Impacts of Wildfires on Water Quantity and Quality
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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

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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

Predicted post-fire erosion one year after wildfire

Source: Miller et al. (2011)
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
Wildfires & Water Quality
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
Lessons from Fourmile Canyon Fire, CO

**EXPLANATION**

- **Upstream from burn**
  - FCCR
- **Downstream from burn**
  - FCLM
  - FCBC

**Drinking-water treatment threshold**

Nitrate, in milligrams per liter

Turbidity, in nephelometric units

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

- Difficulty reaching your water utility
- Loss of power
- Physical damage to well house or treatment plant
- Loss of telemetry/SCADA/Electrical components
- Long-term reduction in source water quality
- Short-term contamination of drinking water sources
- Need for additional water sampling
- Loss of source water
- Water demand in excess of production
- Loss of water pressure
- Disruption in service due to infrastructure damage
- Insufficient or inadequate staff access to facilities
- Loss of revenue from water sales
- Long-term reduction in source water quantity
- Damage to distribution system pipes
- Need for additional treatment
- Loss of water storage
- Problems repressurizing distribution system
- Other
- Contamination in distribution system
- Need to evacuate treatment plant(s)

Sham et al., 2013

Damages sustained by drinking water utilities during a wildfire
2013 Water Research Foundation Survey on the Impacts of Wildfire on Drinking Water Systems

- Contaminants in source water
- Increase sedimentation/debris flows to reservoir
- Increased total suspended solids
- Debris in reservoirs
- Unreliable water quantity/availability
- Loss of storage capacity due to sedimentation
- Unreliable source water quality
- Increase in organic carbons
- Increase in manganese
- Increase in iron
- Increase in nitrates
- Change in alkalinity
- Increase in mercury
- Increase in lead
- Increase in dissolved phosphorus
- Increase in arsenic
- Change in pH
- Increase in conductivity
- Other

Sham et al., 2013

Short term and long term impacts resulting from wildfire
References


References


References

Questions?

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