Post Fire Ecosystem Response:
Changes in Hydrology

Lorrie Flint
U.S. Geological Survey
California Water Science Center
How does fire impact hydrologic resources?

- Fire removes the vegetation that uses soil water, changing the water balance.
- Removal of vegetation also influences runoff on slopes.
- Fire may burn soil organic matter creating water repellency, increased runoff, and changes in nutrient availability.
- Changes in the water balance with temporary increases in soil water and reduced climatic water deficit may favor some returning plants over others.

*note: most fires occur in dry years*
TOTAL BASIN OUTFLOW (runoff + baseflow (a portion of recharge)) = PRECIPITATION – EVAPOTRANSPIRATION – CHANGE IN SOIL WATER STORAGE (WITHIN THE ROOT ZONE) - RECHARGE (BELOW THE ROOT ZONE)
TOTAL BASIN OUTFLOW (runoff + baseflow (a portion of recharge)) = PRECIPITATION – EVAPOTRANSPIRATION – CHANGE IN SOIL WATER STORAGE (WITHIN THE ROOT ZONE) - RECHARGE (BELOW THE ROOT ZONE)
Analysis tool: Basin Characterization Model

A grid-based water balance model

- Uses gridded climate data downscaled to fine spatial scales (historical and future)
- Incorporates detailed soil properties and estimates of bedrock permeability
- Calculates spatially distributed water supply as recharge and runoff
- Calculates climatic water deficit as estimate of demand
Runoff

Recharge

Monthly model at 270-m spatial resolution
Calculating Basin Discharge from Recharge and Runoff to Match Streamflow Measurements

Takes into account surface, shallow, and deep water reservoirs, using exponential notation to produce flow recession and match hydrographs.
Percent of Total PET related to Fire Burn Intensity

Tuolumne River subbasin
Post-fire Impacts to Streamflow

Full PET

Scaled PET post-fire

TUOLUMNE R AB EARLY INTAKE NR MATHER CA

Streamflow, millions of m³

Rim Fire alarm date
### Post-fire Impacts to Recharge and Runoff

![Image](image.png)

**Average annual precipitation = 37 in/yr**

<table>
<thead>
<tr>
<th></th>
<th>2 yrs Pre-fire</th>
<th>2 yrs Post-fire</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full PET</td>
<td>Scaled PET</td>
</tr>
<tr>
<td></td>
<td>WY2012&amp;13</td>
<td>WY2014&amp;15</td>
</tr>
<tr>
<td>Precip (in/yr)</td>
<td>32</td>
<td>18</td>
</tr>
<tr>
<td>Recharge (af/mo)</td>
<td>1,089</td>
<td>322</td>
</tr>
<tr>
<td>Runoff (af/mo)</td>
<td>712</td>
<td>143</td>
</tr>
<tr>
<td>Rch/Run</td>
<td>1.5</td>
<td>2.3</td>
</tr>
</tbody>
</table>
Fire has variable effects on soils

- Fire affects soil properties due to combustion of organic matter resulting in changes to chemical, physical, and microbiological properties of underlying soil.
- Fire increases availability of some nutrients, while N, P, and S are volatilized.
- Loss of OM affects CEC, organic chelation, aggregate stability, microorganisms.
- Changes in surface properties due to fire (macropores, organic matter content), and depending on fire intensity, may result in water repellency (hydrophobicity), that reduces infiltration and increases runoff.
- The process is often very spatially heterogeneous and reduction in infiltration may be fairly short-lived, 1 or 2 years.
Summary

• Hydrologic influence of fires is due to a combination of loss of PET (resulting in increased recharge and runoff) and changes in soil properties with potential hydrophobicity increasing flashiness.

• PET losses may be consistent with fire severity distribution across the landscape and should increase with regrowth over time.

• With loss of PET post-fire, recharge will increase more than runoff in dry conditions.

• In wet conditions following fire, the loss of PET will increase runoff more than recharge.
Summary

• Increased recharge leads to more baseflows, which can extend streamflow later into the dry season
• Fire may cause soil hydrophobicity to increase runoff
• Hydrophobicity is dependent on soil properties and fire intensity (heat) and is spatially and temporally variable
• Increases in soil water post-fire will decrease climatic water deficit and is likely to contribute to revegetation