Modeling the Impact of Wildfire on Reservoir Capacity

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Objectives

1. Research parameter inputs for a pre-existing capacity model and analyze outputs in comparison to survey data.

2. Adjust the model to simulate yearly fire frequency via modified sedimentation rates.

Tributaries upstream of Ruth Lake

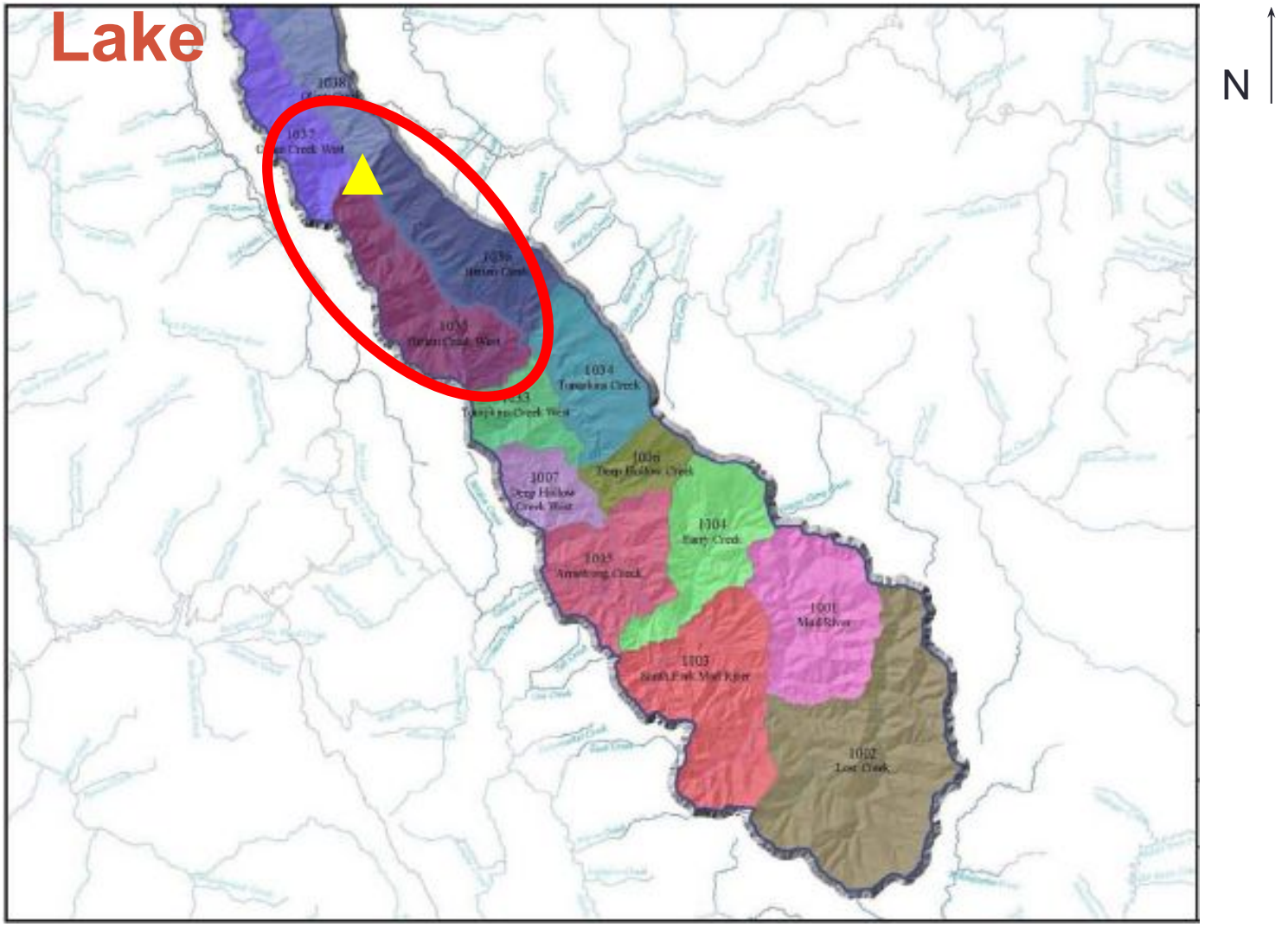

Image source: USEPA (2007). *Mad River Total Maximum Daily Loads for Sediment and Delivery*. Retrieved from https://www3.epa.gov/region9/water/tmdl/mad/Mad-TMDL-122107-signed.pdf.

Fire-Flood Regime

- Fire impact
  - Hydrophobic soils = lowers soil infiltration
  - Sudden loss of vegetation = increases sediment availability
- Precipitation
  - Cannot infiltrate soil, thus contributes to surface runoff
  - Carries available sediment down stream

"Event-based surface runoff to rainfall ratios approached 0.45 during the first year post wildfire, compared to reported values <0.01…"

Noske, P. J., P. N. J. Lane, P. Nyman, and G. J. Sheridan (2016), Effects of aridity in controlling the magnitude of runoff and erosion after wildfire, Water Resour. Res., 52, 4338–4357, doi:10.1002/2015WR017611.

Shakesby, R. A., & Doerr, S. H. (2006). Wildfire as a hydrological and geomorphological agent. *Earth-Science Reviews*, *74*(3-4), 269–307. http://doi.org/10.1016/j.earscirev.2005.10.006

Methods Overview

I. Review capacity modeling done by Minear and Kondolf.

II. Data collection of Ruth Lake and research of various parameter values.

III. Addition to previous model of varying sedimentation rate to reflect fire events.

IV. Capacity estimation comparisons between:

A. Minear's original spreadsheet model
B. Survey data of Ruth Lake
C. Modified (for fire regime) spreadsheet model

I. Summary of Reservoir Capacity Model by Minear & Kondolf

Objectives

1. Apply the median sedimentation yield of surveyed reservoirs in a geomorphic region to un-surveyed reservoirs of the same region.

2. Predict future yearly reservoir capacities in reservoirs based on region.

Minear, J. T., & Kondolf, G. M. (2009). Estimating reservoir sedimentation rates at large spatial and temporal scales: A case study of California. *Water Resources Research*, *45*(12), 1–8. http://doi.org/10.1029/2007WR006703

Sedimentation relationships modeled by Minear and Kondolf

Trap efficiency (%)

$$T_e = 1 - \frac{1}{1+0.1\times\frac{\left(\frac{K_{t-1}}{1233.482}\right)}{\left(\frac{W}{2.59}\right)}}$$

Reservoir sedimentation (m^3)

$$R = T_e * W * Y$$

Reservoir capacity (m^3)

$$K = K_{t-1} - R$$

W = Watershed area (km^2)
K_{t-1} = Previous year's capacity (m^3)
Y = Regional median sedimentation rate ($m^3/km^2/yr$)

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II. Data collection of Ruth Lake

Parameter	Minear & Kondolf	Alternative inputs
Initial Capacity (m^3)	63,894,368	59,244,044 (Ruth Lake Community District Services, 2014)
Watershed Area, W(km^2)	310.8	313.389 (USGS, 2016)
Regional (Coastal) sedimentation rate, Y ($m^3/km^2/year$)	261.83	261.83
Trap efficiency	0.9774	0.9754
Reservoir 2016 capacity (m^3)	59,523,337	54,845,930

Minear, J. T., & Kondolf, G. M. (2009). Estimating reservoir sedimentation rates at large spatial and temporal scales: A case study of California. *Water Resources Research*, *45*(12), 1–8. http://doi.org/10.1029/2007WR006703

Ruth Lake Community Service District (2014). "Humboldt Bay Municpal Water District R.W. Matthews Dam- Project # 3430" http://www.ruthlakecsd.org/sidebar/area-history/.

U.S. Geological Survey (2012). The StreamStats program for California, online at http://streamstatsags.cr.usgs.gov/streamstats/

III. Adjustments to Minear's spreadsheet

Fire frequencies

- Each year was assigned as a "**fire year**" or "**non-fire year**"
- Evaluated every 40, 30, 20, 10, and 5 years

Sedimentation, Y, for **fire years** was estimated using RUSLE

Sedimentation, Y, for **non-fire years** was evaluated at three different values based on various input parameters

Source	**Y ($m^3/km^2/year$)**
Minear & Kondolf regional median	261.83
RUSLE 2007	82.14
Observations (Matthews, 2007)	147.25
RUSLE 2016	155.68

Minear, J. T., & Kondolf, G. M. (2009). Estimating reservoir sedimentation rates at large spatial and temporal scales: A case study of California. *Water Resources Research*, *45*(12), 1–8. http://doi.org/10.1029/2007WR006703

Matthews, G. (2007). Mad River Sediment Source Analysis, (December).

IV. Capacity estimation comparisons

Model Scenario	Sedimentation input unburned ($m^3/km^2/year$)	Sedimentation input fire ($m^3/km^2/year$)	2016 Capacity (m^3) W=310.8 km^2 K=63,894,368 m^3	2016 Capacity (m^3) W=313.389 km^2 K=59,244,044 m^3
Completely Unburned	261.83	---	59,523,335	54,845,928
	82.14	---	60,581,276	55,910,305
	147.25	---	61,435,307	56,769,589
Modified fire frequency to every 10 years	261.83	155.68	59,795,918	55,120,160
	82.14		62,413,349	57,753,707
	147.25		61,464,645	56,799,108
2015 Ruth Lake Survey	---	---	49,741,375	

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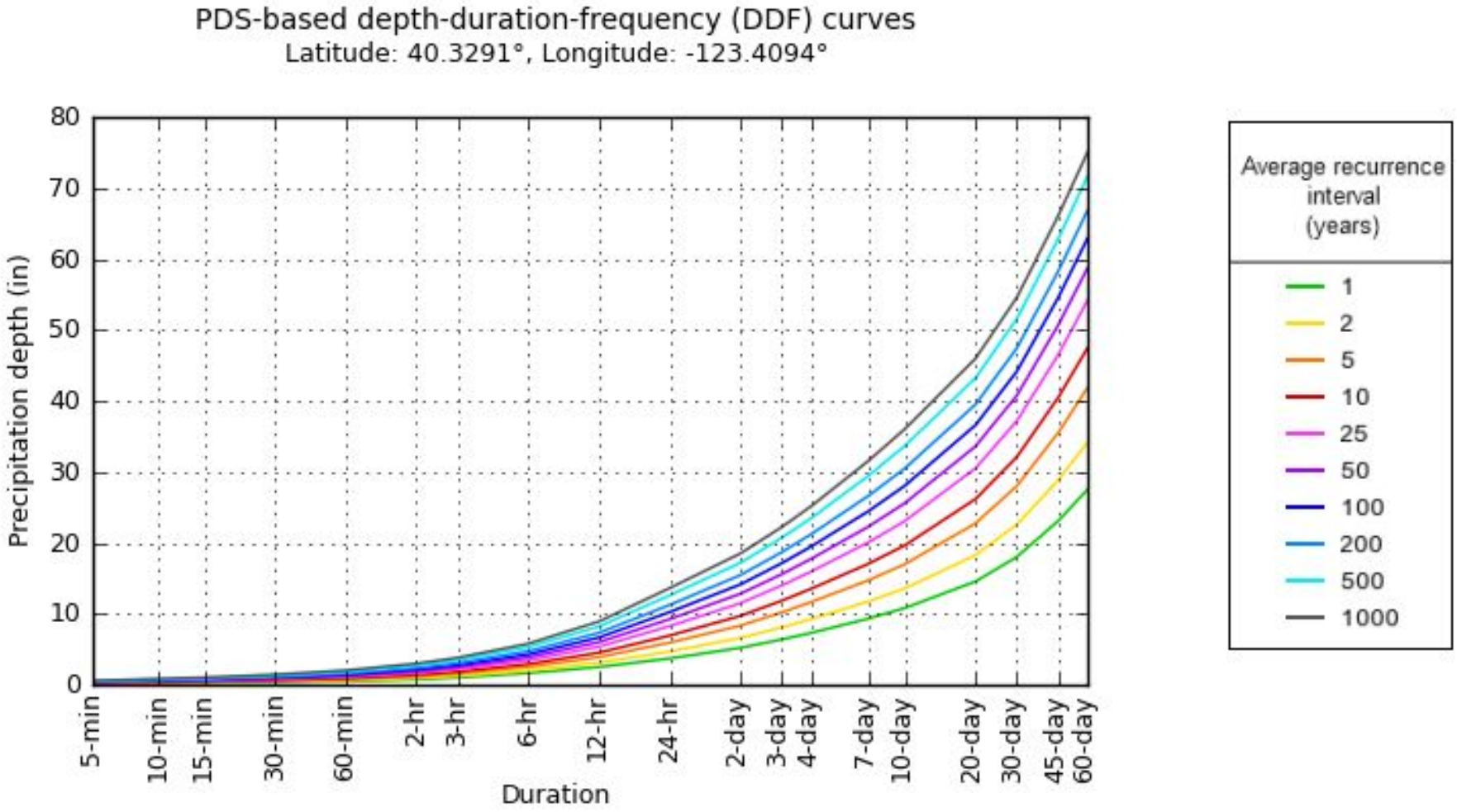
Implications & Suggestions for Further Development

- Survey data could overestimate volume of Ruth Lake, even though capacity seems low compared to other projections
  - Survey capacity = 49,741,375 m^3
  - Conducted after 2015 fire, but before a major precipitation event
- Fire frequency does not have a drastic impact on reservoir capacity in this simplified model adjustment
  - Not to say fire events do not have an impact at all
  - 'On/Off' pattern does not encompass ecological complexities such as climate, vegetation, soil factors, and precipitation.
- Specify sediment yields to reflect rainfall after wildfire
  - Simulate various precipitation events: Intensity-Duration-Frequency curve

Intensity-Duration-Frequency curve



Source: National Oceanic and Atmospheric Administration (2015). NOAA Atlas 14 Point Precipitation Frequency Estimates, online at http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=ca

Thank you

Questions?

References

Matthews, G. (2007). Mad River Sediment Source Analysis, (December).

Minear, J. T., & Kondolf, G. M. (2009). Estimating reservoir sedimentation rates at large spatial and temporal scales: A case study of California. *Water Resources Research*, *45*(12), 1–8. http://doi.org/10.1029/2007WR006703

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