STARR II
Incorporation of Burned Areas in Hydrology in Lake County, California

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Outline

- Project Overview and Study Area
- Climate Change and Wildfires
- Effects of Burn Areas on Hydrology
- Different Burn Hydrology Methods
- Selection of USGS Regression Method
- Results
- Questions

Project Overview

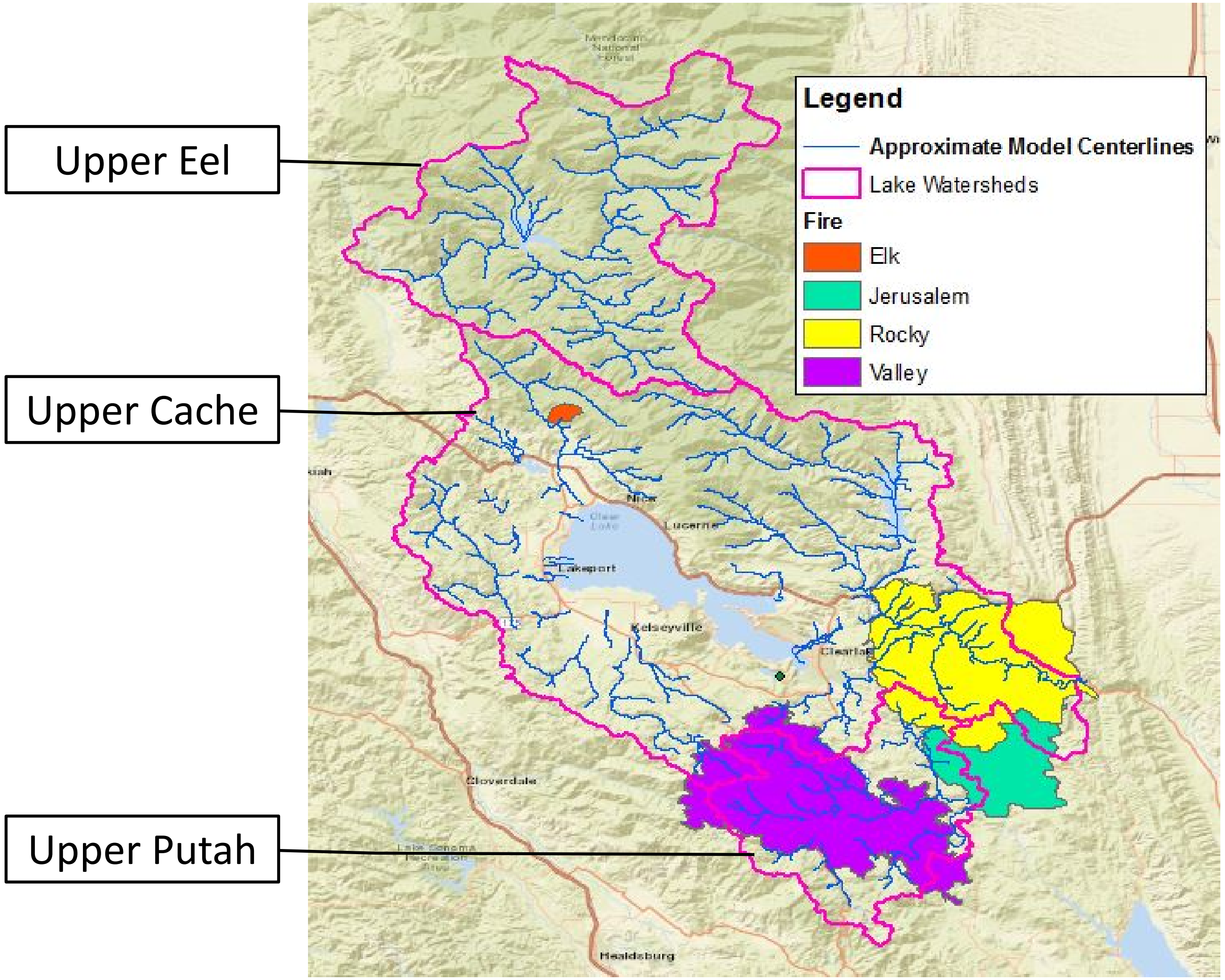
- Automated Engineering Practicing Analysis to support flood risk analysis in Lake County, CA, located in FEMA Region IX
- Completed for streams with drainage areas of at least one square mile in three watersheds: Upper Eel, Upper Cache, and Upper Putah
- Peak flow estimates for the 1%, 1% plus, and 1% minus flood events were derived
- The primary steps used to develop the hydrologic data are:
  1. Prepare stream network, hydrologic network, and delineate watersheds
  2. Develop gridded input parameters and peak flows from the rural regression equations
  3. Modify peak flows of 1% flood event to account for changes in hydrologic conditions due to wildfires

Study Area – Lake County, California

- Named for Clear Lake, a large lake in the center of the County
- As of the 2010 census, the population was 64,665
- Lake County California covers an area of 1,327 square miles
- Multiple national and state protected areas; Mendocino National Forest (MNF) is the largest landholding in the county

Wildfires in Lake County

- Four large fires occurred in Lake County in the Summer/Fall of 2015
  - Rocky Fire – 69,438 acres
  - Jerusalem Fire – 25,118 acres
  - Elk Fire – 673 acres
  - Valley Fire – 76,067 acres
- In August of 2016, the Clayton Fire burned approximately 4,000 acres in Lake County
- Multiple small fires each year



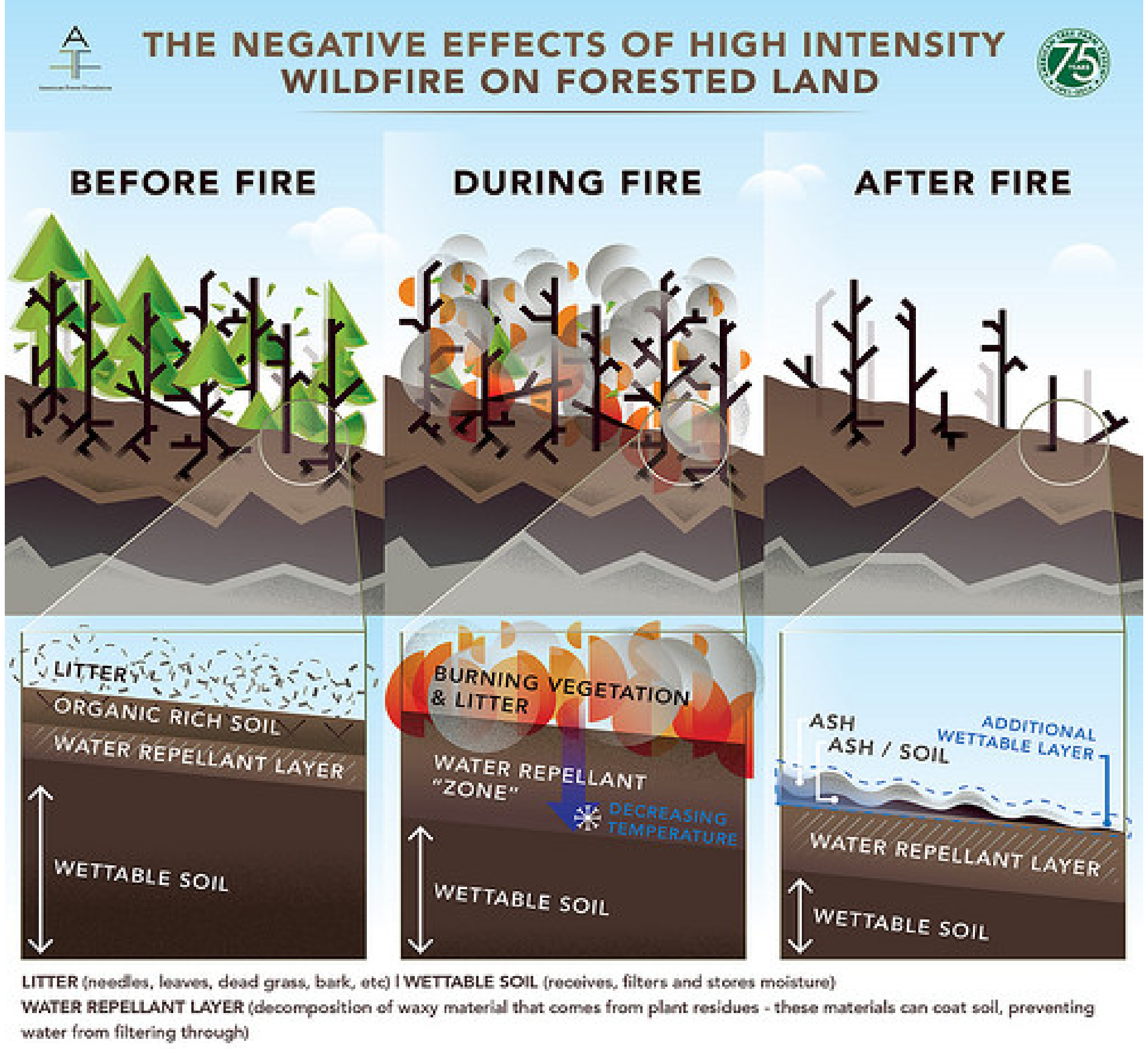
Climate Change Effects

- The Intergovernmental Panel on Climate Change (IPCC) forecasts a temperature rise of 2.5 to 10 degrees Fahrenheit over the next century
- The extent of climate change effects on individual regions will vary over time
- Climate Change Effects include:
  - Increase in the length of the frost-free season (and the corresponding growing season)
  - Increased heavy precipitation events, including in regions where total precipitation is expected to decrease
  - Droughts and heat waves increase in intensity, and cold waves decrease in intensity
  - Summer temperatures increase, and a reduction of soil moisture, which exacerbates heat waves
  - Sea Level Rise
  - Increased frequency and intensity of hurricanes

Climate Change and Wildfire

- Climate Change effects can exacerbate wildfires
  - ↑ Temperature
  - ↑ Drought severity
  - ↑ Insect outbreaks
  - ↑ Length of summer fire season
  - ↑ Heat waves / extreme heat days
  - ↓ Winter and spring precipitation
  - ↓ Soil moisture
- Fires can also contribute to climate change

Effects of Burn Areas on Hydrology



- Increased runoff and decreased time of concentration due to:
  - ↑ Ash, Sediment, and Debris
  - ↓ Litter
  - ↓ Vegetation
  - ↓ Interception
  - ↓ Infiltration
  - ↓ Moisture storage
- Low severity fires minimally change watersheds
- A typical recovery period of burned watersheds is about 5 years

Methods for Estimating Post-Fire Hydrology

- USGS Regression Method (most commonly used by BAER)
- NRCS Curve Number Method (second most commonly used by BAER)
- FEMA Post-Burn Adjustment Factors
- County-specific methods

USGS Regression Method

Method Summary: $Modifier = 1 + Percent\ Runoff\ Increase \times (A_H + A_M) / A_T$

1) Estimate pre-fire runoff using USGS regression equations
2) Determine modifier that is defined as a ratio of post-fire to pre-fire runoff
3) Estimate post-fire runoff by multiplying the modifier and pre-fire runoff

Applicability:

1) Watershed > 5 sq. miles
2) Can be used to estimate both pre- and post-peak flows
3) Events with longer duration and snowmelt
4) More accurate with gaged data

NRCS Curve Number Method

Method Summary:

1) Choose a Curve Number (CN) based on cover type, treatment, hydrologic conditions, and Hydrologic Soil Group for both pre-fire and post-fire conditions

2) Use WILDCAT4 or FIRE HYDRO spreadsheet to calculate peak flow

Applicability:

1) Watershed < 5 sq. miles

2) Two CN methods/models are available for post-fire

3) Models consider 15-min to 24-hr storms

FEMA Post-Burn Adjustment Factors

Method Summary:

$$Q_{post-burn} = Q_{regression} \times Clear\,Water\ Adjustment\ Factor \times Bulking\ Adjustment\ Factor$$

1) Estimate pre-fire runoff using USGS regression equations
2) Determine post-burn adjustment factors
3) Estimate post-fire runoff by multiplying the adjustment factors to pre-burn flows

Applicability:

1) Southern California Land Cover (Chaparral)
2) FEMA recommended factors for 5- and 100- year storms

Burn Condition	Adjustment Factor
Pre-Burn	1.00
Low Burn	1.76
Moderate Burn	2.20
High Burn	2.62

Various County Methods

Some counties have their own post-burn hydrology methods :

- Los Angeles County
  - Uses an adjusted burned runoff coefficient be used in the Modified Rational Method (MODRAT) based on a 50-year recurrence interval fire factor

$$Q_{burn} = C_{burn} * I * A$$

- Ventura County
  - Ventura County manual does not provide guidance for post-burn clear-water runoff. The Sediment/Debris Bulking Factor and Post-Fire Hydrology for Ventura County Final Report (2011) recommends increasing the pre-burn discharge using a “burn severity factor” or BSF and applying Bulking Factor.

Selection of USGS Regression Method

1) The Lake County Hydrology Design Standards does not include methodology for post-burn hydrology
2) All watersheds in Study are large (greater than 100 sq. miles)
3) Study Area has difference land cover than Southern California / Chaparral
4) Most common method used and endorsed by BAER team members
5) Pre-burn peak flows for the 1%, 1% plus, and 1% minus events were computed utilizing the USGS regression equations
6) A multi-agency team evaluated the Valley Fire in the Valley Fire Post Fire Watershed Emergency Response Team Report (CNRA, 2015), which used the USGS Regression Method in its flood flow modeling

Application of USGS Regression Method: Development of the Modifier

$$Modifier = 1 + Percent\ Runoff\ Increase \times (A_H + A_M) / A_T$$

- For the first year after the wildfire, the ratio of post fire flow to pre-fire flow increases from 2 to 3 fold for less frequent, large magnitude storms (5 to 100-year recurrence intervals)
- The USGS Regression method has less confidence for larger return periods, therefore, a 200 percent runoff increase (three-fold) was used in determining the modifier for postburn flows

Application of USGS Regression Method: Development of the Modifier

$$Modifier = 1 + Percent\ Runoff\ Increase\ x\ (A_H + A_M)\ /\ A_T$$

- GIS files of burn areas were taken from CalFire's Fire and Resource Assessment Program (FRAP) website and the USGS Geosciences and Environmental Change Science Center website; BLM was also contacted
- In August of 2016, the Clayton Fire burned approximately 4,000 acres in Lake County; GIS data was not yet available for Clayton fire at the time of this study and as such, the Clayton Fire was not included in this analysis
- Upon reviewing size and proximity to CNMS lines, wildfires considered in this analysis include the Valley, Elk, Jerusalem, and Rocky fires, which all occurred in 2015
- Burn severity information was not available for all fires, therefore, a high or moderate burn severity was assumed

Application of USGS Regression Method: Application of the Modifier

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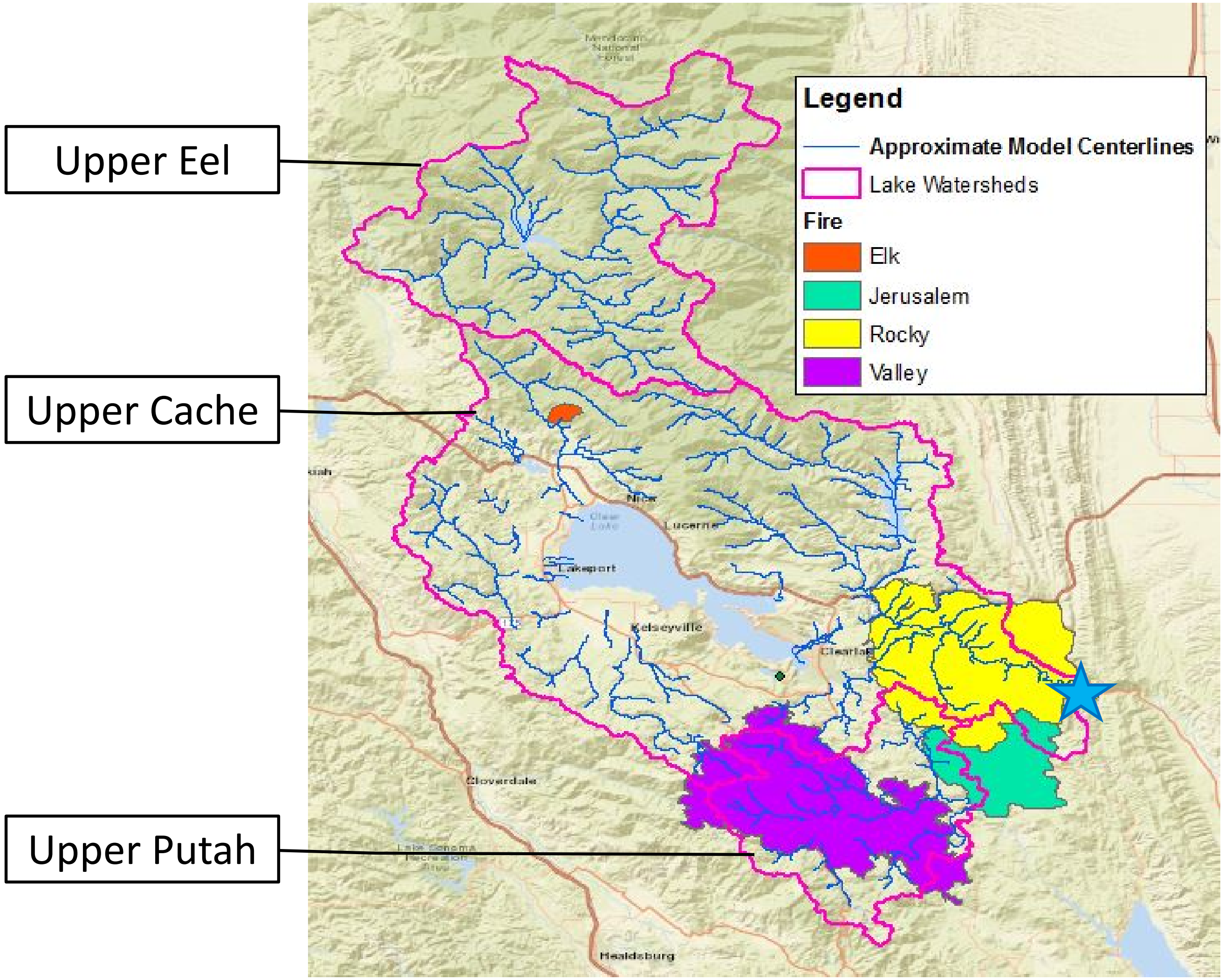
$$Modifier = 1 + Percent\ Runoff\ Increase \times (A_H + A_M) / A_T$$

- A grid of the burn areas of the Valley, Elk, Jerusalem, and Rocky fires was created
- A flow grid was created for the input parameter (fraction of burn area) of the post-burn flow modifier
- A grid of the area-weighted basin average burn fraction was created and was used to apply the modifier to the pre-burn flow and produce a grid of post-burn peak flow of the 1% event

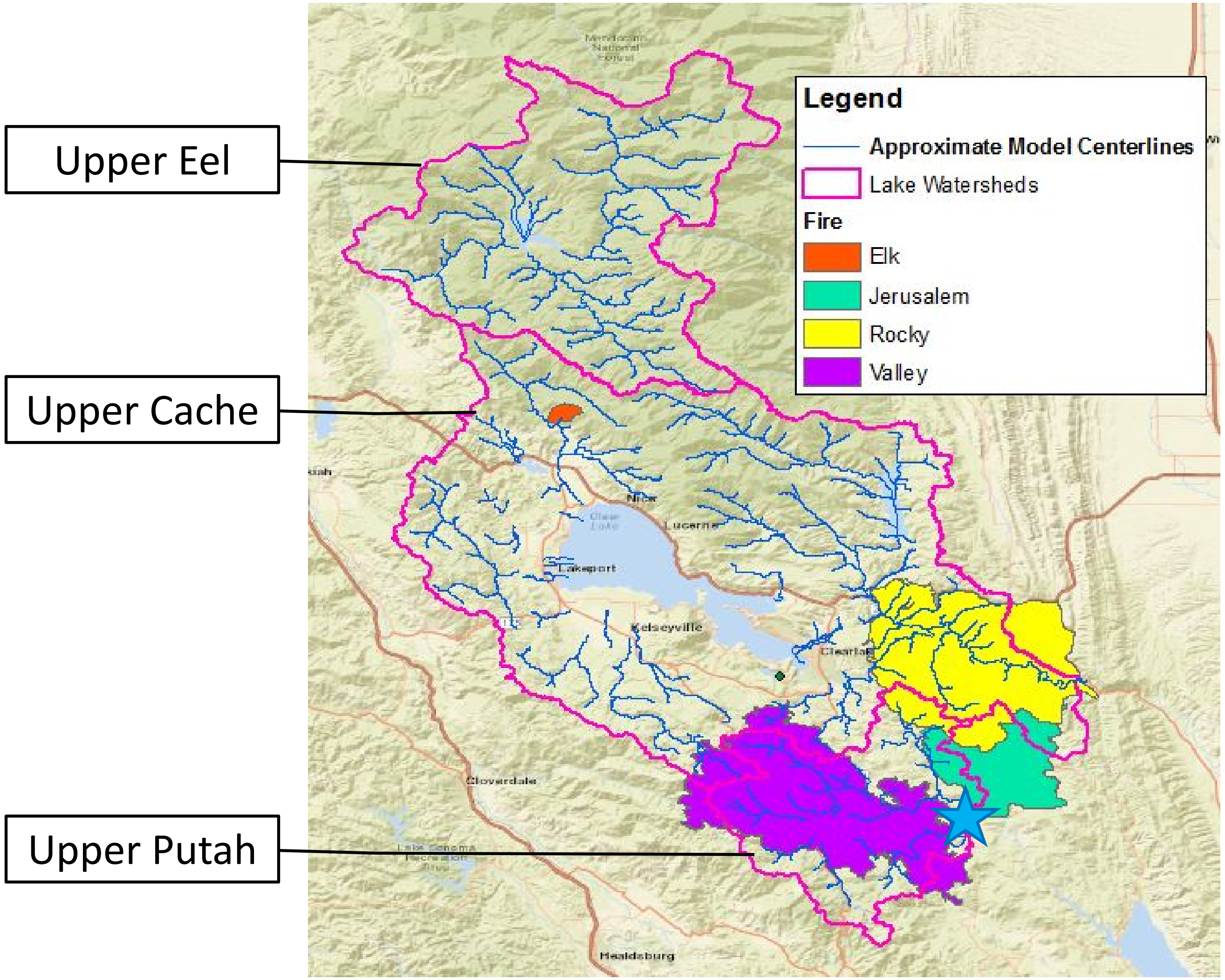
Results

- No fires were included in the Upper Eel watershed, therefore, only pre-burn peak flows were developed
- The Elk fire and part of the Rocky and Valley fires burned in the Upper Cache watershed
- The post-burn 1% peak flows of Cache Creek at the downstream end of the Upper Cache watershed were approximately **1.3 times** that of the pre-burn 1% peak flows.



Results

- Part of the Rocky, Jerusalem, and Valley fires burned in the Upper Putah watershed
- The majority of the Upper Putah watershed area was burned
- The post-burn 1% peak flows of Putah Creek at the downstream end of the Upper Putah watershed were approximately **2.3 times** that of the pre-burn 1% peak flows.



Questions?

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