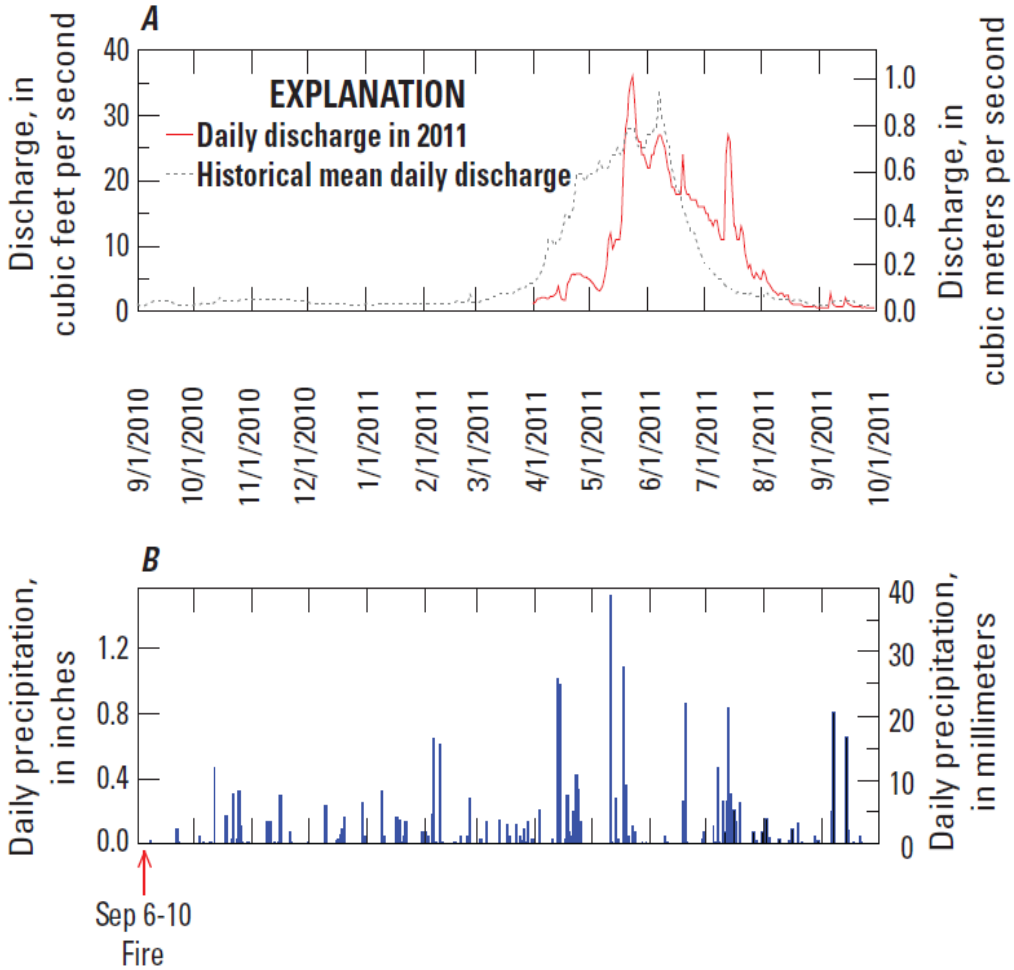
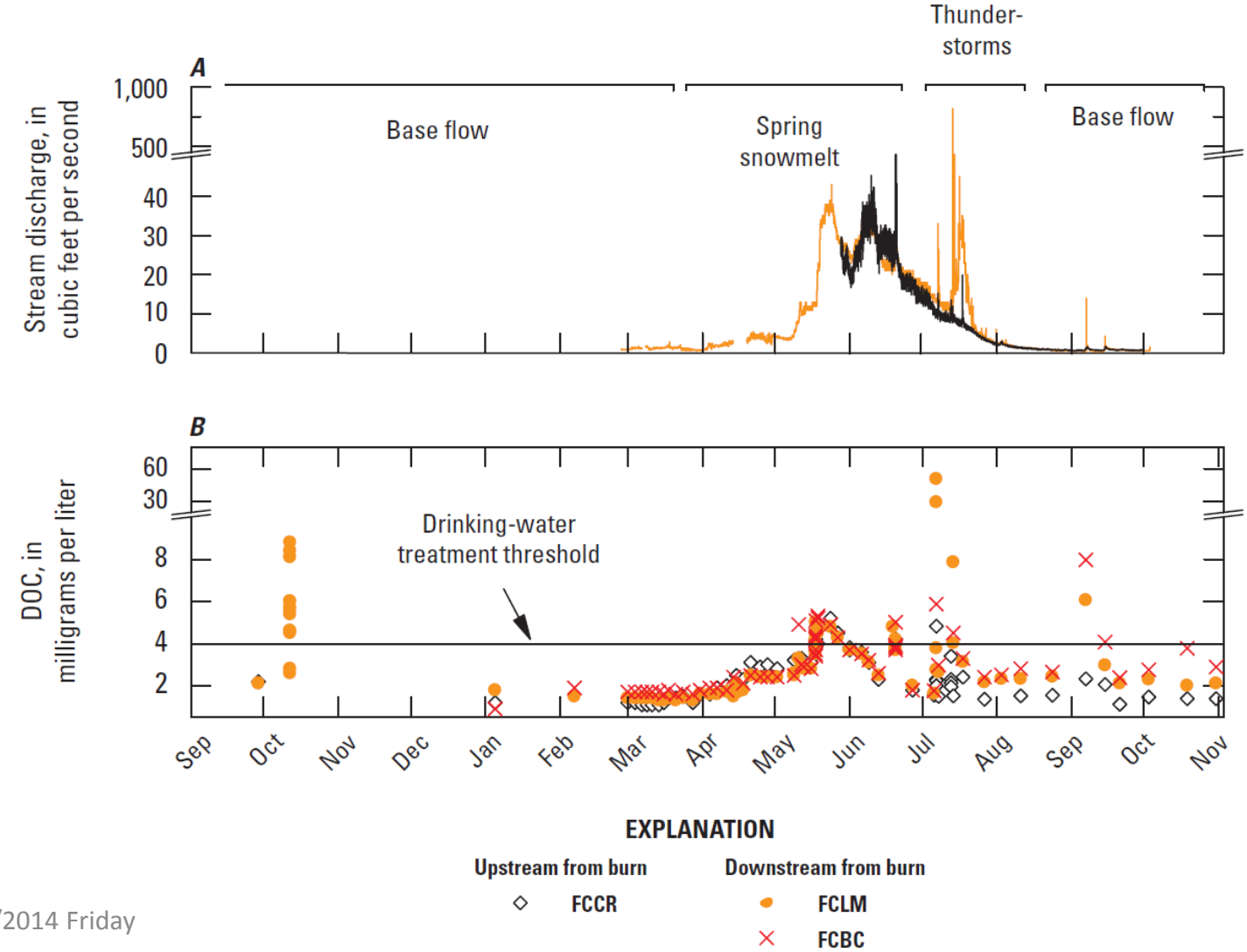
Lessons from Fourmile Canyon Fire, CO



The Fourmile Canyon fire in Boulder County, Colorado (September 6–10, 2010) burned 23 percent of the Fourmile Creek Watershed.

Writer and Murphy, 2012

Lessons from Fourmile Canyon Fire, CO



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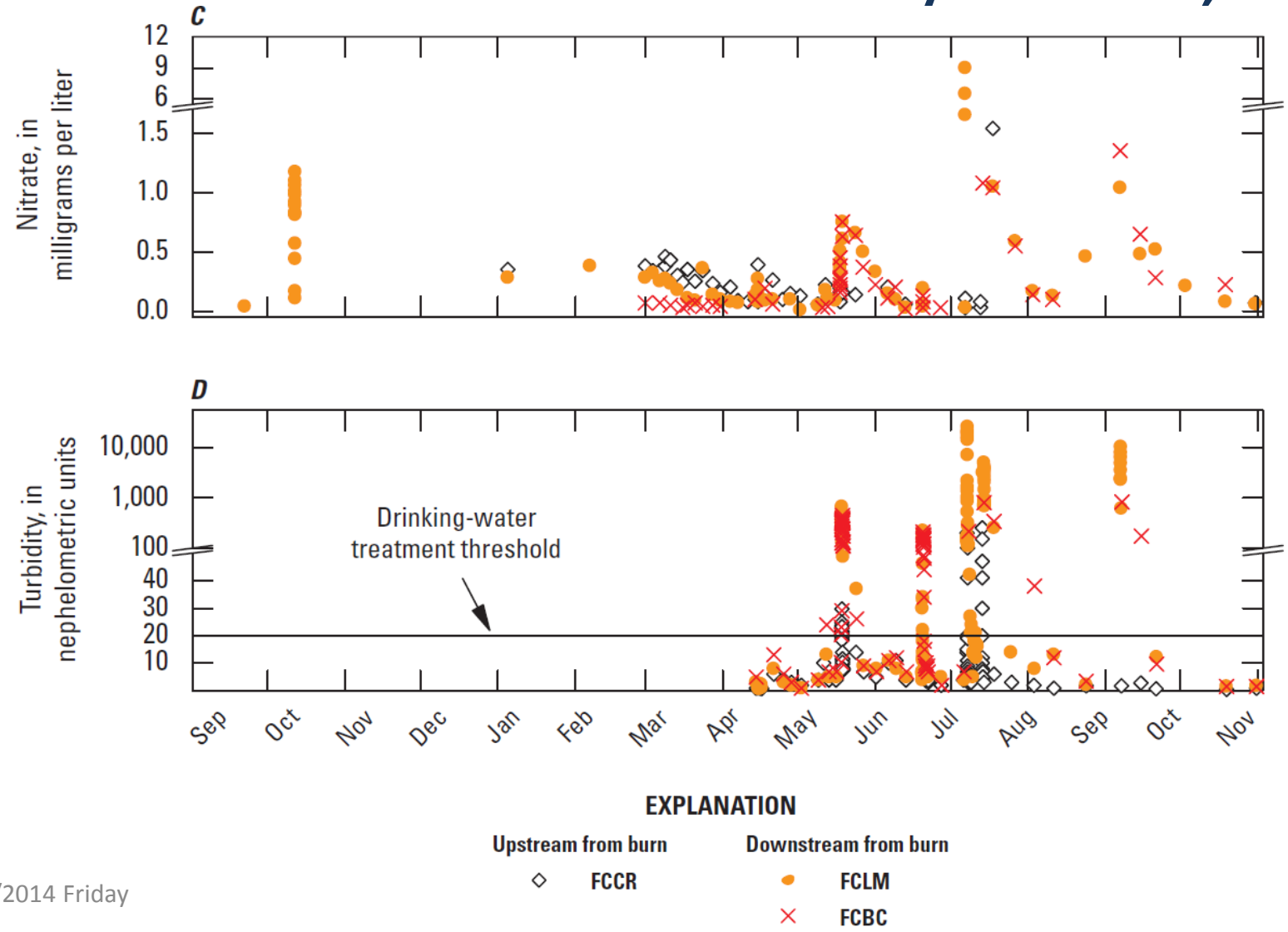
Lessons from Fourmile Canyon Fire, CO



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Implications for Drinking Water

- Reservoir sedimentation
- Elevated turbidity
- Dissolved organic carbon
- Increased nitrate and other nutrients
- Increased pH and alkalinity; elevated metals such as iron and manganese

Lexington Hills Community Hazard Rating Map

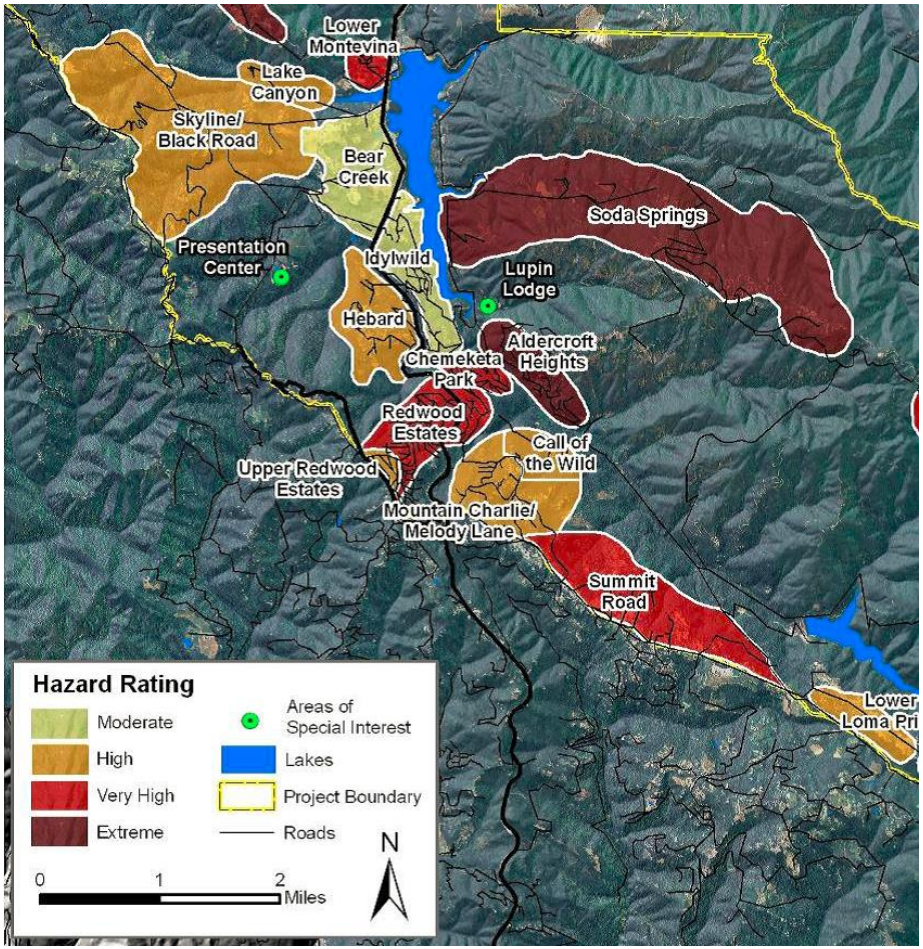

Image courtesy of Anchor Point Group, LLC

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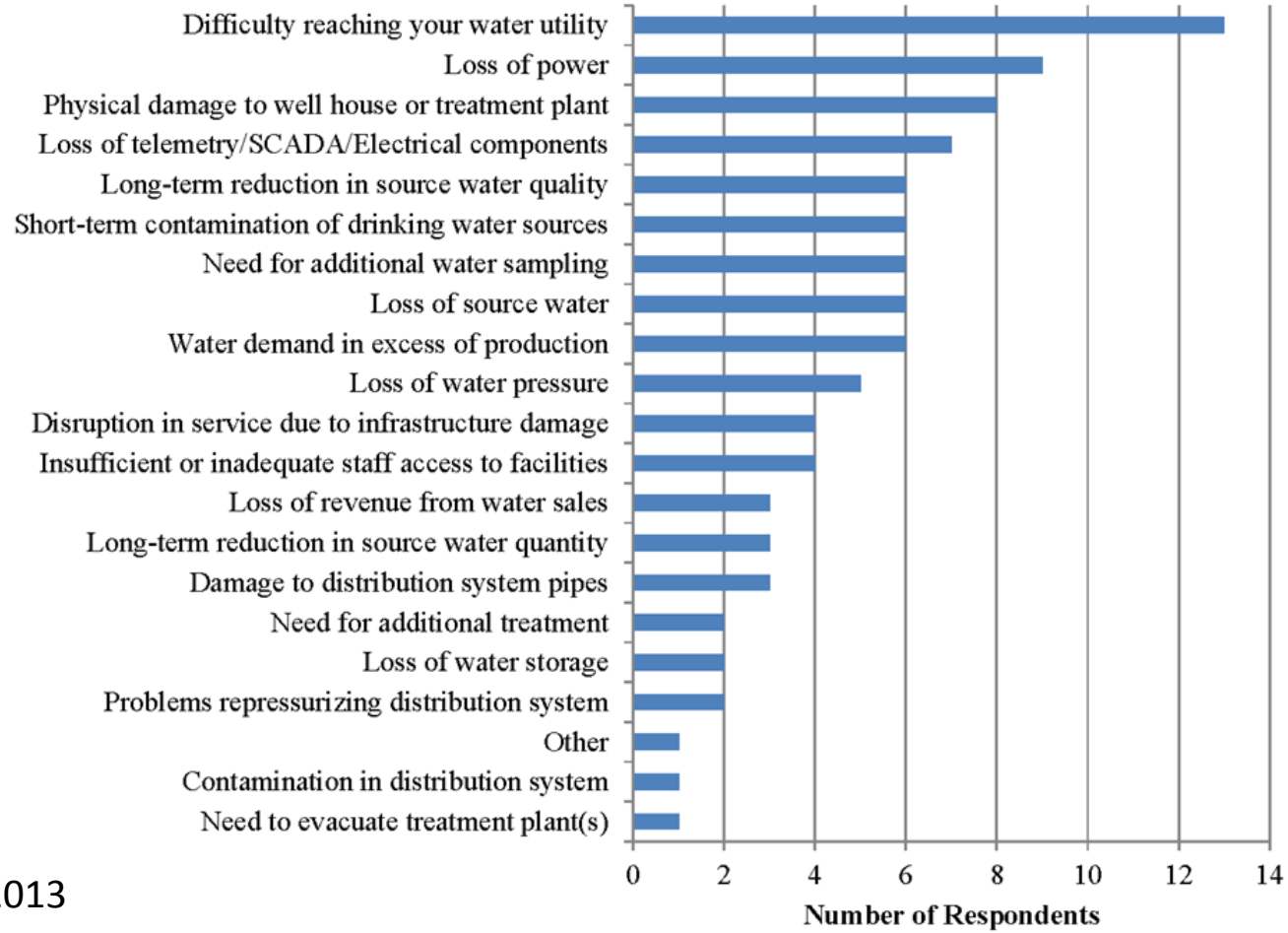
2013 Water Research Foundation Survey on the Impacts of Wildfire on Drinking Water Systems



Sham et al., 2013

Damages sustained by drinking water utilities during a wildfire

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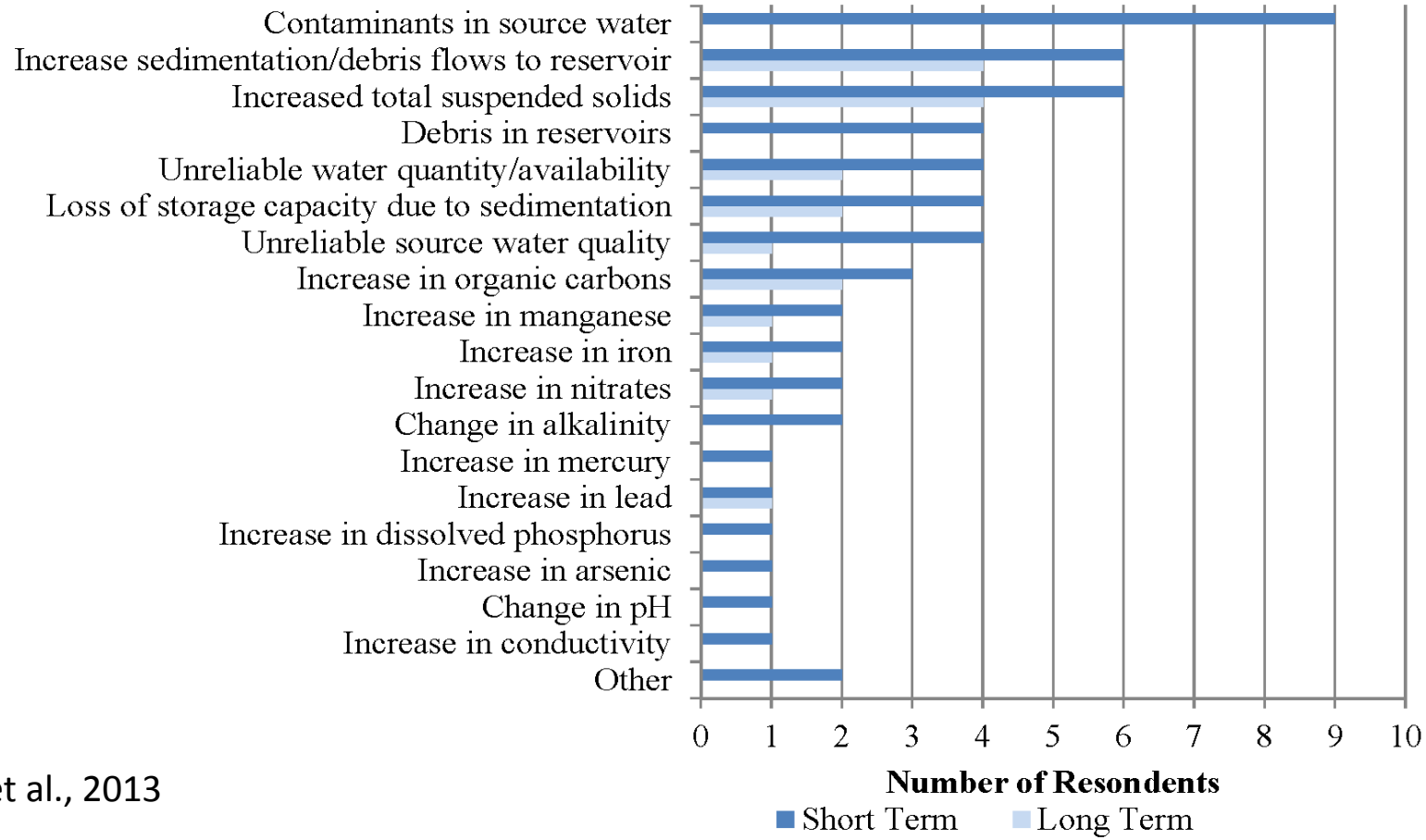
2013 Water Research Foundation Survey on the Impacts of Wildfire on Drinking Water Systems



Sham et al., 2013

Short term and long term impacts resulting from wildfire

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Questions?

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Additional resource: Emelko, M. and C.H. Sham. 2014. Wildfire Impacts on Water Supplies and the Potential for Mitigation: Workshop Report. Web Report #4529. Denver, CO: Water Research Foundation, 36 p. Available on the Internet at: http://www.waterrf.org/Pages/Projects.aspx?PID=4529