Hydrological Analysis of Post-Fire Responses within the Little Creek Watershed of Swanton Pacific Ranch

Alex Wiens – M.S. Environmental Sciences and Management
Adviser: Christopher Surfleet, PhD
Cal Poly – San Luis Obispo
April 2024
Background

• Various factors such as climate change, forest densification, etc. can be associated with:
  → longer, more severe wildfire seasons
  → more burned area (Dennison et al., 2014; Pausas & Keeley, 2021; Radeloff et al., 2005)

• Subsequently, fires can impact:
  → water supplies, water quality
  → **flooding, changes in peak flows**
  → terrestrial and aquatic ecosystems (Niemeyer et al., 2020)
  → increased likelihood of hazardous and deadly debris flows (Esposito et al., 2019; Nalbantis & Lymperopoulos, 2012).
General Theory of Post-Fire Hydrology

- **Less vegetation**
  - Reduced evapotranspiration and interception
  - More water passing through
- **Burning/volatization of material**
  - Reduced soil infiltration
  - Also boosts water repellency
- **Ultimately...**
  - More runoff & erosion

(Hallema et al., 2017; Ebel & Moody, 2013).
Problem Statement

• The measurable extent to which fires affect the hydrology of a watershed has proven difficult. Some challenges include:
  • limited research efforts,
  • lack of available data (Seibert et al., 2010),
  • and short research timespans (Moody et al., 2013)
• Fire agencies need reliable data for accurate predictions to make decisions (Chen et al., 2013).
• Knowledge gaps also arise in addressing postfire hydrology for coastal-redwood forests.
Objective

- Evaluate the hydrological responses of the Little Creek watershed for hydrologic years (HY) 2021 through 2024 after exposure to the 2020 CZU Lightning Complex Fire.

- Specific sub-goals include:
  - Develop rating curves based on stage and streamflow data.
  - Develop a time series of streamflow and rainfall, and a compilation of storm events.
  - Analyze the pre- versus post-fire storm volume and peak flows via linear regression analysis.
  - Make post-fire runoff predictions from commonly used post-fire assessments.
  - Compare the post-fire runoff predictions to the actual post-fire runoff calculations.
Procedure

• Data Collection – rainfall, stage, and streamflow
  • Additionally calculate API (soil moisture indicator)
Procedure

- Rating curves plotted
  - these curves relate stage to streamflow
  - were used to convert stage data into a continuous time series of streamflow
Procedure

• Identify and separate events on the hydrographs into “storms”
  • Use baseflow recession rates to determine end of storm events

• Gather peak-flow and total storm volume from the events

• Compare post-fire data (2023-2024) to pre-fire calculations, which are estimated from a statistical regression equation from 2001-2008 data, Dupuis, 2022.
Concurrent Results (HY2023)

Corrected Discharge HY2023

Discharge, Q (cfs)

Time

08/27/2022 10/16/2022 12/05/2022 01/24/2023 03/15/2023 05/04/2023 06/23/2023 08/12/2023 10/01/2023 11/20/2023

MAIN STEM  NORTH FORK  SOUTH FORK
Concurrent Results (HY2024)
Sample Storm Separation

Main Stem, HY2023, 02/24/2023 – 04/04/2023

- Main Stem, HY2023, 02/24/2023 – 04/04/2023
- MSLC Post-fire Discharge (cfs)
- Baseflow (cfs)
Preliminary Results: Pre-versus Post-Fire Peak Flows

Main Stem

\[ y = 1.0101x + 0.2982 \]
\[ R^2 = 0.7602 \]

North Fork

\[ y = 0.7438x + 0.3259 \]
\[ R^2 = 0.2955 \]

South Fork

\[ y = 1.3525x + 0.0719 \]
\[ R^2 = 0.4985 \]
Preliminary Results: Pre- versus Post-Fire Storm Volumes

- **Main Stem**
  - Equation: $y = 0.5119x + 50611$
  - $R^2 = 0.7163$

- **North Fork**
  - Equation: $y = 0.201x + 56113$
  - $R^2 = 0.0492$

- **South Fork**
  - Equation: $y = 0.4091x + 21563$
  - $R^2 = 0.2388$
Next Steps

• Analyze the pre- versus post-fire storm volume and peak flows via linear regression analysis
• Use Little-Creek data to improve commonly used post-fire flood-assessment estimates
Acknowledgements

• This research was funded by grants from the Agricultural Research Institute and McIntire-Stennis

• Thanks to:
  • Swanton Pacific Ranch for access and housing during research
  • Christopher Surfleet, PhD for advising the thesis
References


