Surface water quality monitoring following the Camp Fire: preliminary results

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Dry Creek @ Pearson Rd on Feb.2, 2019

Acknowledgements

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- Erica Plasencia-Campos (Civil Engineering)
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- Eric Dearden (Env. Sci.)
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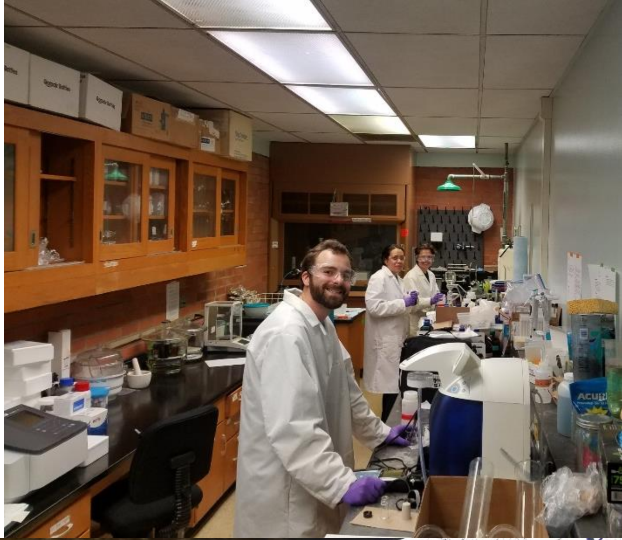
- Jillian Olivar (Env. Sci.)
- Brice Vanness (Biochemistry)
- Andrea Villegas (Env. Sci.)
- Gabrielle Wyatt (Biology)
- Robert Gruenberg (MS, Env. Sci.)
- John Machado (MS, Env. Sci.)



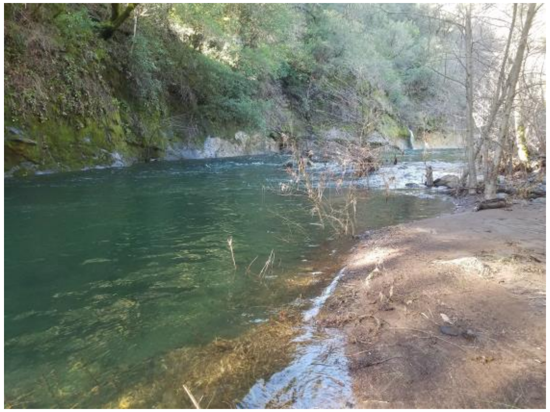
Overview (Webster)

- Conceptual understanding post-wildfire water quality drivers
- Effects of heating on dissolved organic carbon
- Effects of heating on nutrients in soil
- Ongoing work looking for urban contaminants in the watersheds

Butte Creek on Jan.17, 2019

Understanding post-wildfire water quality

Background Water Chemistry



- Bedrock geology
- Mining legacy
- Land use

Generally known

Changes to Landscape

- Altered hydrology and soil chemistry
- Charcoal and ash

Moderately understood

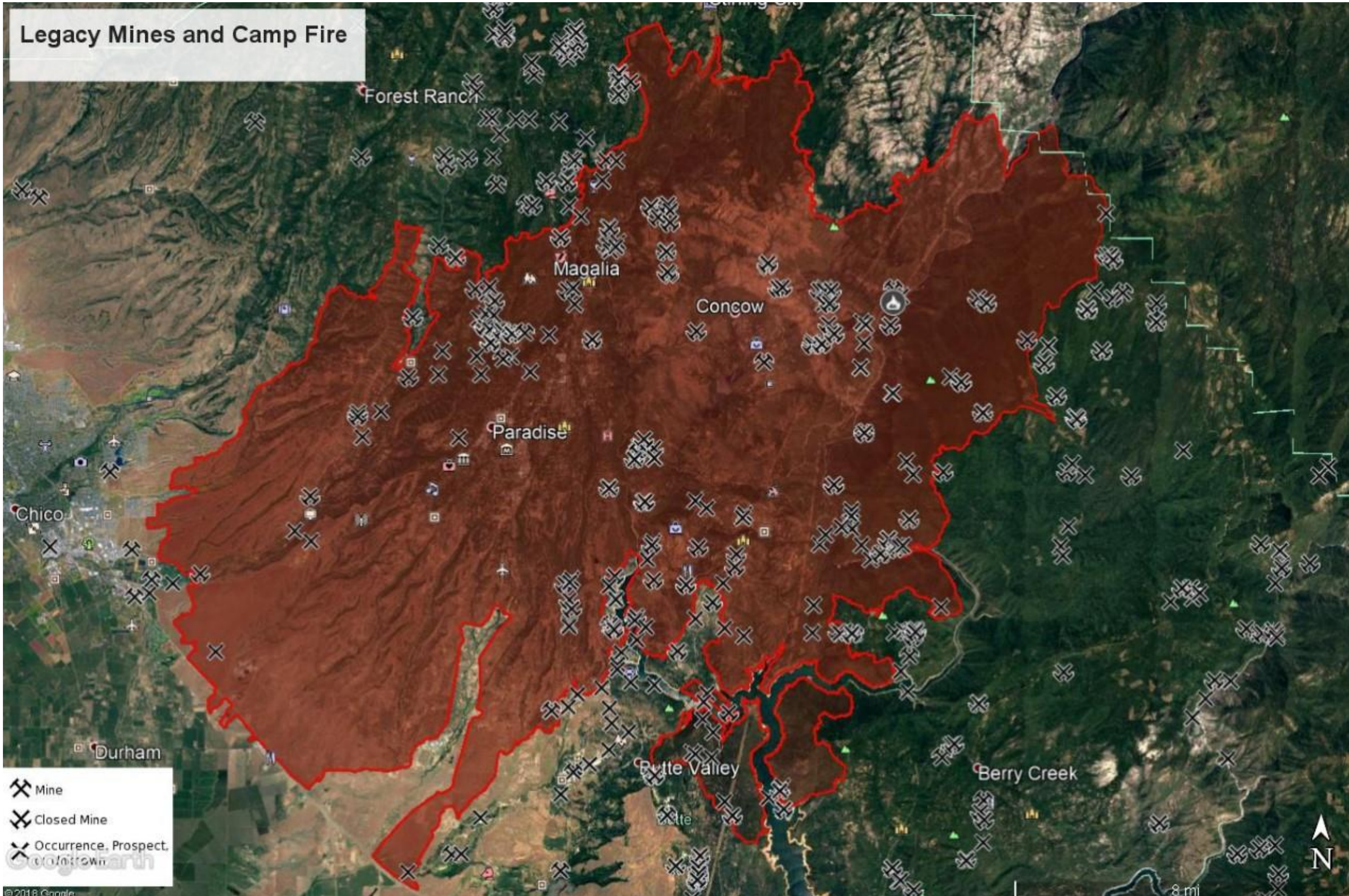
Urban Drainage

- Building materials
- Electronics
- Household/industrial chemicals

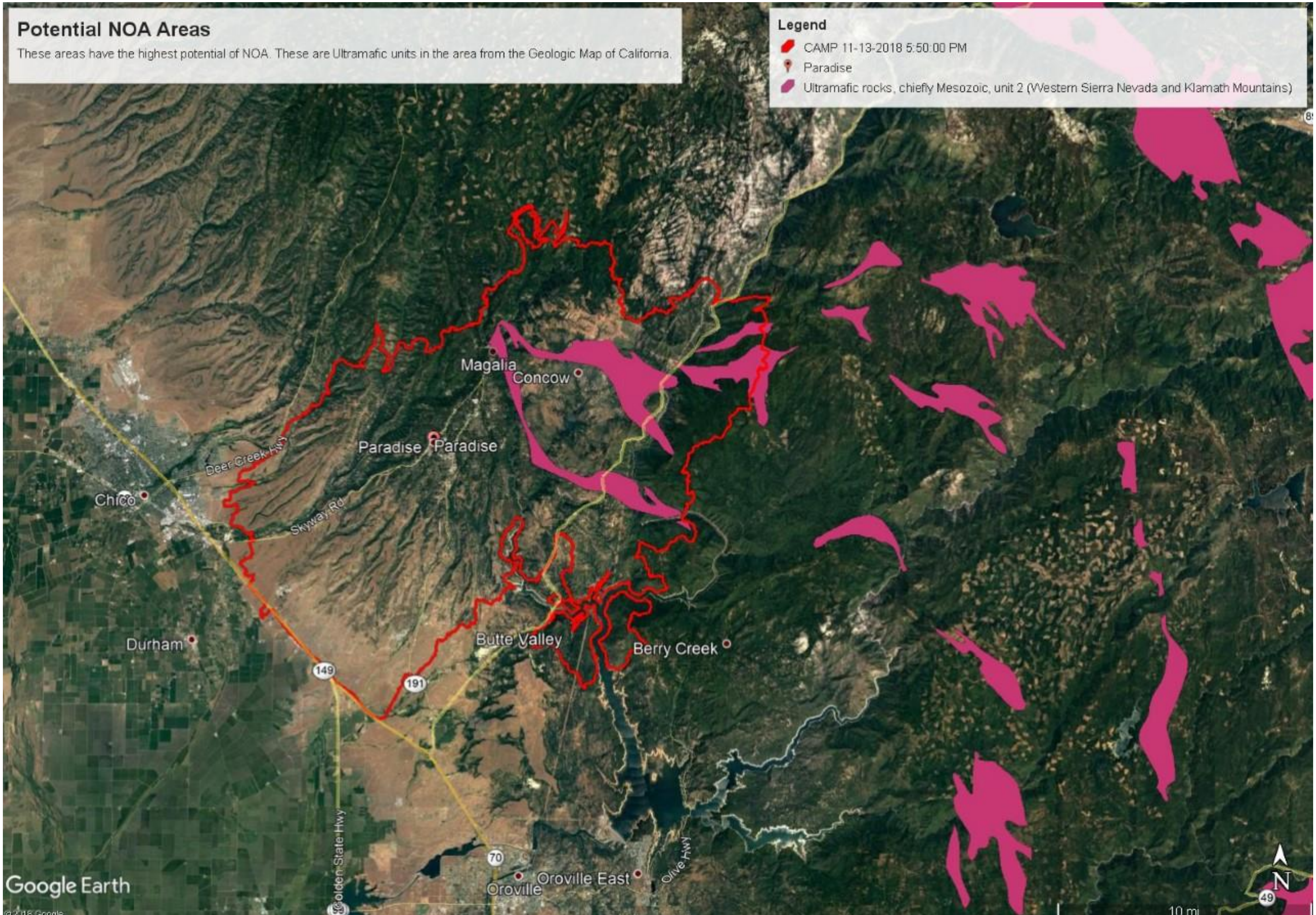
Widely unknown

Downstream Water Quality

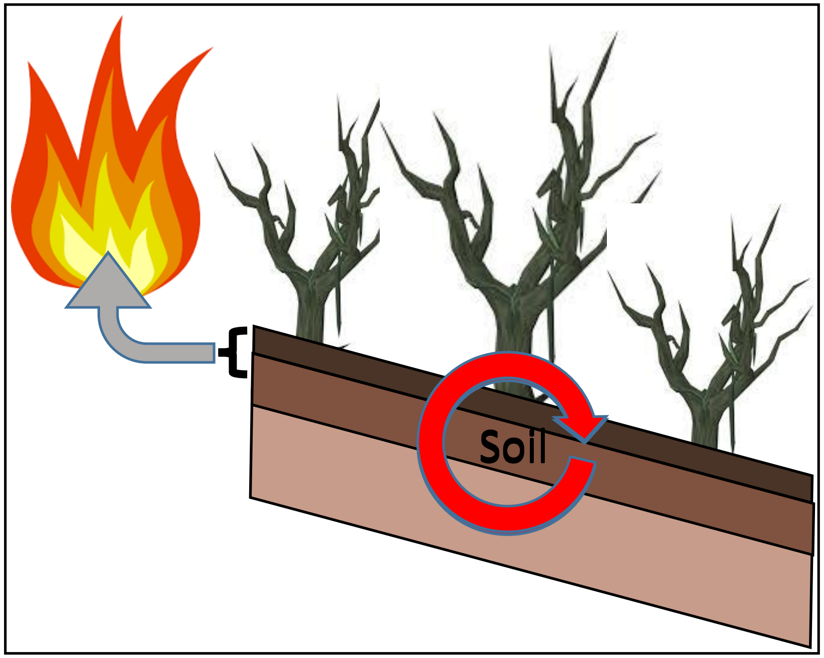
Mining legacy



Bedrock geology

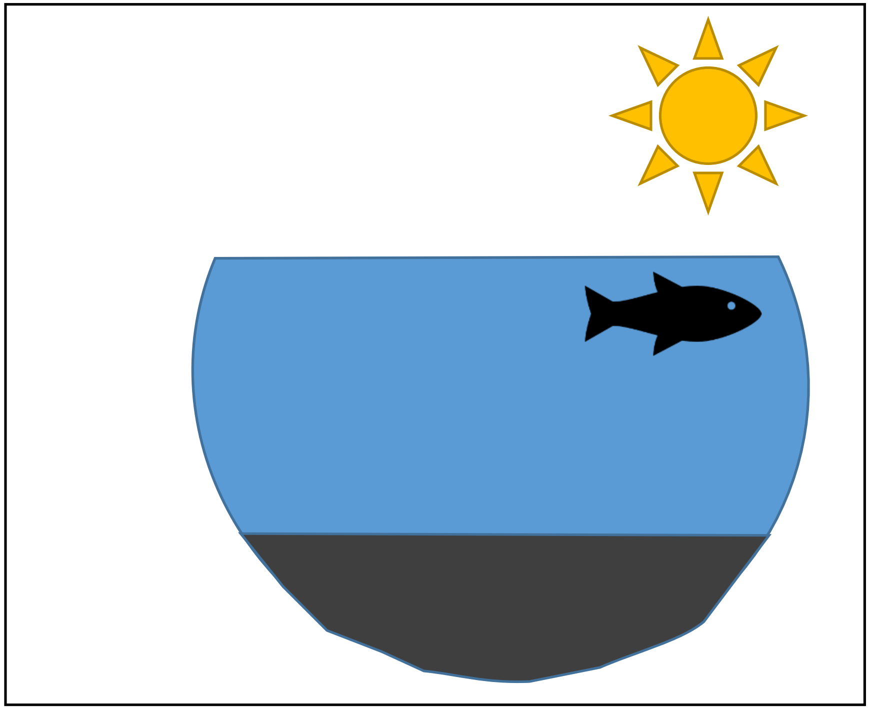


Wildfire effects on watershed biogeochemical cycling



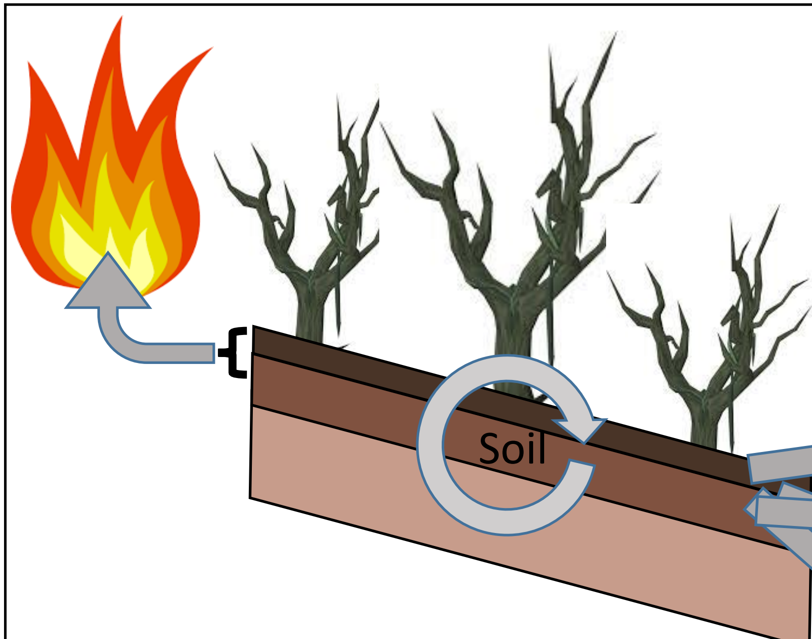
Soil heating alters:

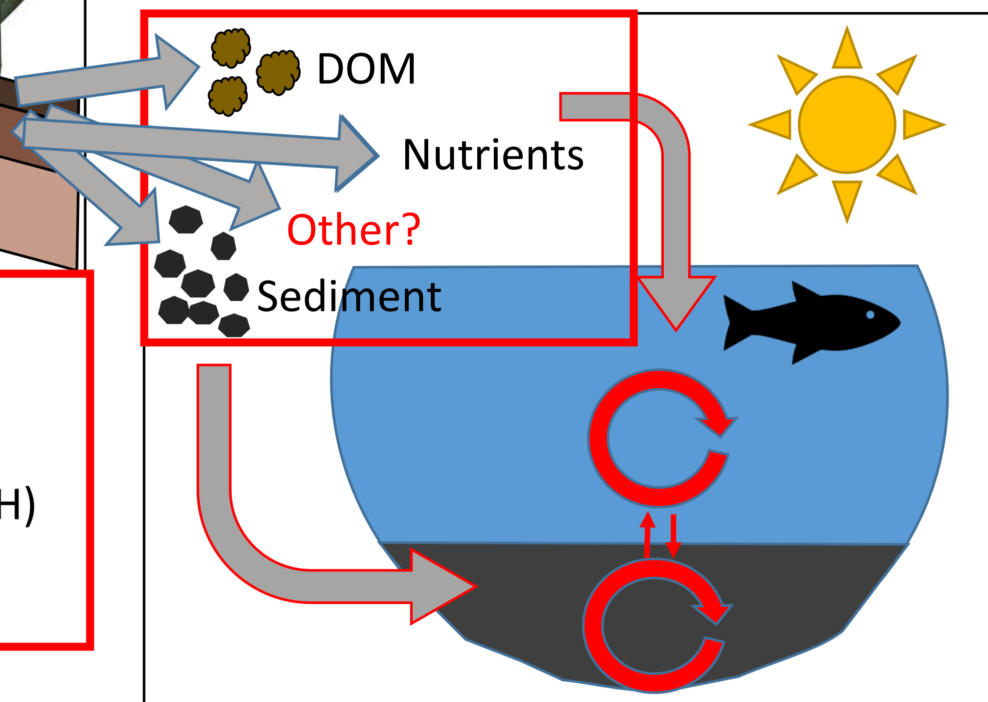
- Soil stability
- Carbon character
- Nutrient content



Wildfire effects on watershed biogeochemical cycling

- Increased DOM
- Increased nutrient export
- Increased total metals, dissolved metals





- Oxidation of metals (e.g. Cr)
- Changes to soil organic matter
- Polycyclic aromatic hydrocarbon (PAH) generation in soil

Previous work on soil leaching

- Soils and litter collected from 4-5 locations per site

- Each sample air dried

- Sieved (1 mm)

  Soil > 1 mm was discarded

  Litter < 1 mm was discarded

- Heated for 2 h at 225°C and 350 °C

Leachate preparation and analysis

1.25 g of soil was mixed for 24 h in ultrapure (18.2 MΩ) water

Filtered using 0.45 µm glass fiber filter

Filtrate was adjusted to pH 2

DOC and nutrients were measured in parallel experiments

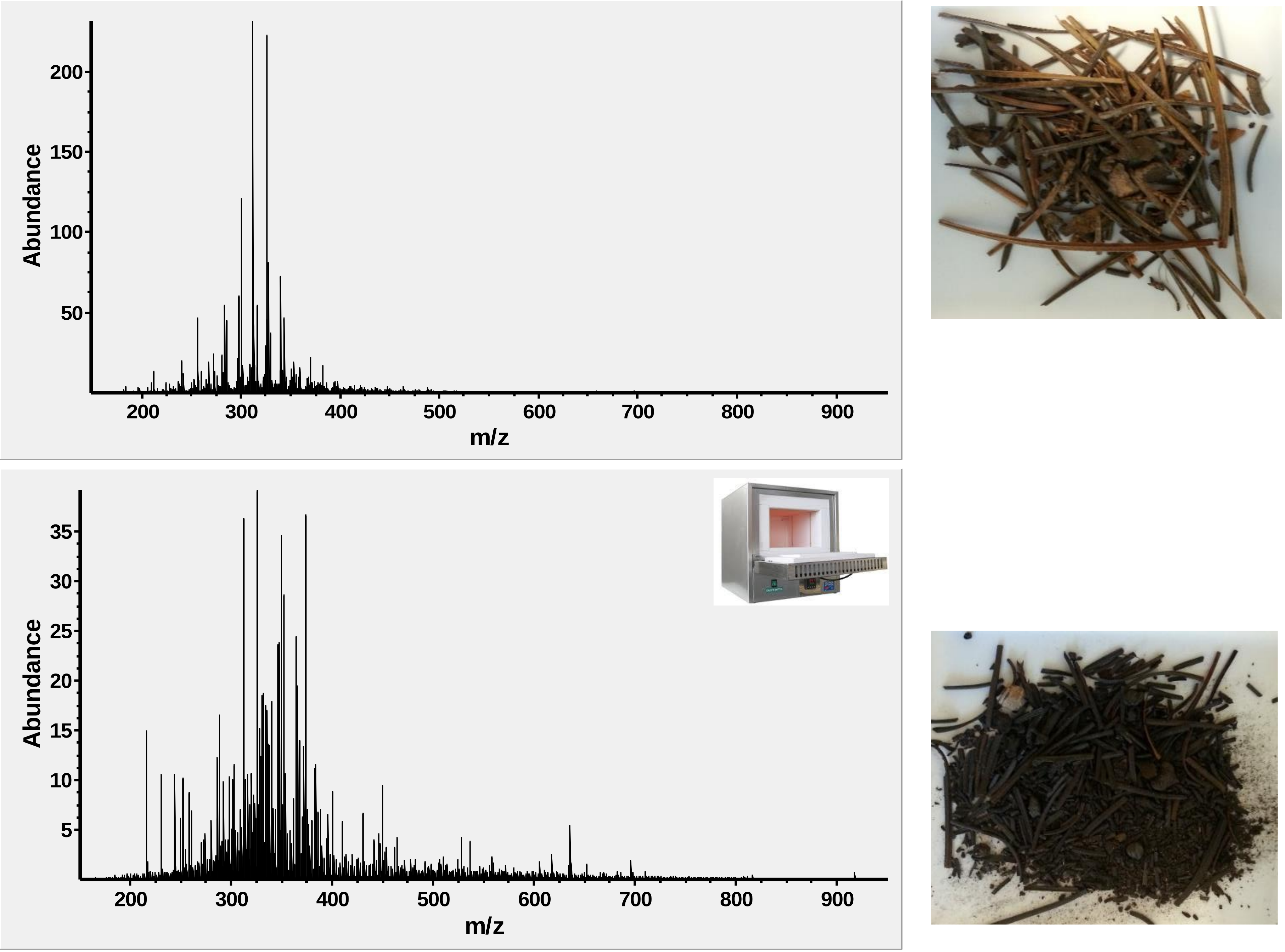
DOM was extracted on a C18 cartridge

Rinsed in 0.01 M HCl and then air dried prior to

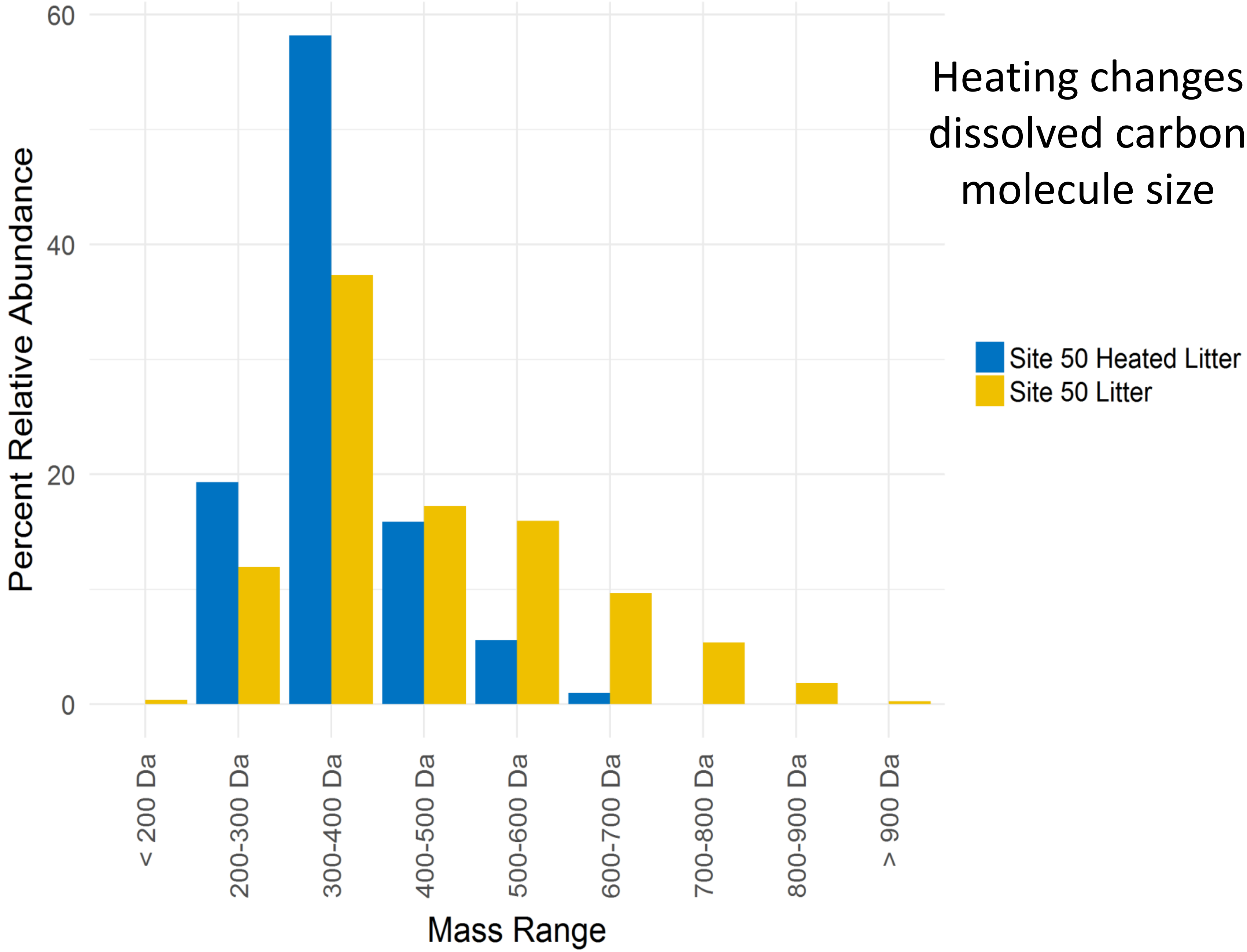
Extracted with 1 mL of methanol

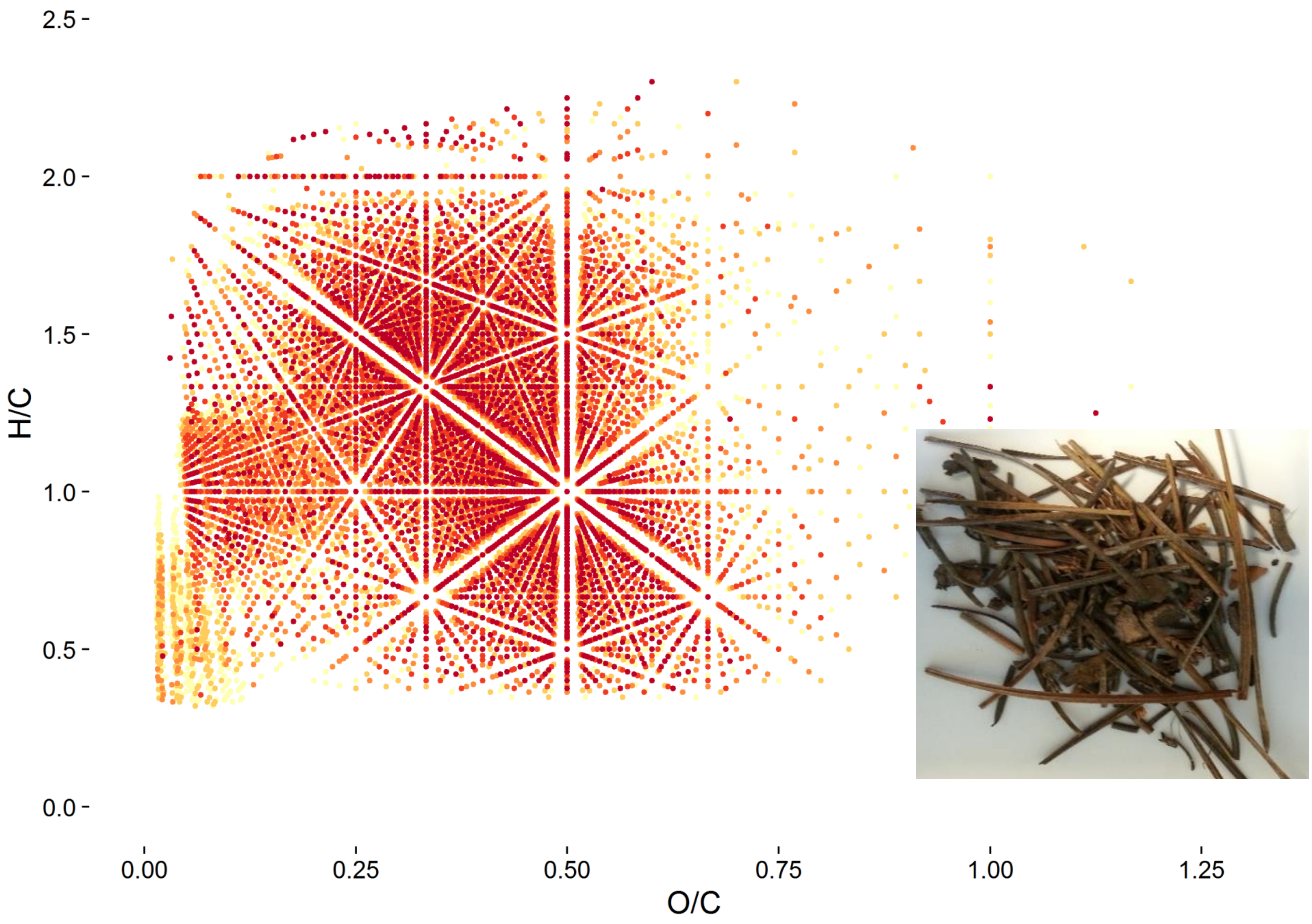
FT-ICR-MS analysis was performed at the National High Magnetic Field Laboratory, Tallahassee, FL

Extracted samples were analyzed using electrospray ionization in the negative mode


Abundance
200
150
100
50
200
300
400
500
600
700
800
900
m/z
Abundance
35
30
25
20
15
10
5
200
300
400
500
600
700
800
900
m/z

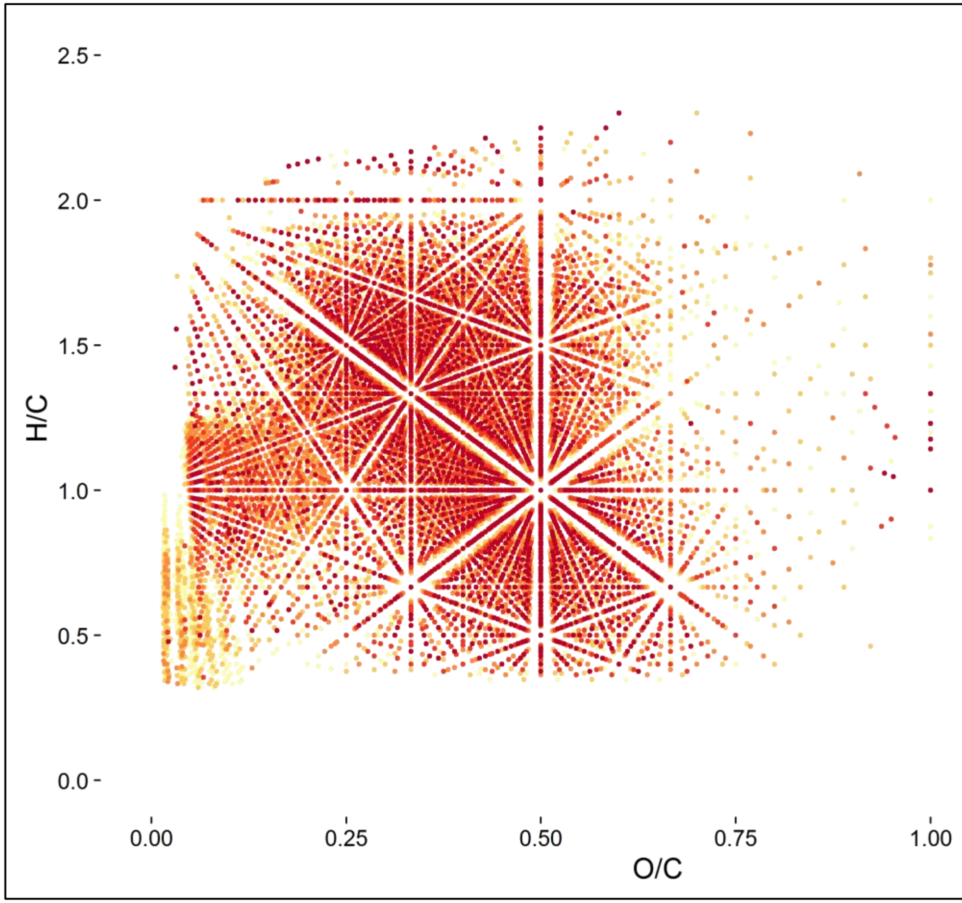
Heating changes dissolved carbon molecule size



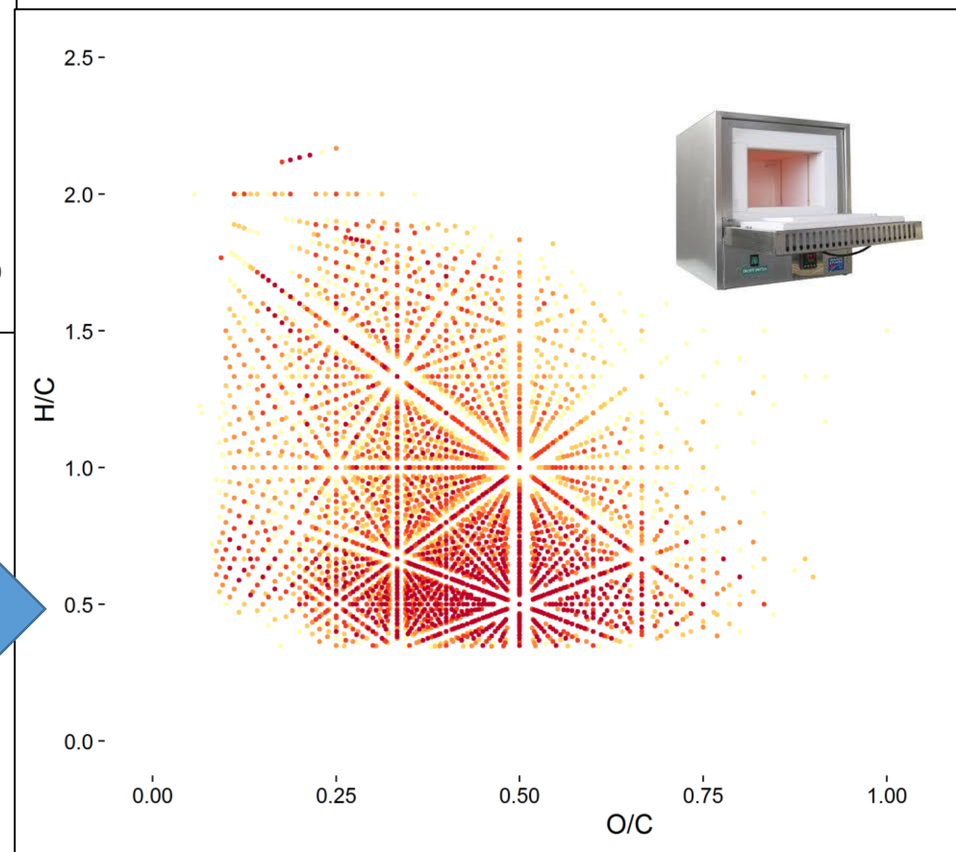


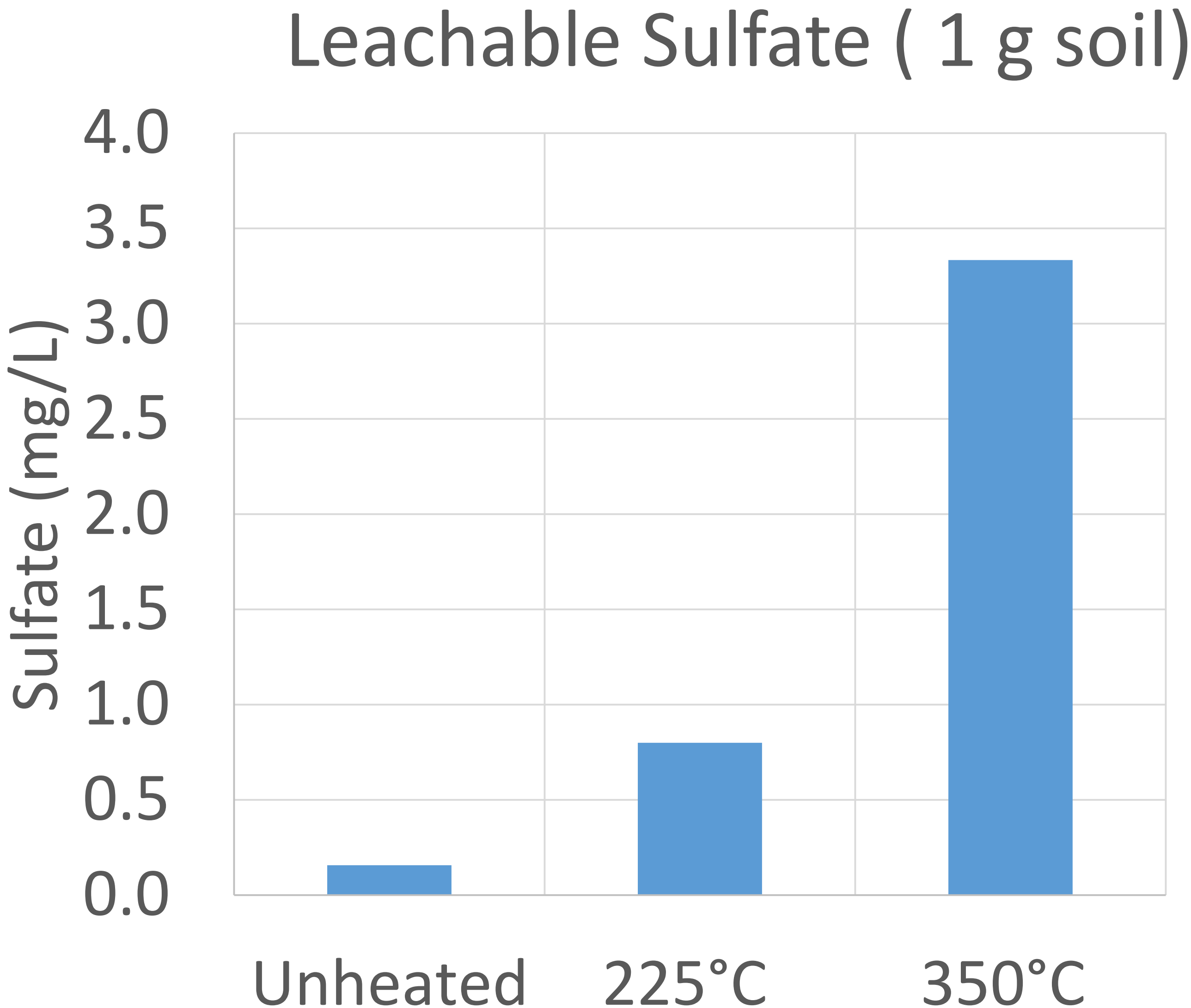
2.5
2.0
1.5
1.0
0.5
0.0
H/C
0.00
0.25
0.50
0.75
1.00
1.25
O/C

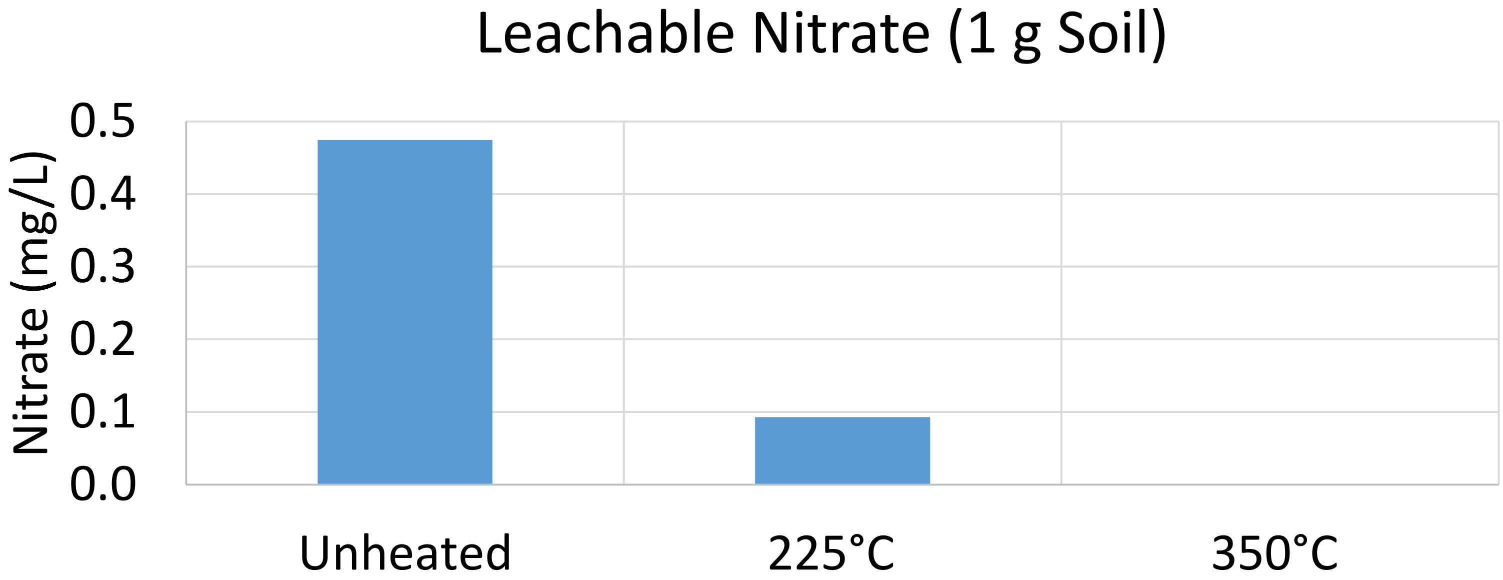
Heating changes dissolved carbon character

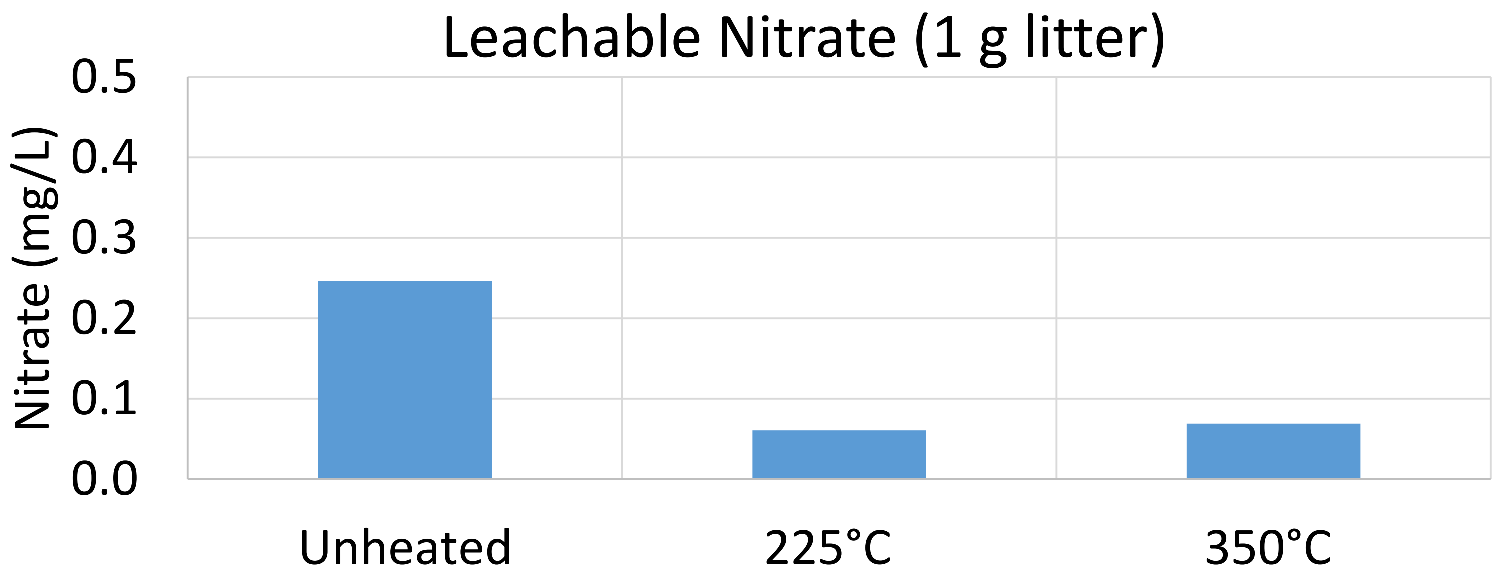


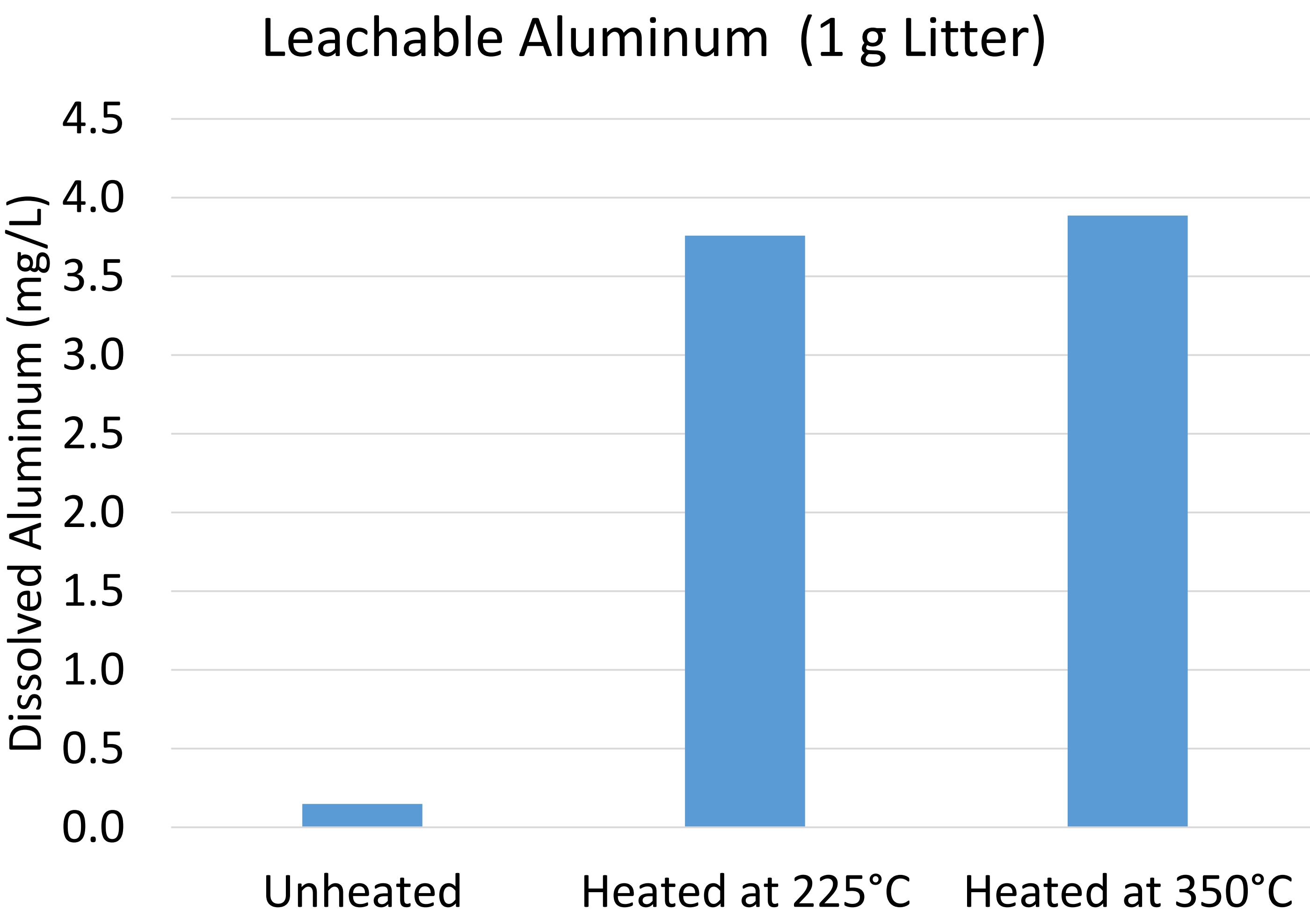
Greater mass density at low H/C ratios = increased condensed structure



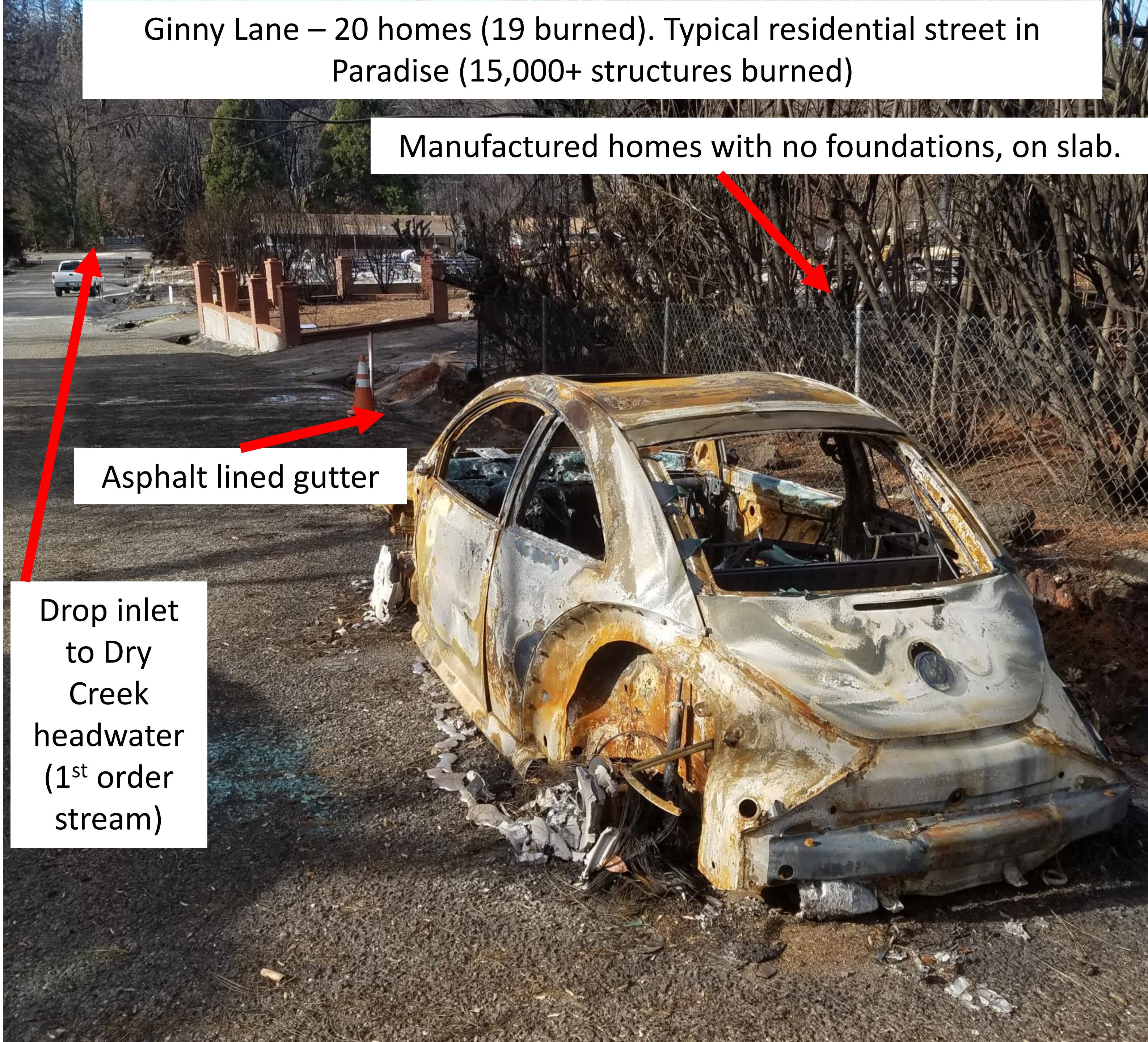

Leachable Sulfate (1 g soil)
Sulfate (mg/L)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Unheated
225°C
350°C


Leachable Nitrate (1 g Soil)
Nitrate (mg/L)
0.5
0.4
0.3
0.2
0.1
0.0
Unheated
225°C
350°C


Leachable Nitrate (1 g litter)
Nitrate (mg/L)
0.5
0.4
0.3
0.2
0.1
0.0
Unheated
225°C
350°C


Leachable Aluminum (1 g Litter)
Dissolved Aluminum (mg/L)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Unheated
Heated at 225°C
Heated at 350°C


Rear Aluminum wheel
Copper wiring harness
Steel tire belts
Aluminum Radiator
Lead Battery
Tire


Ginny Lane – 20 homes (19 burned). Typical residential street in Paradise (15,000+ structures burned)
Manufactured homes with no foundations, on slab.
Asphalt lined gutter
Drop inlet to Dry Creek headwater (1st order stream)


SEPTIC

Contaminants of concern

- Common household items and industrial materials contain toxic metals (e.g., Al, Cd, Cr, Cu, Hg, Ni, Pb, Sn, Zn)

- EPA-regulated toxic organic chemicals (e.g. PAHs, PCBs, PBBs, brominated fire retardants, dioxins)

- Asbestos

- Sewage contamination

Organics, Microbes, and Nutrients in Water

Constituent	Medium	Analyzing Institution *
E. coli	water	RWQCB / Butte County
PAHs (polycyclic aromatic hydrocarbons)	water	RWQCB
PCBs (polychlorinated biphenyls)	water	RWQCB
VOCs (volatile organic compounds)	water	Paradise Irrigation District
PBBs (polybrominated biphenyls)	water	Univ. of Washington, Tacoma *
PFAS (per- and poly-fluoroalkyl substances)	water	Univ. of Washington, Tacoma *
PFCs (perfluorinated compounds)	water	Univ. of Washington, Tacoma *
unknown organic compounds	water	Univ. of Washington, Tacoma *
DOC (dissolved organic carbon)	water	CSU Chico *
TDN (total dissolved nitrogen)	water	CSU Chico *
DOM (dissolved organic matter) fluorescence	water	Clemson Univ. *
MeHg (methylmercury)	water	Univ. of North Carolina, Greensboro *

* part of CSU Chico research team

Inorganics in Water, Soil, and Sediment

Constituent	Medium	Analyzing Institution *
Trace metals (Ag, Cd, Cu, Mo, Pb, Sb)	water	RWQCB / Butte County
Major anions	water	RWQCB
Hg (mercury)	water	Univ. of North Carolina, Greensboro *
Trace metals and major cations	water	Univ. of Colorado *
Trace metals and major cations	water, soil, suspended sediment & streambed sediment	USGS - Boulder and Denver, CO *
Metal isotopes (Sr)	water, soil, suspended sediment & streambed sediment	USGS - Menlo Park, CA *
Metal speciation (Cr)	soil	USGS - Menlo Park, CA *
Asbestiform minerals	water (suspended sediment)	USGS - Denver, CO *

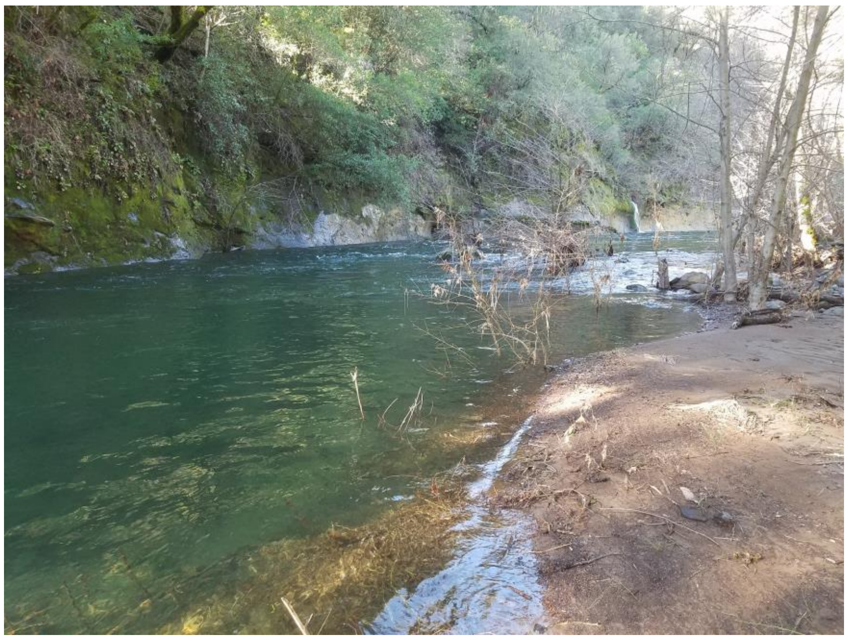
* part of CSU Chico research team

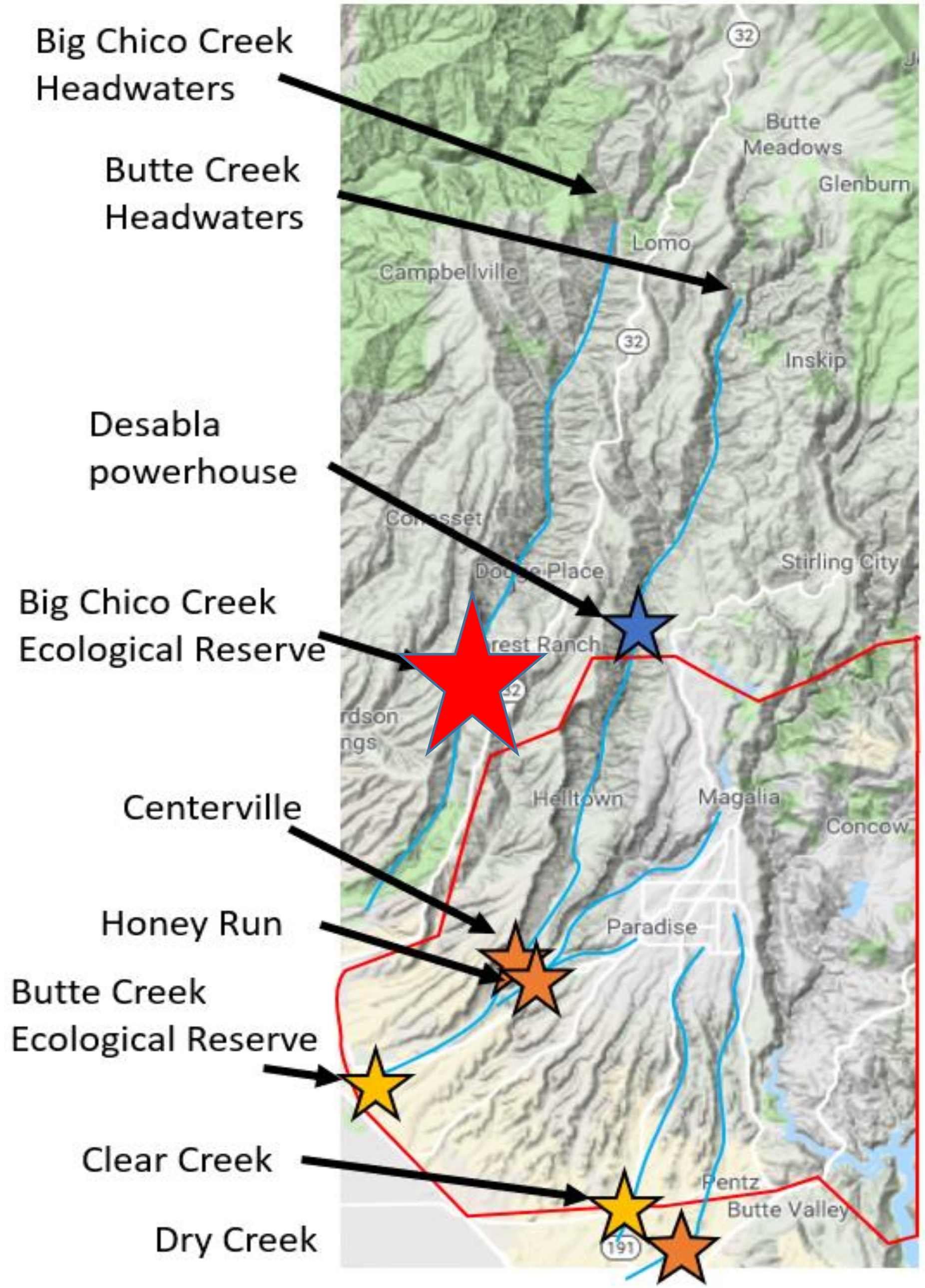
Overview (Matiasek)

- Current study sampling locations
- Dissolved organic carbon
- Total dissolved nitrogen
- Tracing combustion products with absorbance

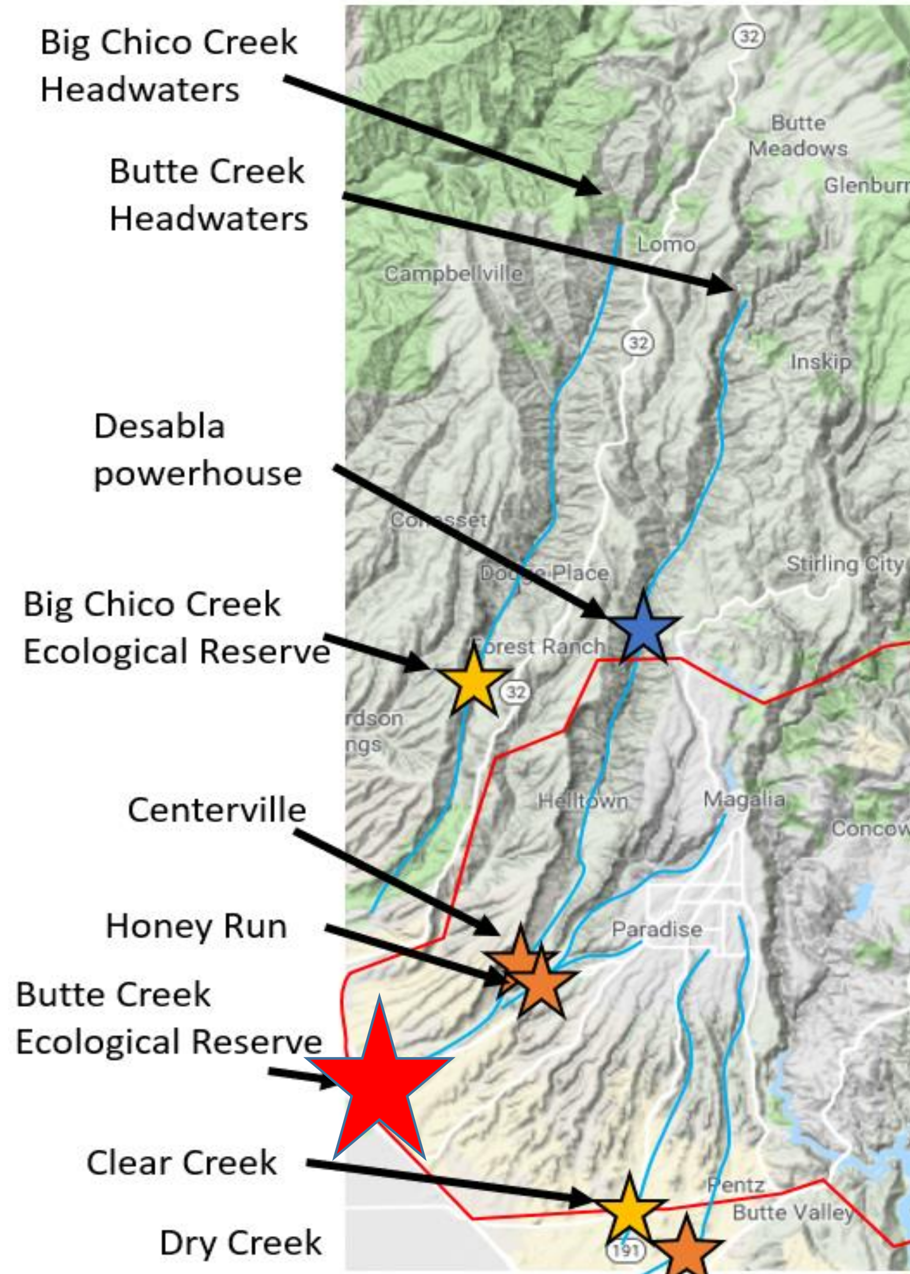
Butte Creek on Jan.17, 2019

Current study sampling locations

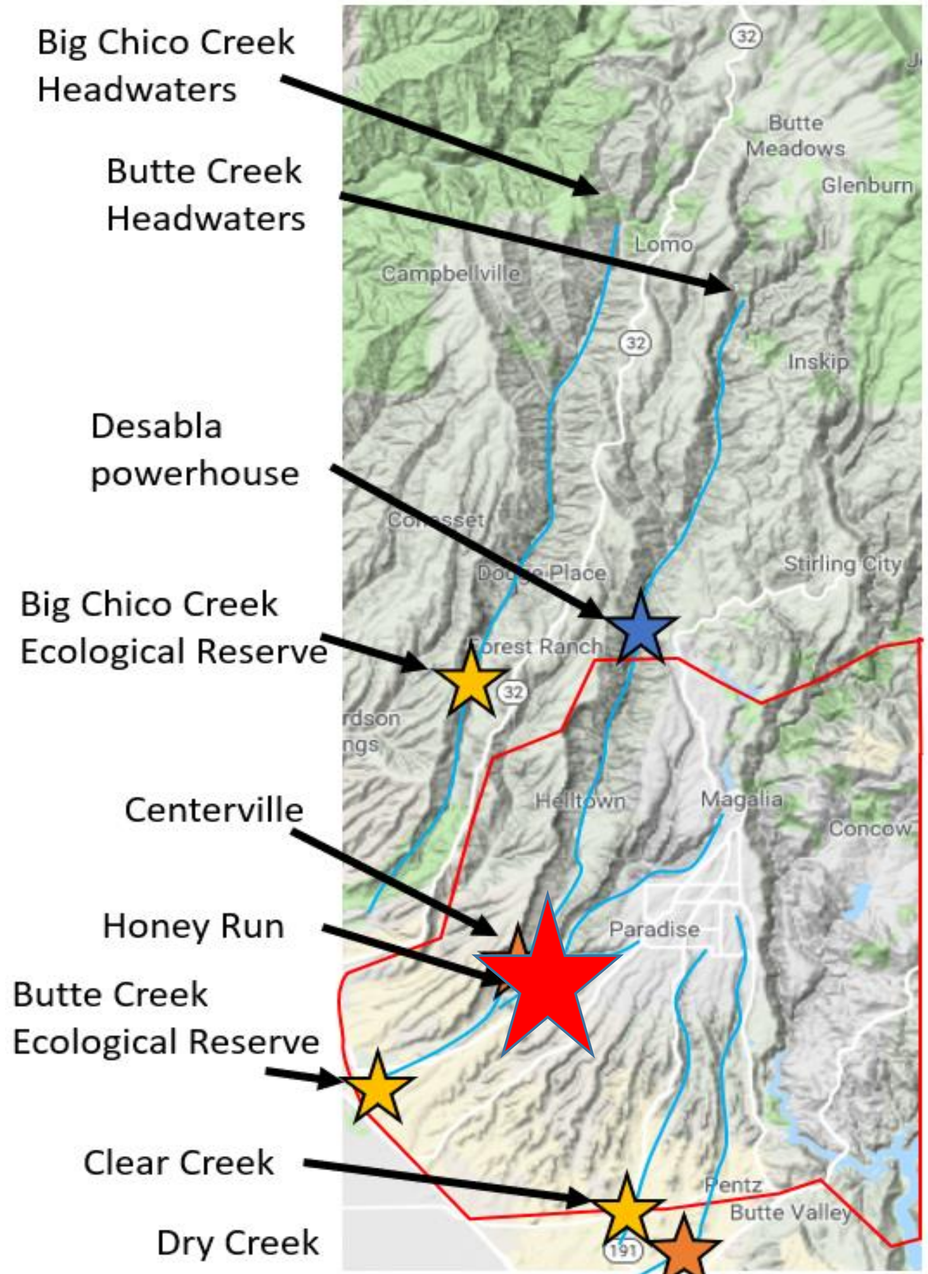




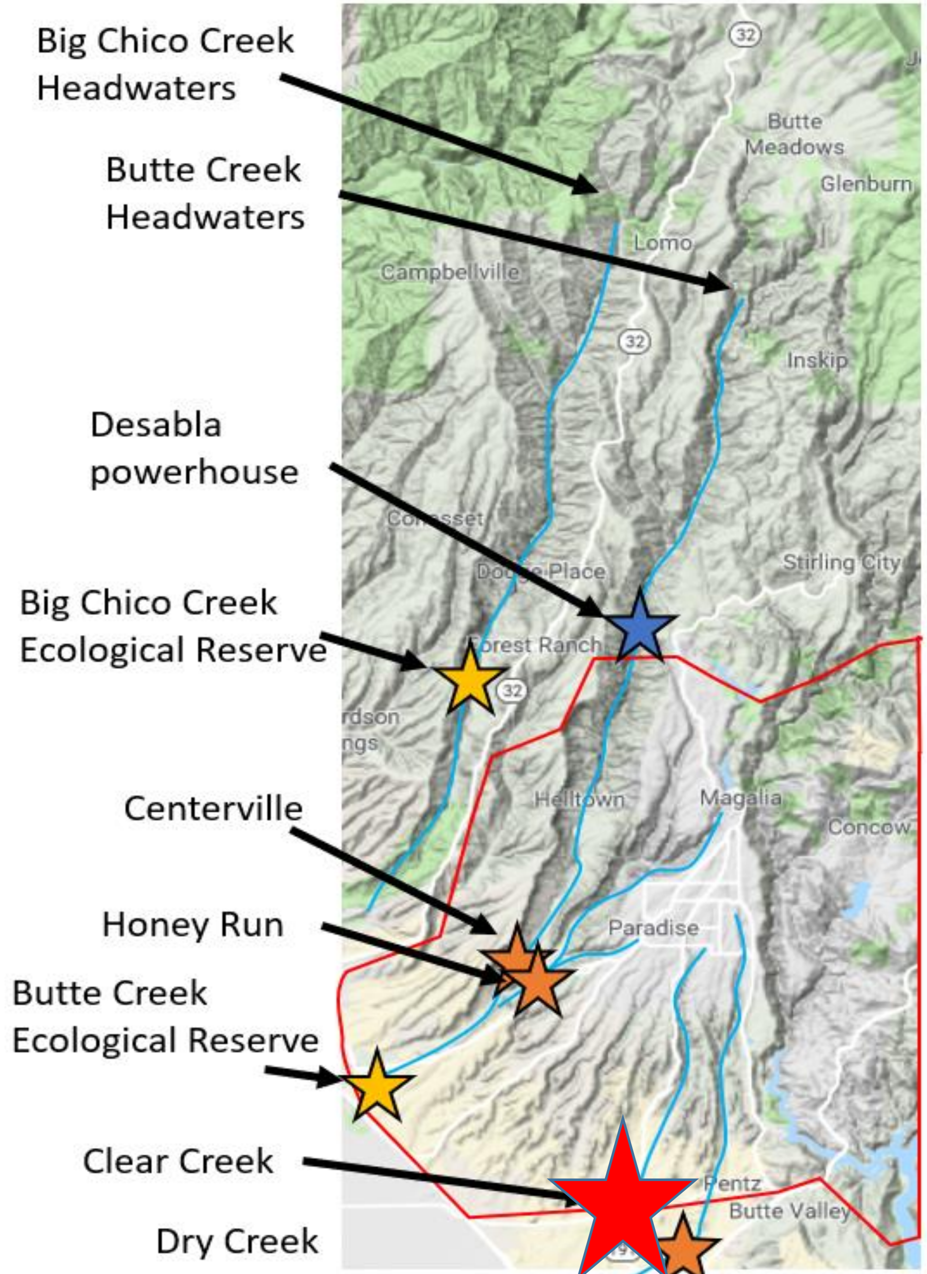
Current study sampling locations



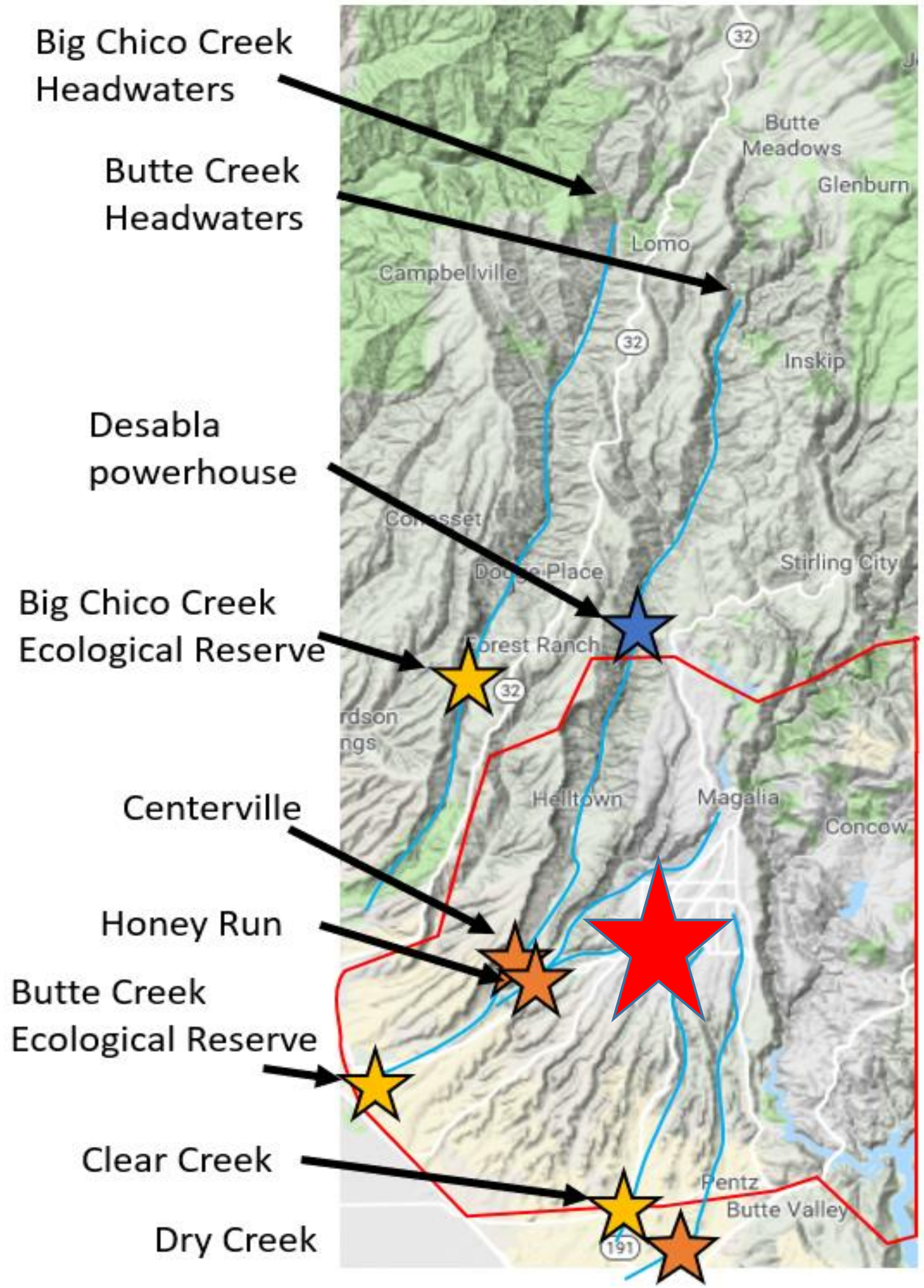
Current study sampling locations



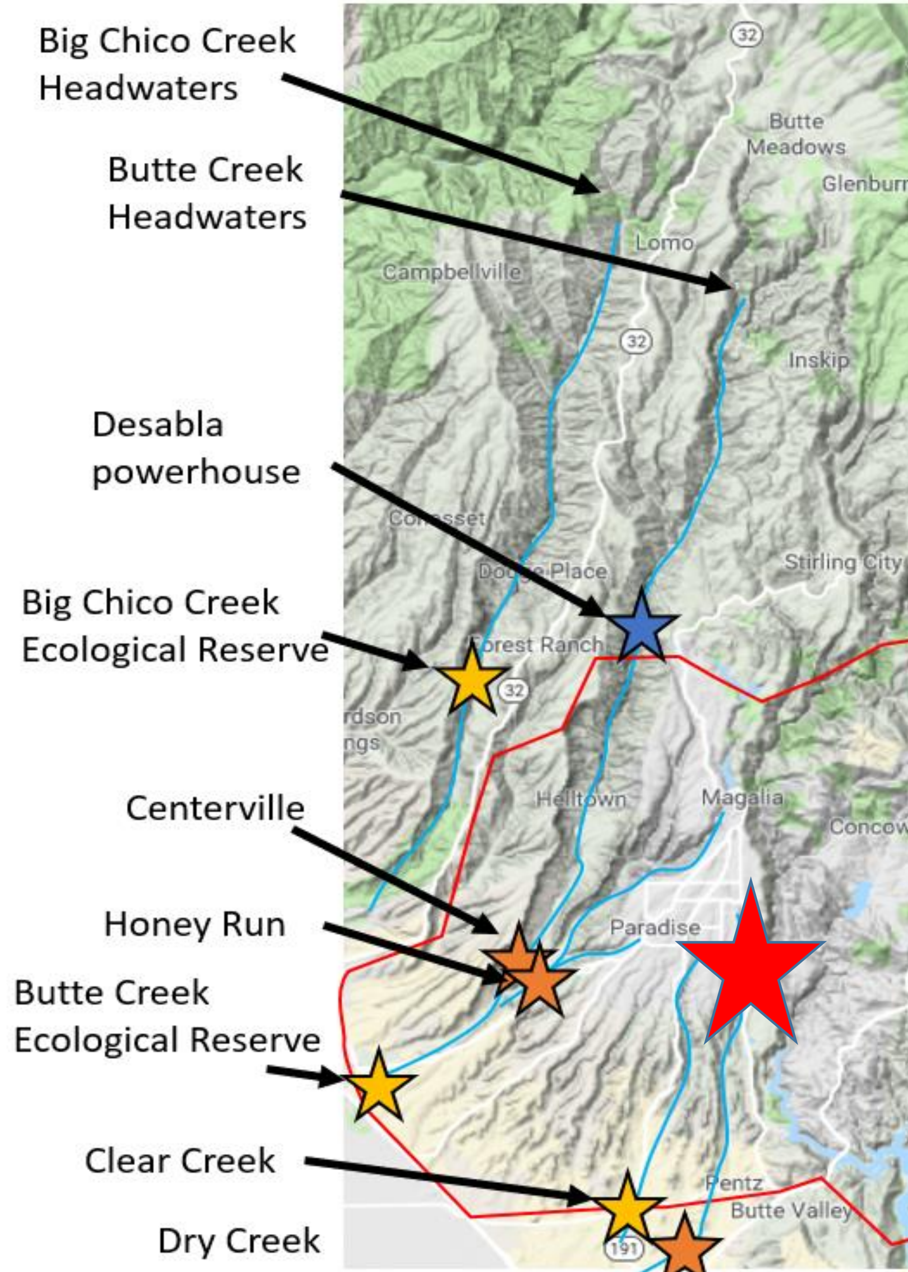
Current study sampling locations



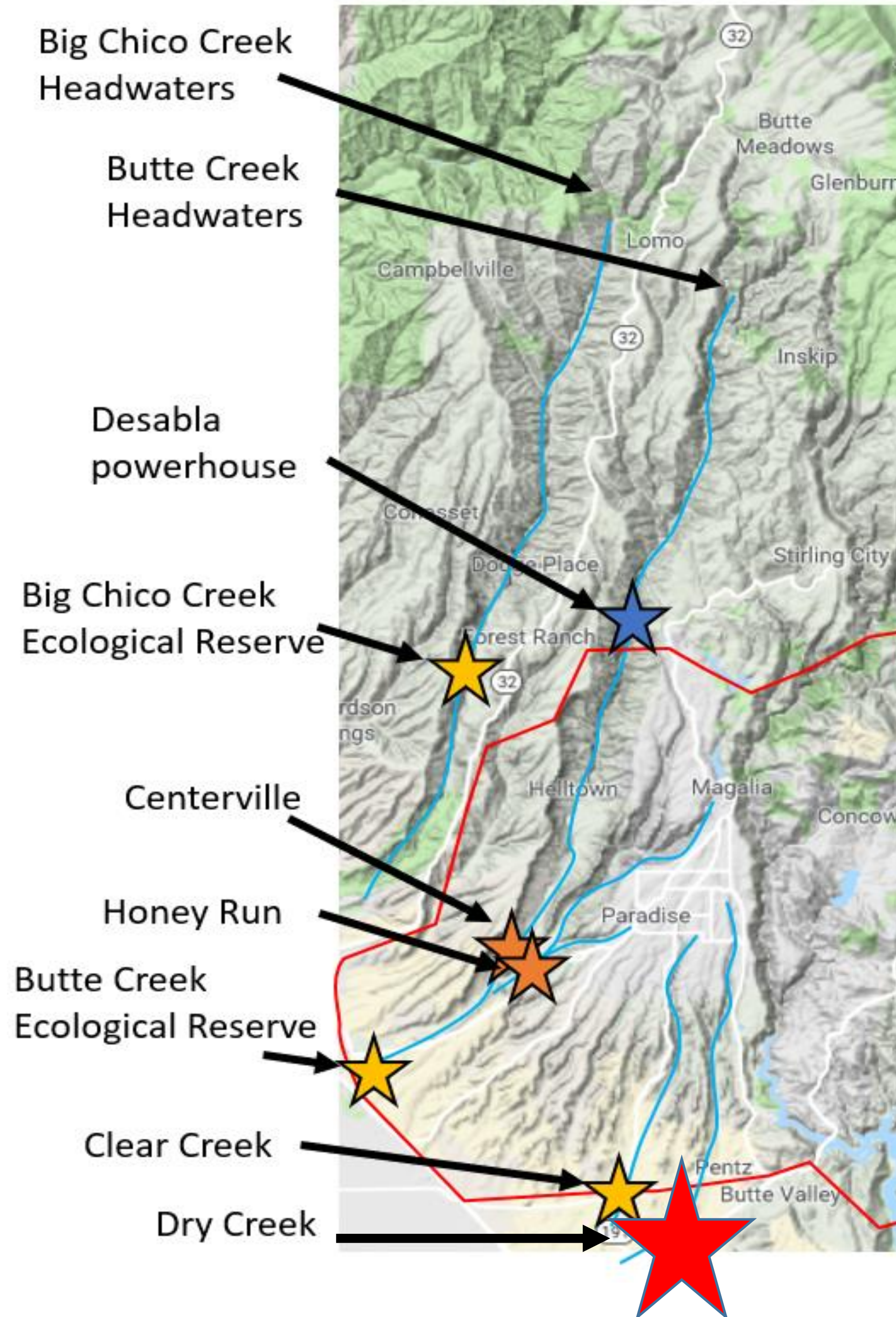
Current study sampling locations



Current study sampling locations



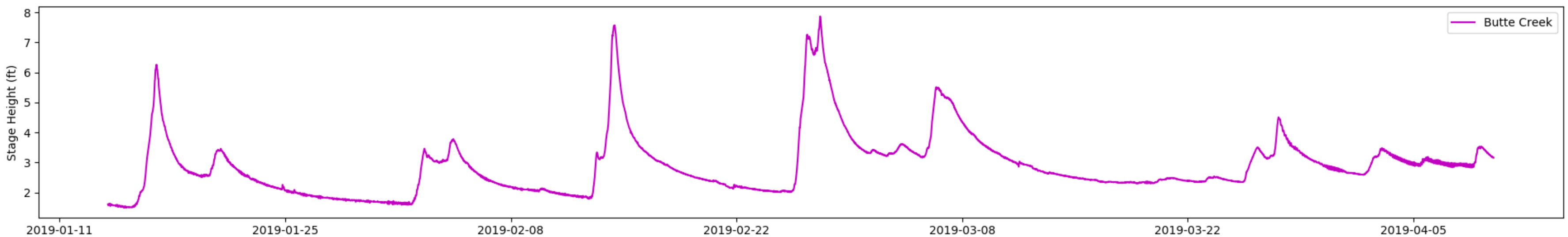
Current study sampling locations



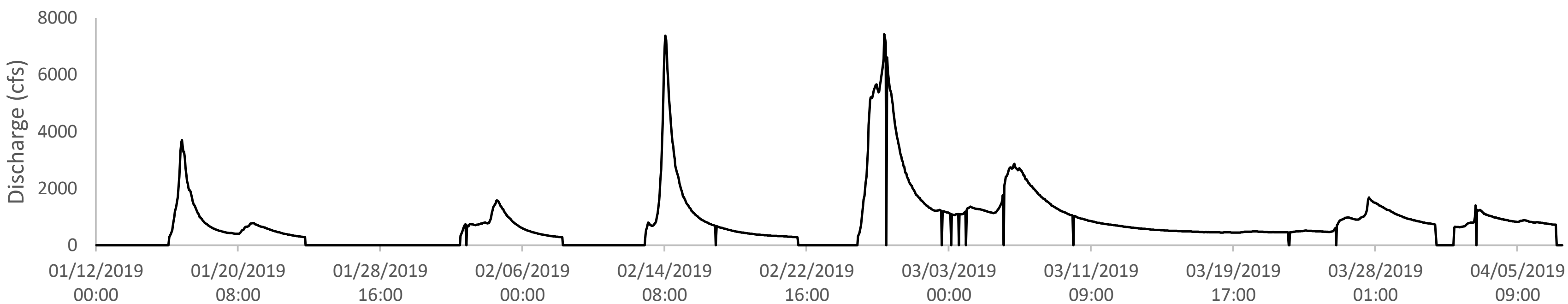
Streamflow monitoring

Similar stream responses during storms –> Butte Creek for reference

Butte Creek (USGS, CDEC)



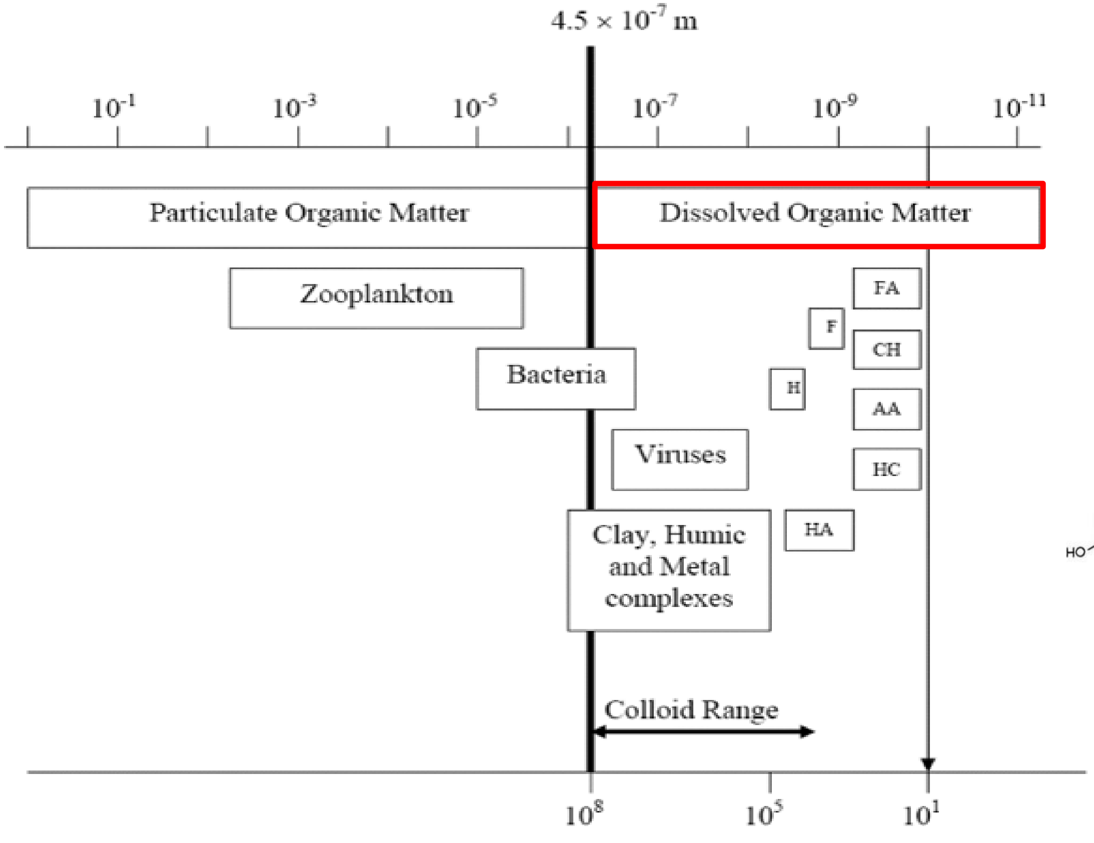
Big Chico Creek (DWR, CDEC)



Dissolved Organic Matter (DOM)

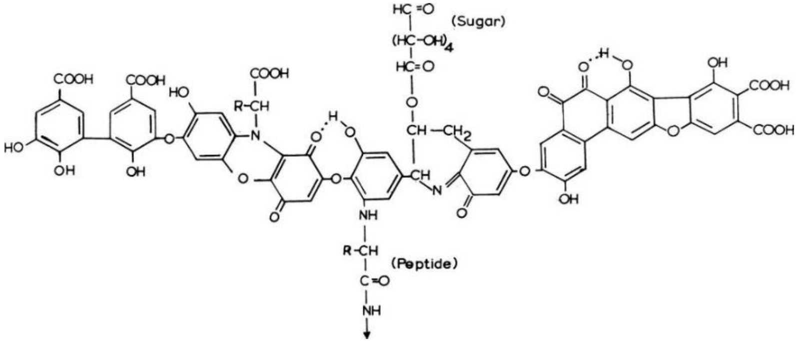
Mixture of biomolecules of diverse sizes and functional groups

Waccamaw River
Conway, SC
(Flickr.com)



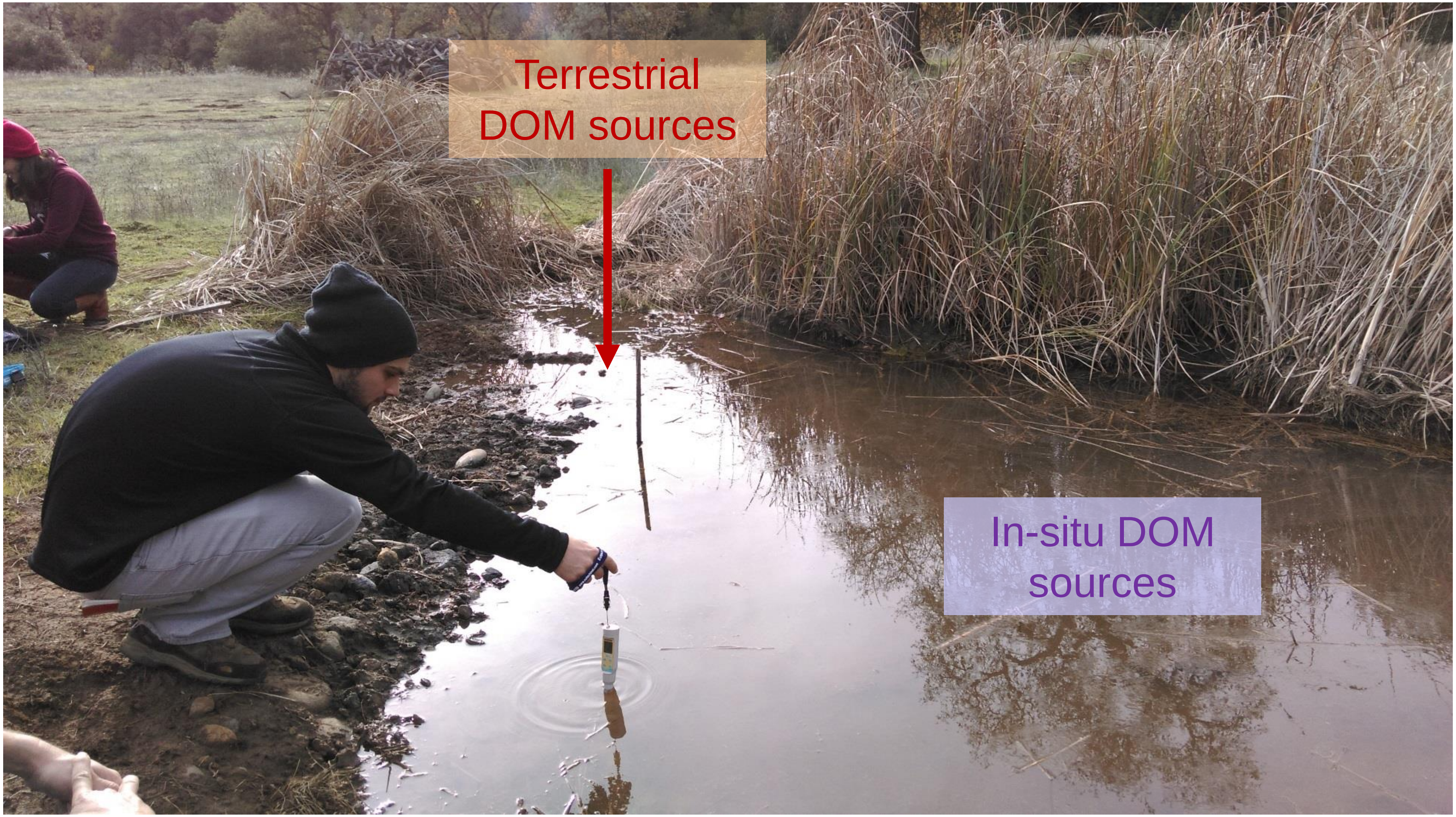
www.omicsonline.org

DOM polymer model



dl.sciencesocieties.org

DOM sources



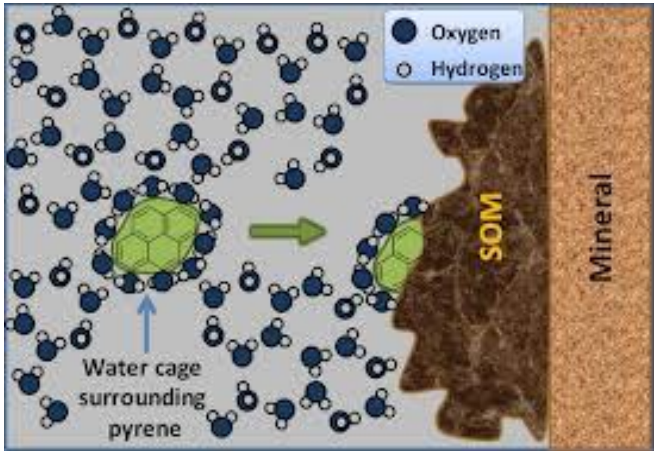
Big Chico Creek Ecological Reserve - Nov. 16, 2014

Why study DOM in freshwaters?

Contaminant transport and uptake

DOM enables the transport of **metals**

and **organic contaminants**

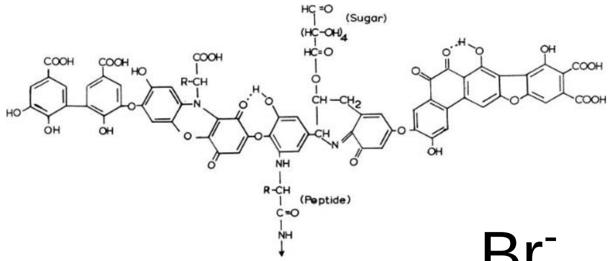


Thompson & Goyne (2012)

Why study DOM in freshwaters?

Water Quality

DOM is a precursor for carcinogenic **disinfection by-products** (DBPs)



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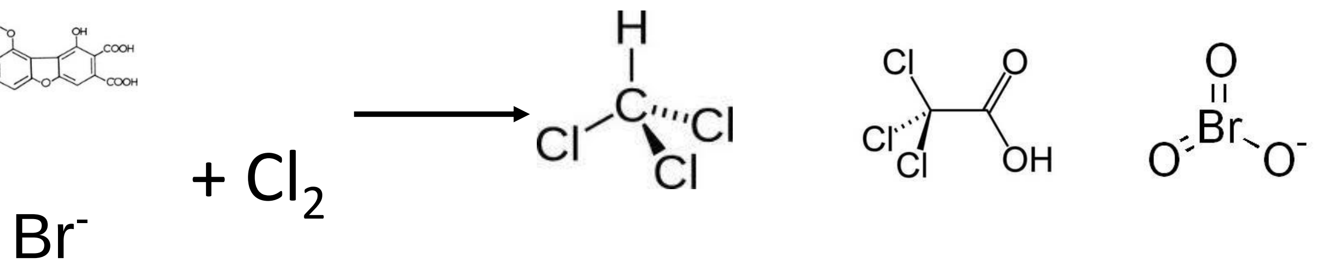


trihalomethanes haloacetic acids bromate

EPA regulates one group of DBPs: trihalomethanes (MCL: 80 µg/L)

Target for drinking water intakes: **< 3 mg/L DOC** (CALFED, 2007)

Dissolved Organic Carbon – summary

Highest DOC concentrations in Clear and Dry Creeks in the valley

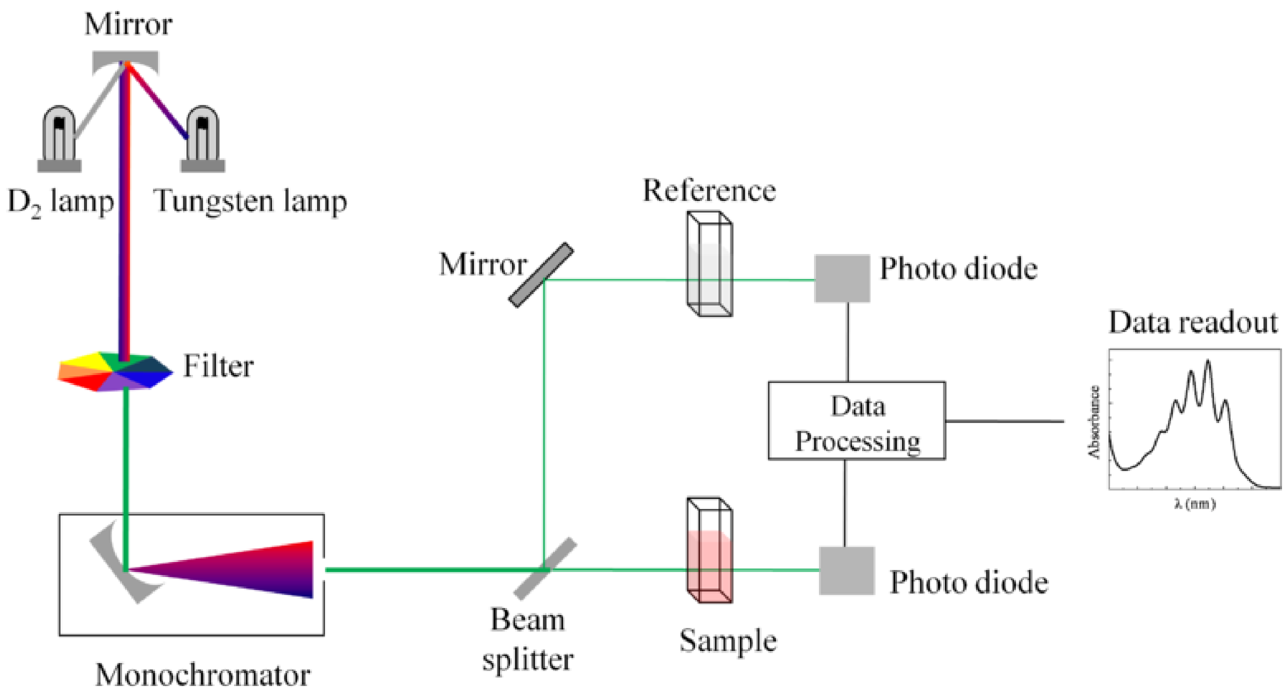
Over the course of the rainy season, DOC concentrations increased in creeks affected by the fire but decreased in Big Chico Creek (unaffected by the fire)

Total Dissolved Nitrogen – summary

Highest TDN concentrations in waters draining from burned areas

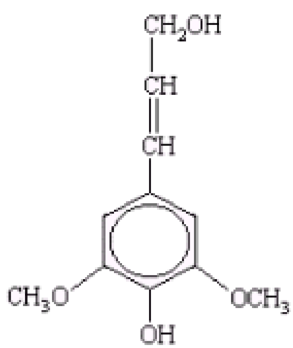
Tracing combustion products with UV-visible absorbance

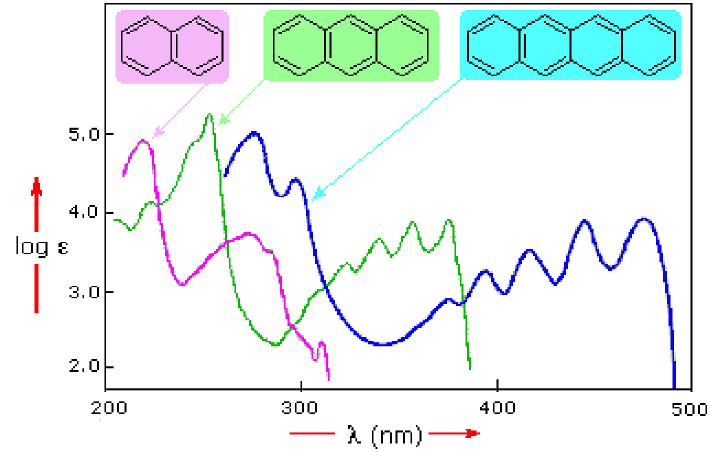
UV-visible spectroscopy measures the absorbance of a sample



Absorbance of aromatic molecules

- Many combustion products are **aromatic** molecules and absorb light (have color)

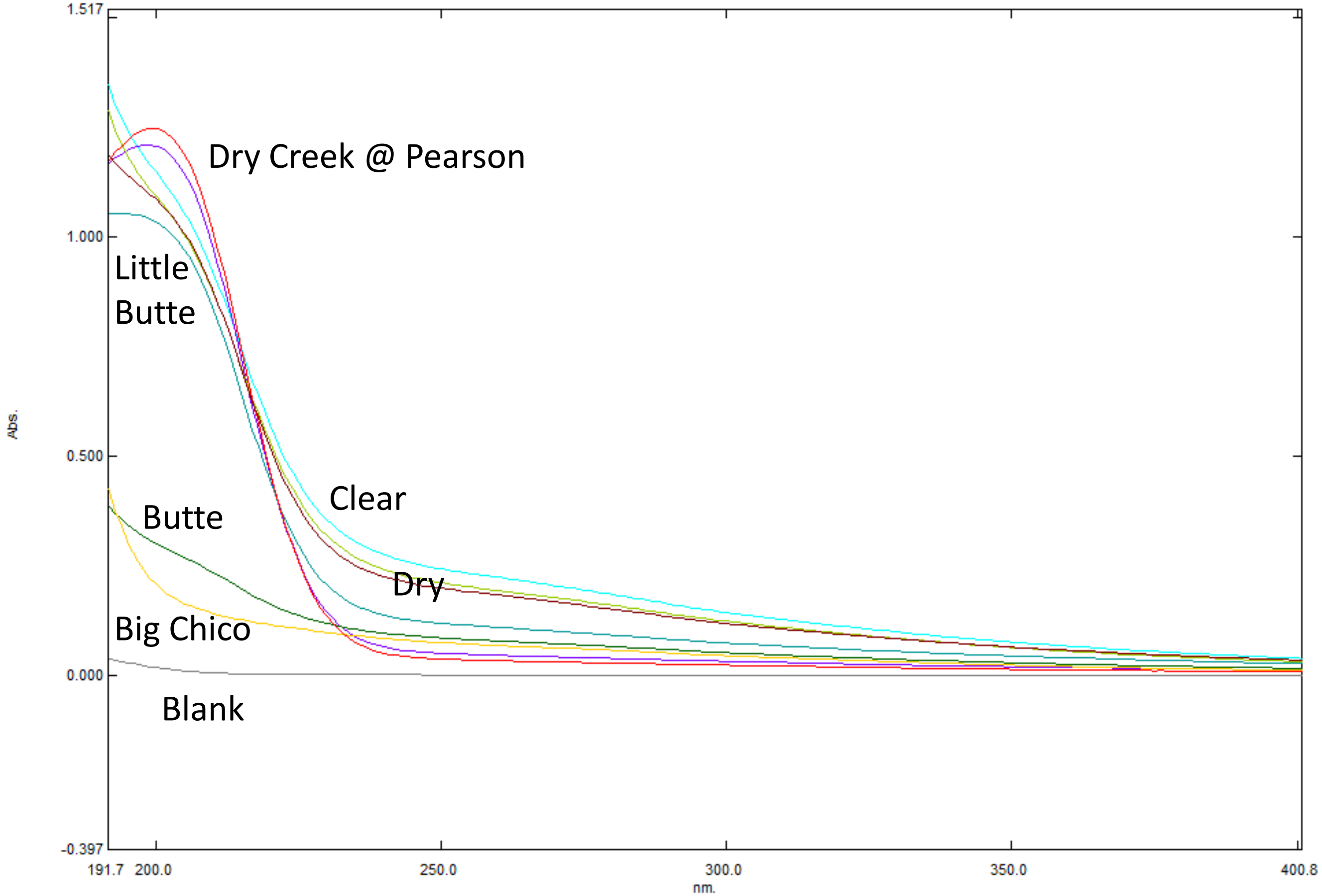




- Each organic molecule absorbs light in a specific way

Absorbance of aromatic molecules

Absorbance spectra summarize the aromatic composition of samples



Specific UV Absorbance at 254 nm ($SUVA_{254}$)

- **S**pecific **UV A**bsorbance at 254 nm ($SUVA_{254}$) is the carbon-normalized absorbance of a filtered sample at 254 nm:

$$SUVA_{254} = \frac{UV\ absorbance\ @\ 254\ nm\ (m^{-1})}{DOC\ (mg\ L^{-1})} * 100$$, units: (mg L^{-1} m^{-1})

SUVA is proportional to the **aromatic character** of a sample, provides a “snapshot” of the DOC composition

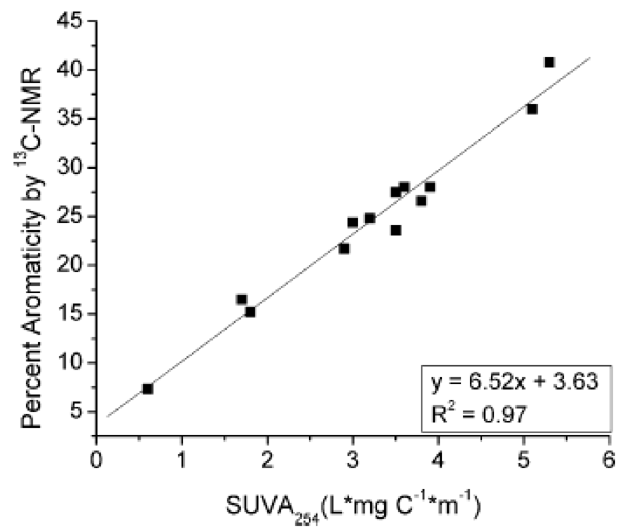


FIGURE 1. $SUVA_{254}$ versus percent aromaticity determined by ^{13}C NMR.

Environ. Sci. Technol. **2003**, *37*, 4702−4708

$SUVA_{254}$ – summary

Generally greater aromaticity ($SUVA_{254}$) in waters affected by burning

Conclusions

Butte Creek Mobile Home Park on Feb. 2, 2019

- Documented export of **organic compounds** over the course of the rainy season
- Clear **increase in nitrogen export** in streams affected by burning
- Export of aromatic molecules (**combustion products**) also enhanced by burning