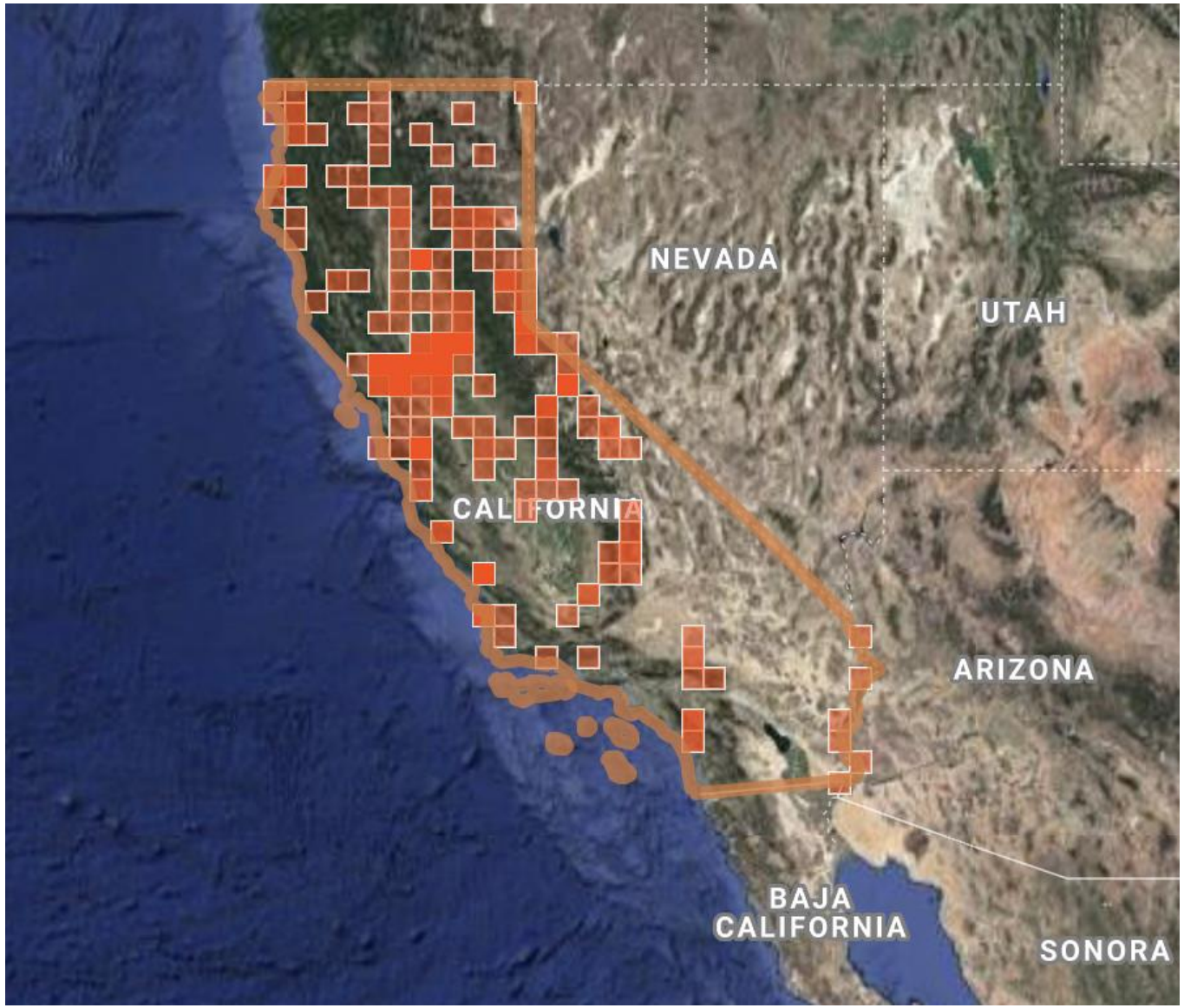
Smokey the Beaver

how beavers help build landscape-scale climate resilience

Presented by Emily Fairfax, Ph.D.
Assistant Professor of Environmental Science and Resource Management
California State University Channel Islands

Prologue: Beavers in California

Are beavers native to California?



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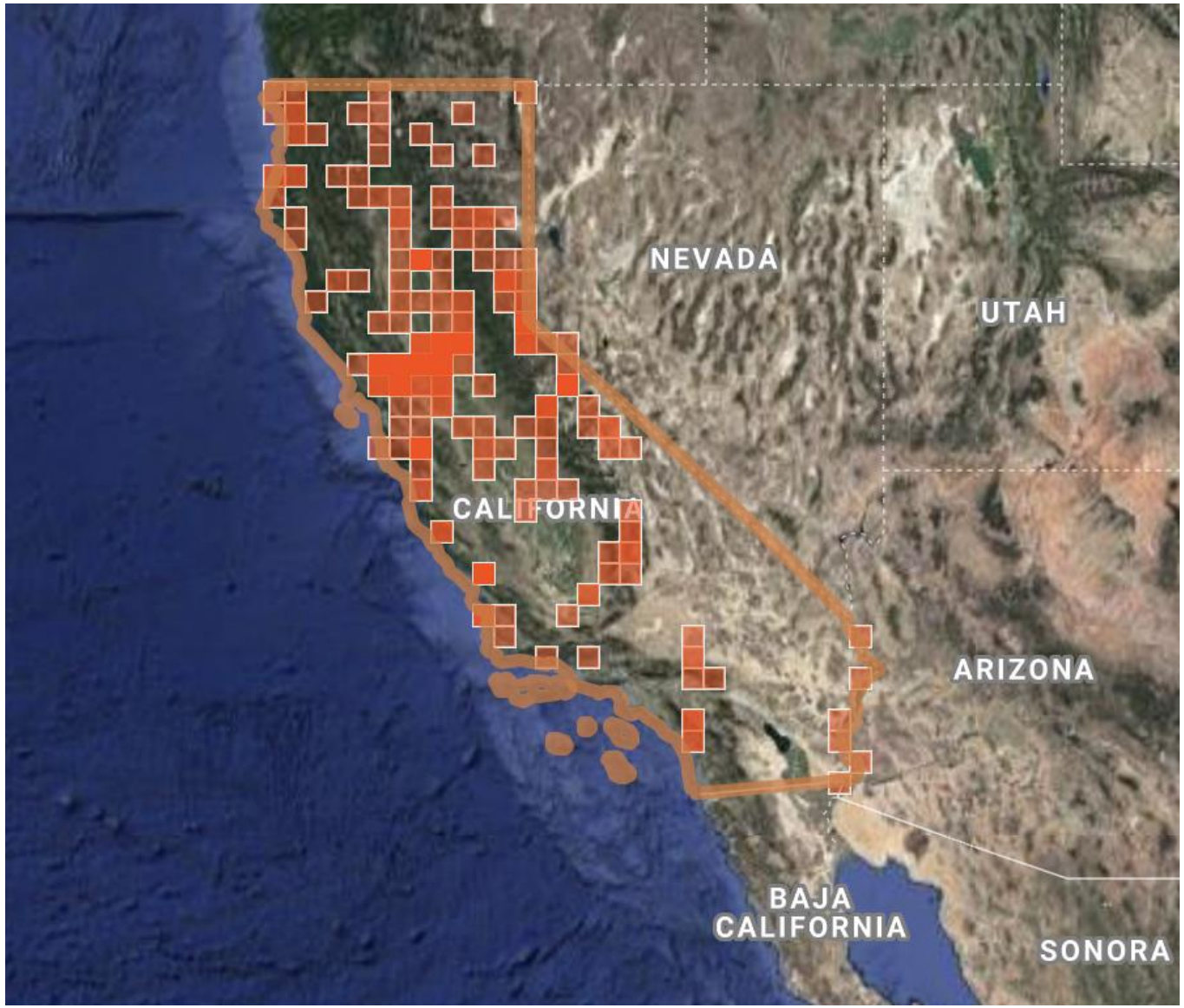
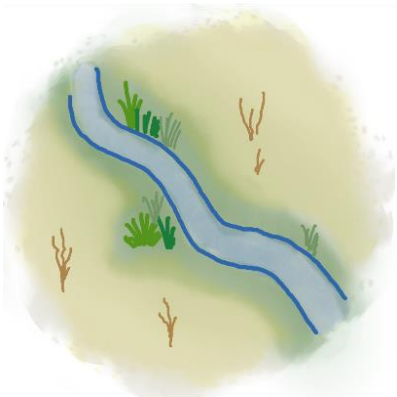


Beavers…and wildfire?

Beavers: Nature's Engineer…and Firefighter?

Photo and Drawing by Emily Fairfax (Sept 2021)

Beavers: Nature's Engineer…and Firefighter?



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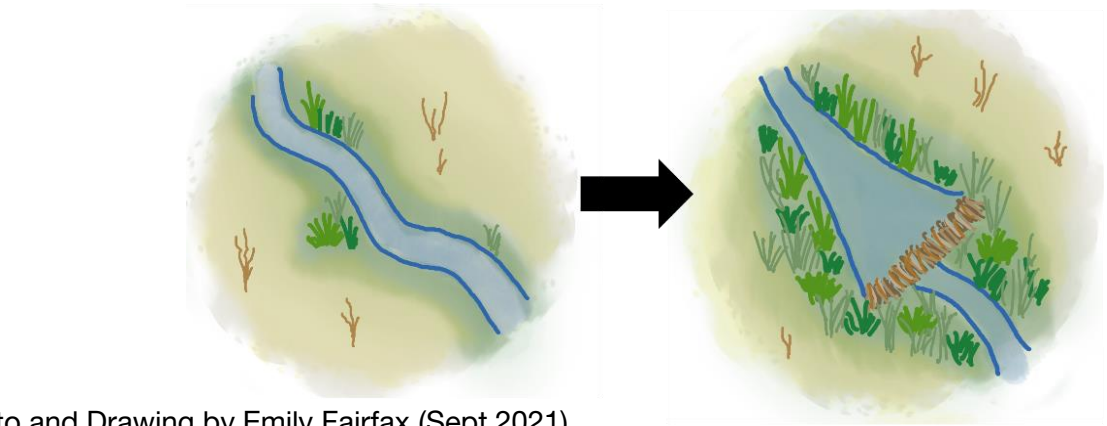

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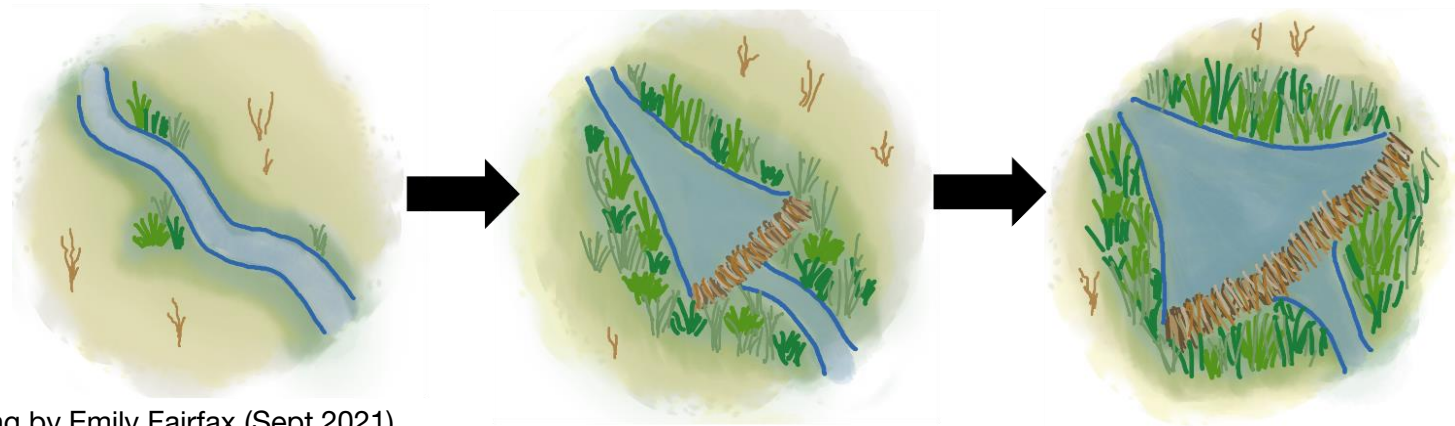

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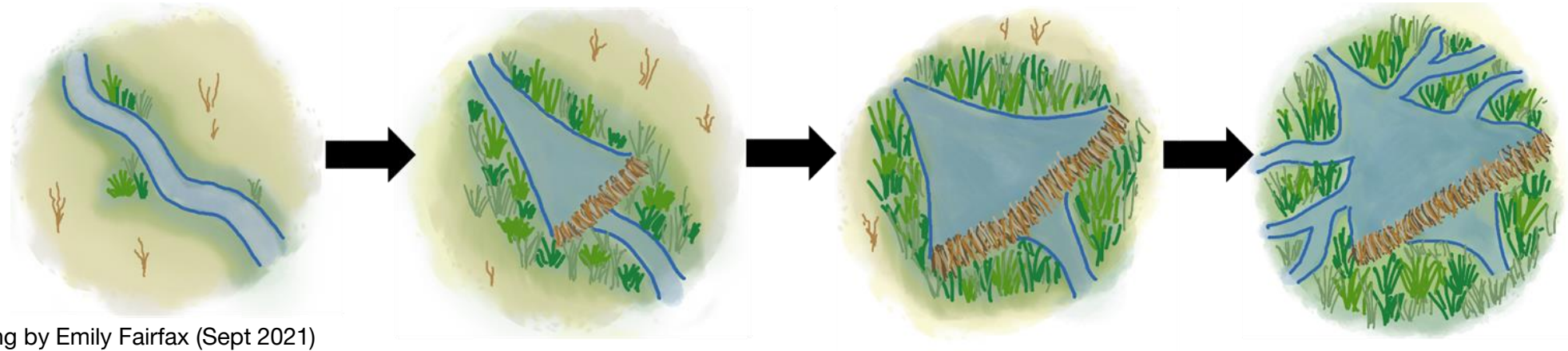

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Felling trees
Dammed lake
Dam
Underwater entrance
Lodge

Beavers create hydrologic complexity

Original Satellite Image

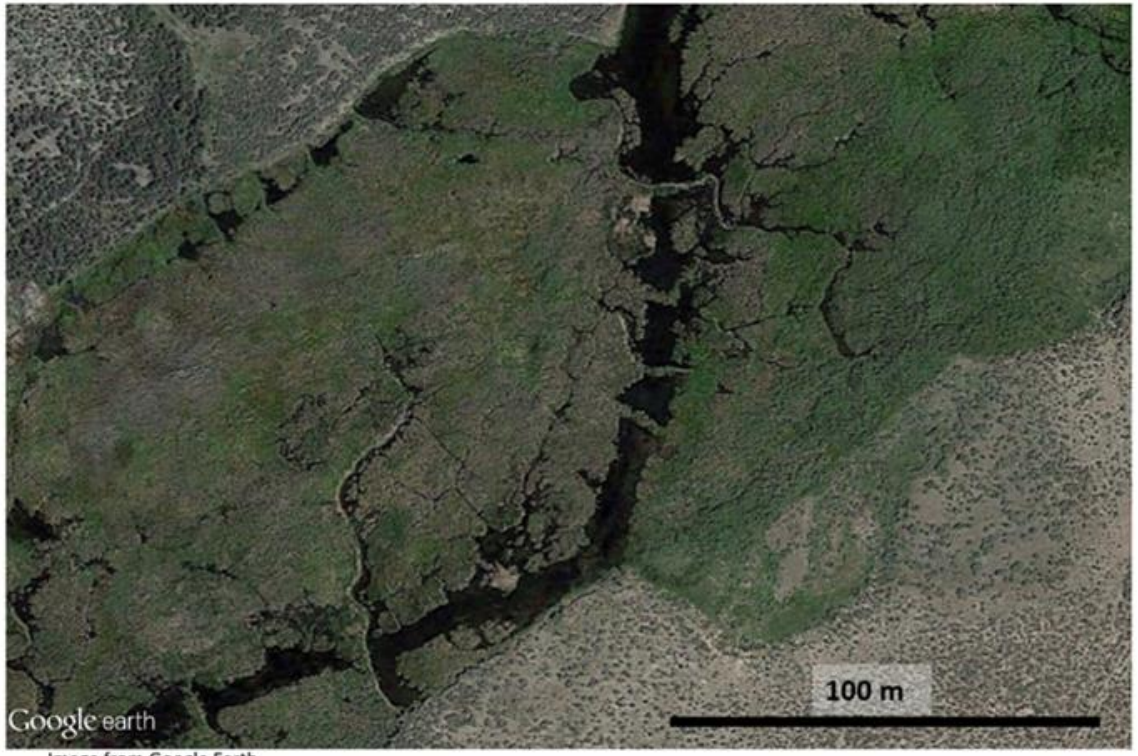

Image from Google Earth

Satellite Image with Beaver Activity Identified

Image from Google Earth

Beaver Dams

Beaver Channels

Beaver Lodge

Beavers create hydrologic complexity

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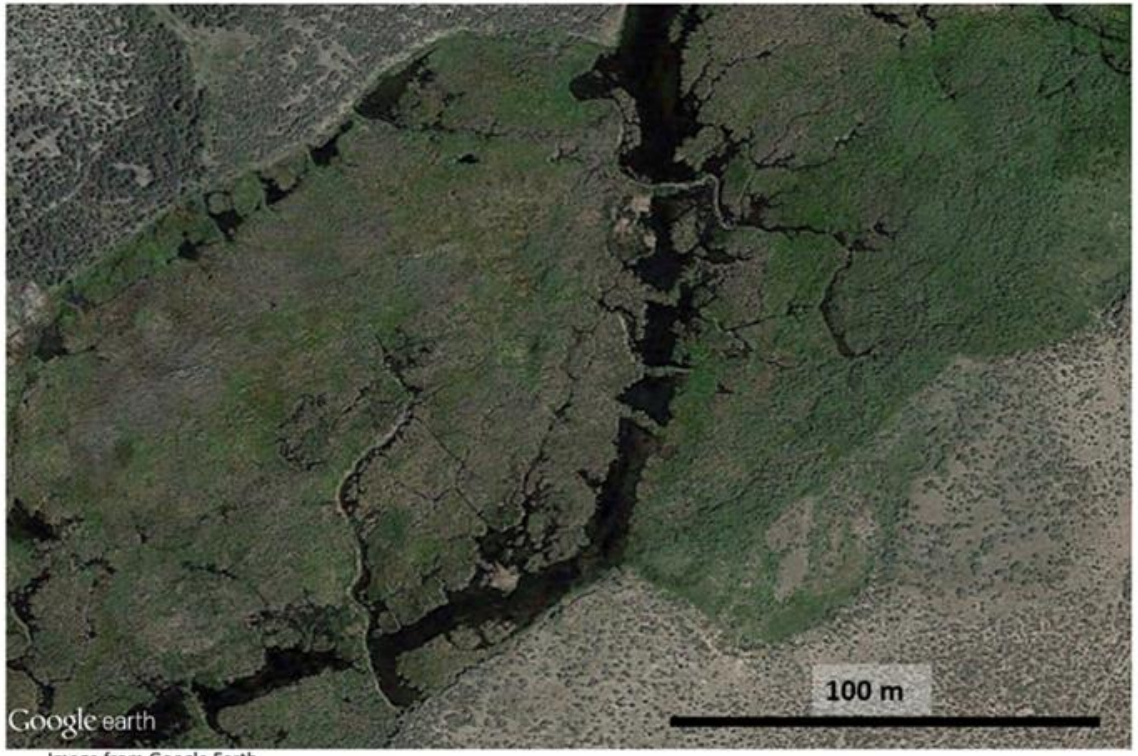

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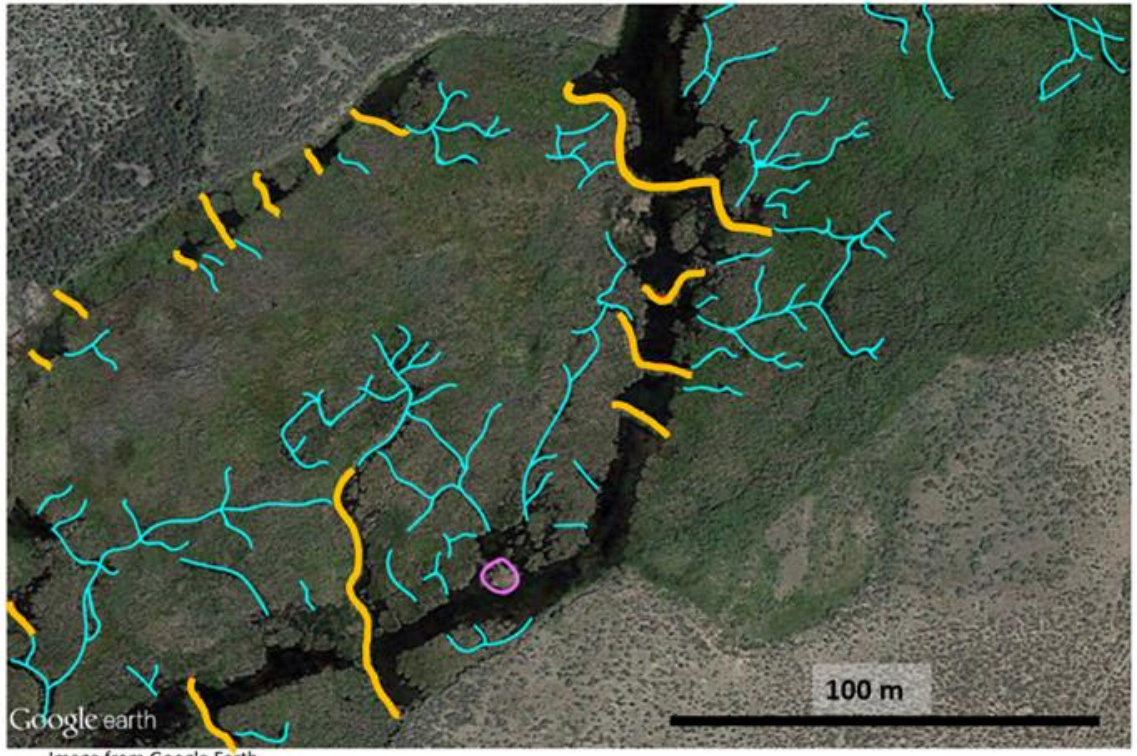

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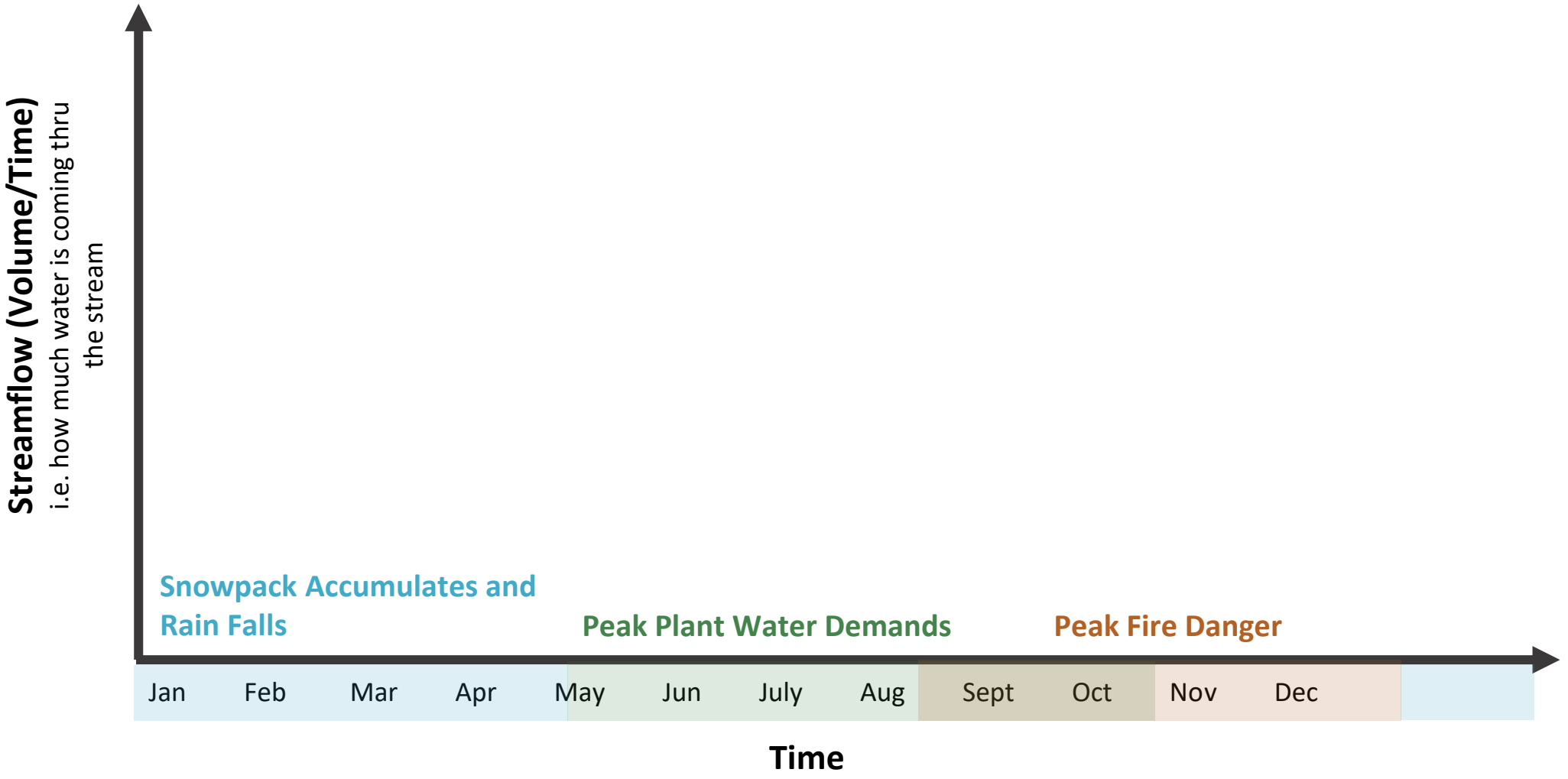
Beaver Dams

Beaver Channels

Beaver Lodge

Beavers slow, but don't stop the water



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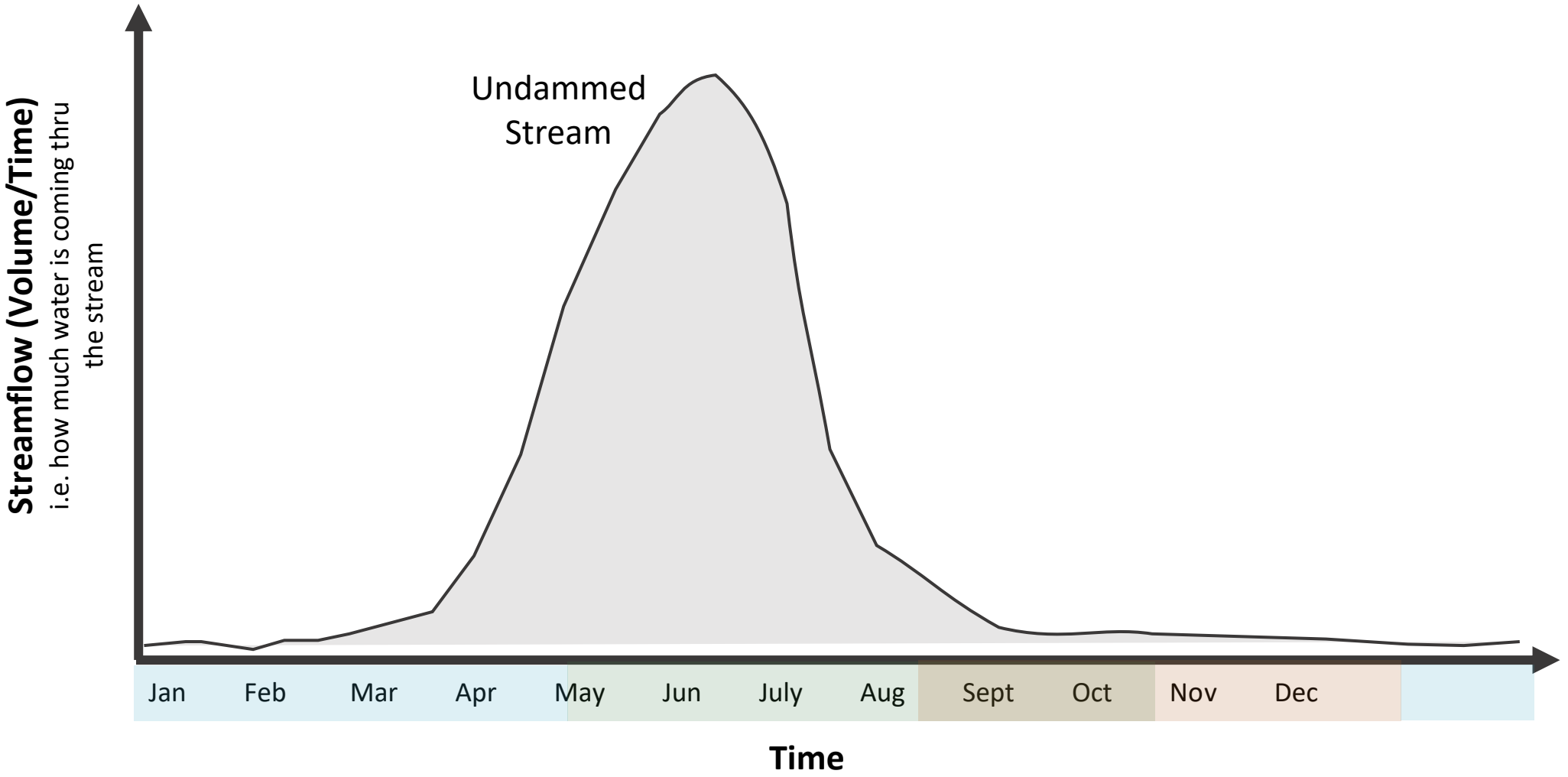

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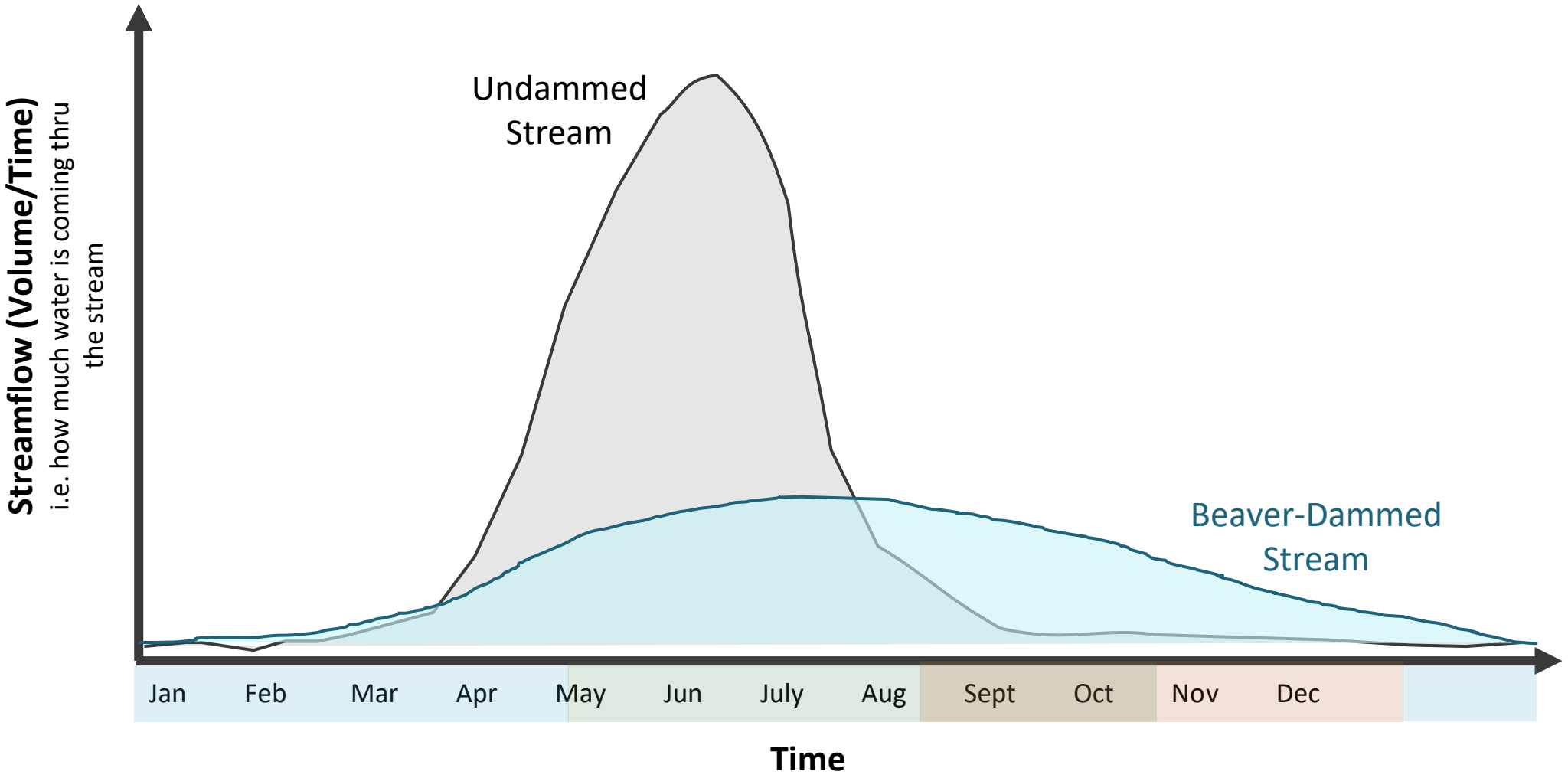

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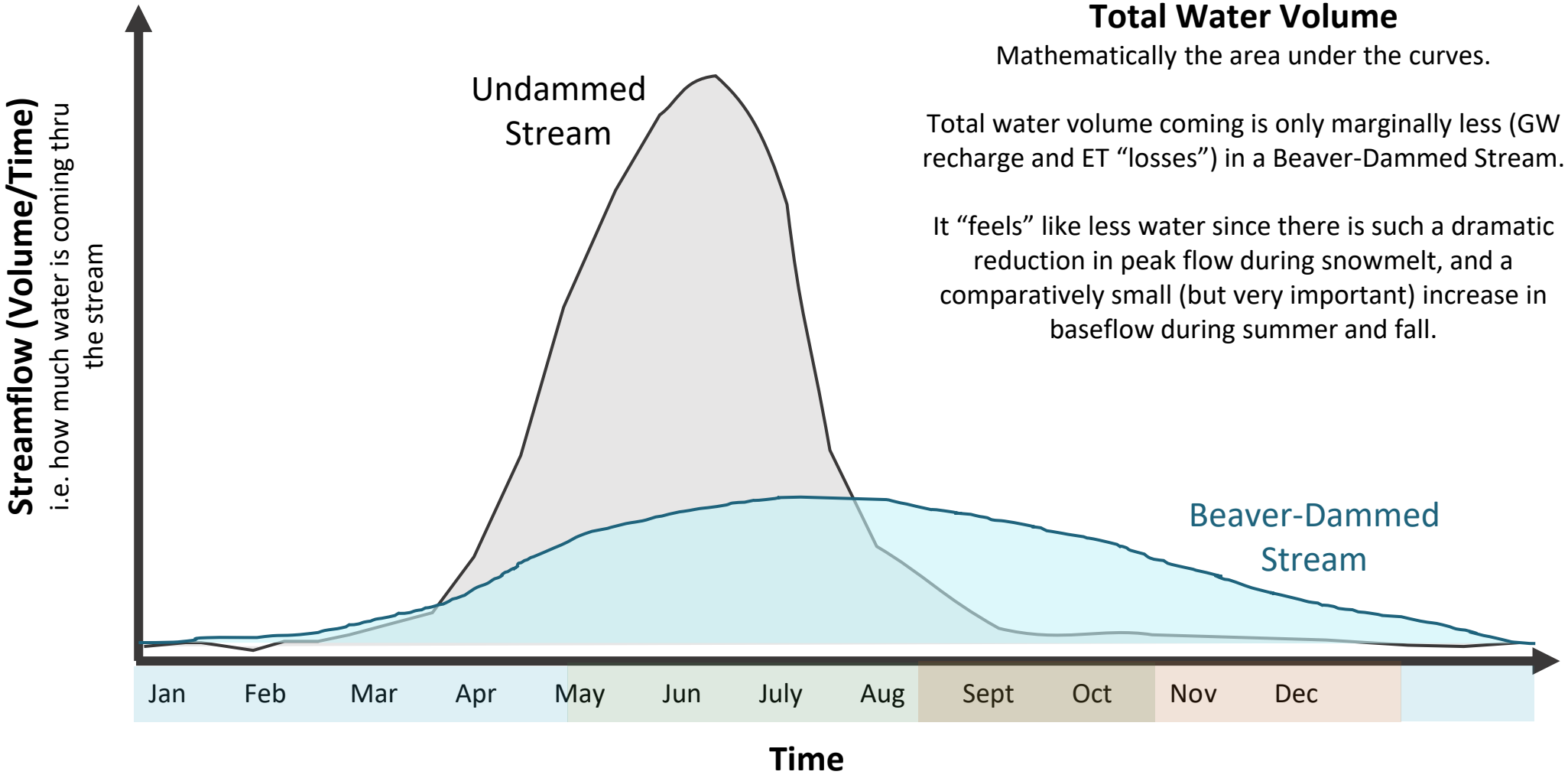


Total Water Volume

Mathematically the area under the curves.

Total water volume coming is only marginally less (GW recharge and ET "losses") in a Beaver-Dammed Stream.

It "feels" like less water since there is such a dramatic reduction in peak flow during snowmelt, and a comparatively small (but very important) increase in baseflow during summer and fall.

Beaver complexes “irrigate” the landscape

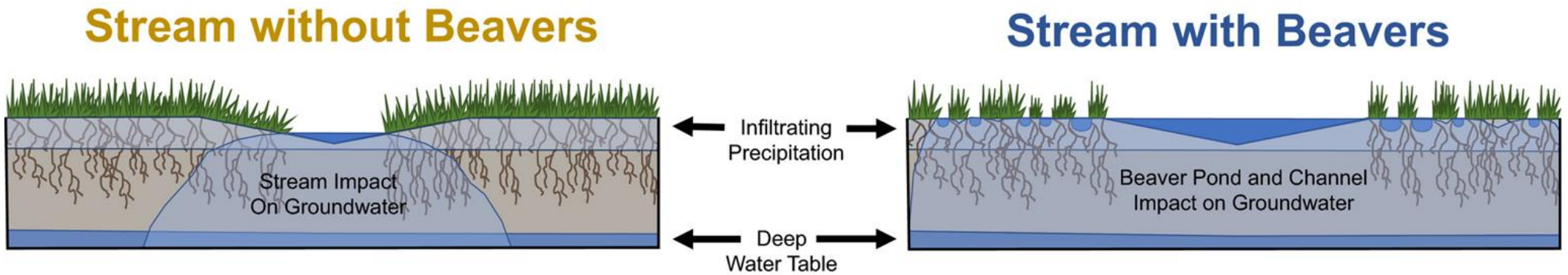
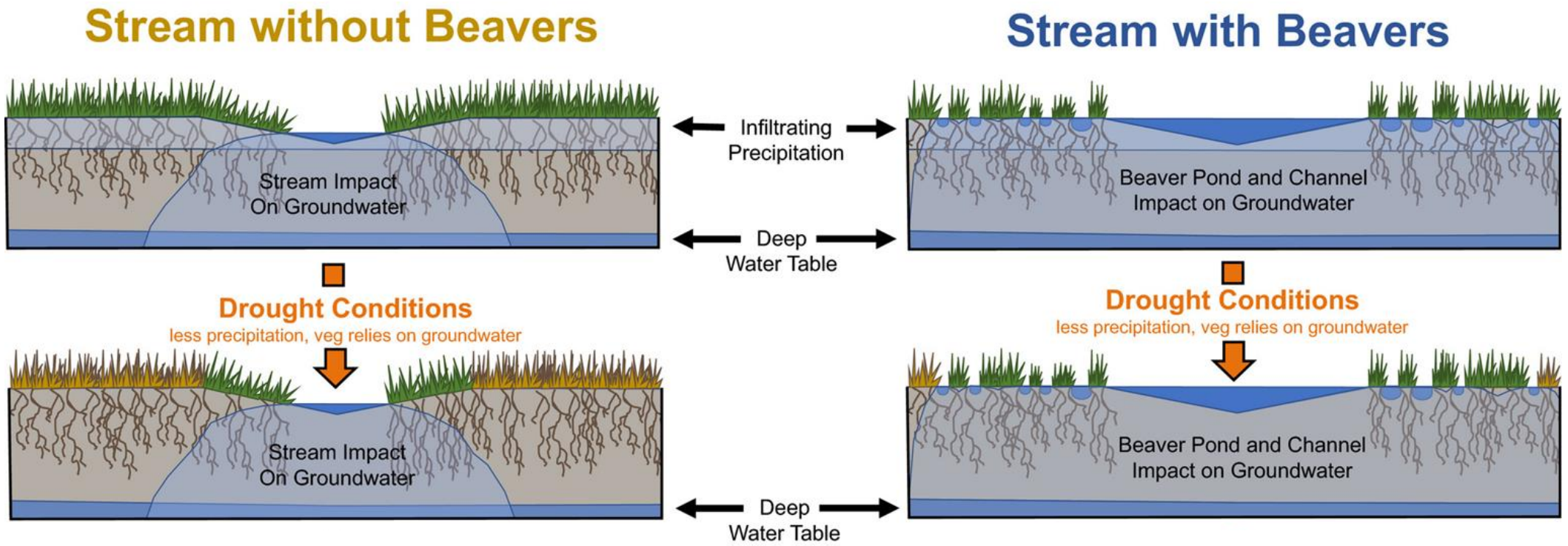


Figure by Emily Fairfax (from Fairfax & Whittle 2020)

Beaver complexes “irrigate” the landscape



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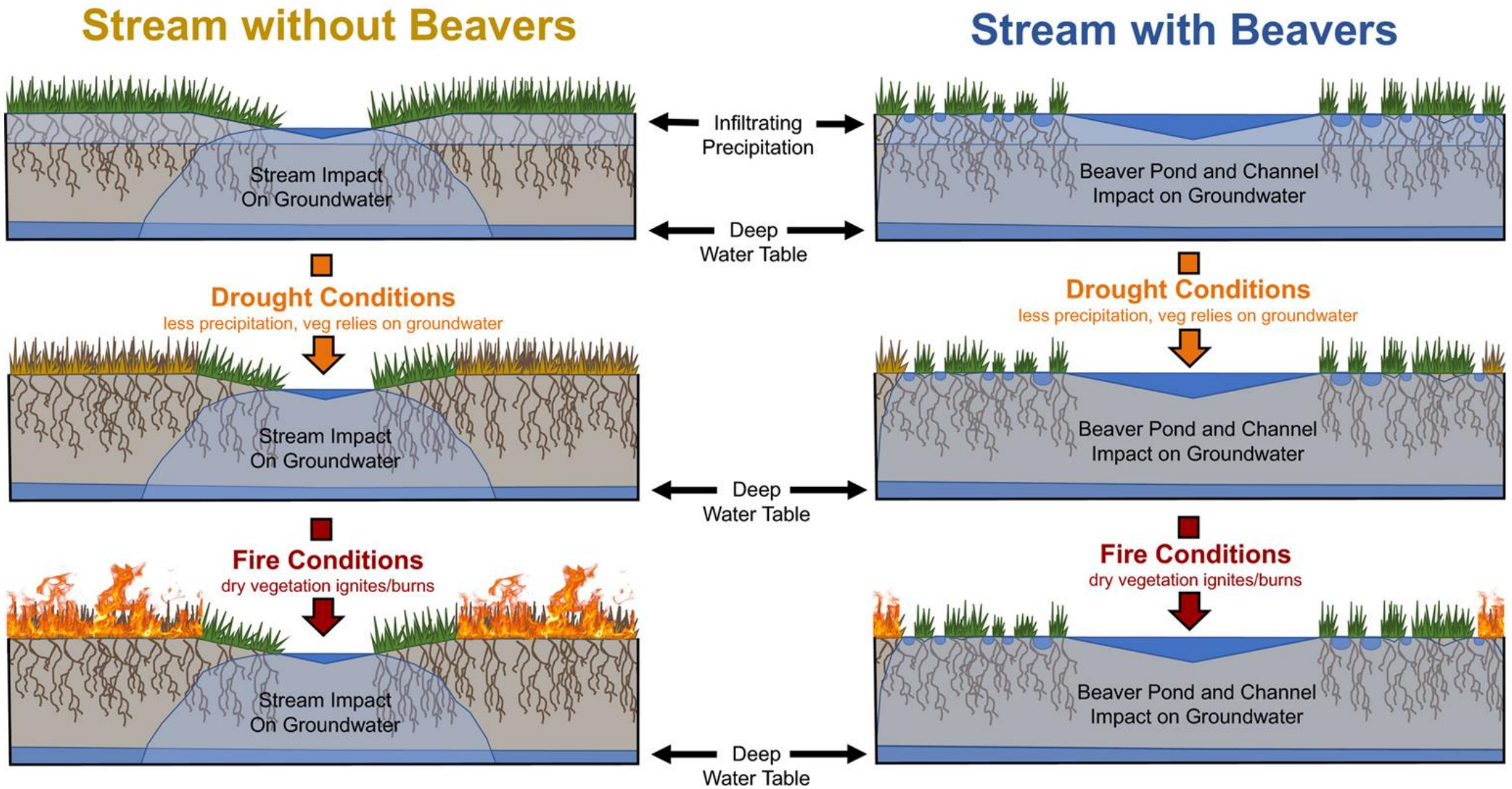

Figure by Emily Fairfax (from Fairfax & Whittle 2020)

Water doesn’t burn. Beaver complexes are wet.

Without Beavers

With Beavers

Photos by **Dr. Joe Wheaton (Utah State University)** of the 2018 Sharps Fire in Idaho. Licensed under CC-BY-4.0

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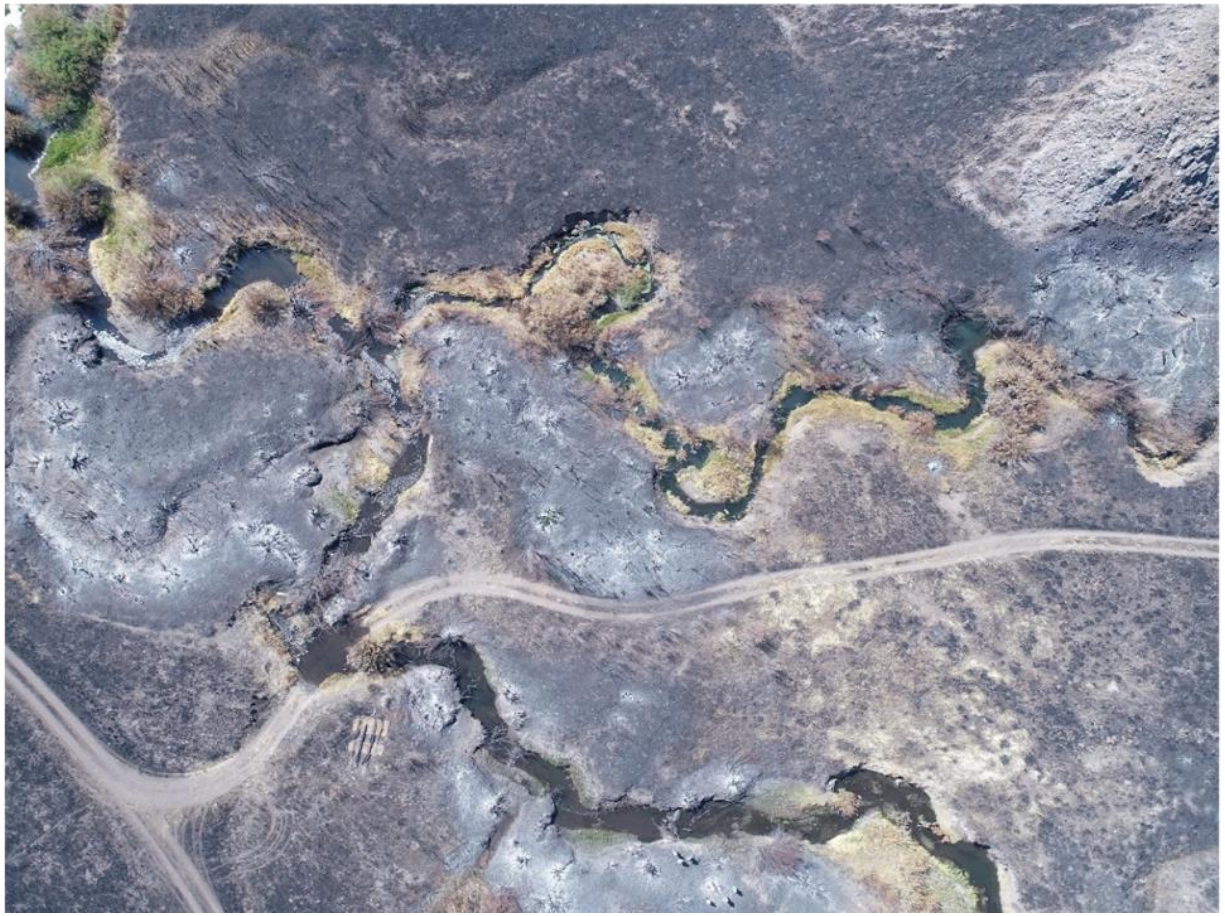
Without Beavers



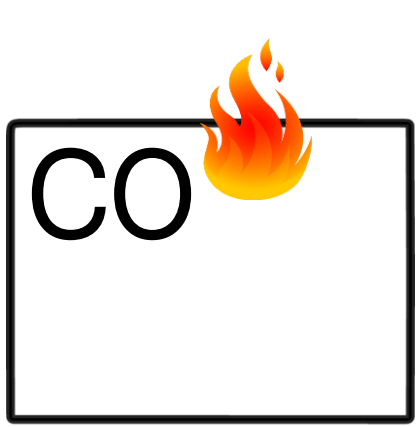
With Beavers

Photos by **Dr. Joe Wheaton (Utah State University)** of the 2018 Sharps Fire in Idaho. Licensed under CC-BY-4.0

From Fairfax & Whittle (2020)

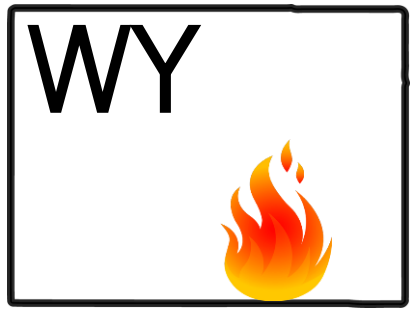
Does it happen everywhere? Or was it an anomaly?

79,000 acres



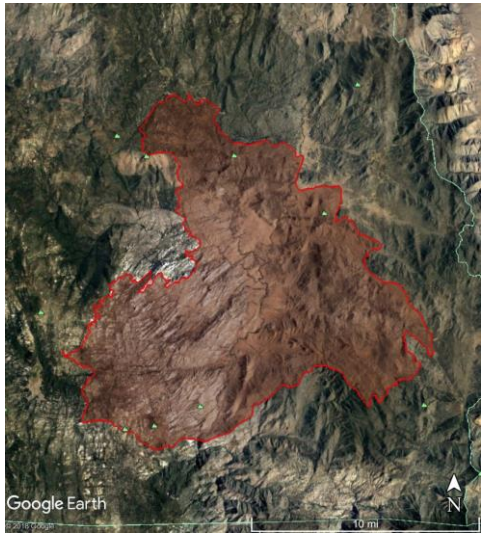
38,000 acres

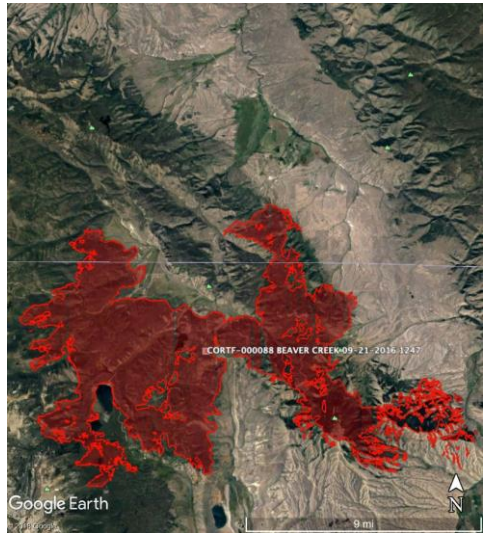
65,000 acres

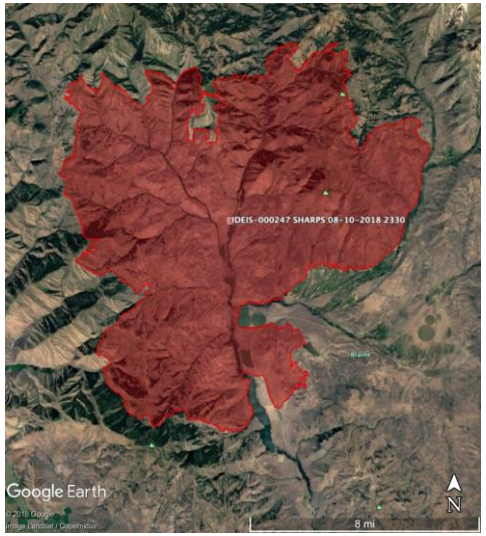


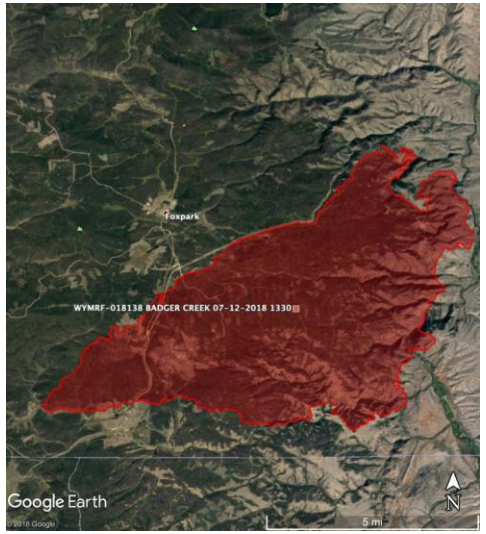
21,000 acres

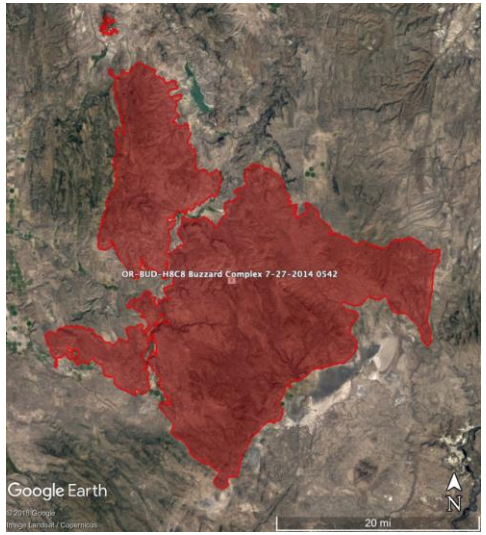
395,000 acres



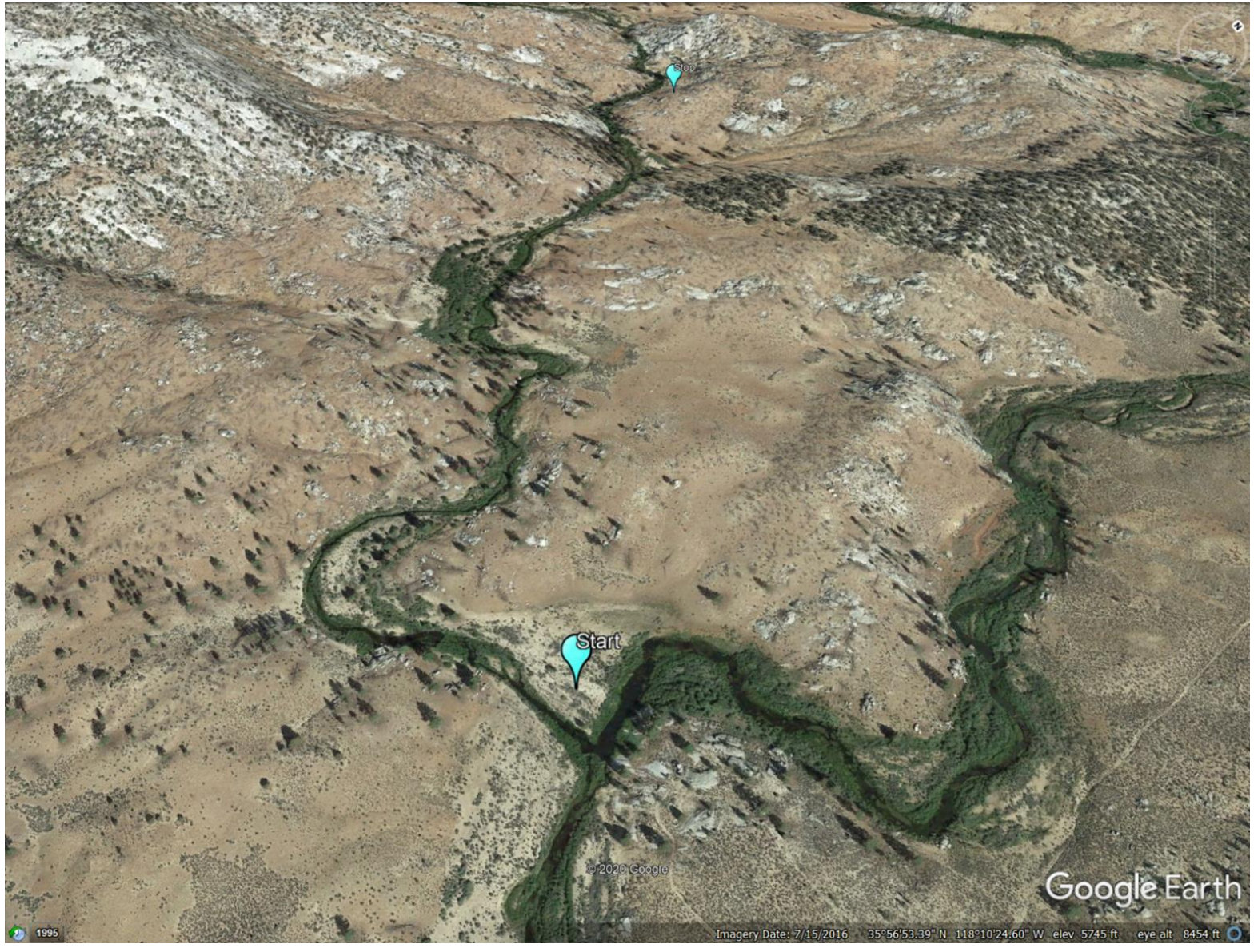






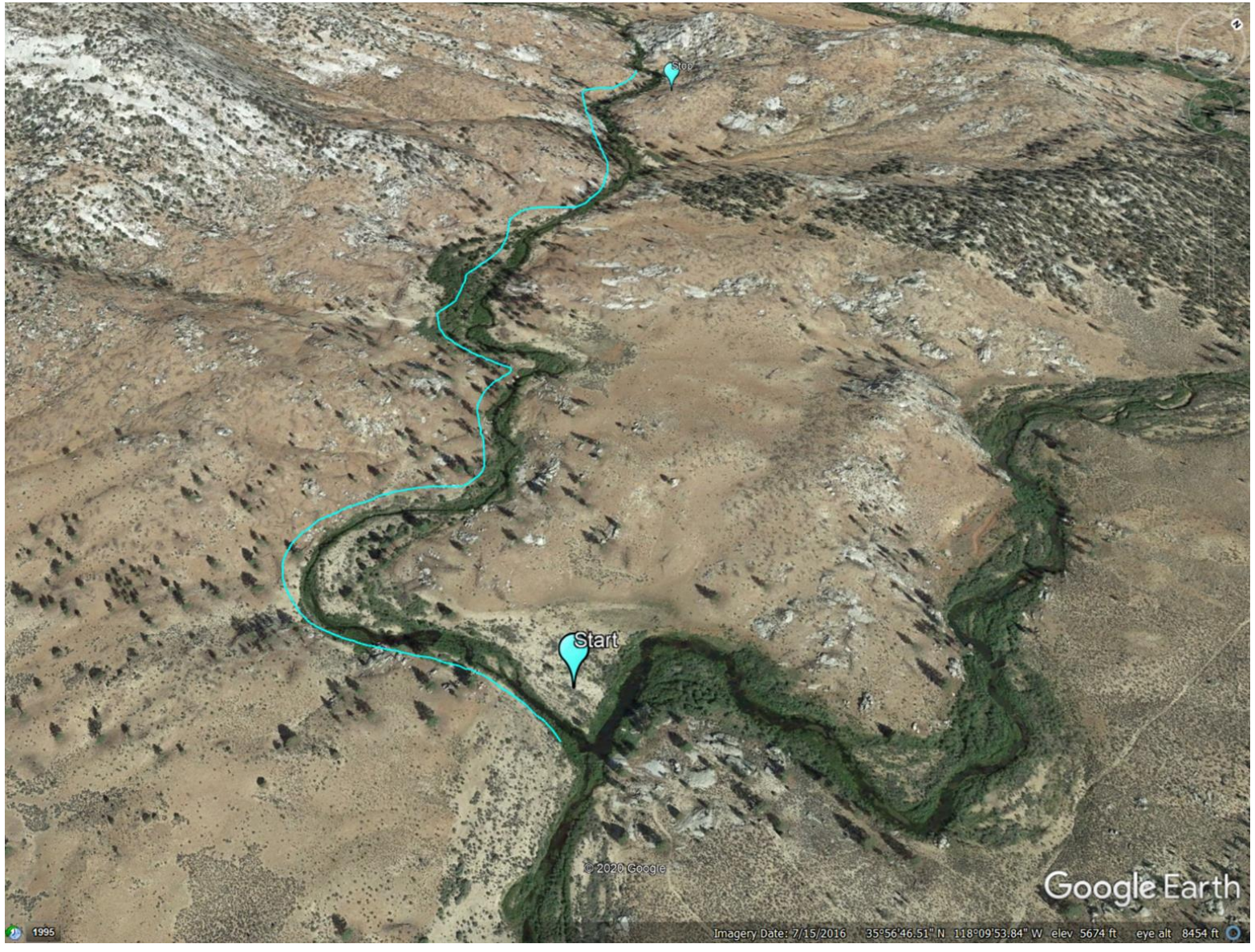


How did we measure the impact of the fire?



Imagine walking along each creek, from a designated start point to a stop point. And doing this for every creek

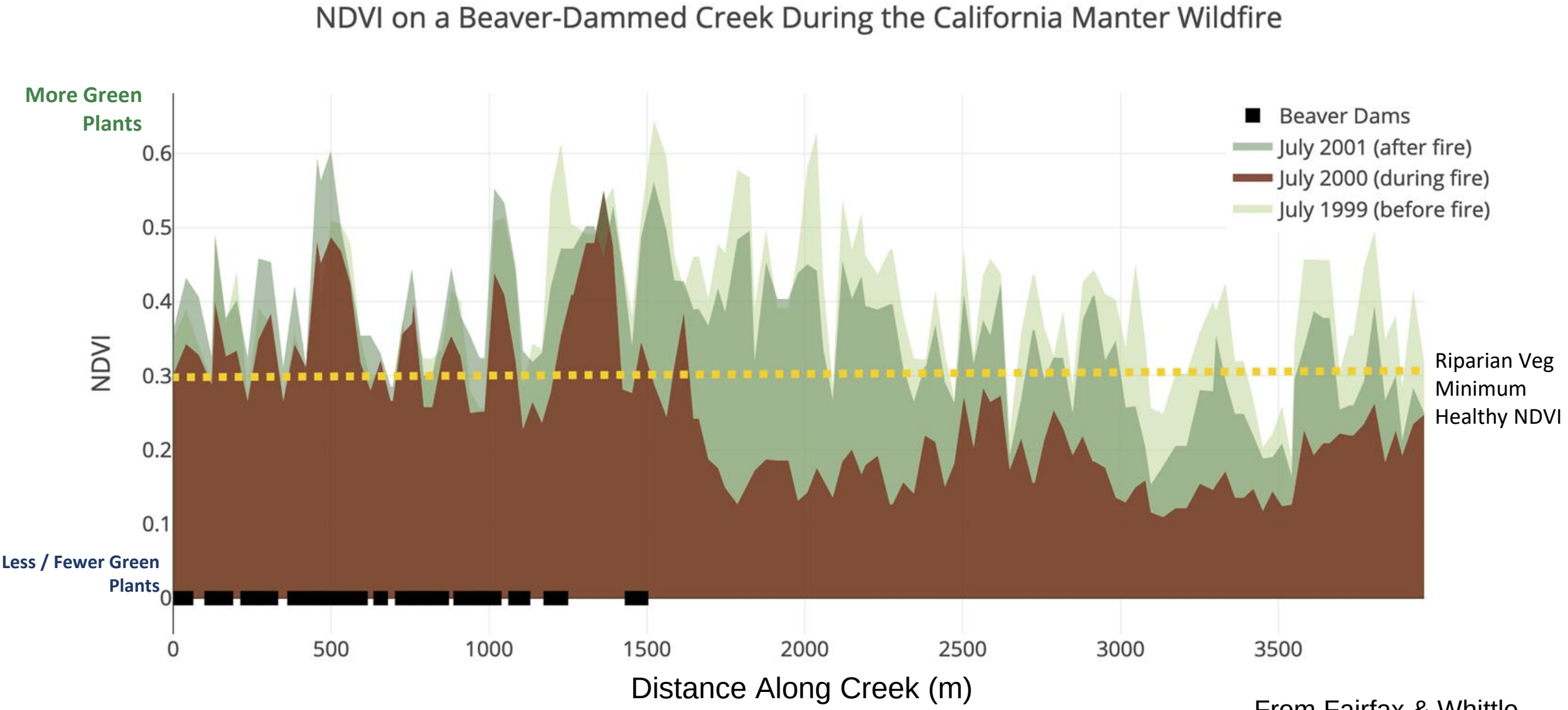
How did we measure the impact of the fire?



Making sure you walk as close to the river as possible, seeing how green plants are as you go.

That is essentially what we did, except instead of walking them we looked at satellite images and extracted “pixel” values along the river corridors.

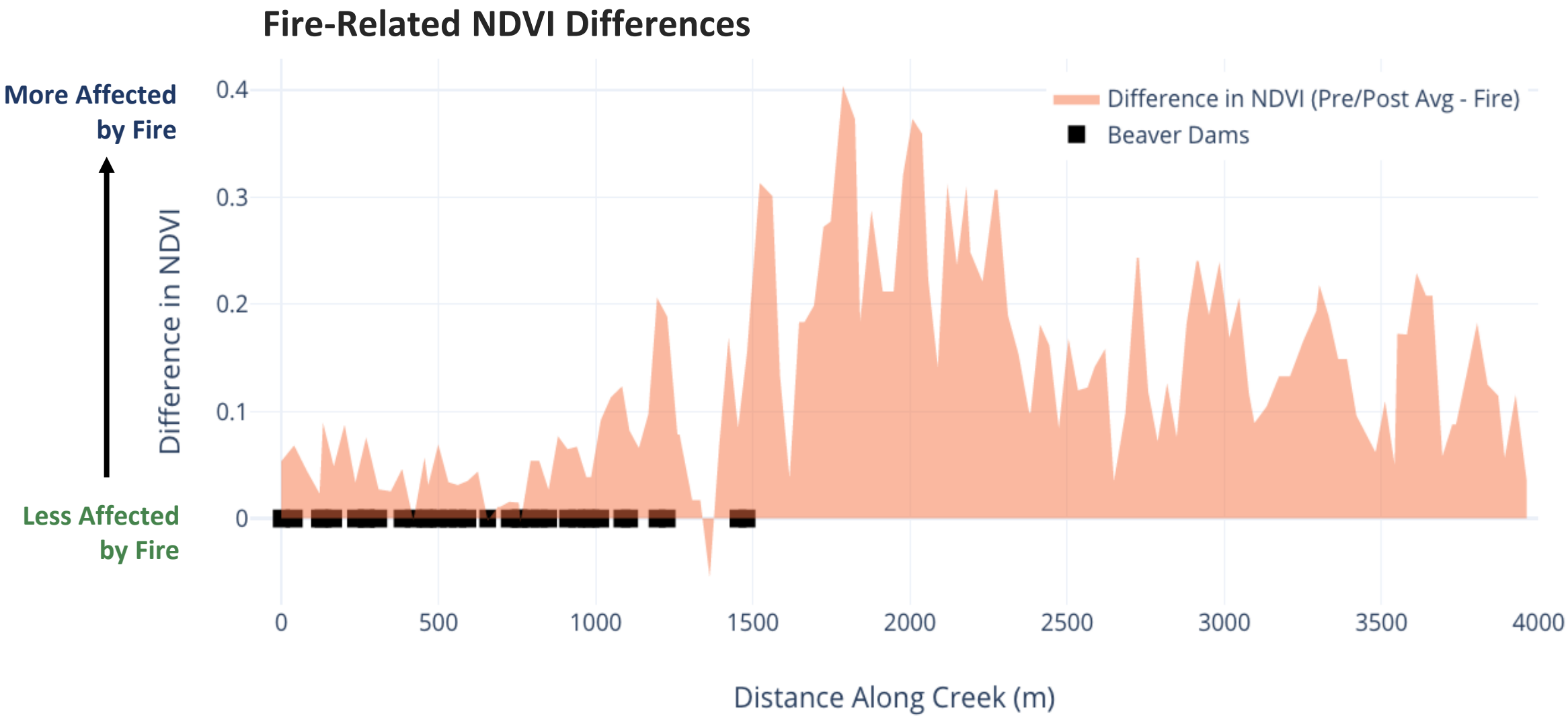
Are the plants green? Before, during, and after fire?



From Fairfax & Whittle

From Fairfax & Whittle (2020)

Beaver complexes suppress the effects of fire.



Consistently. Repeatedly. Reliably.

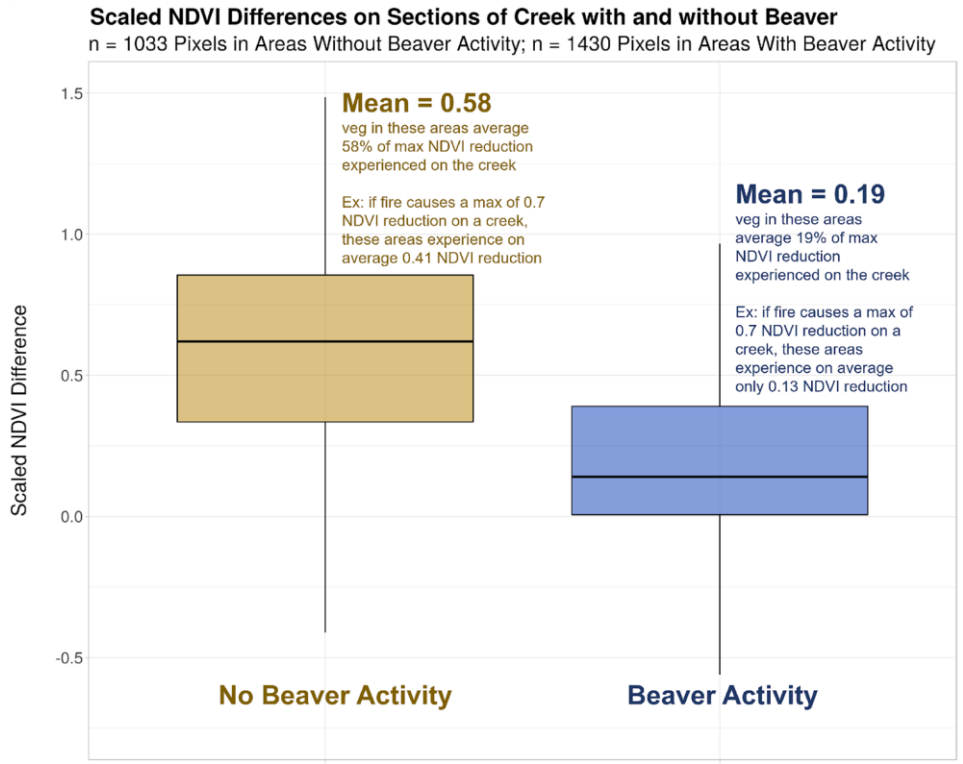
Smokey the Beaver: beaver-dammed riparian corridors stay green during wildfire throughout the western United States

EMILY FAIRFAX [1,3] AND ANDREW WHITTLE [2]

[1]*Department of Environmental Science and Resource Management, California State University Channel Islands, Camarillo, California 93012 USA*
[2]*Department of Geology and Geological Engineering, Colorado School of Mines, Golden, Colorado 80401 USA*

Citation: Fairfax, E., and A. Whittle. 2020. Smokey the Beaver: beaver-dammed riparian corridors stay green during wildfire throughout the western USA. Ecological Applications 30(8):e02225. 10.1002/eap.2225

Photo by Manter Fire BAER Team (2000)



What makes megafires different?

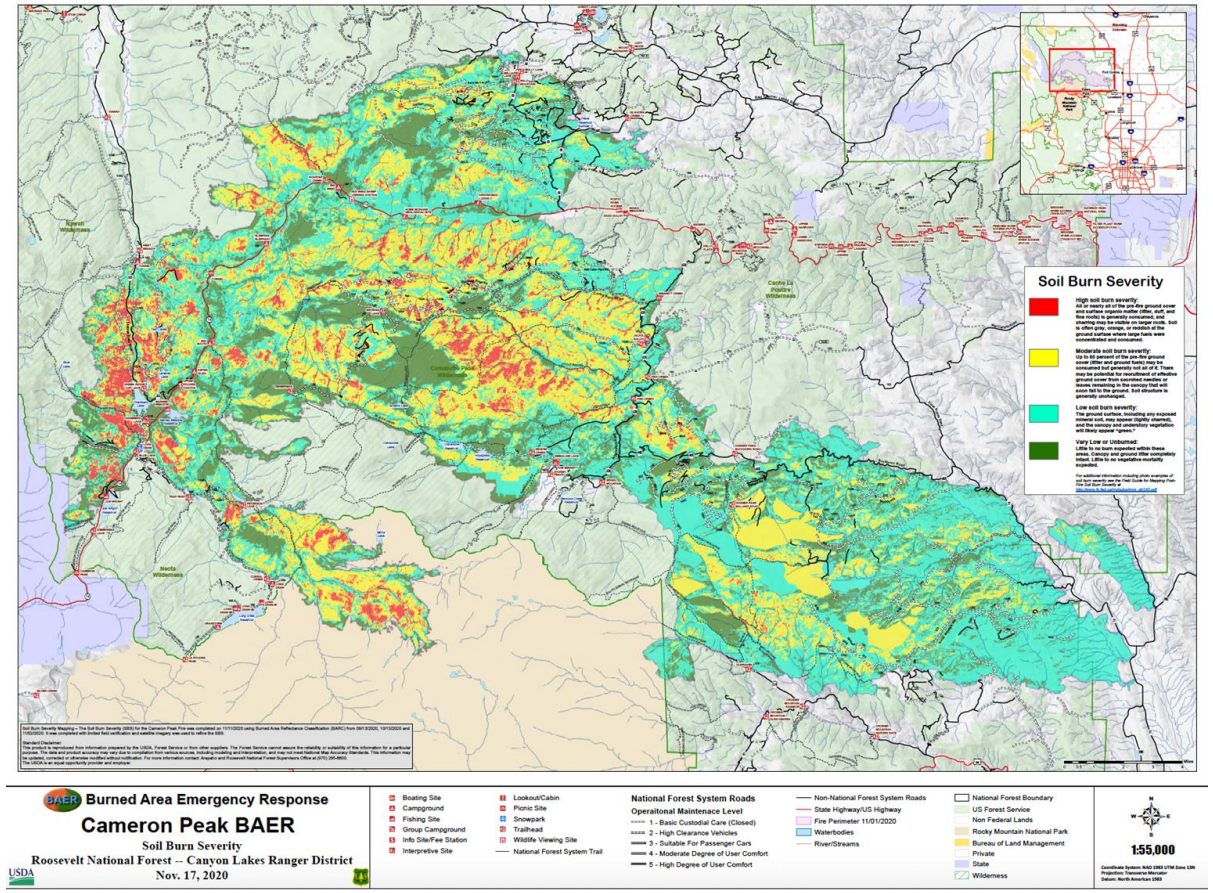
Megafire: a fire with a burn area larger than 100,000 acres

Many megafires exhibit extreme, often self-sustaining fire behaviors such as:

- **Creating Pyrocumulus Clouds** (ember and ash spewing clouds)
- **Creating Pyrocumulonimbus Clouds** (the “fire-breathing dragons of clouds”)
- **Explosive Spread Rates** (e.g. ~100,000 acres in < 24hrs)
- **Larger Moderate-Severe Burn Areas** (faster-growing fires tend to be more destructive)

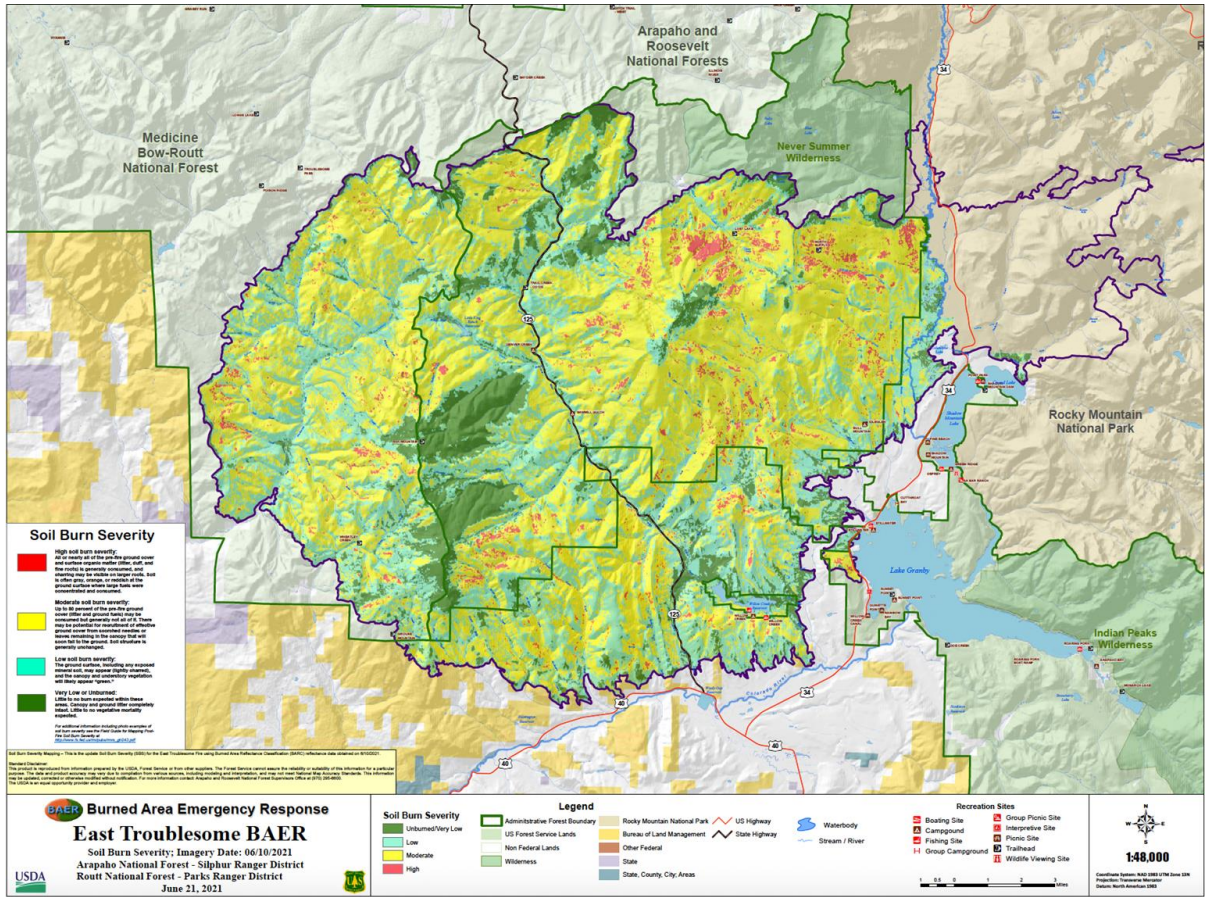
Colorado's Largest Wildfires in (at least) 100 Years

Cameron Peak Fire



Aug 13, 2020 – Dec 2, 2020
208,913 acres, 99 satellite-visible beaver dams

East Troublesome Fire



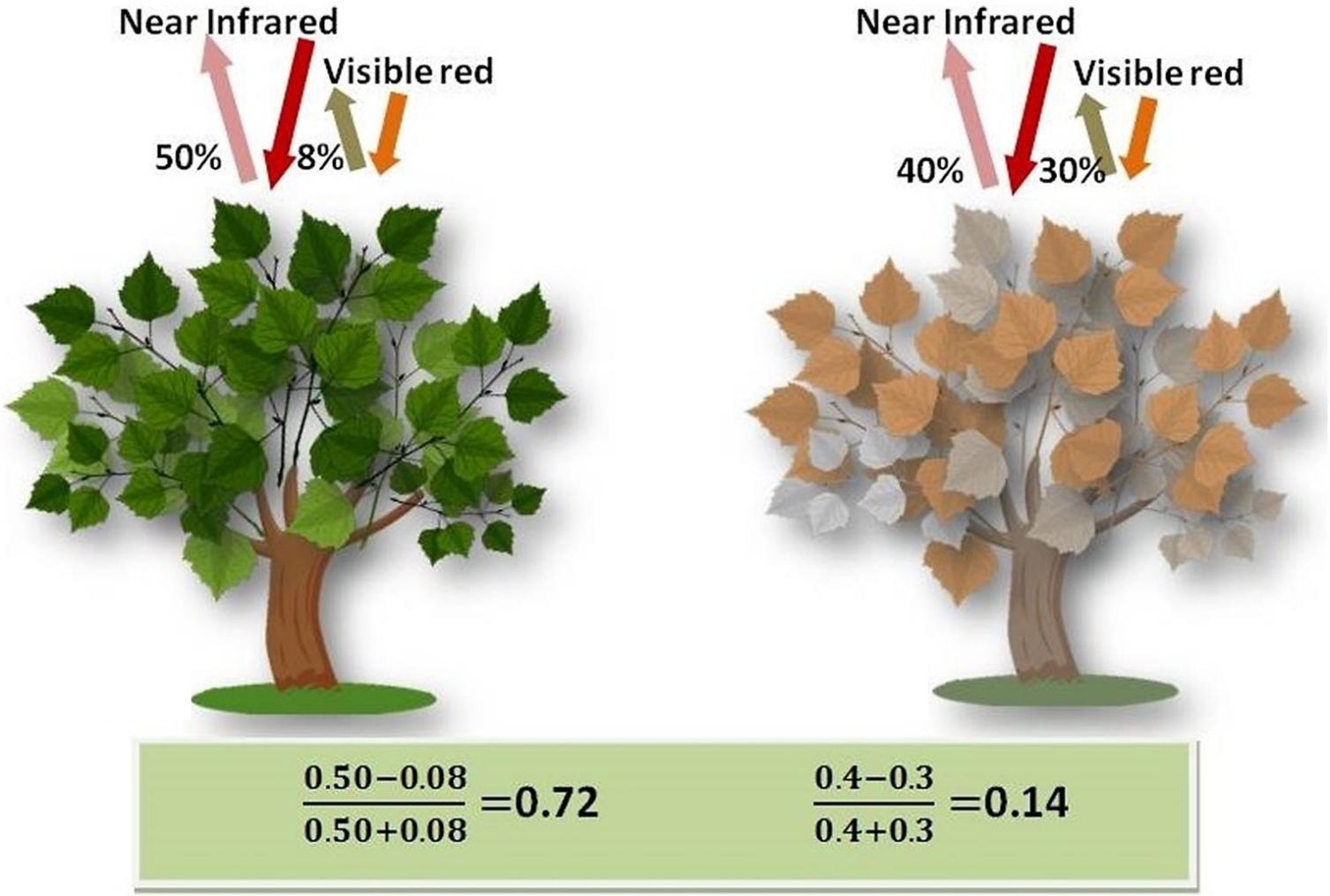
Oct 14, 2020 – Nov 30, 2020
193,812 acres, 512 satellite-visible beaver dams

Autumn & Winter Fires: a remote sensing challenge

NDVI

Normalized Difference Vegetation Index

- Essentially a measure of plant greenness.
- Plants go from green to brown/black when they burn
- Plants also go from green to brown when summer ends in Colorado



Wu, Chih-Da; McNeely, Eileen; G. Cedeño-Laurent, J.; Pan, Wen-Chi; Adamkiewicz, Gary; Dominici, Francesca; et al. (2015): Green vegetation (left) absorbs visible light and reflects near-infrared light; Sparse vegetation (right) reflects more visible light and less near-infrared light.. PLOS ONE. Figure. https://doi.org/10.1371/journal.pone.0108548.g001

Autumn & Winter Fires: a remote sensing challenge

False Color Mapping

Assembles bands of light differently from our eyes / brains so that we can see certain patterns easier

True Color (R, G, B)

Imagery from Sentinel-2 of Cameron Peak Fire on September 3rd, 2020

Autumn & Winter Fires: a remote sensing challenge

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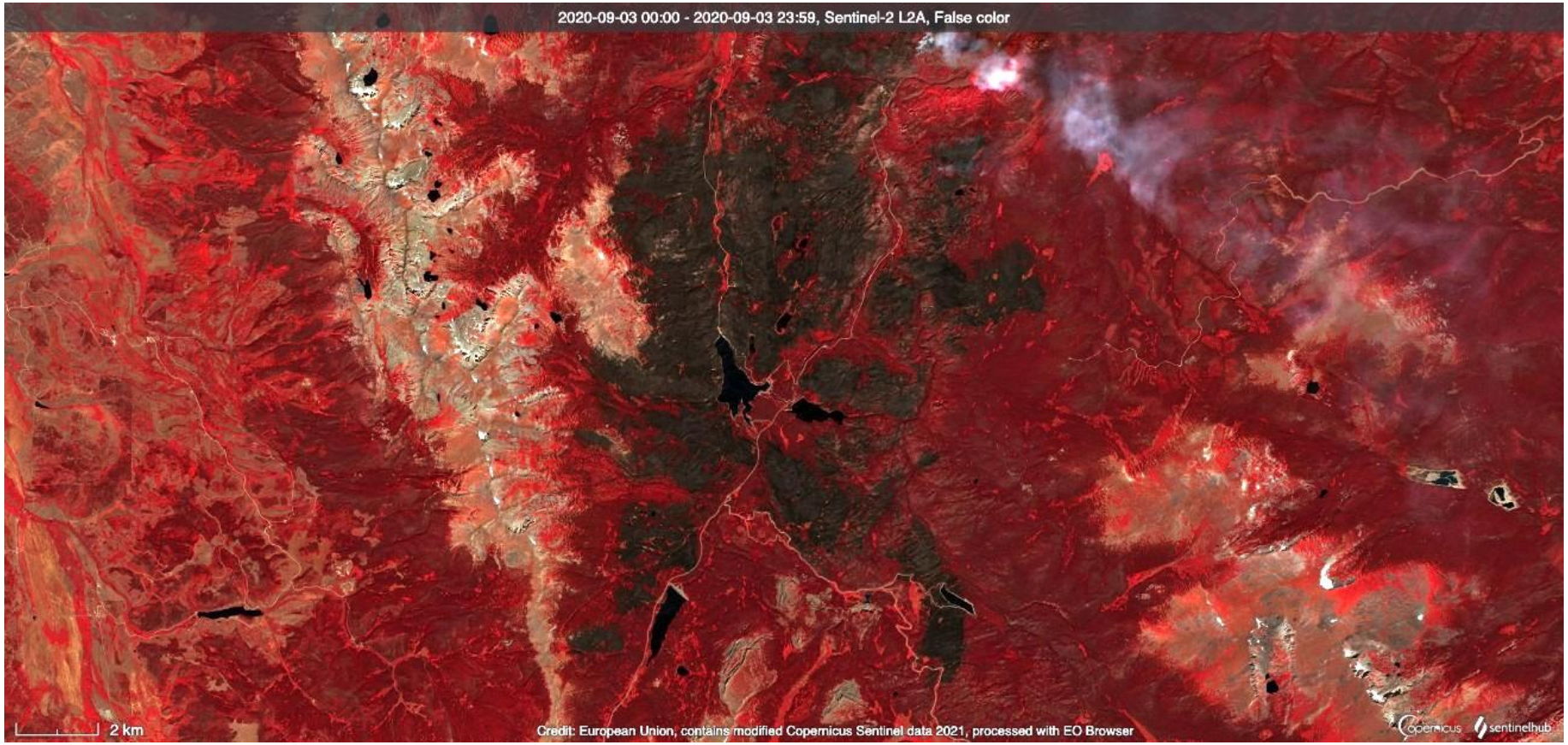

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Autumn & Winter Fires: a remote sensing challenge

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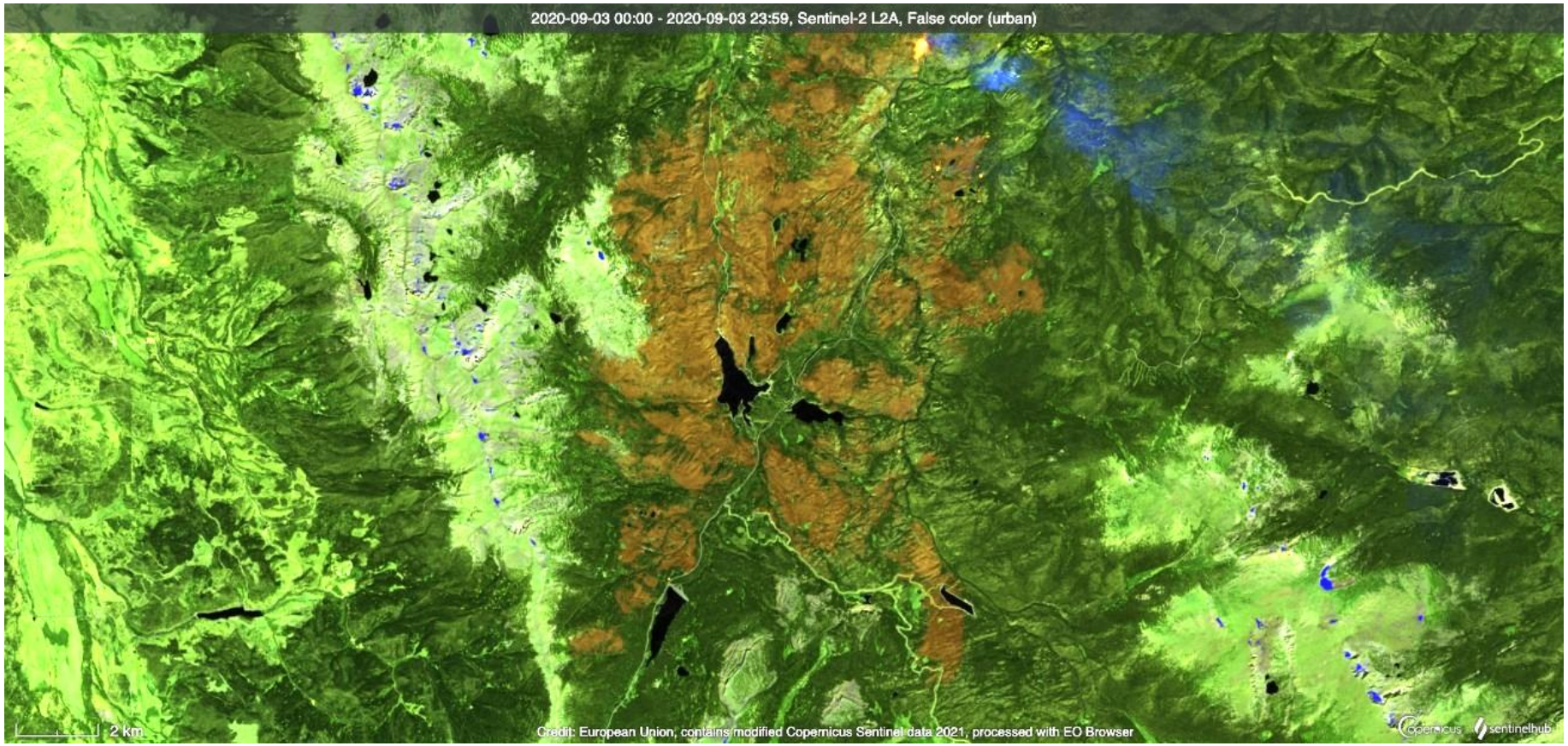
True Color (R, G, B)

False Color (IR, R, G)

False Color Urban (SWIR1, SWIR2, R)



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Identifying and Monitoring Beaver-Created Fire Refugia within the Fires

Example of Fire Refugia Identification from East Troublesome Fire

Recent beaver dams marked with white lines. To be considered beaver-created, pixels of fire refugia had to be touching a beaver dam, lodge, pond, canal, or felled tree.

Beaver Complex in the East Troublesome Fire

False color imagery from Sentinel 2 and Landsat 8
Green = vegetation
Bright Yellow + Orange = fire
Orange-Brown = burned vegetation
Blue = snow or ice

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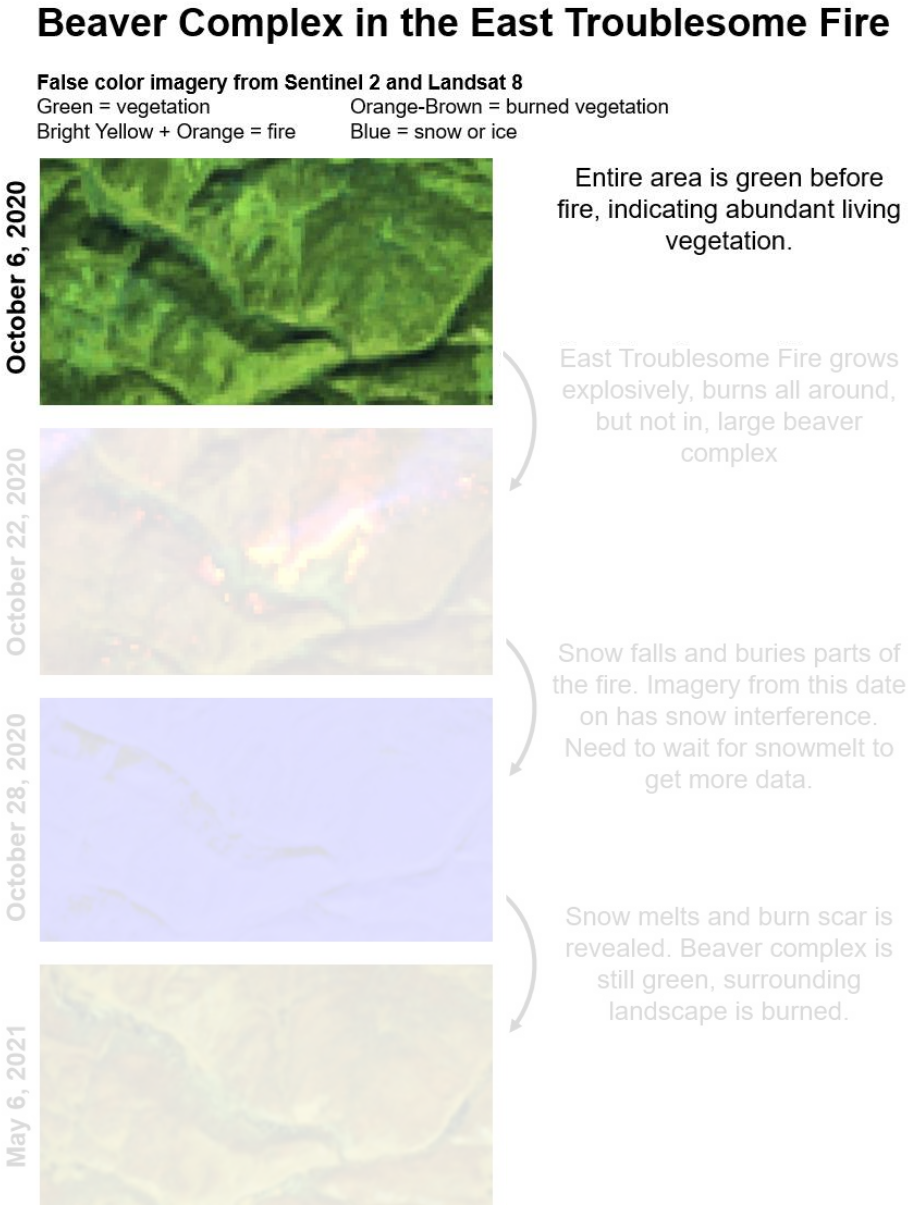

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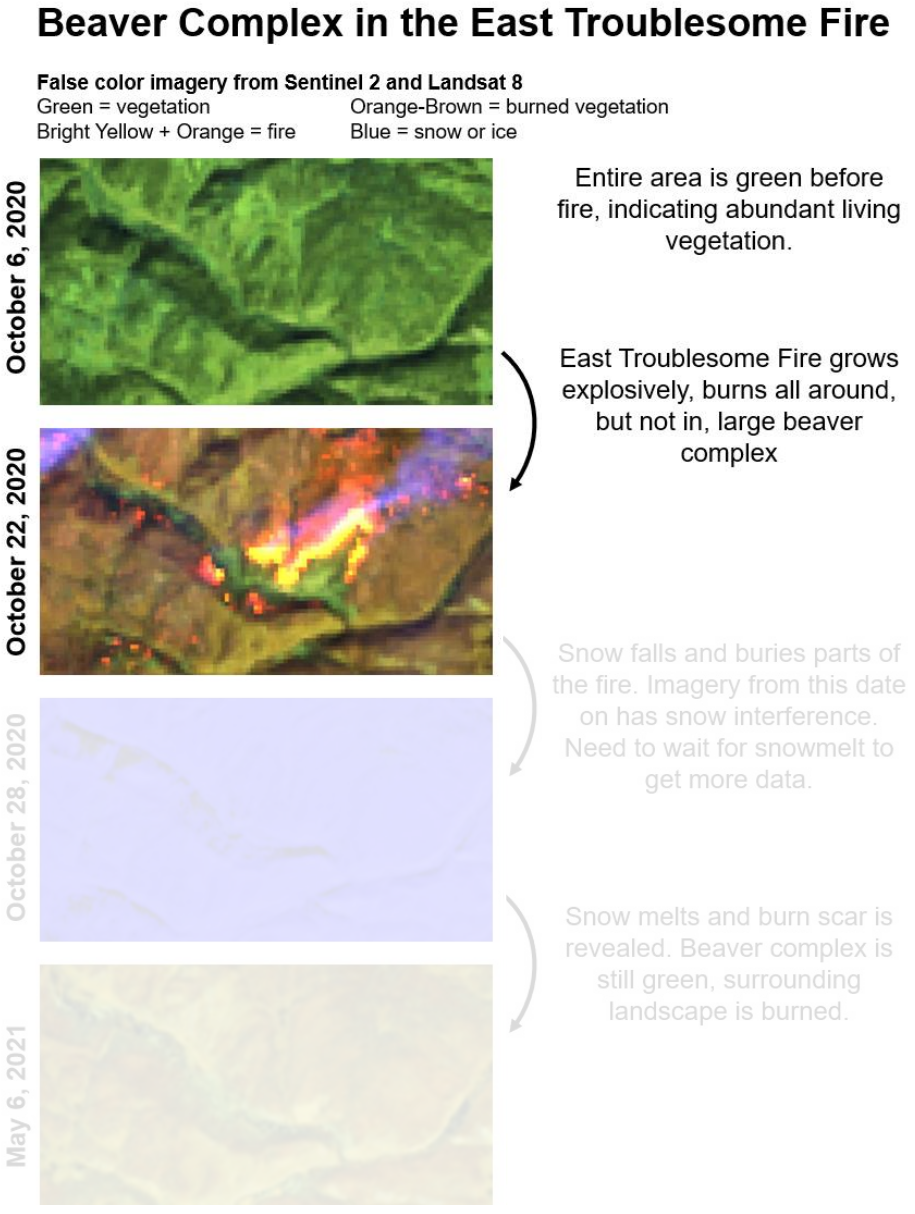

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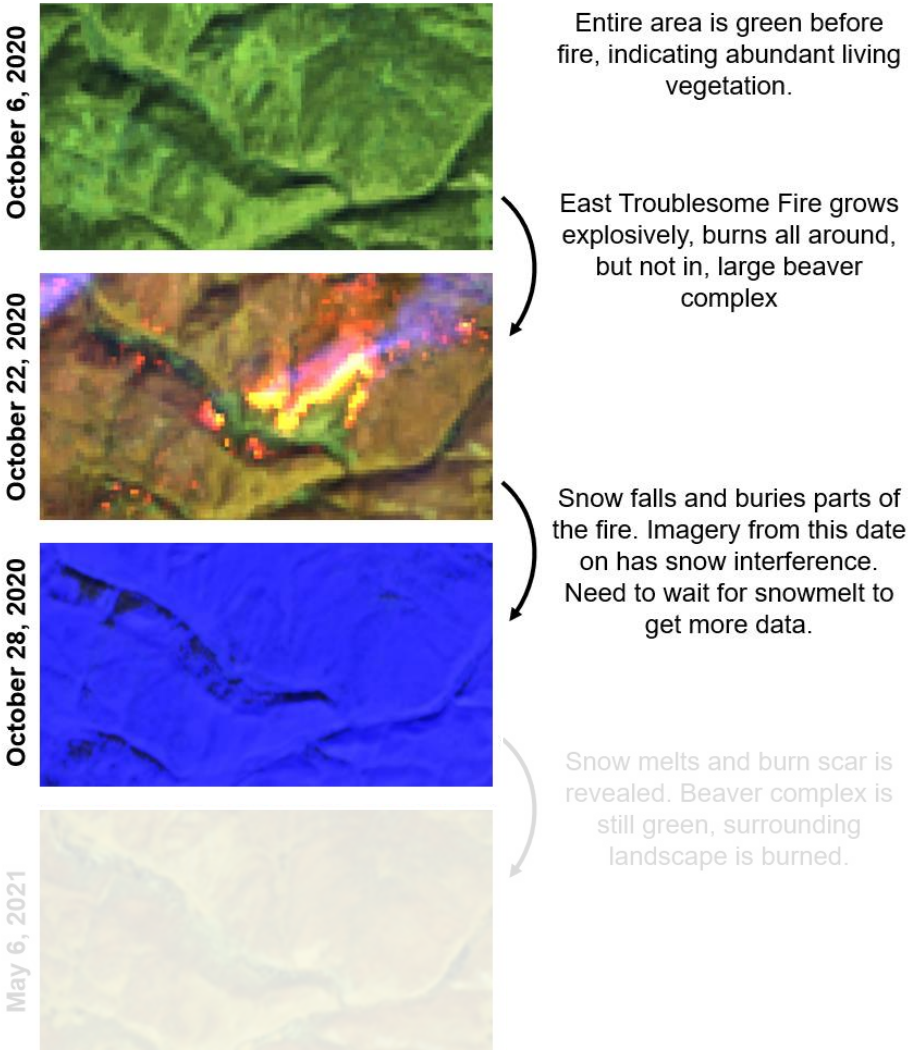

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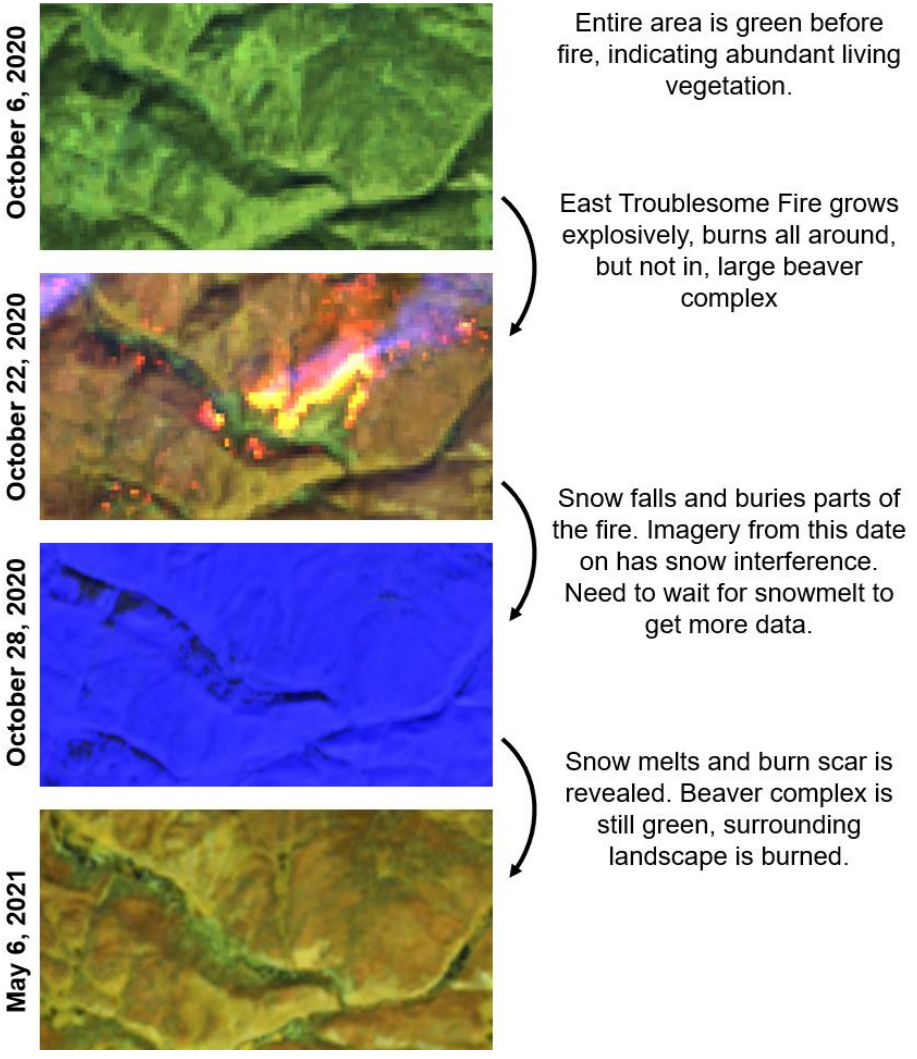

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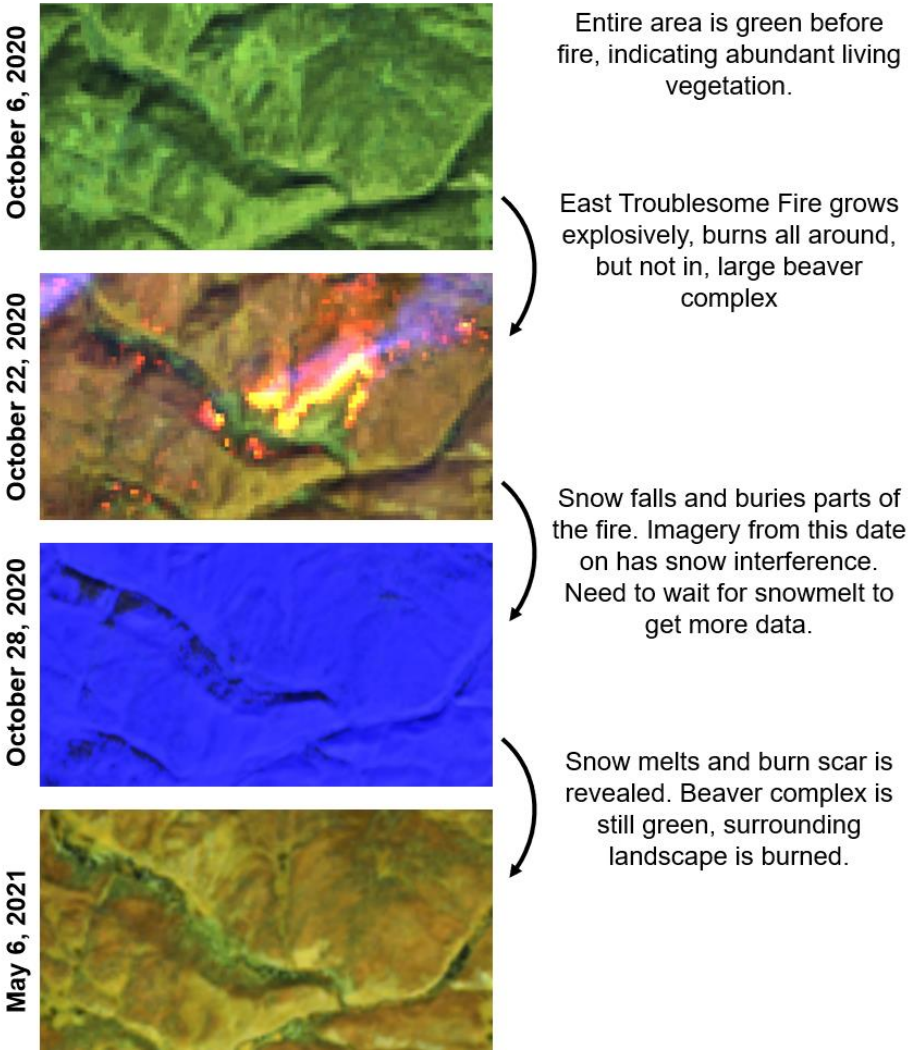

Beaver-created fire refugia (usually) persist, even in these megafires.

Cameron Peak Fire: riparian area **within** beaver complex fire refugia

Photos by Emily Fairfax (Sept 2021)

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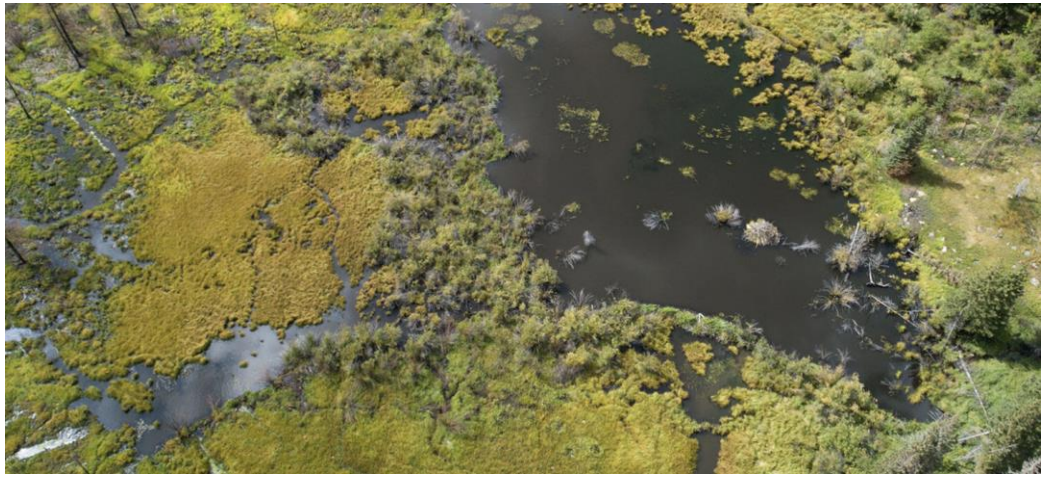
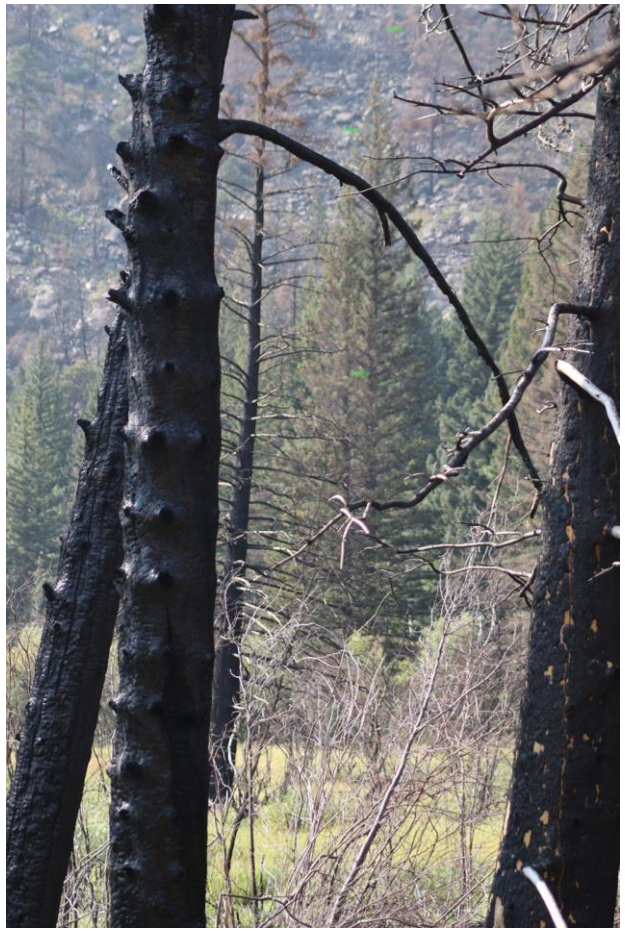


Photos by Evan Barrientos / Audubon Rockies https://rockies.audubon.org/rivers/articles/beavers-offer-help-western-waters

Beaver-created fire refugia (usually) persist, even in these megafires.

Cameron Peak Fire: hills and riparian area **not within** beaver complex



Photos by Shepard Fairfax (Sept 2021)

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Cameron Peak Fire: transition from high burn severity into refugia

← Towards Beaver Complex

Away From Beaver Complex →

Photo by Emily Fairfax (Sept 2021)

How much beaver-created fire refugia was there?

Cameron Peak Fire

Aug 13, 2020 – Dec 2, 2020
208,913 acres, 99 satellite-visible beaver dams

- **87%** of satellite-visible beaver dams had measurable fire refugia around them. **42%** of randomly selected creek/river sections had fire refugia around them.
- Total beaver-supported refugia area ~ **270 acres,** refugia creation rate of ~ **2.7 acres / beaver dam**
- Most refugia occurred in "**clumps**"
- The refugia clumps did not appear to impact fire spread.
- The beaver ponds that did not have any measurable fire refugia were geographically isolated from other ponds, occurred on simplified streams, and/or were partially drained

East Troublesome Fire

Oct 14, 2020 – Nov 30, 2020
193,812 acres, 512 satellite-visible beaver dams

- **100%** of satellite-visible beaver dams had measurable fire refugia around them. **56%** of randomly selected creek/river points had fire refugia around them.
- Total beaver-supported refugia area ~ **1500 acres,** refugia creation rate of ~ **2.9 acres / beaver dam**
- Most refugia occurred in "**ribbons**"
- Some of the larger refugia ribbons had the hillslopes immediately downwind remain unburned or low-burned. Suggests potential for wet, well-connected floodplains (like those with many beaver complexes) to alter fire spread at a larger scale.

Take Home Messages and Questions Remaining

Photo by Emily Fairfax (Sept 2021)

- **Previous research** showed that beaver-dammed sections of creeks were 3x less affected by fire compared to sections without beavers. This happens consistently across landcover/climate/topography/time.
- **Current research** is showing that fire refugia were consistently found around beaver dams in the East Troublesome and Cameron Peak megafires at a rate of ~ 2.8 acres / dam. Well-connected dam complexes had more reliable refugia than isolated, simple dams.
- In the megafires, fire refugia were more likely to be present near beaver dams than in other non-beaver impacted sections of creeks in these megafires
- These fire refugia patches can potentially provide shelter for plants, animals, or even people during fast-spreading wildfires. **More research needed.**
- The fire refugia help catch ash and sediment entering the water post-fire, thus improving water quality. **More research needed.**

This is not an anomaly.

Photo by Manter BAER Team

Photo by Xinli Cai from Canada Wildfire

Photo by Joe Wheaton, CC-by-4.0

Photo by Emily Fairfax

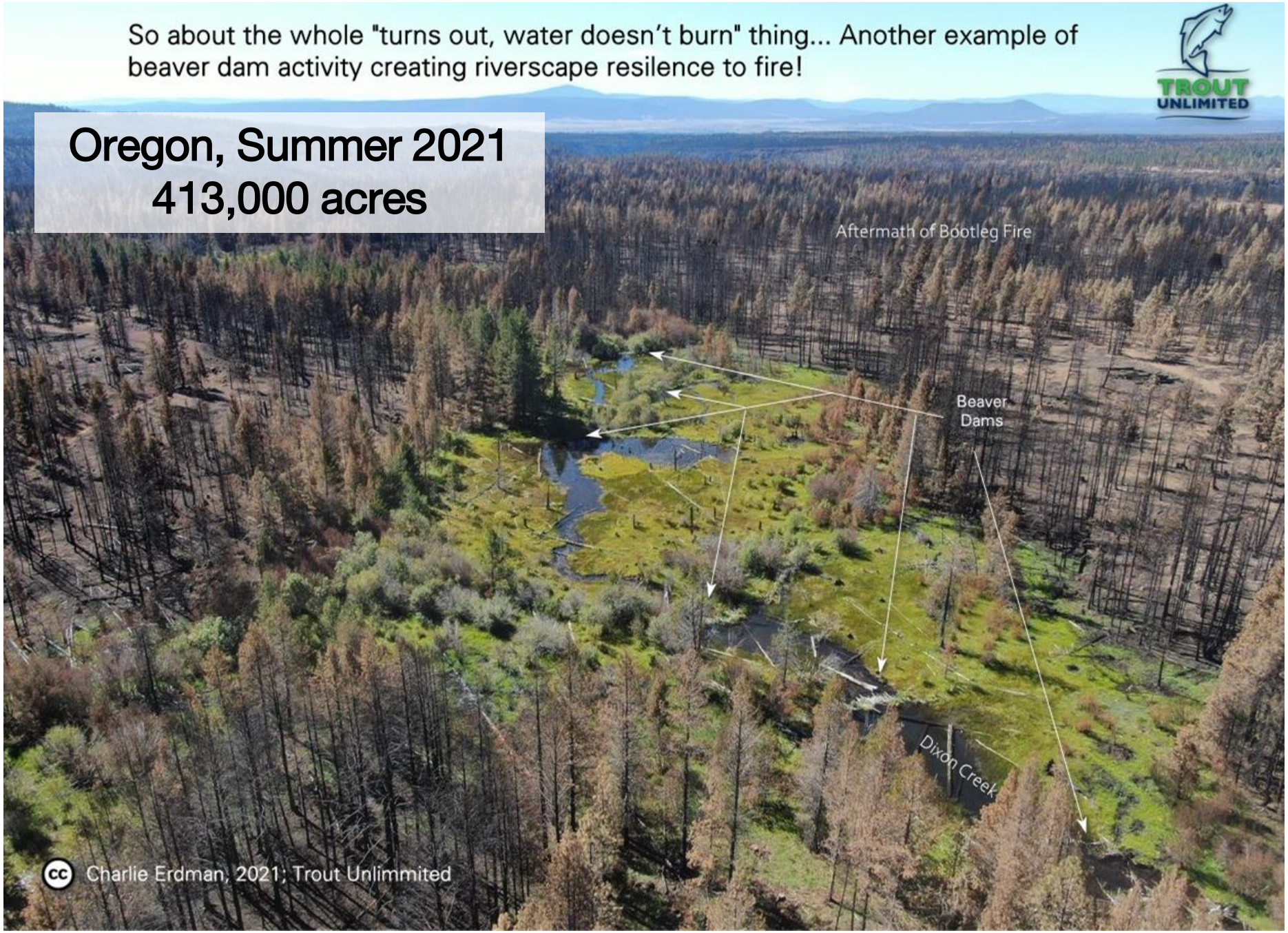

Photo by Charlie Erdman, modified by Joe Wheaton, CC-by-4.0

Acknowledgements

This project was supported by a research grant from Biodiversity First!, The Farmer and the Cook Restaurant, and the National Science Foundation HSI-SMART grant. This material is based upon work supported by the National Science Foundation under Grant No. 1928693.


Questions?
Visit one of our field sites: bit.ly/FireBeavers
emily.fairfax@csuci.edu
@EmilyFairfax