Climate Change Be Dammed!

AN INTRODUCTION TO THE ROLE OF BEAVERS IN A WARMING WORLD

EMILY FAIRFAX, PHD
CALIFORNIA STATE UNIVERSITY CHANNEL ISLANDS

Climate is changing.

What can we do about it?

Climate Mitigation:

Long-term reduction in emissions, slow and/or stop trajectory of warming. **Doesn't necessarily fix the consequences of climate change we are dealing with now.**

Climate Adaptation:

Long- and short-term actions to minimize damage from climate change that has already occurred. **Doesn't necessarily slow or stop climate change, but protects lives and infrastructure being threatened today.**

We need engineers.


But what about nature’s engineer?

Climate is changing.

What can ~~we~~ beavers do about it?

Beavers dampen flood waves.

Published: March 1998

Flood wave attenuation by a wetland following a beaver dam failure on a second order boreal stream

Graham R. Hillman

Wetlands **18**, 21–34(1998) | Cite this article

Hydrological Processes

WOMEN ADVANCING RESEARCH IN HYDROLOGICAL PROCESSES Full Access

Hydrological functioning of a beaver dam sequence and regional dam persistence during an extreme rainstorm

Cherie J. Westbrook, Amanda Ronnquist, Angela Bedard-Haughn

First published: 23 May 2020 | https://doi.org/10.1002/hyp.13828 | Citations: 4

Received: 14 October 2020 | Revised: 17 December 2020 | Accepted: 18 December 2020
DOI: 10.1002/hyp.14017

RESEARCH ARTICLE

Beaver dams attenuate flow: A multi-site study

Alan Puttock | Hugh A. Graham | Josie Ashe | David J. Luscombe | Richard E. Brazier

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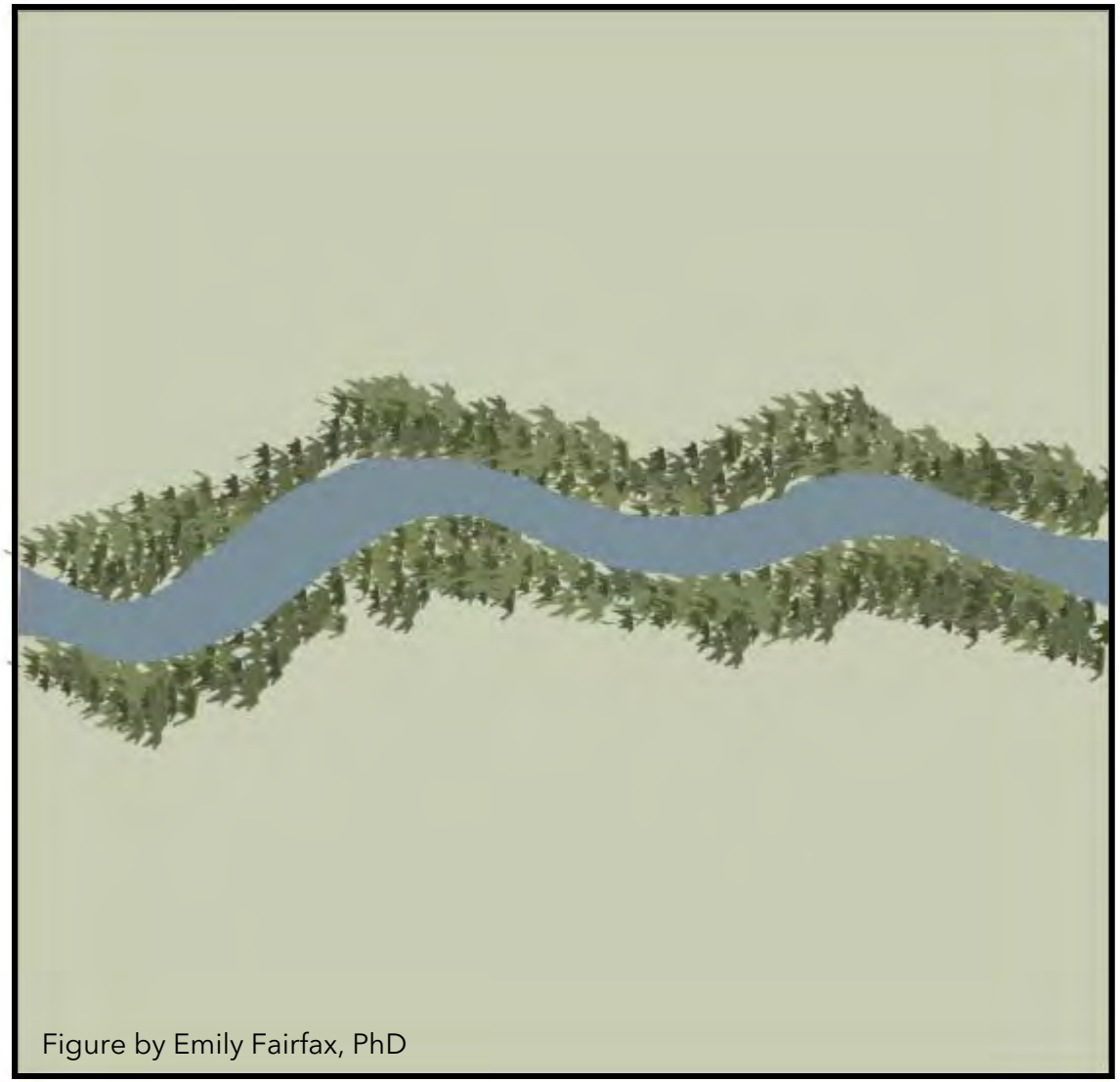
No Beavers



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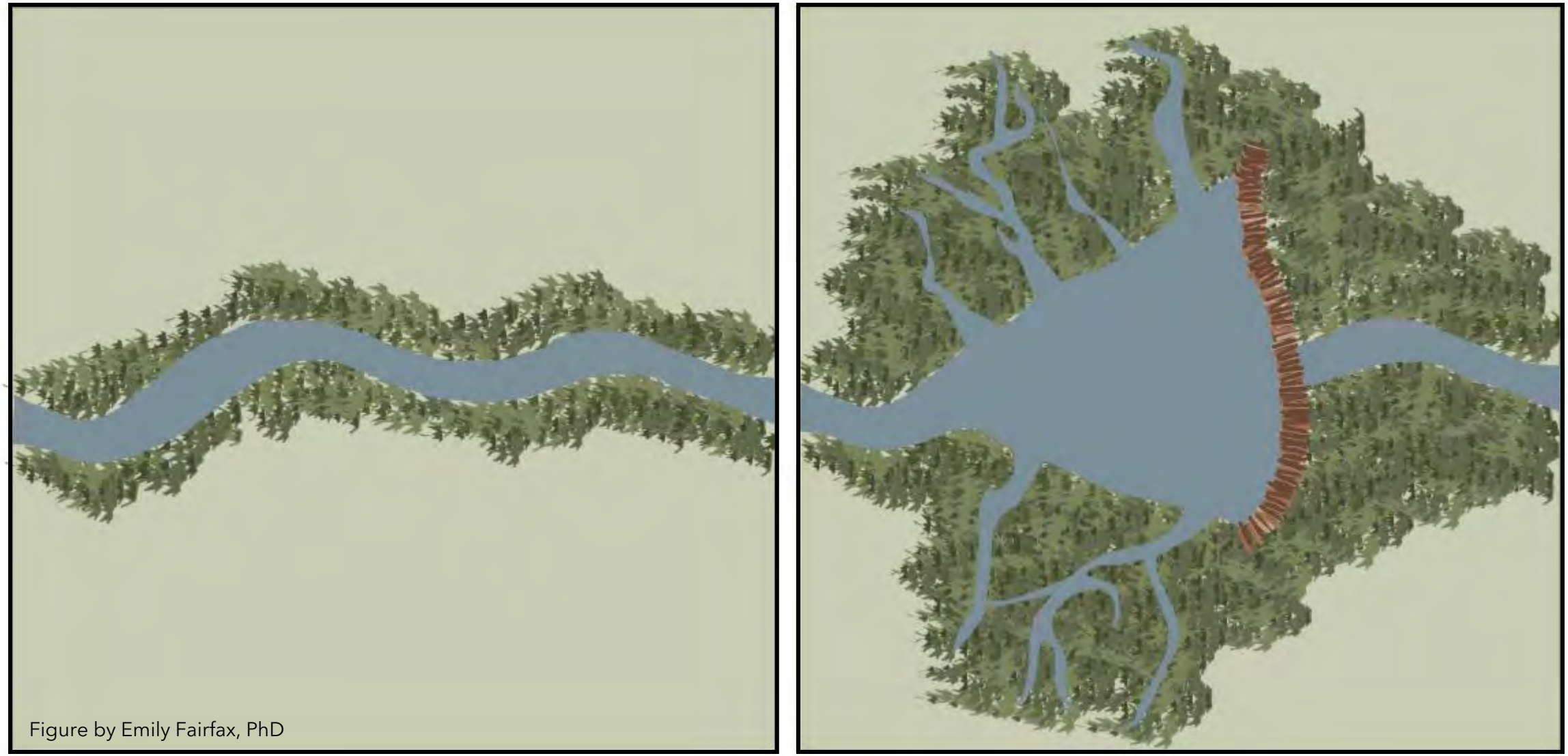

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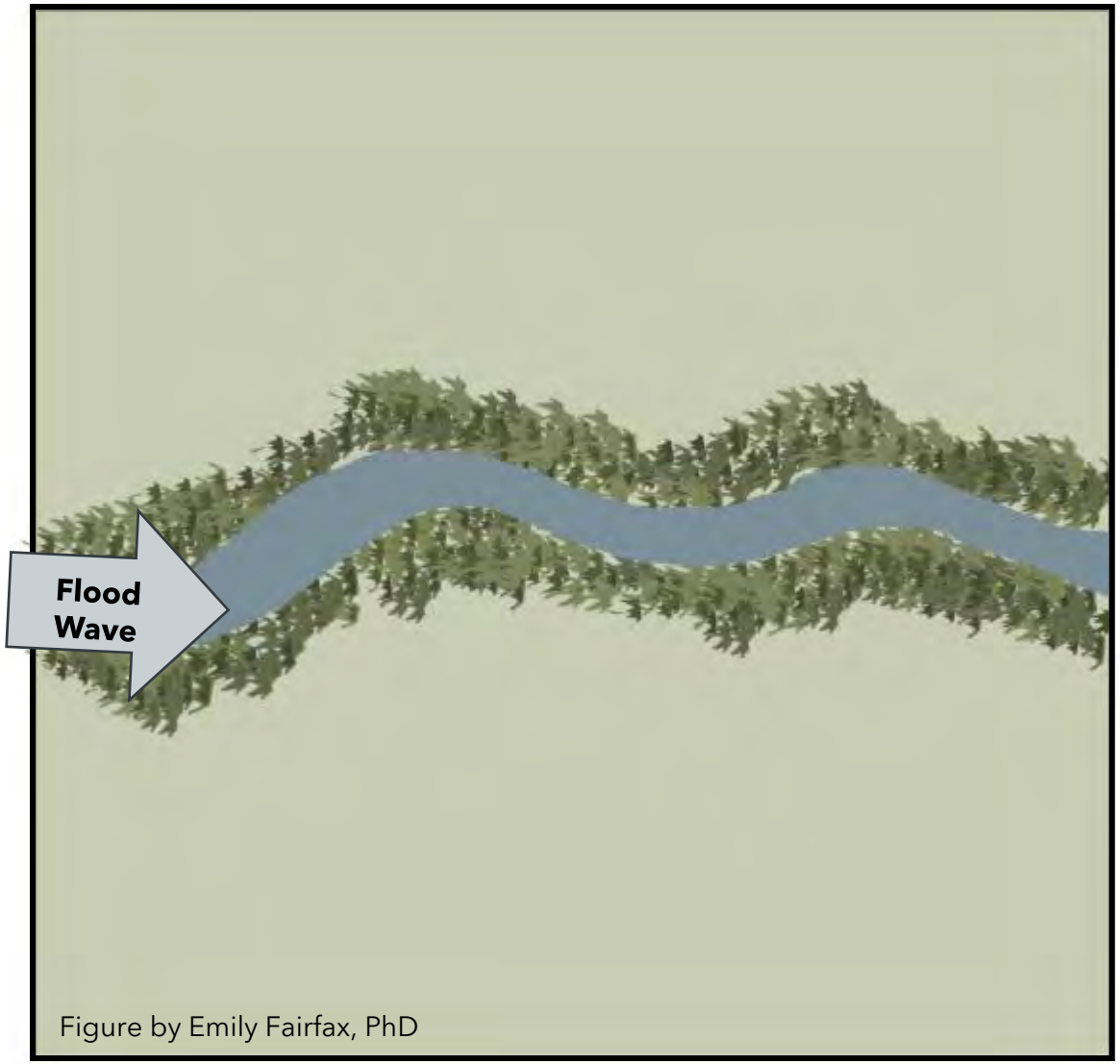

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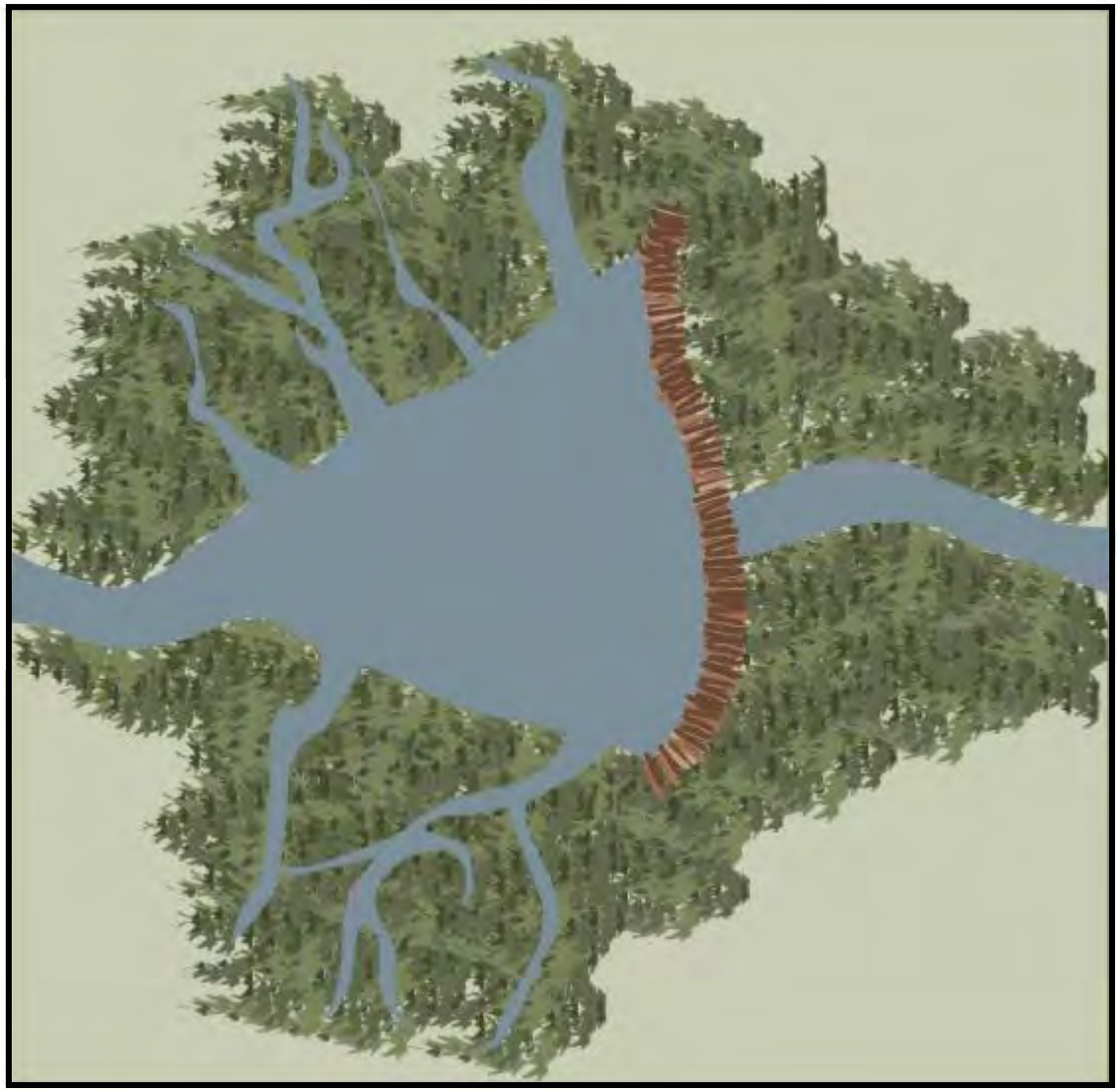

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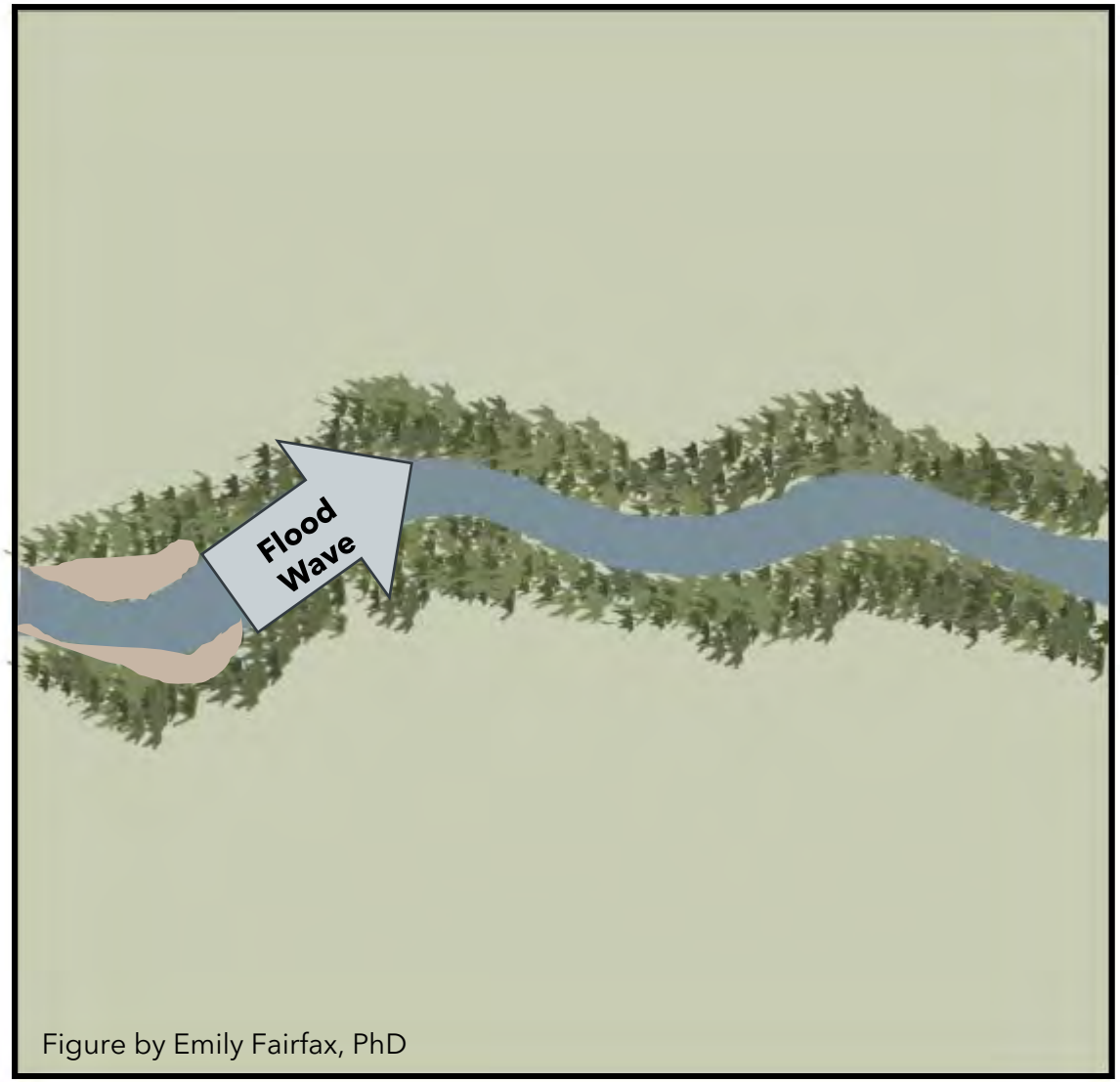

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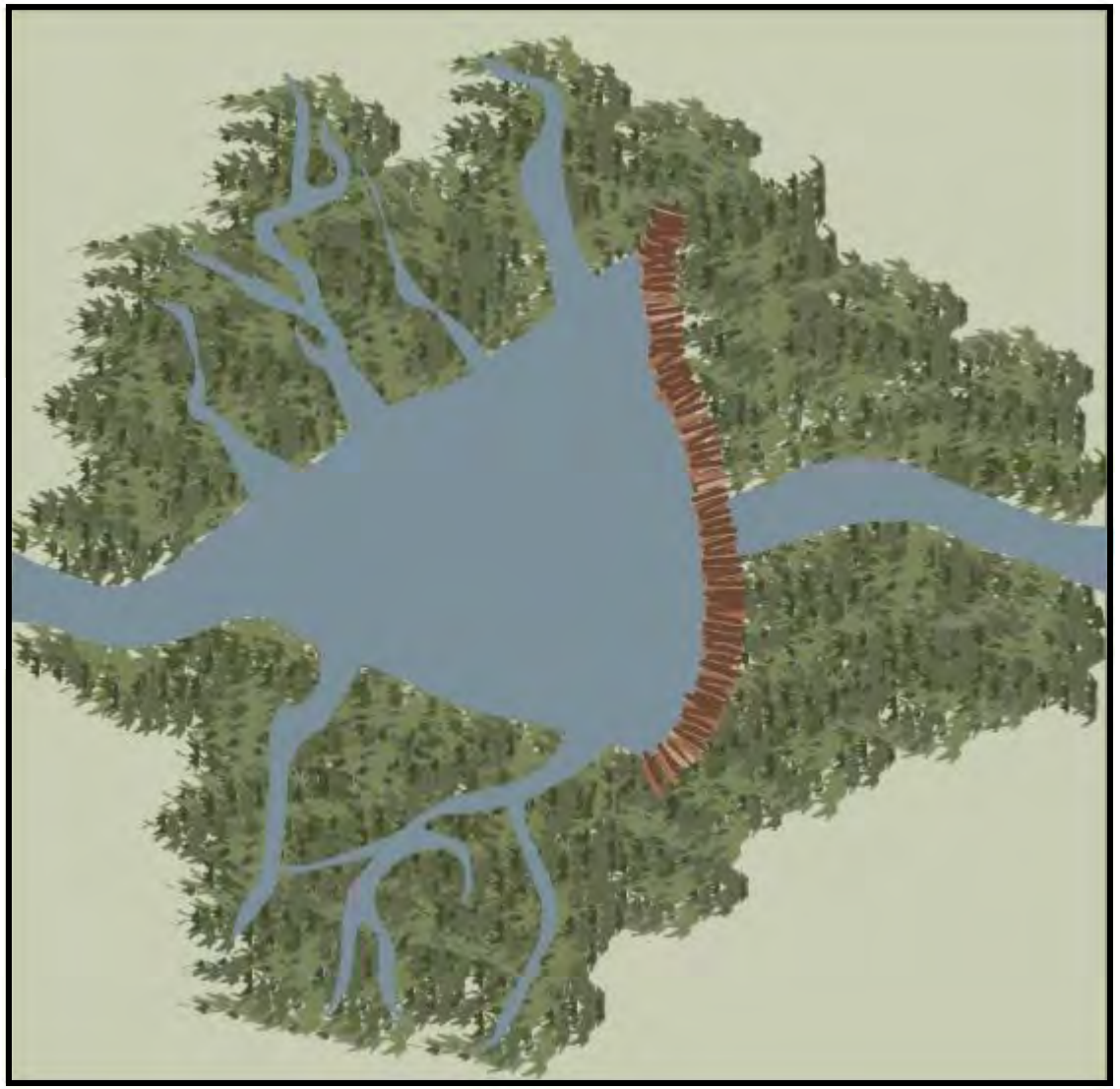

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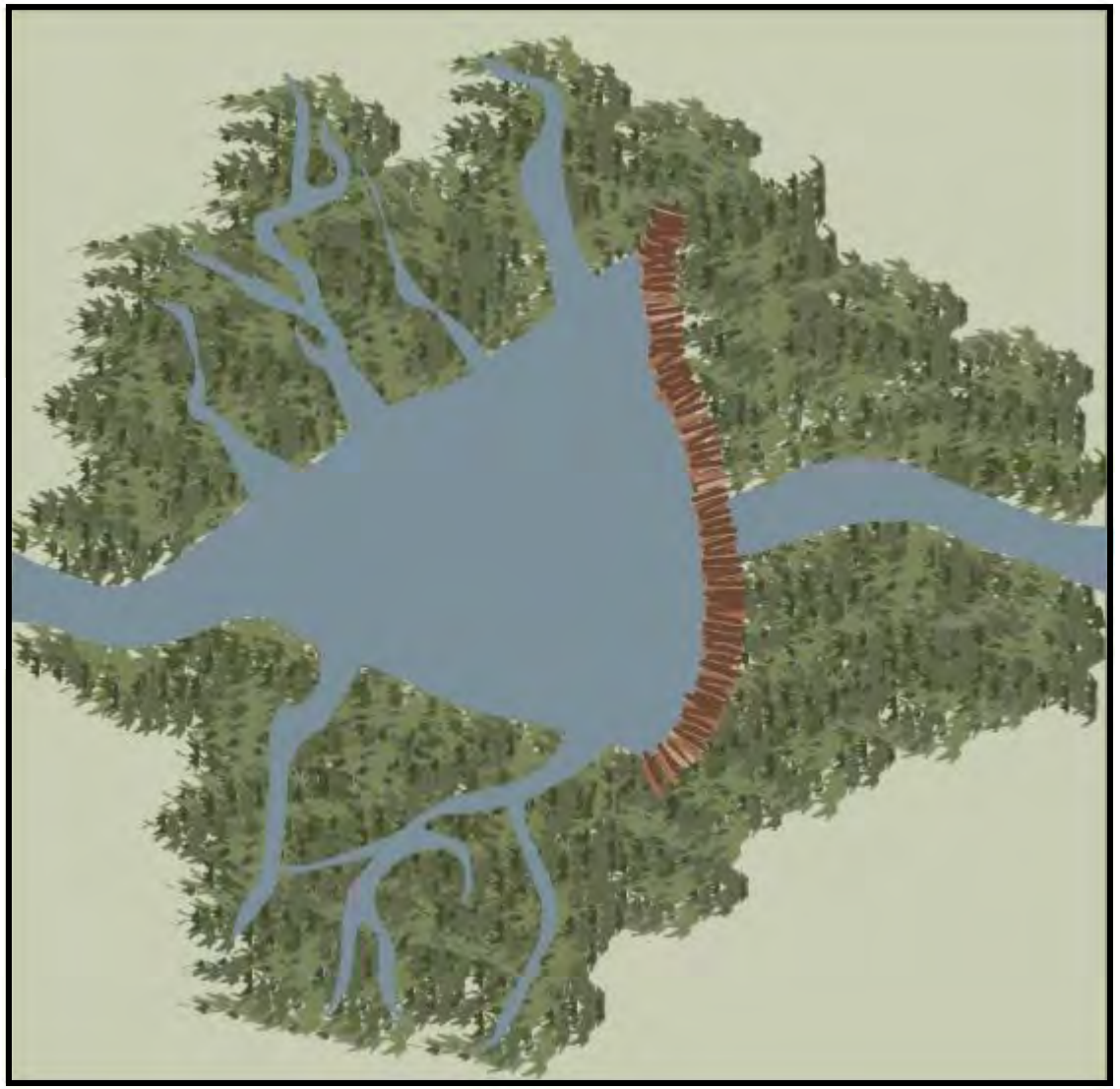

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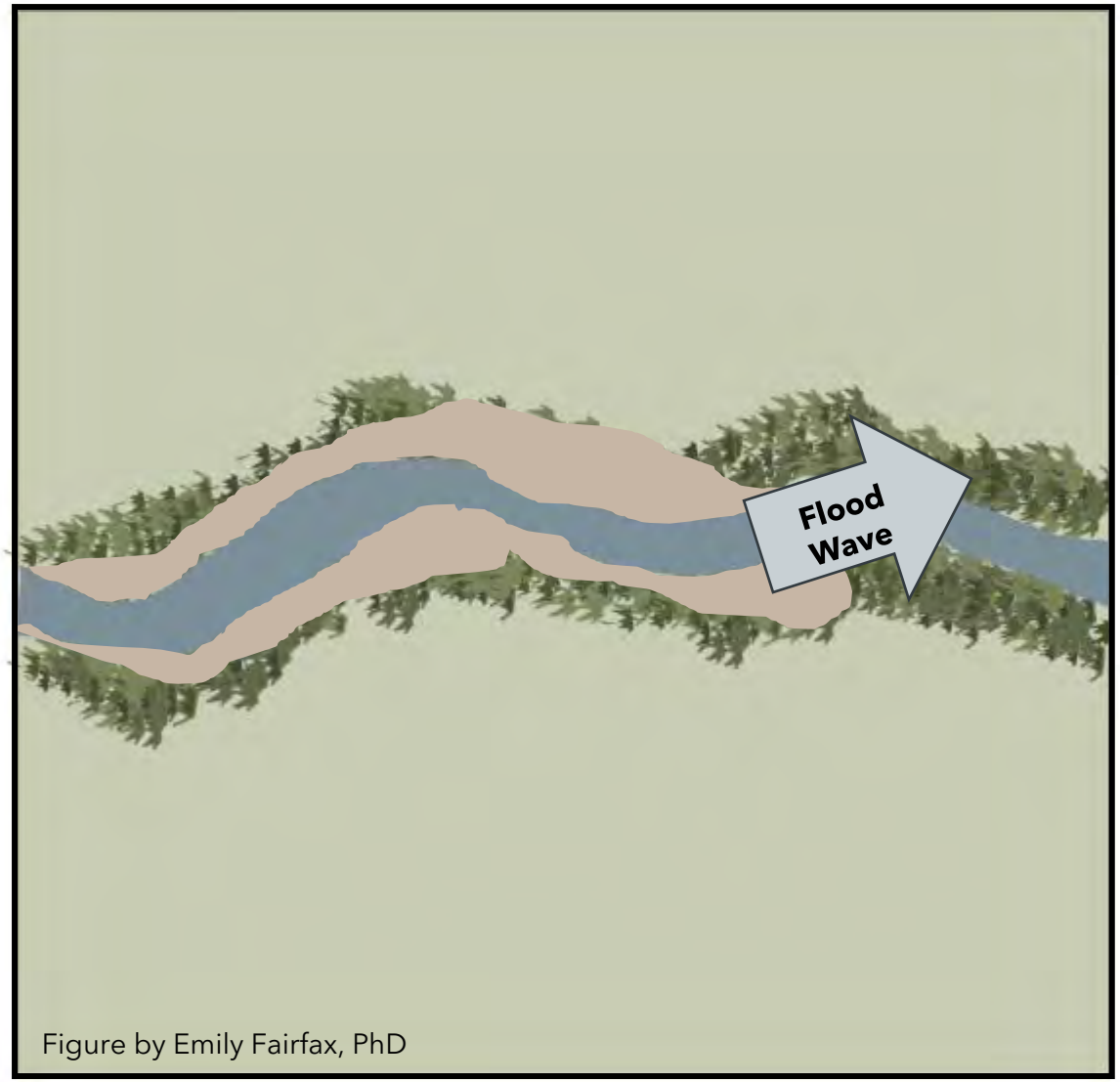

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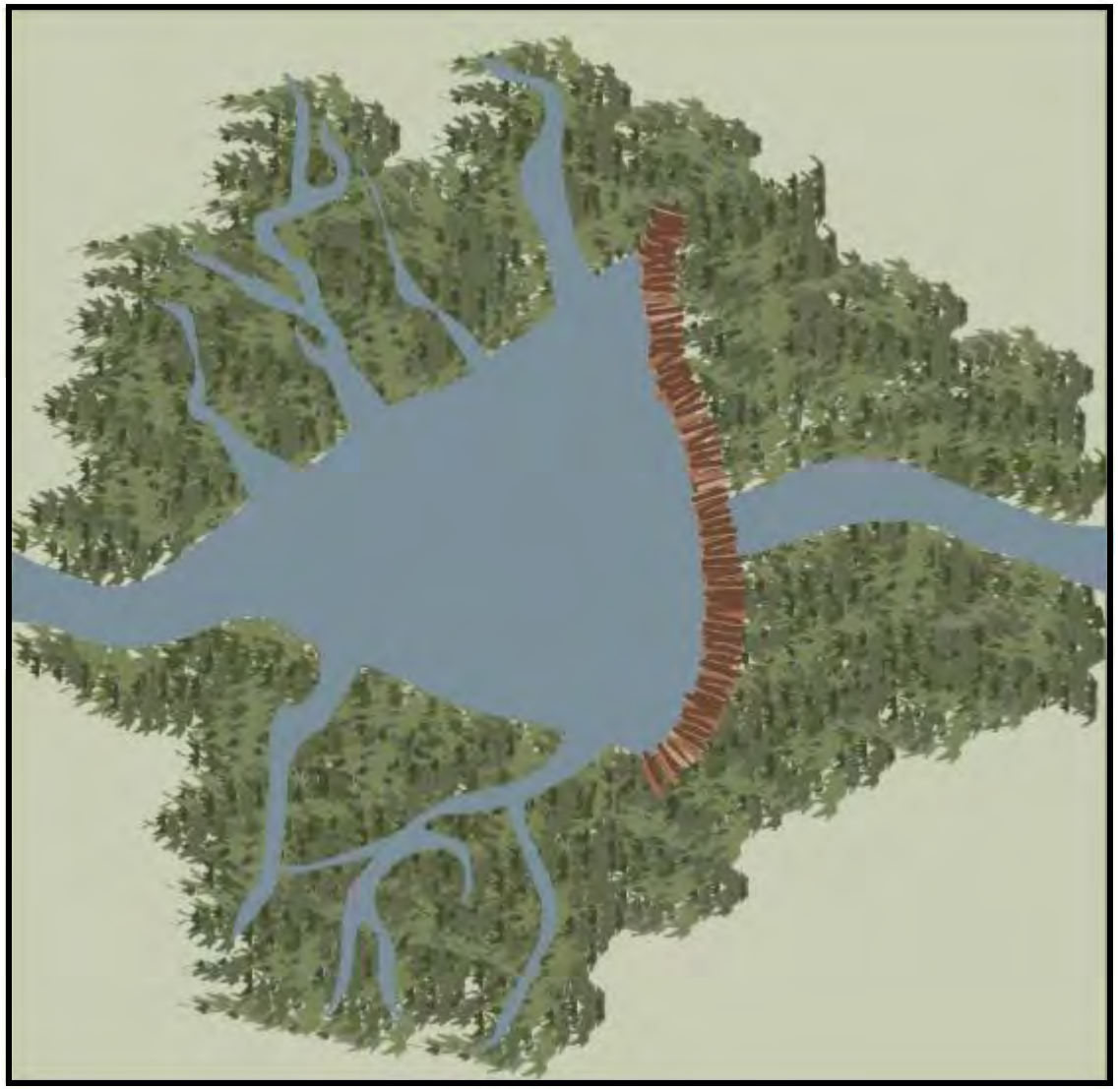

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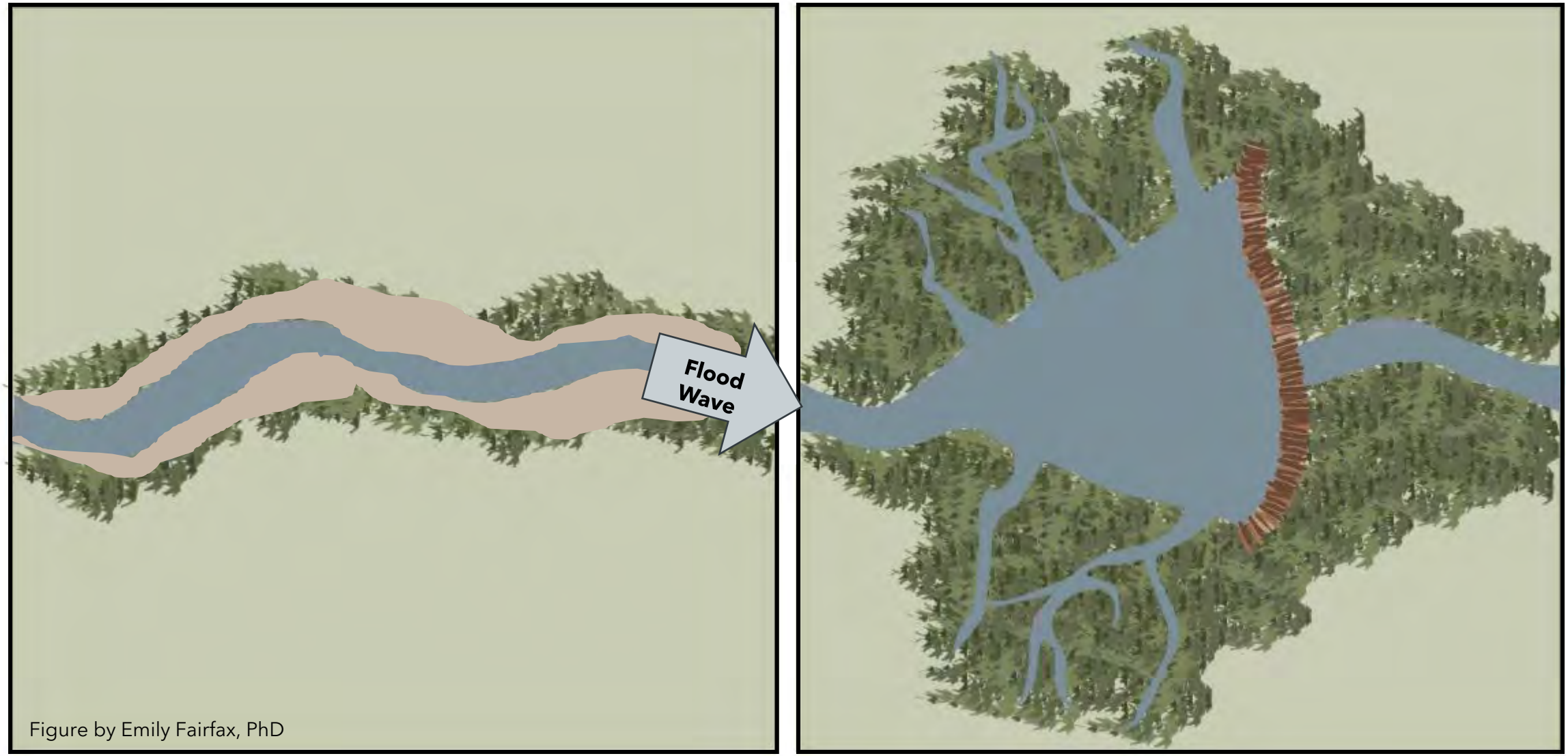

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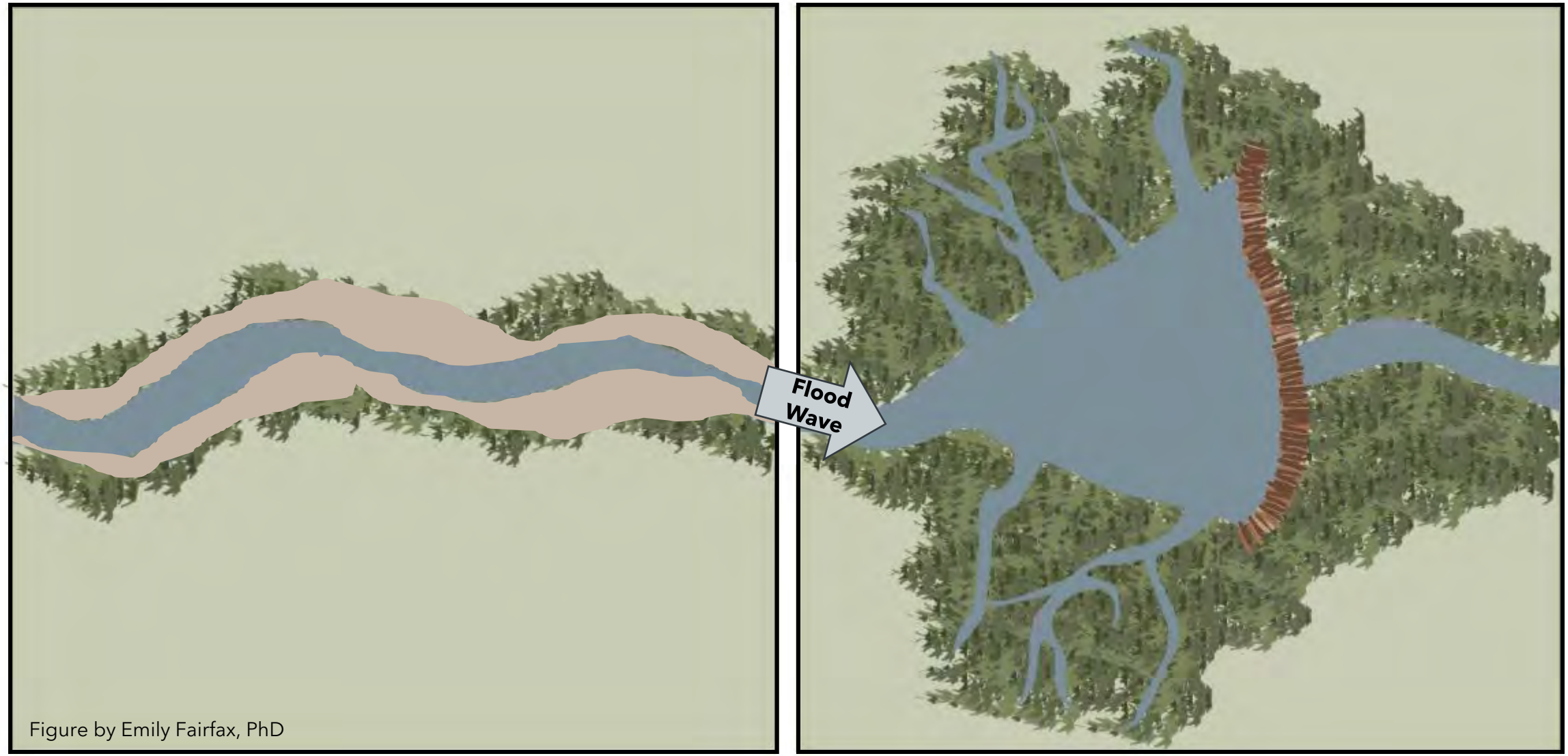

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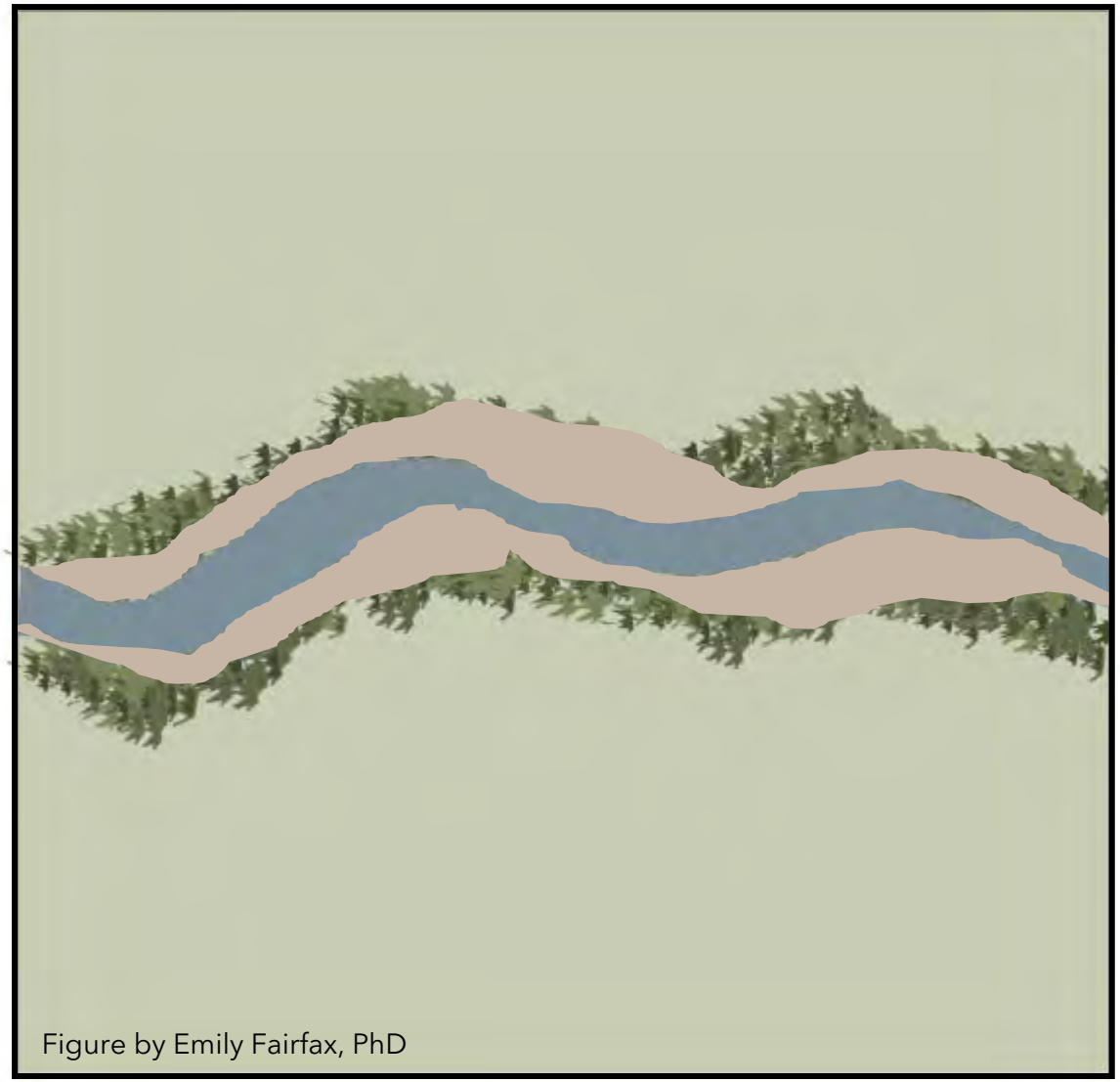

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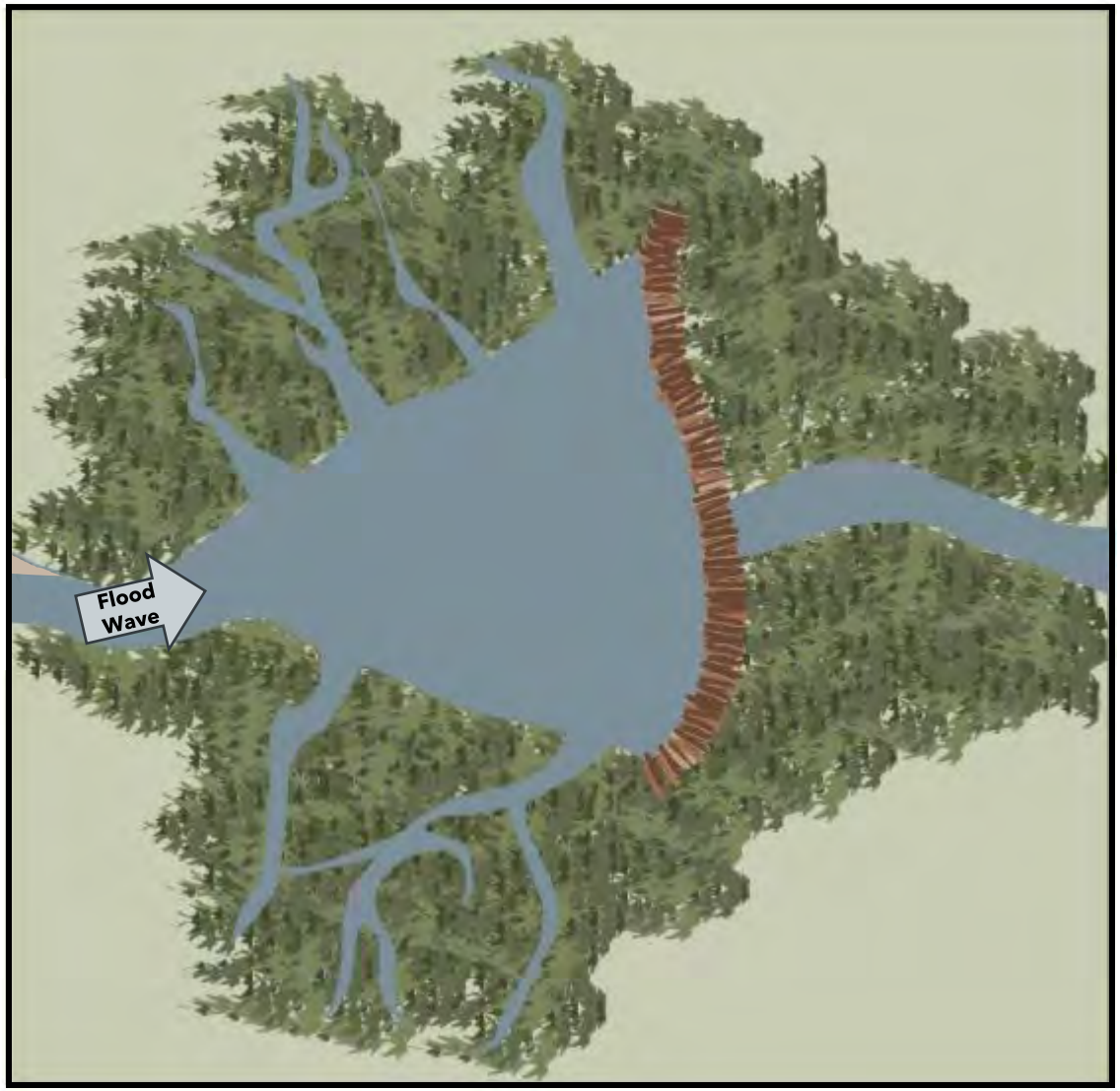

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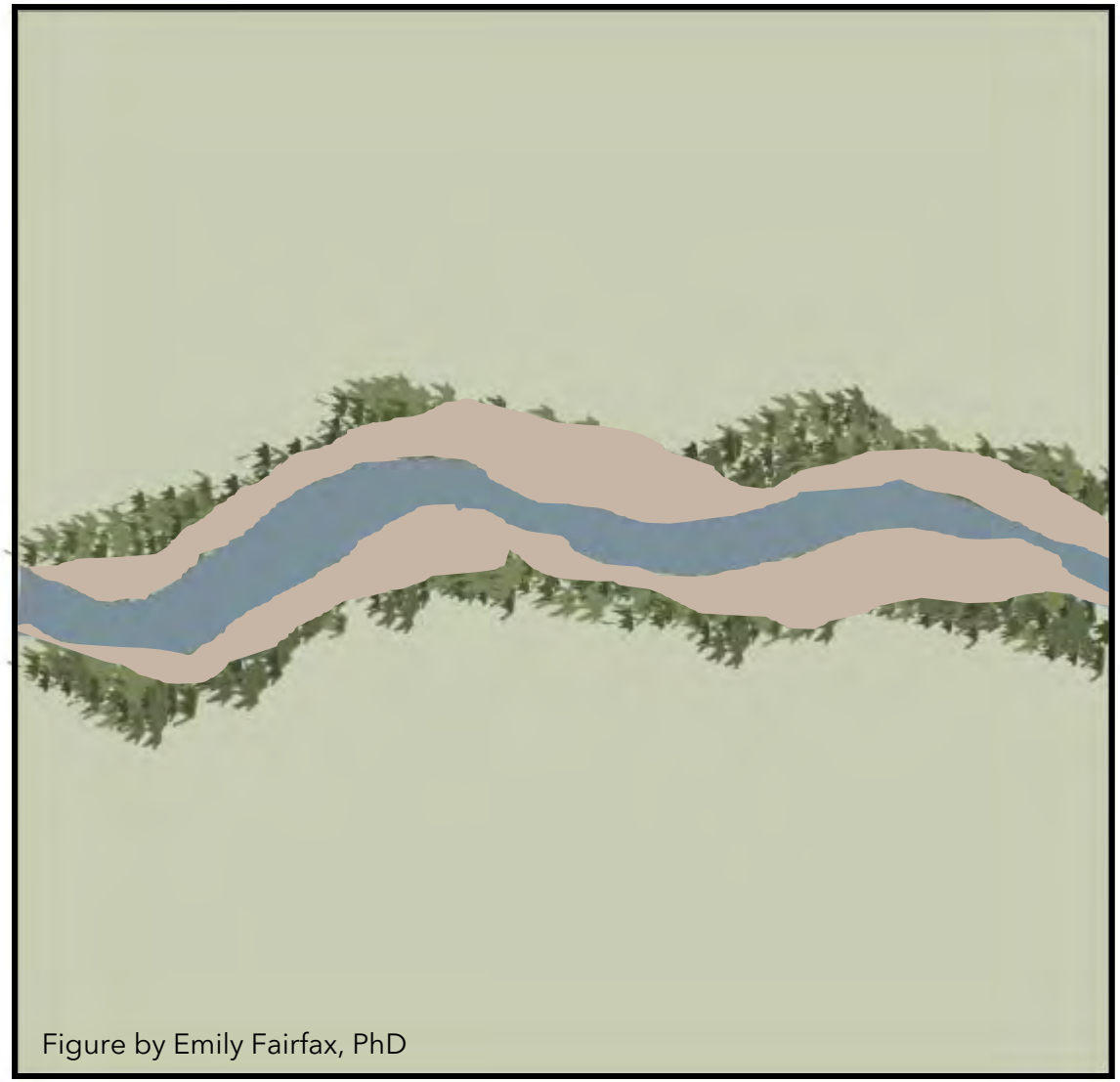

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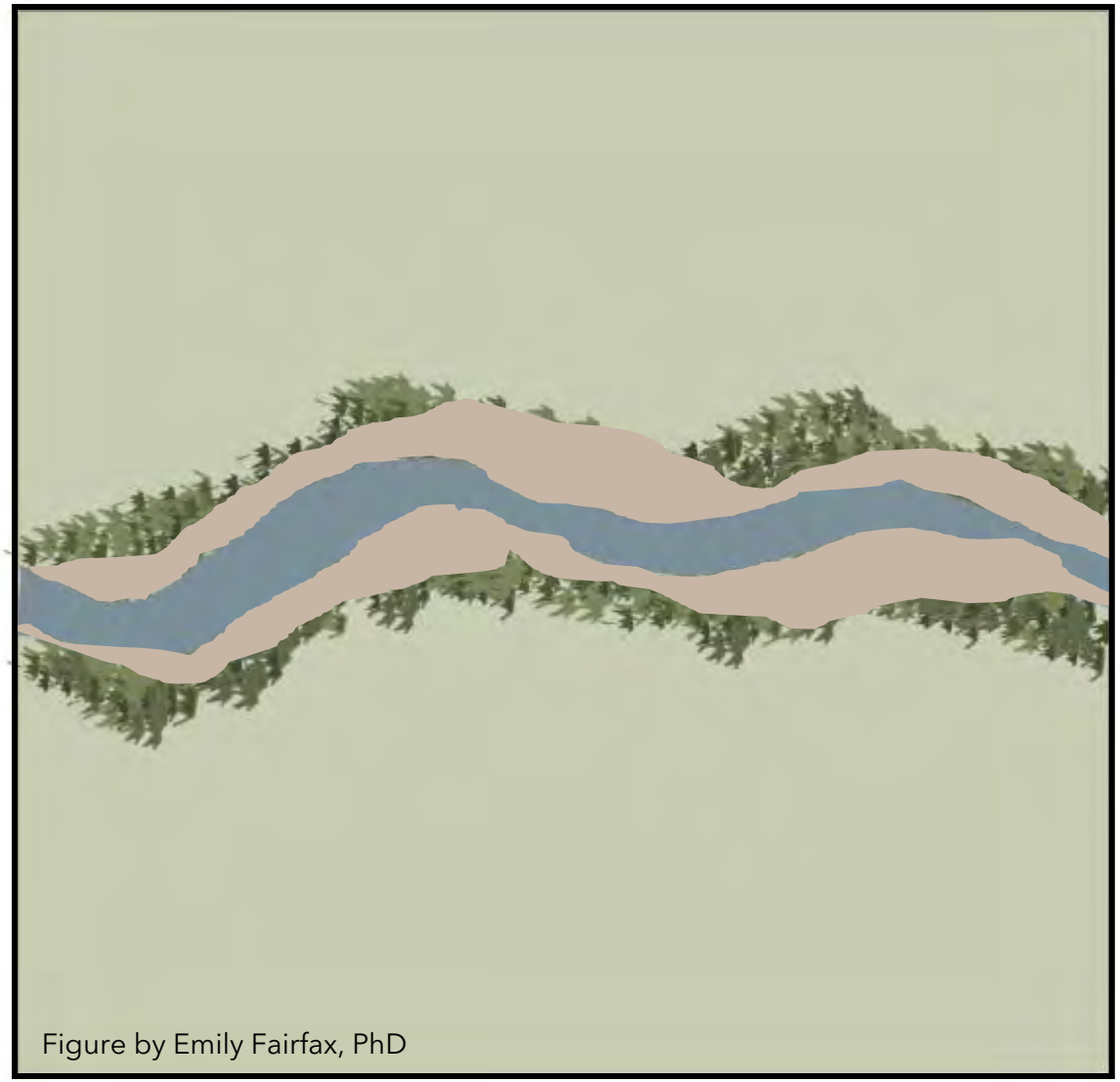

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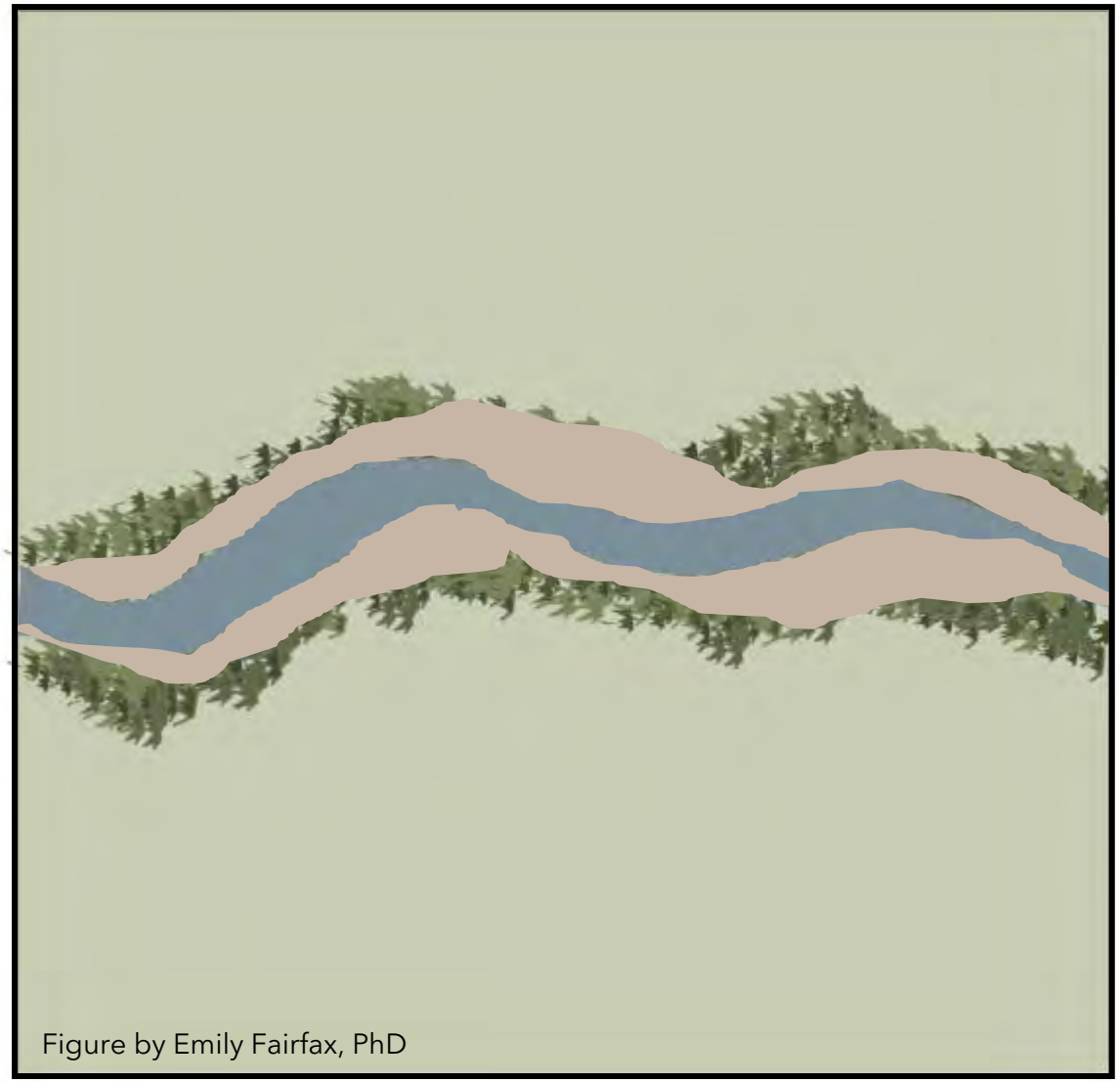

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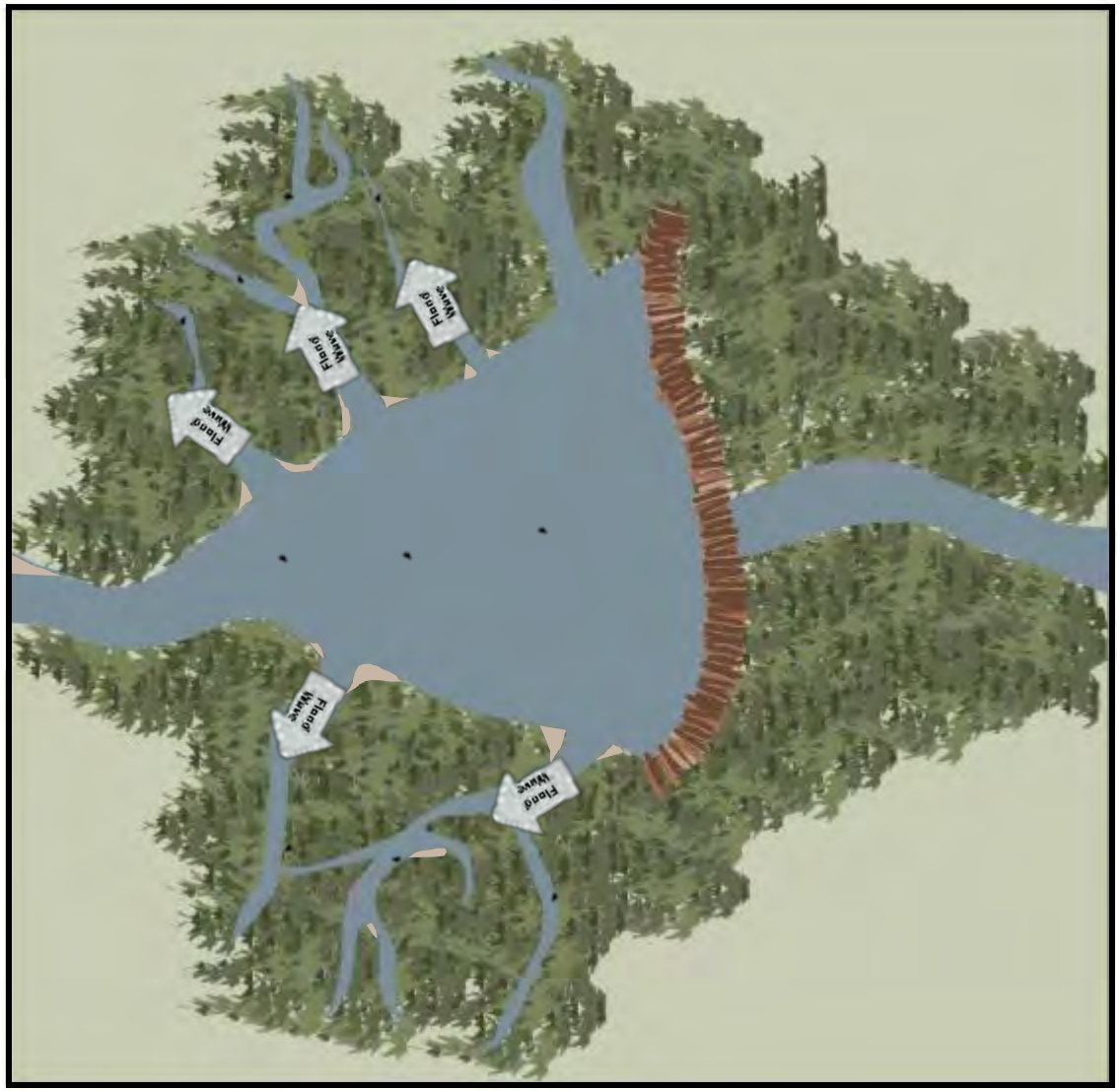

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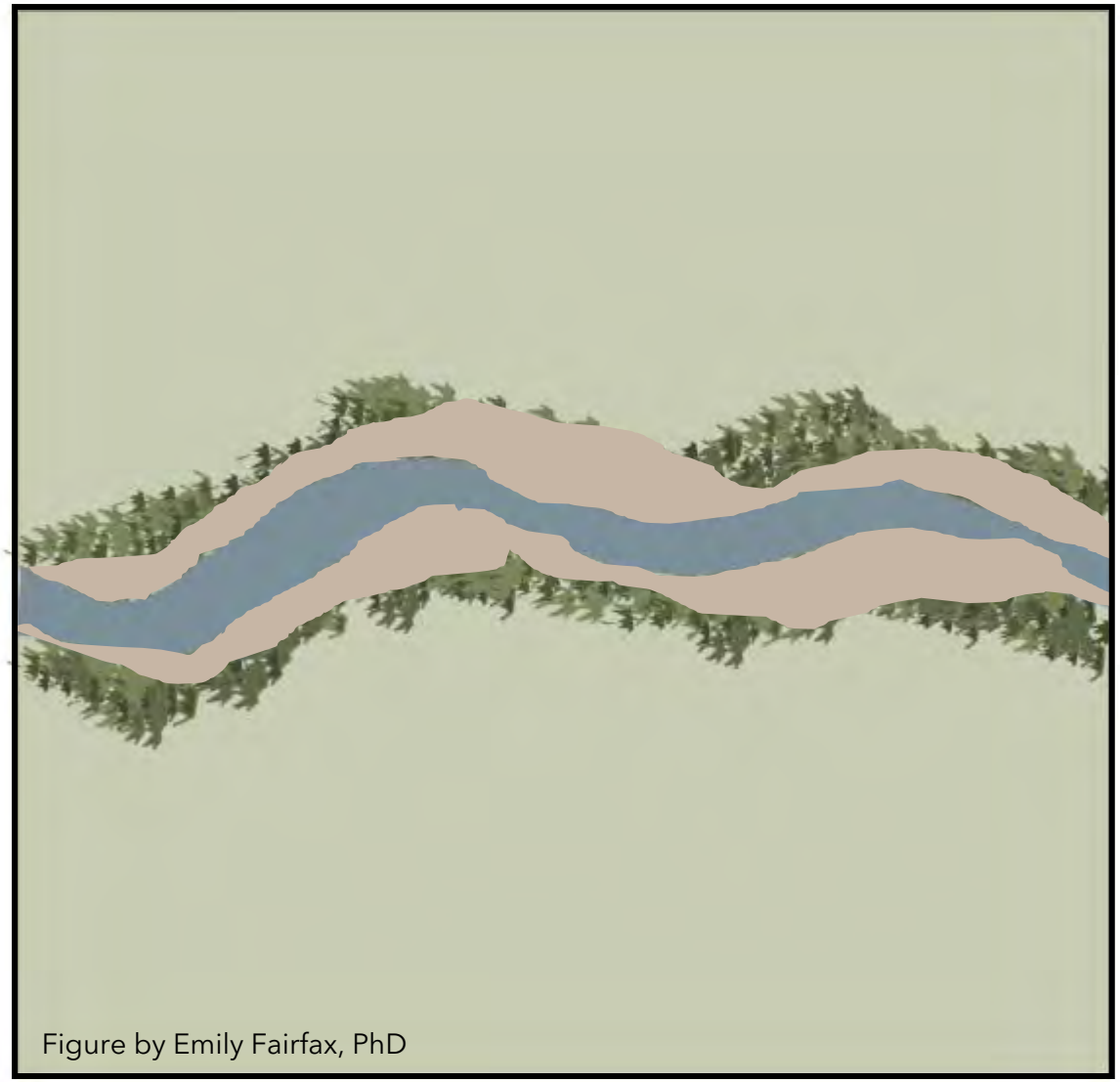

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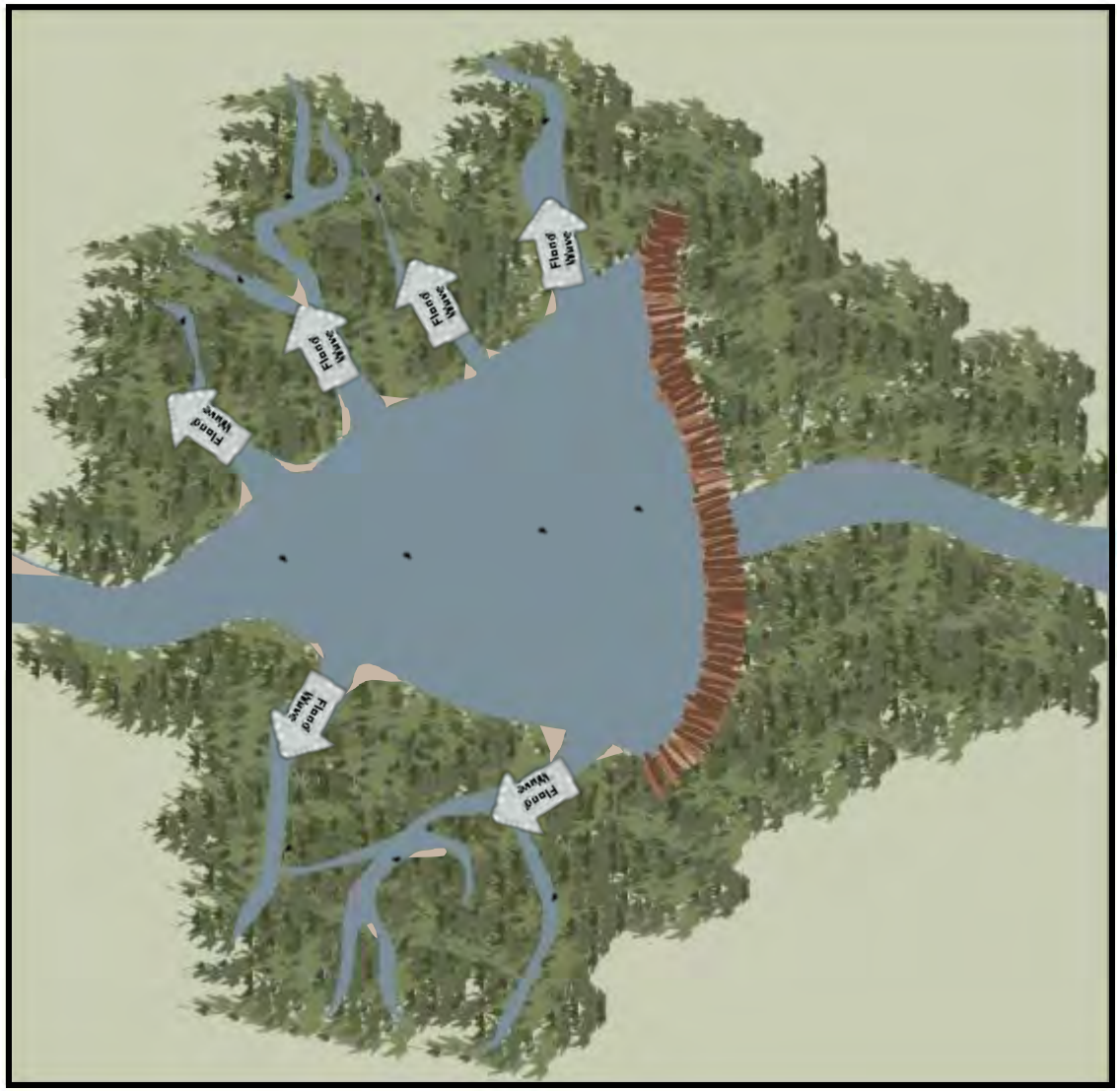

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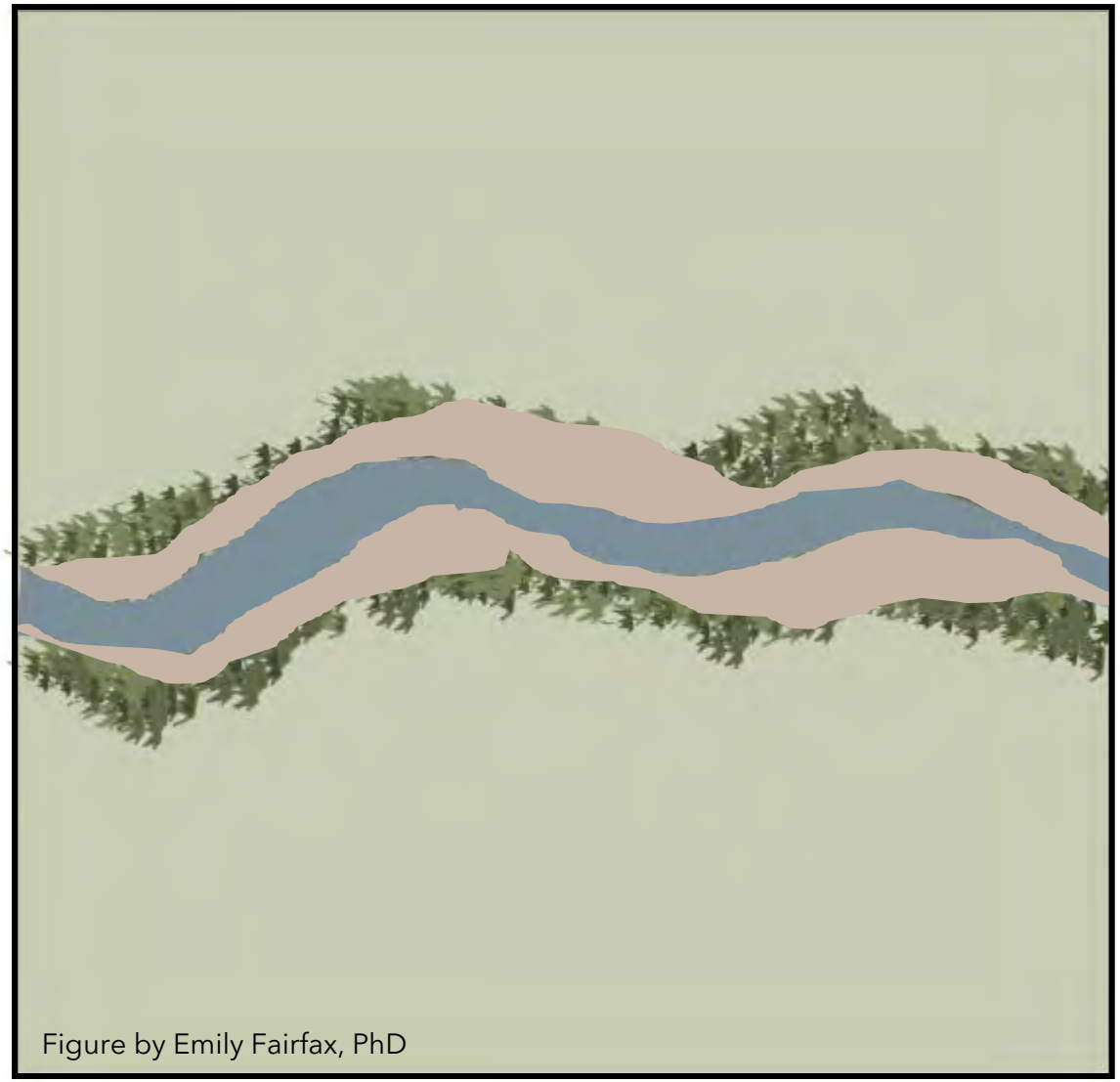

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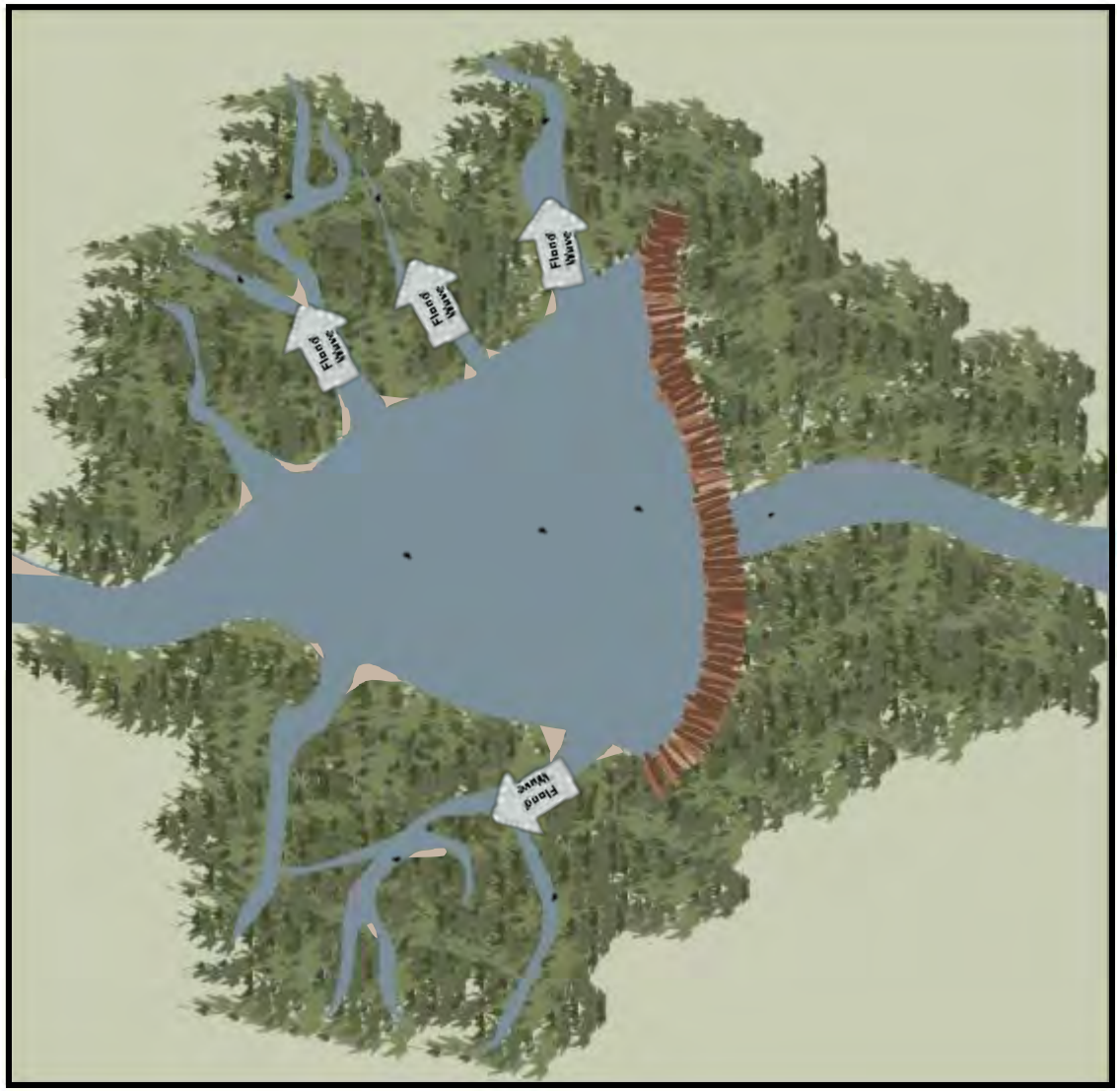

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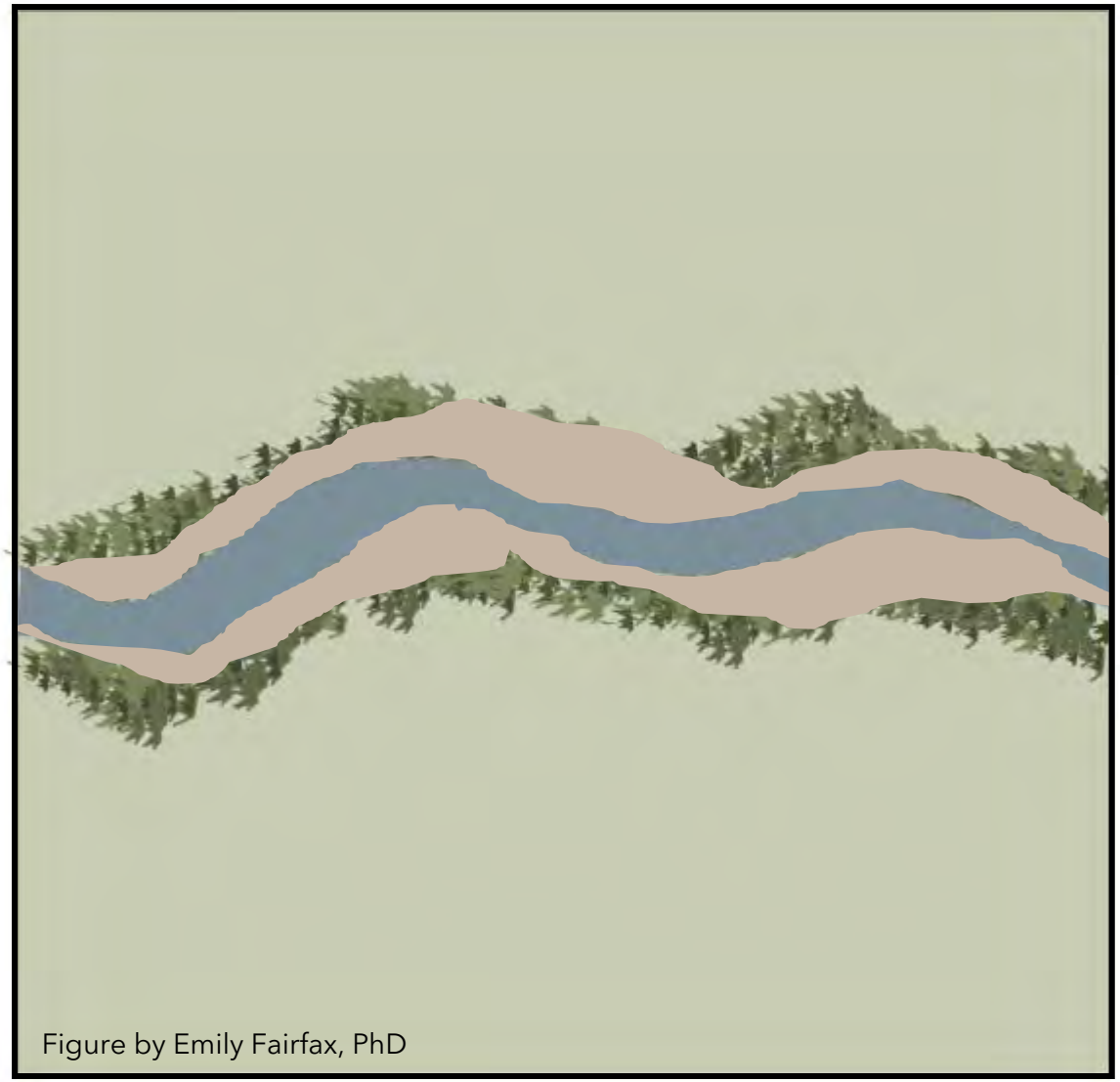

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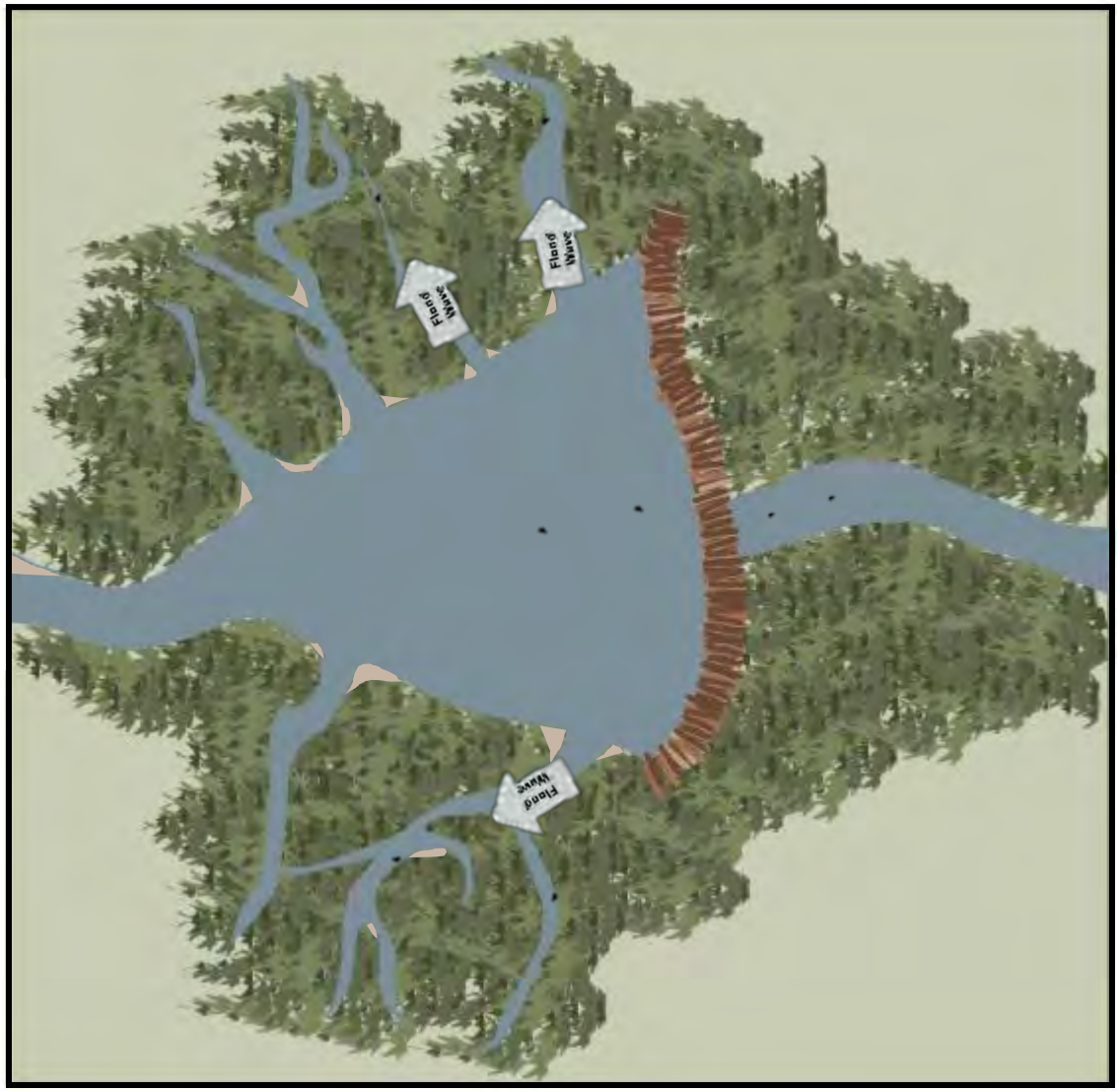

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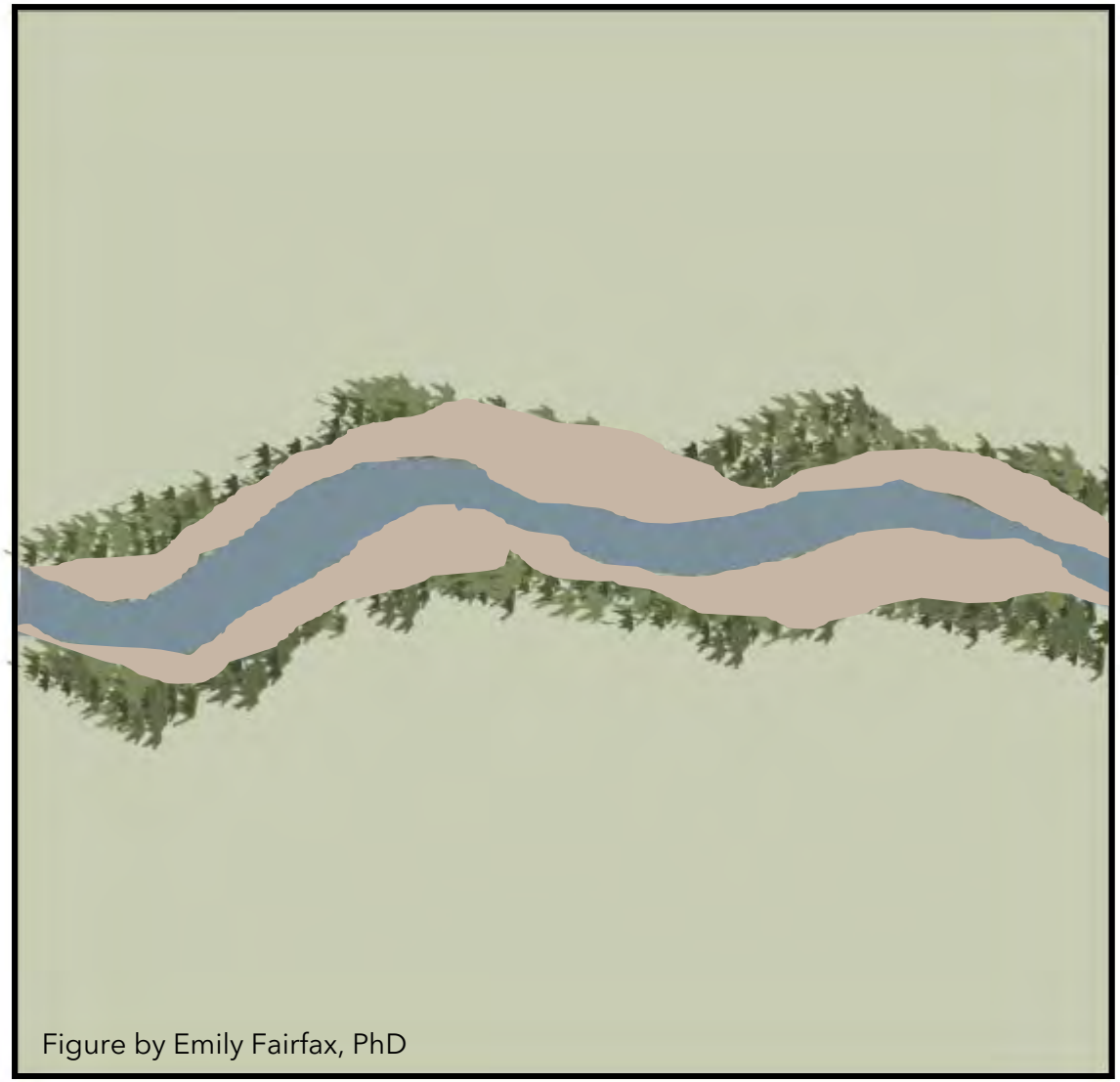

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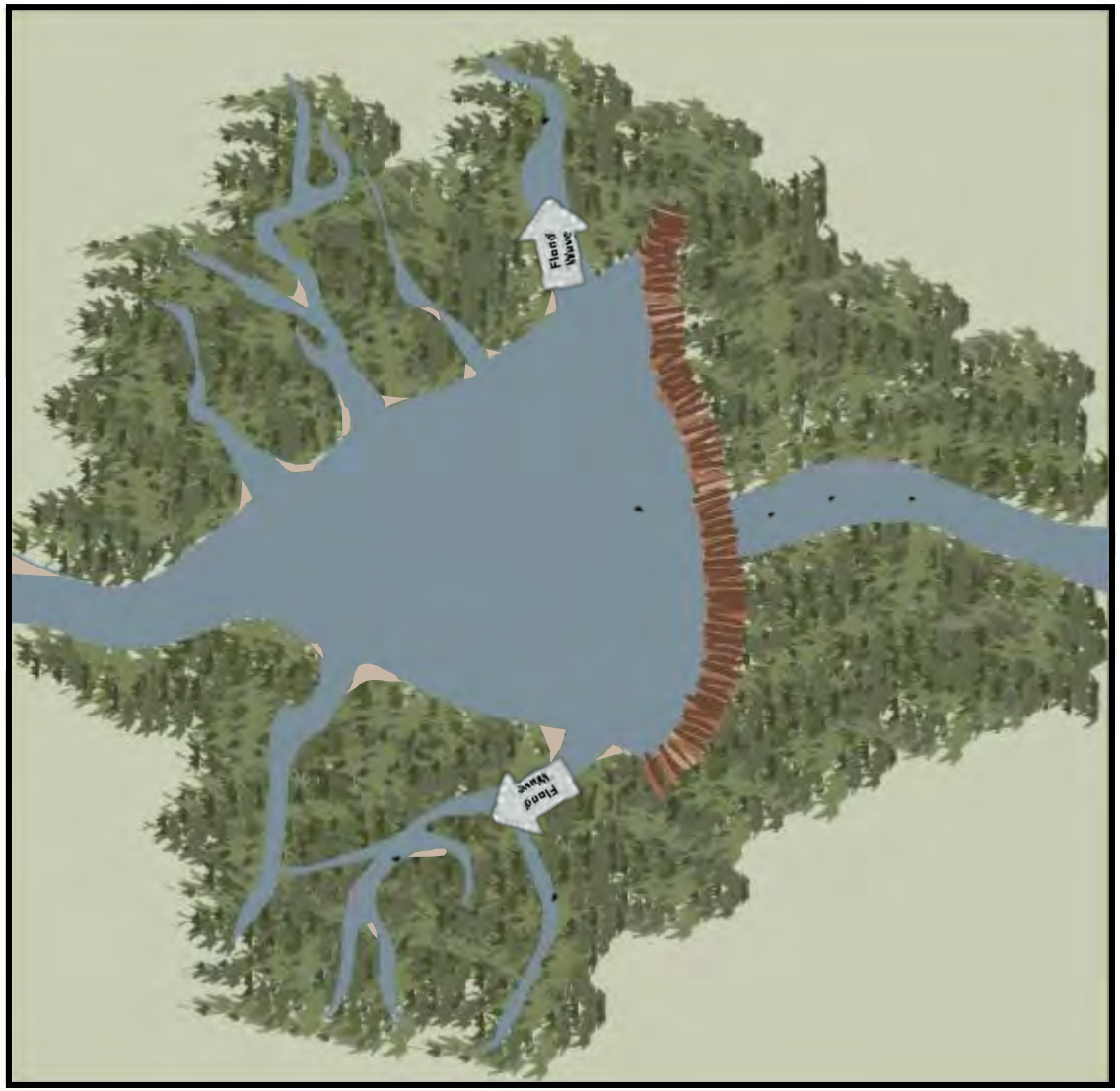

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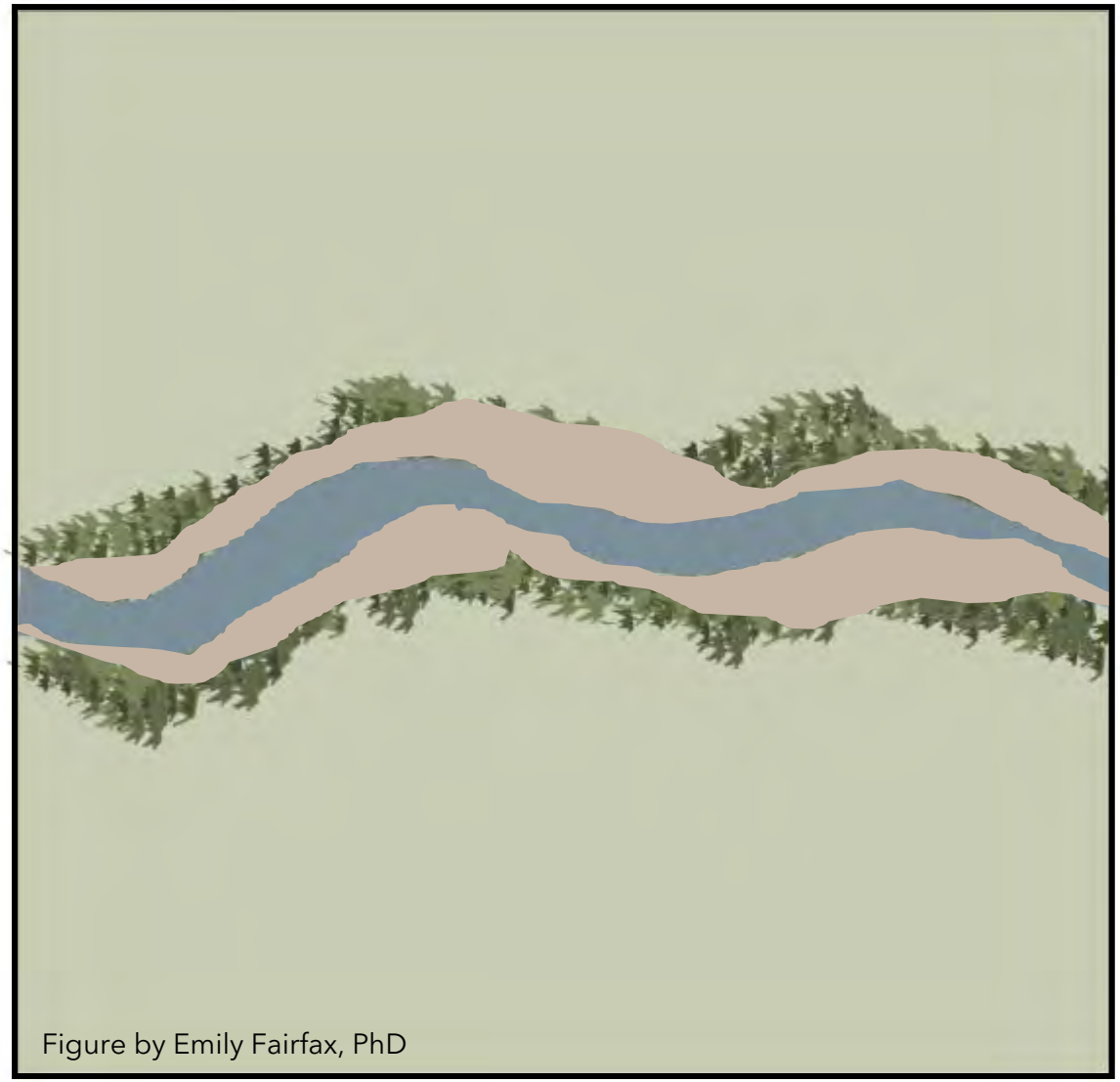

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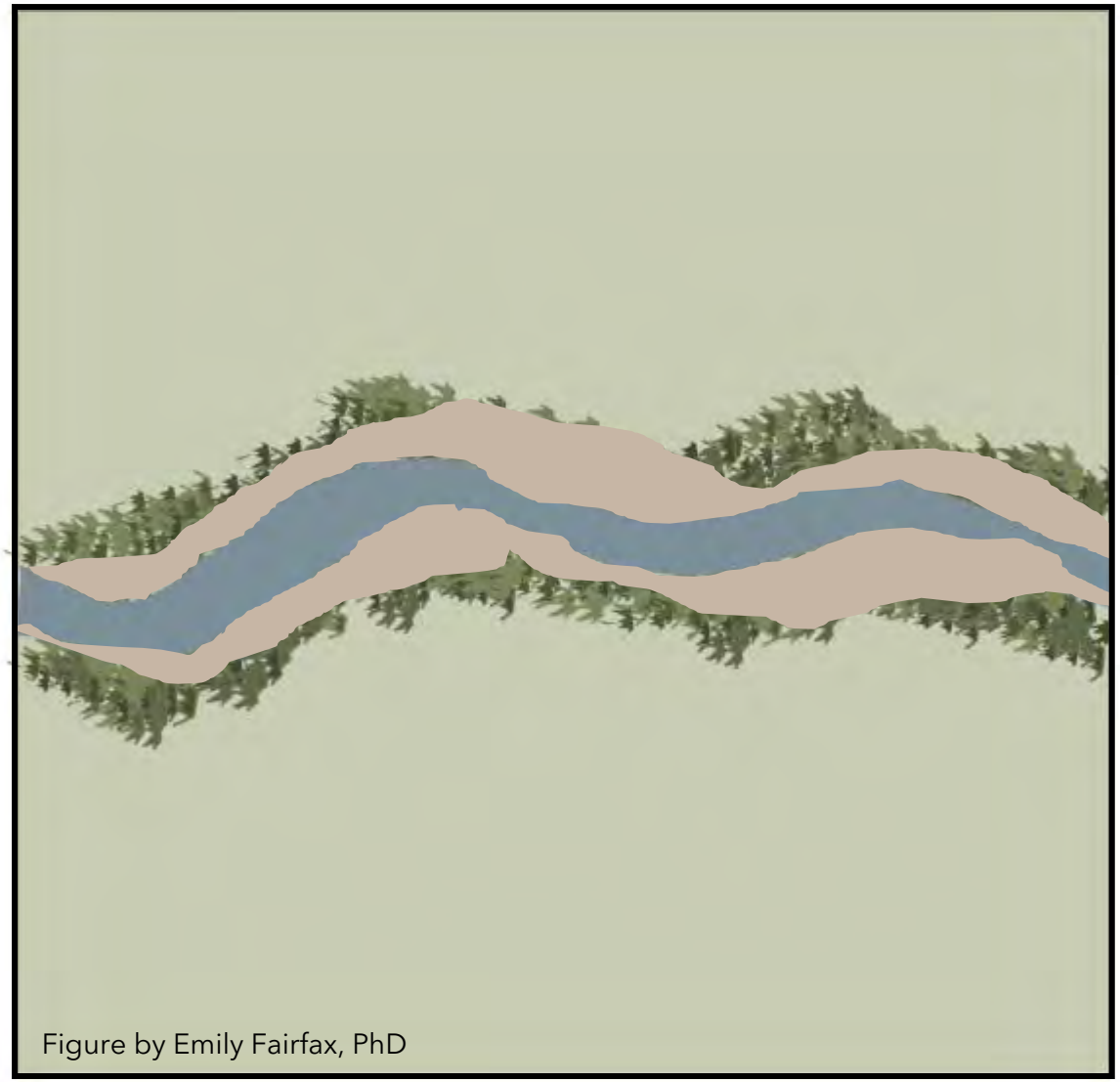

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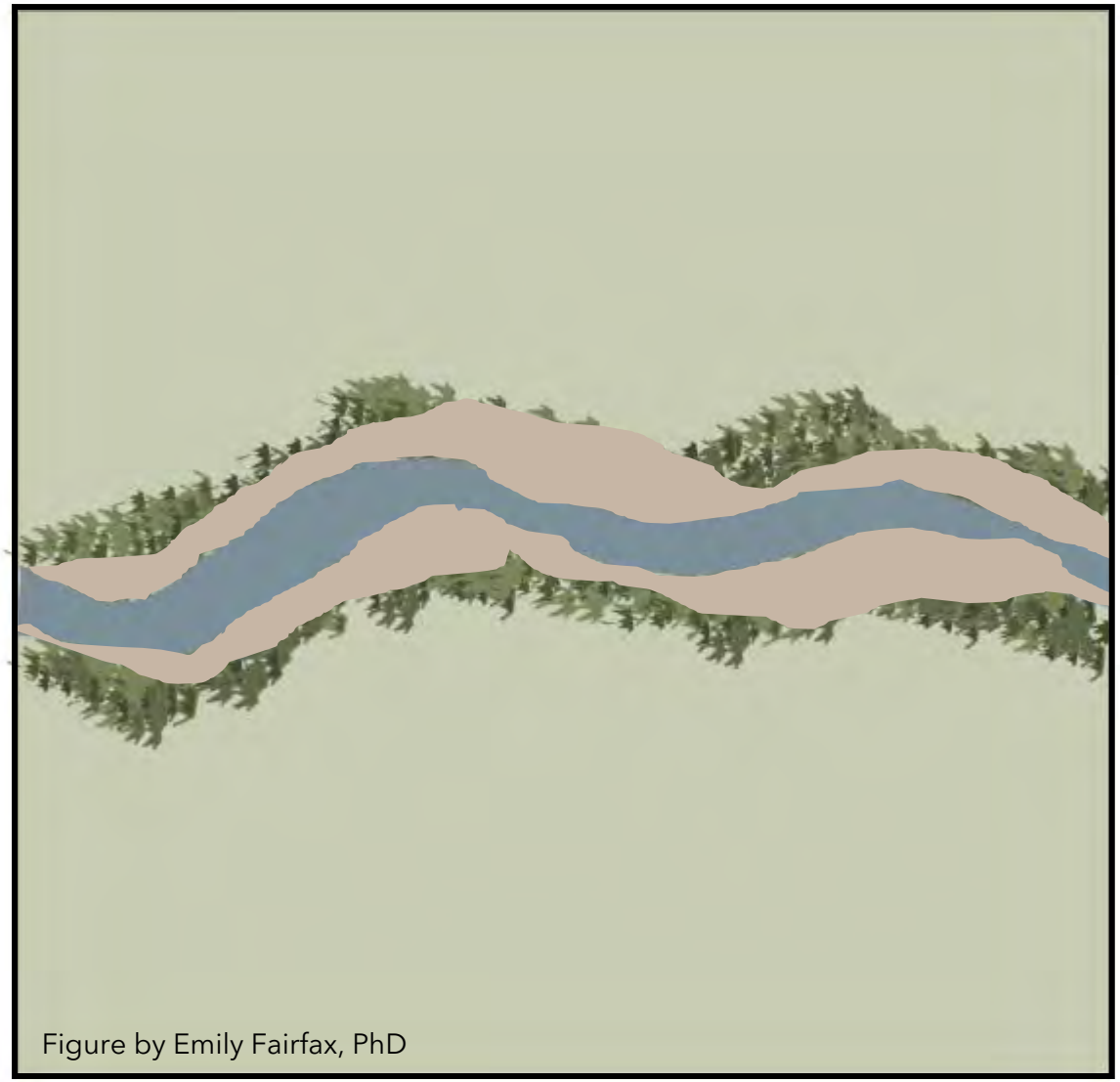

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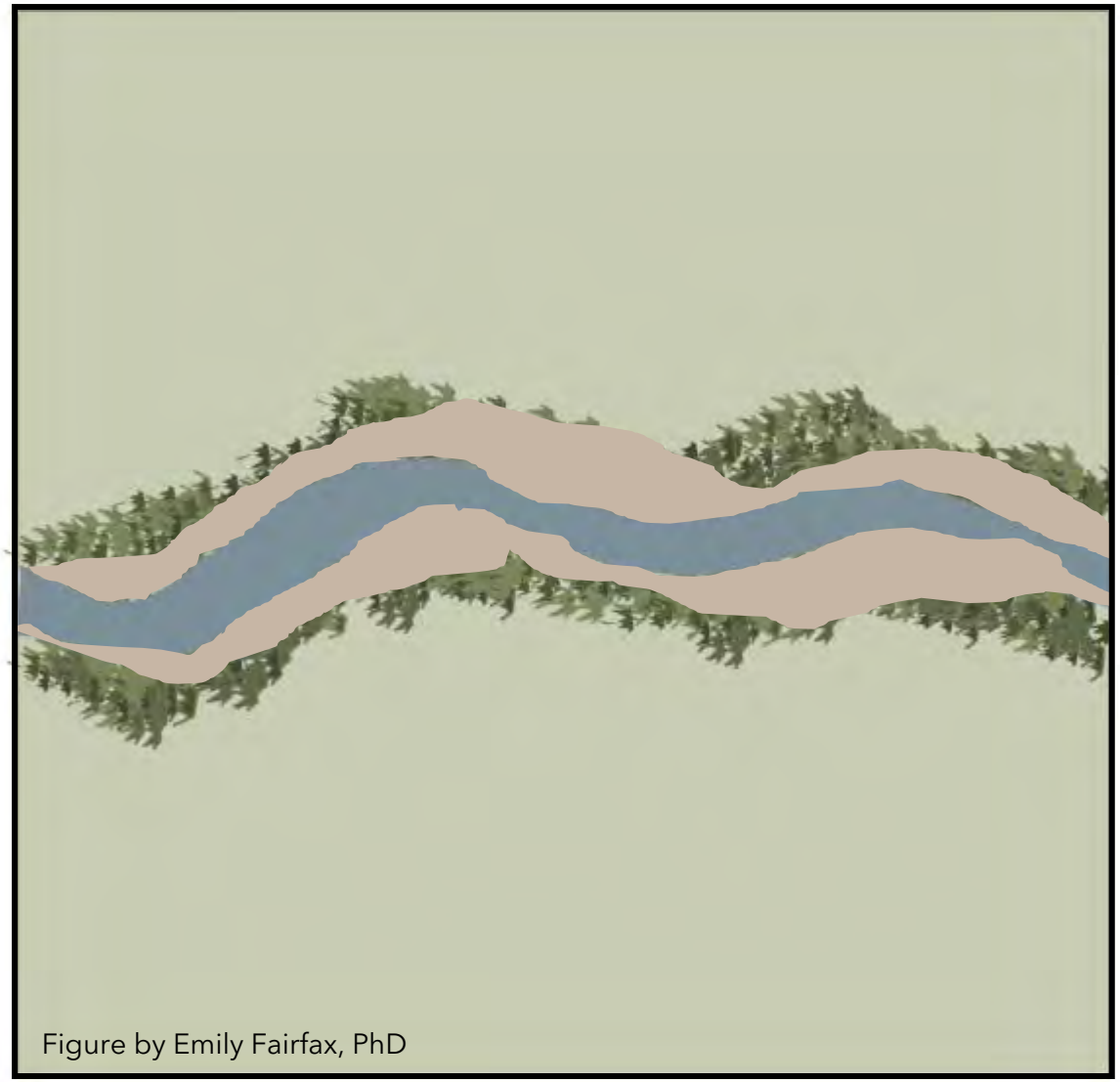

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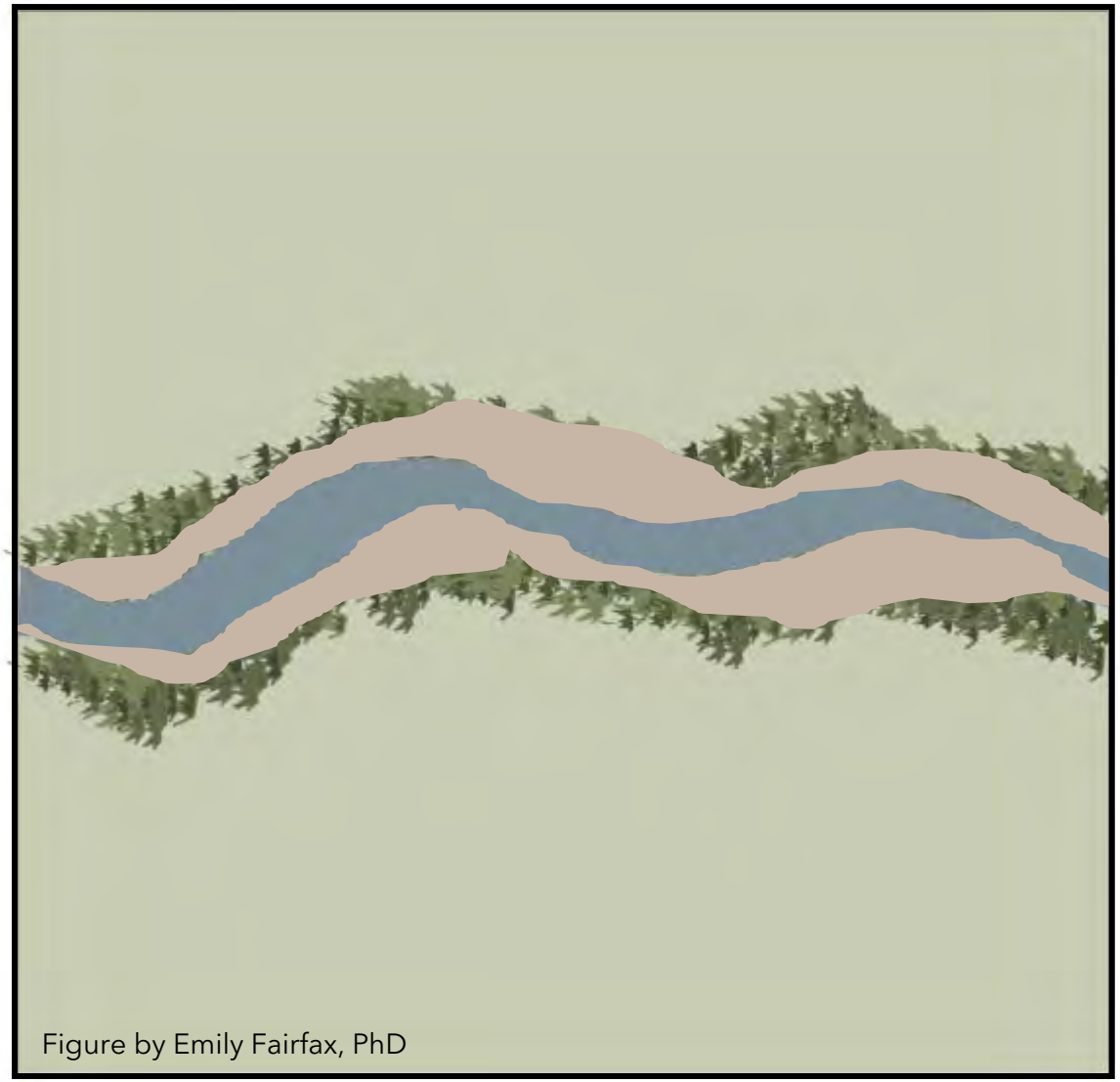

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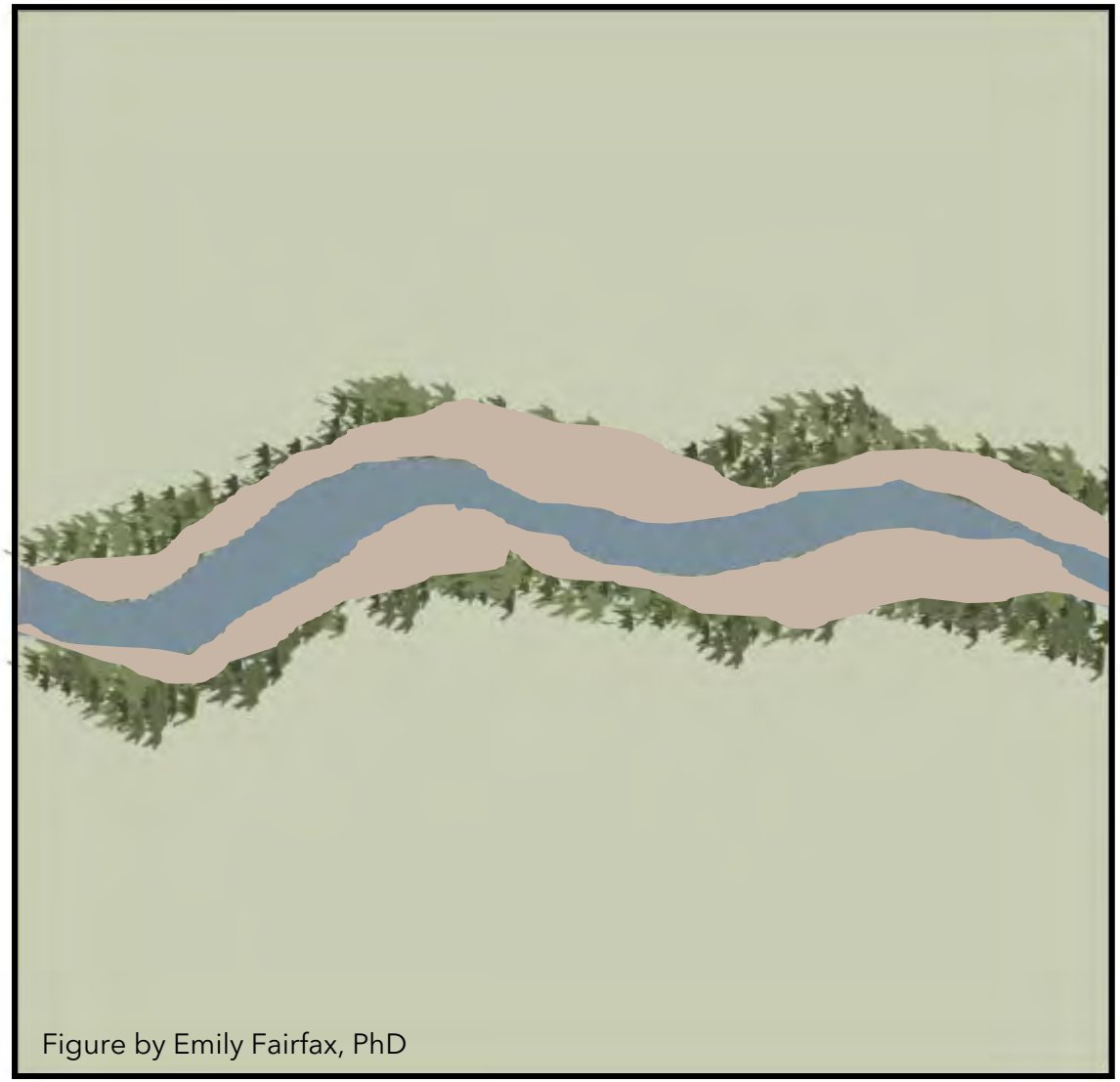

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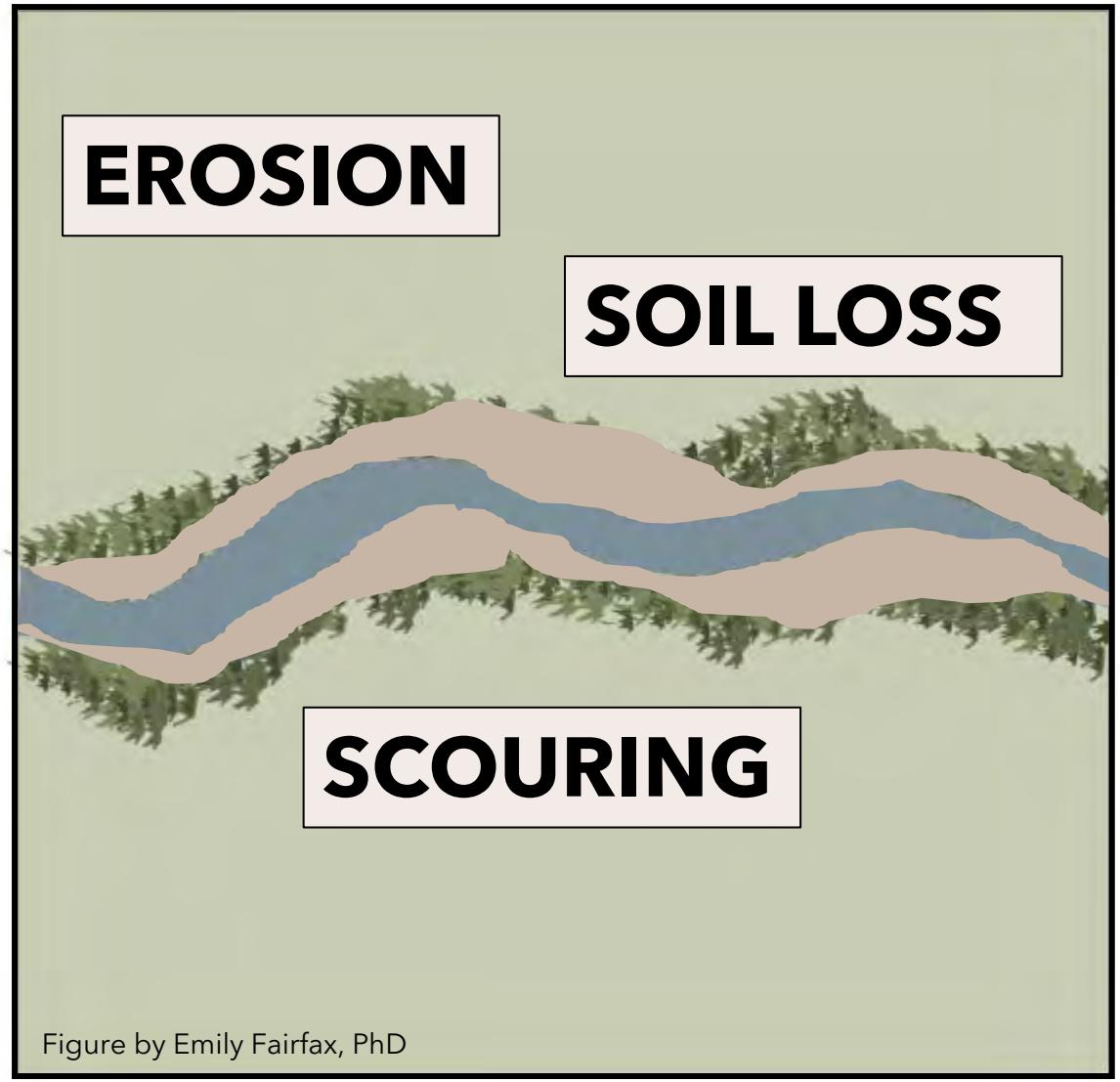

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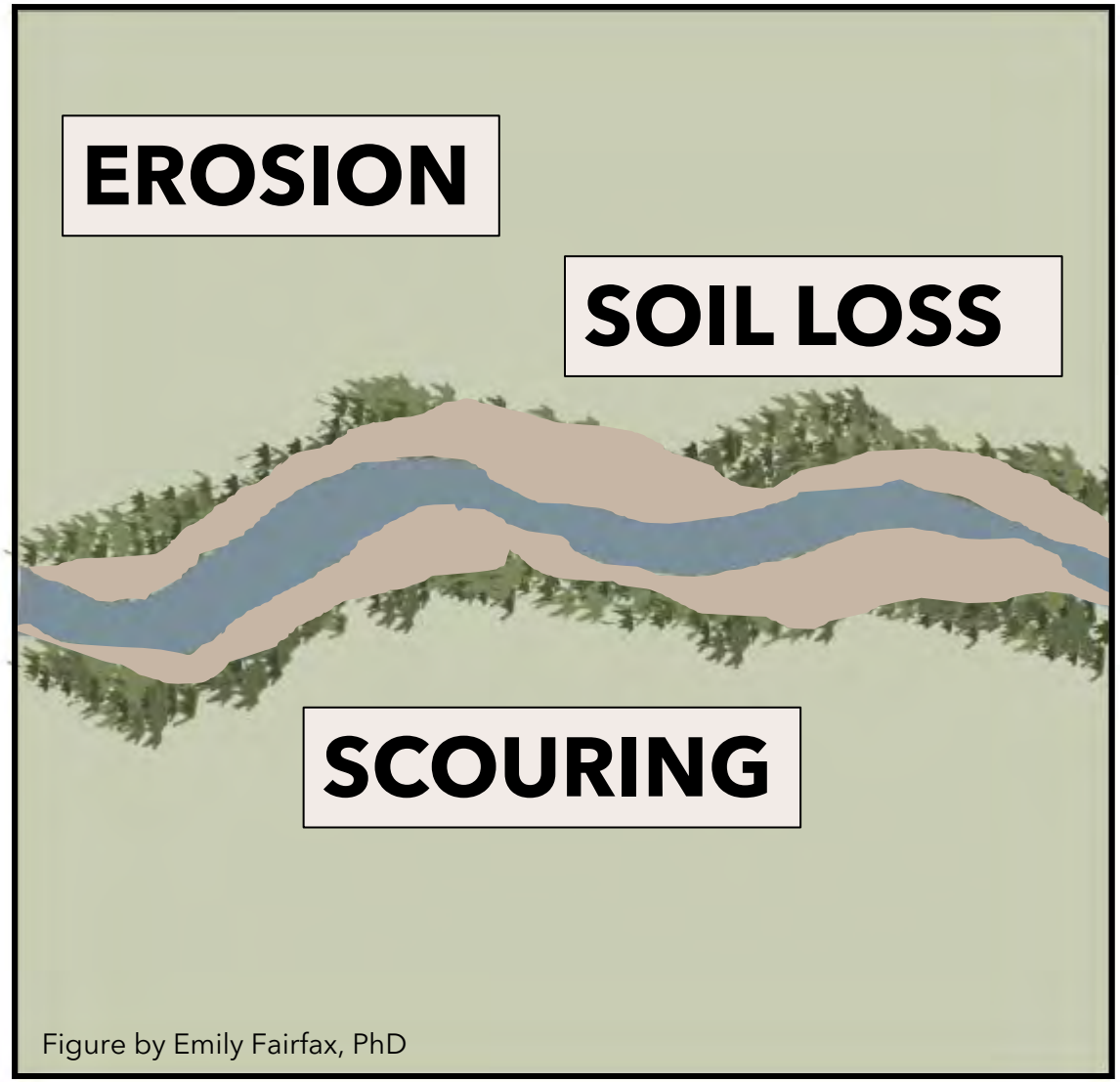

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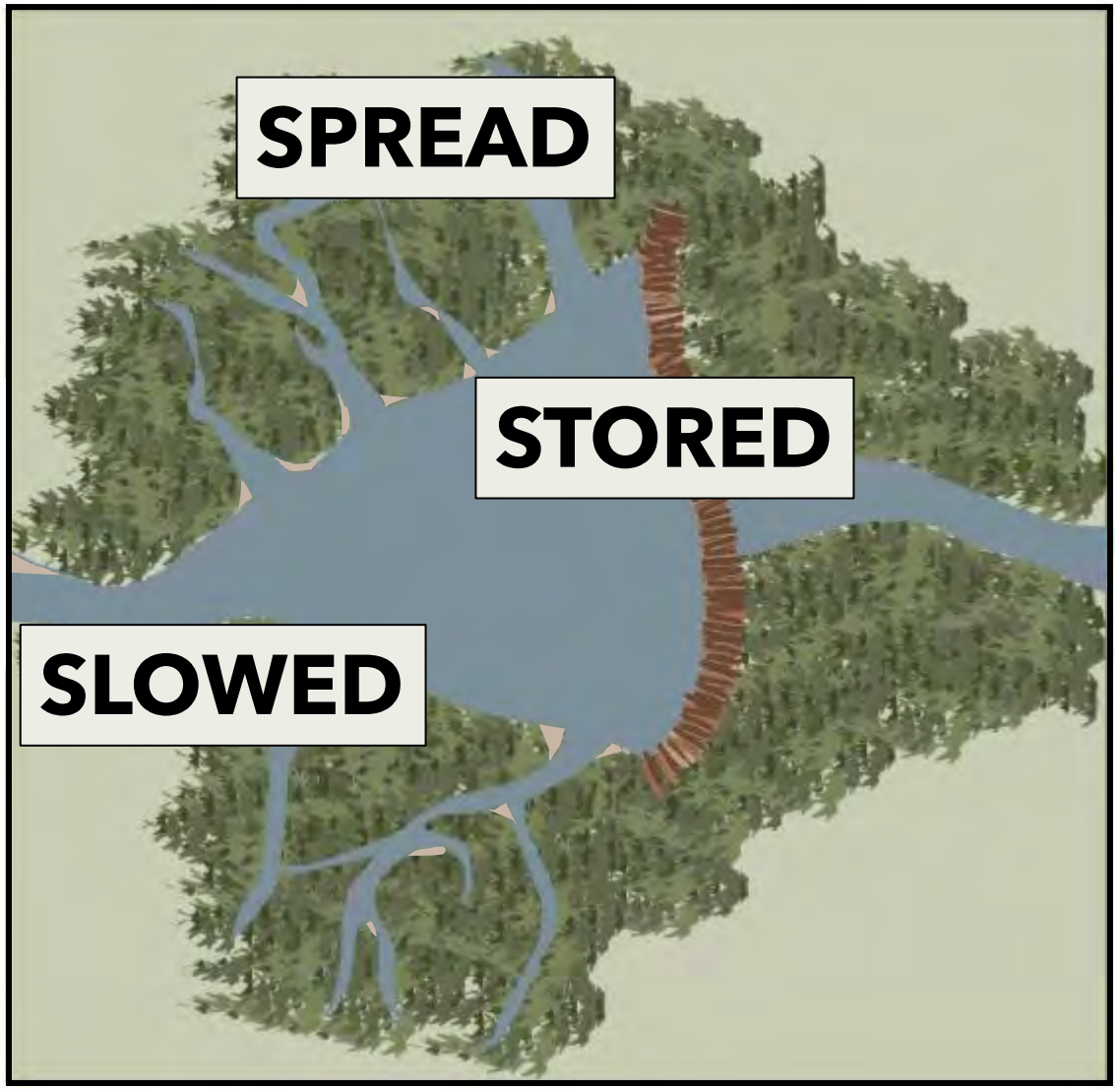
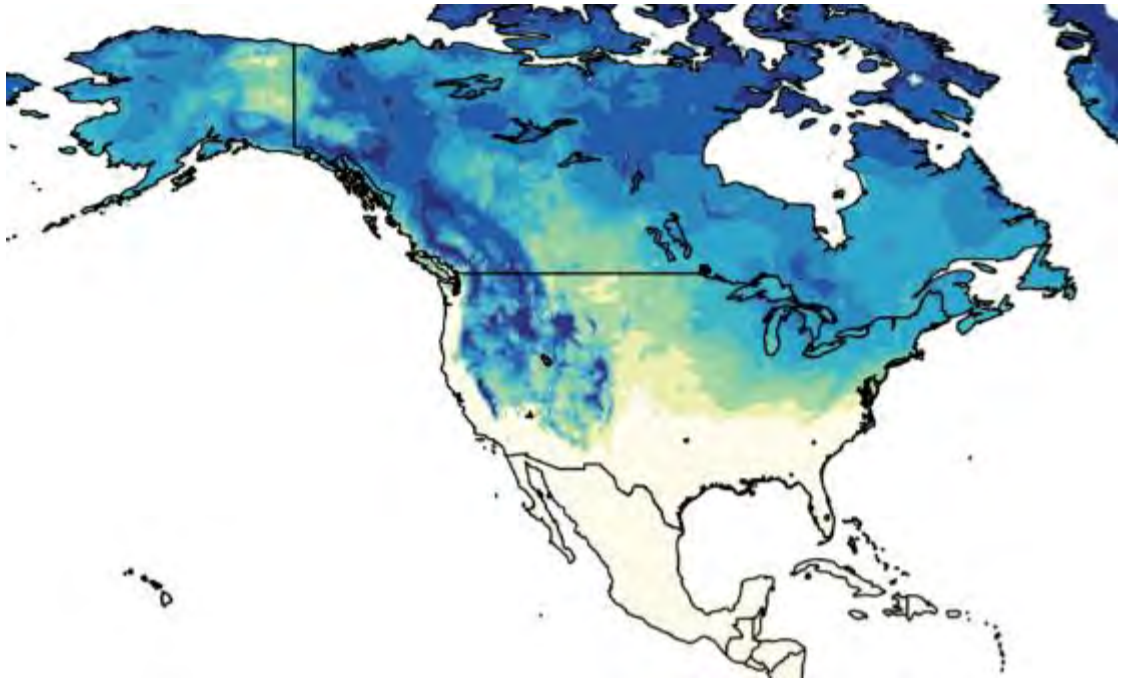


Do beaver dams and ponds stop all the water?

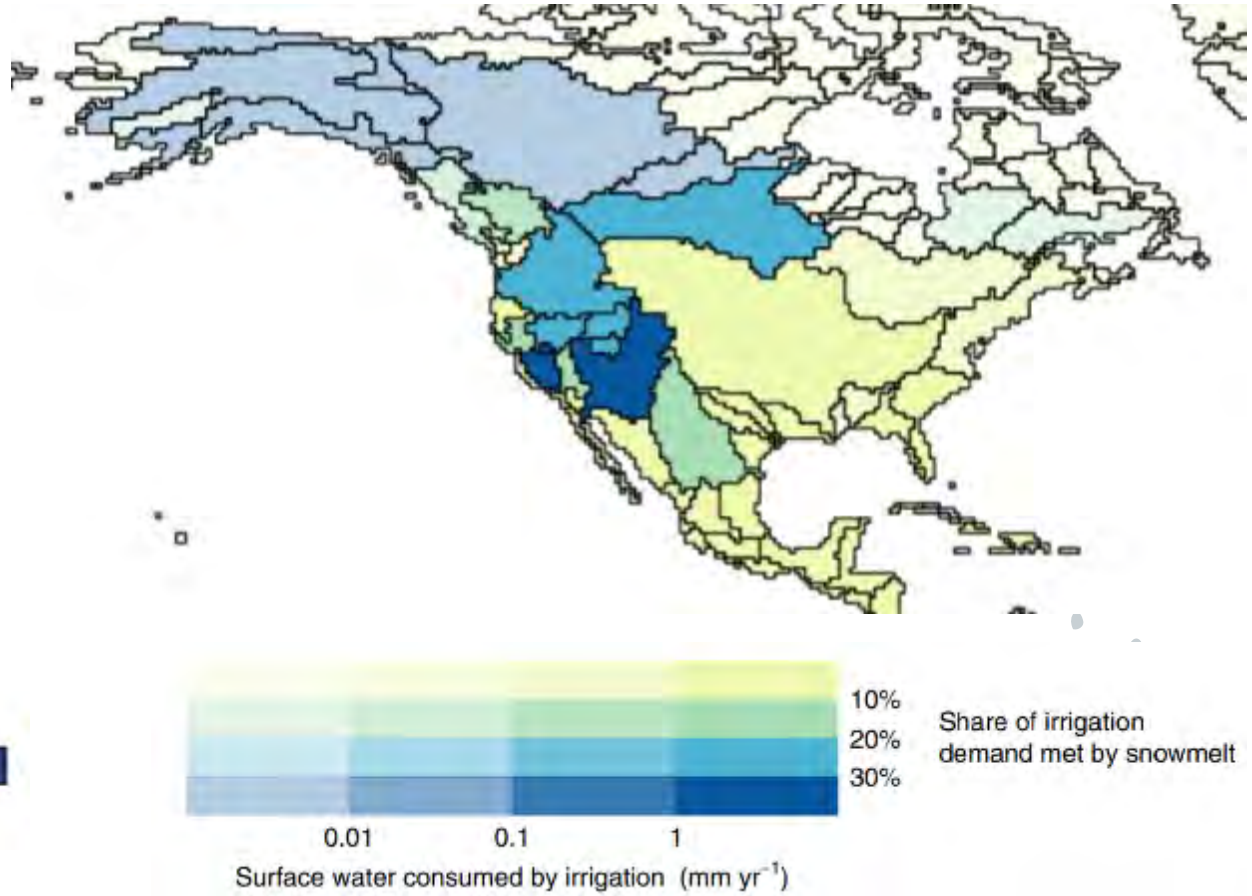
Do they starve the downstream area of water?

The American West is snowmelt dominated.



Snowmelt runoff ratio (%)

10 20 30 40 50 60 70 80 90

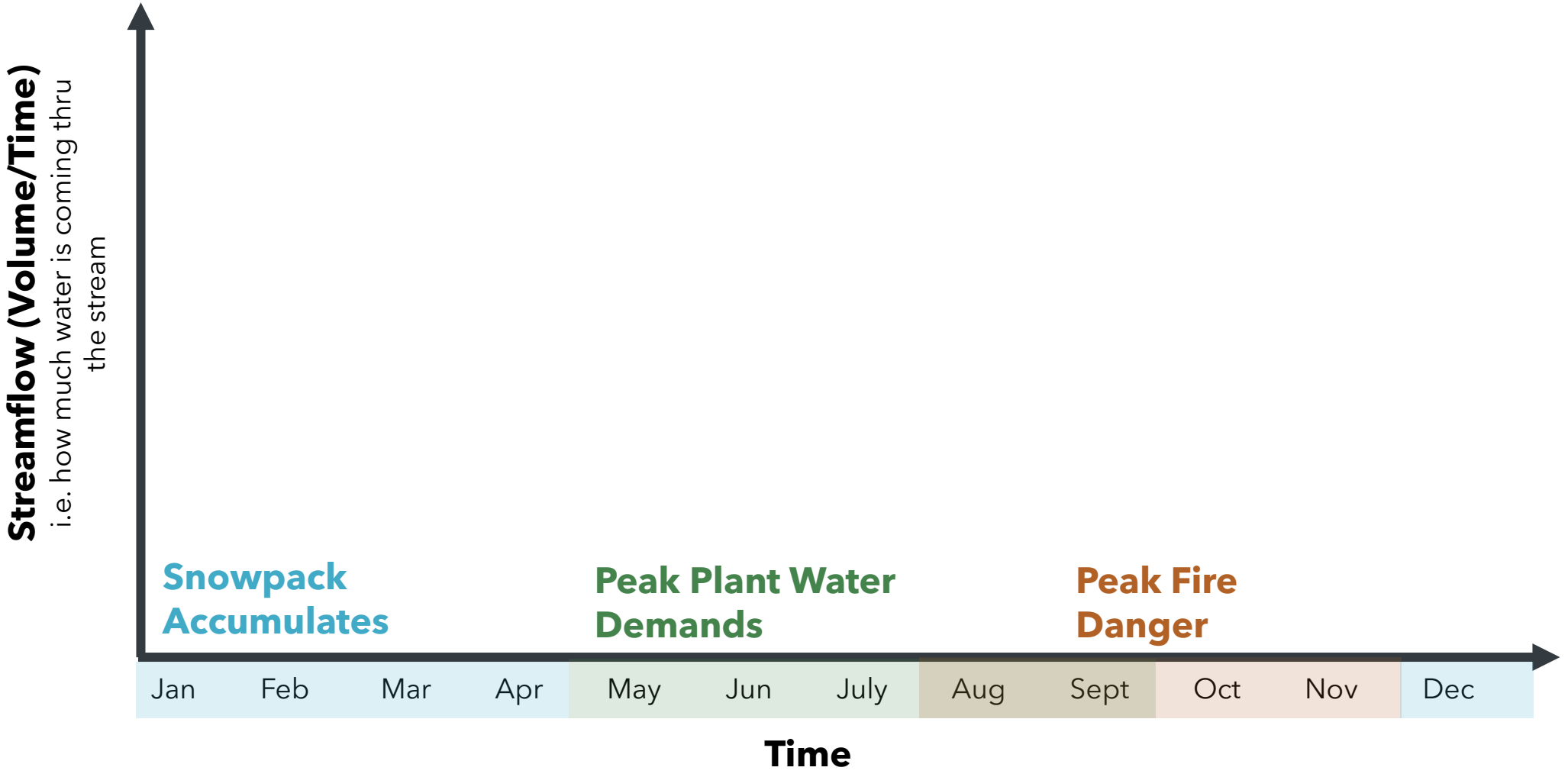


nature climate change
ARTICLES

Agricultural risks from changing snowmelt

Yue Qin, John T. Abatzoglou, Stefan Siebert, Laurie S. Huning, Amir AghaKouchak, Justin S. Mankin, Chaopeng Hong, Dan Tong, Steven J. Davis and Nathaniel D. Mueller

Beaver ponds slow, but don't stop, water.



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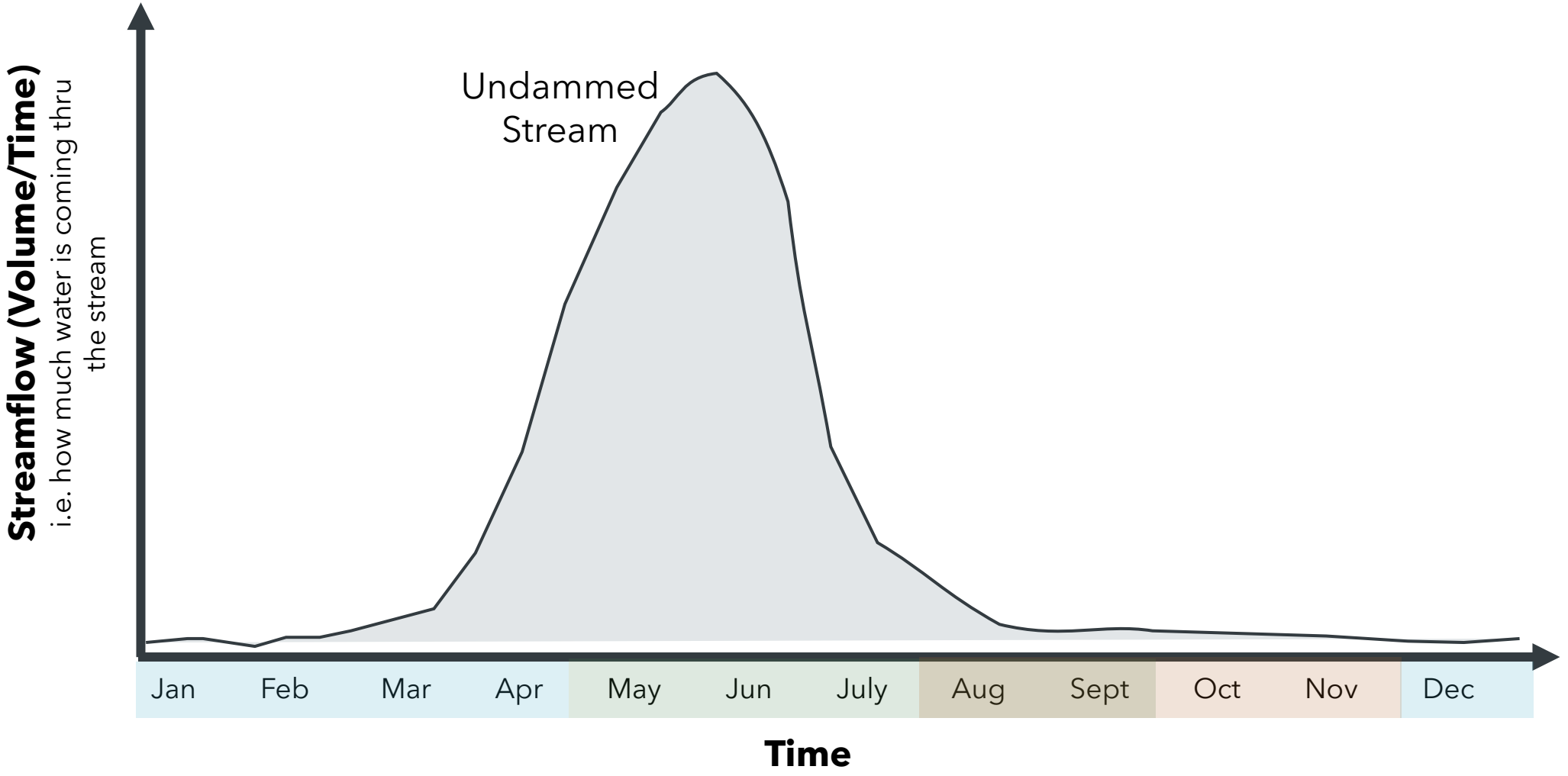

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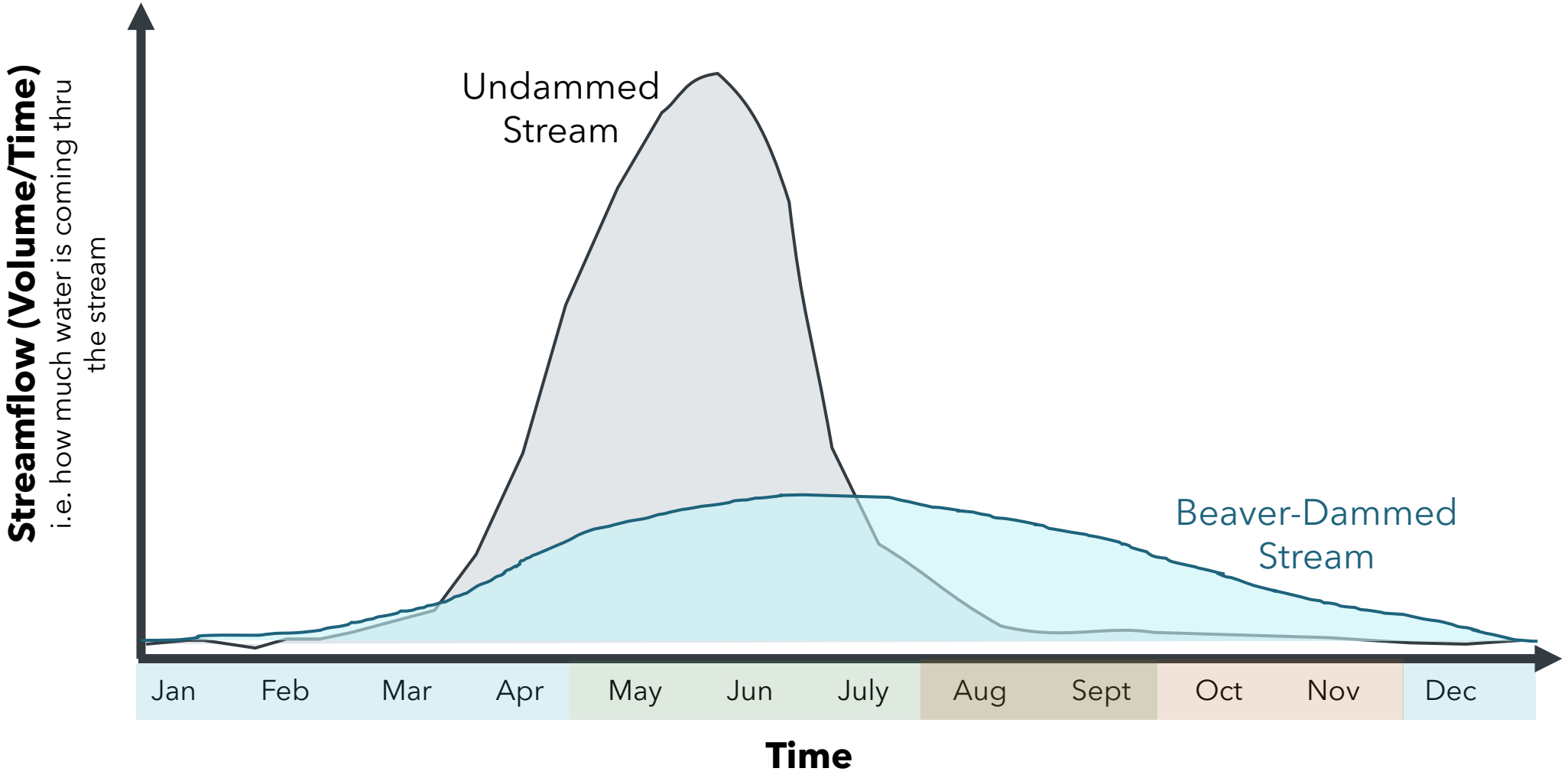

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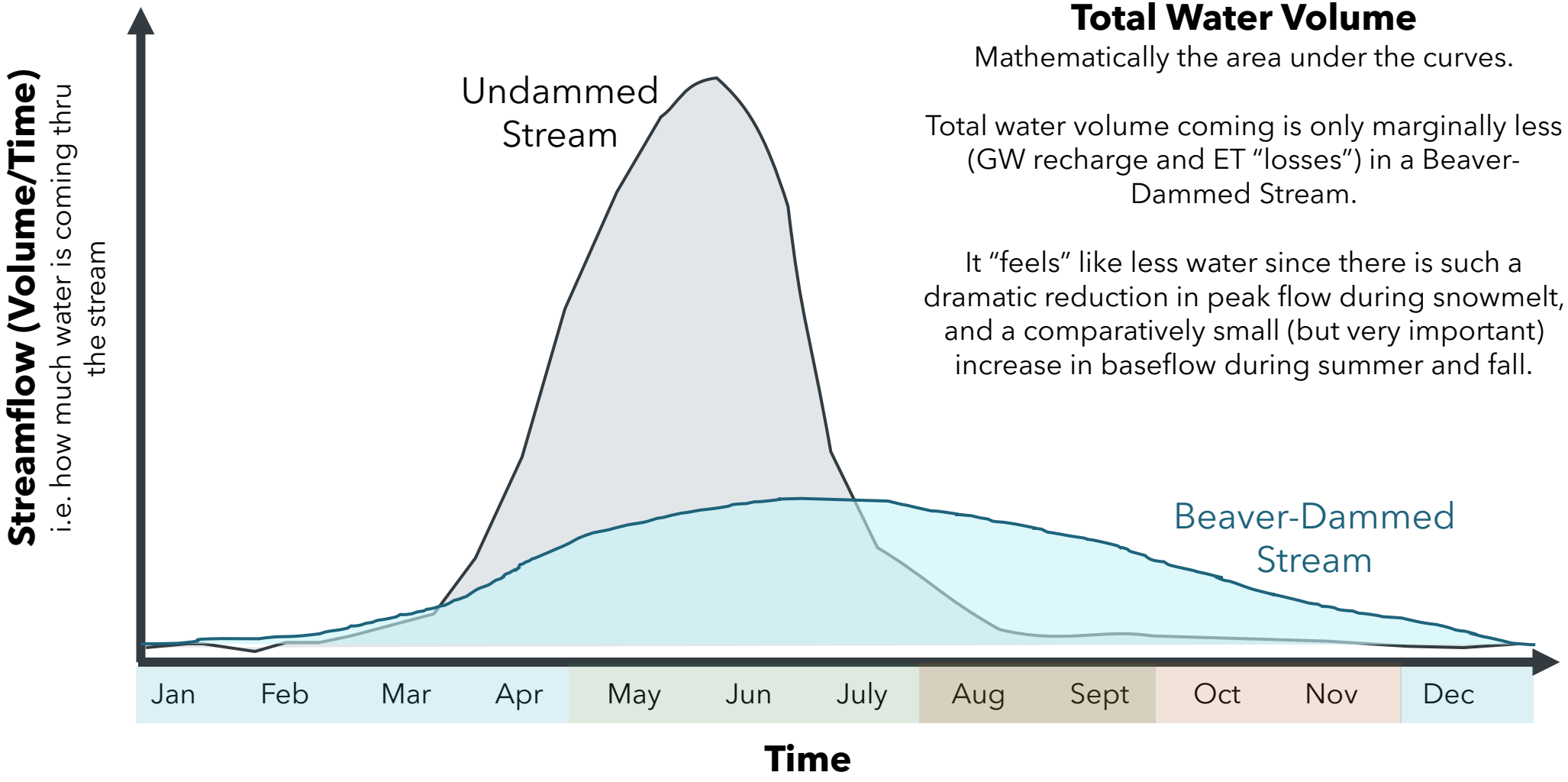


Total Water Volume

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.

What about the water "losses" to groundwater and plants?

Isn't losing water a bad thing?

Beavers keep plants green during drought.

ELSEVIER

Biological Conservation

Volume 141, Issue 2, February 2008, Pages 556-567

Beaver (*Castor canadensis*) mitigate the effects of climate on the area of open water in boreal wetlands in western Canada

Glynnis A. Hood [a, b], Suzanne E. Bayley [a]

Ecohydrology

RESEARCH ARTICLE Full Access

Using remote sensing to assess the impact of beaver damming on riparian evapotranspiration in an arid landscape

Emily Fairfax, Eric E. Small

First published: 25 May 2018 | https://doi.org/10.1002/eco.1993 | Citations: 10

PLOS ONE

OPEN ACCESS PEER-REVIEWED

RESEARCH ARTICLE

Modeling intrinsic potential for beaver (*Castor canadensis*) habitat to inform restoration and climate change adaptation

Benjamin J. Dittbrenner, Michael M. Pollock, Jason W. Schilling, Julian D. Olden, Joshua J. Lawler, Christian E. Torgersen

Published: February 28, 2018 • https://doi.org/10.1371/journal.pone.0192538

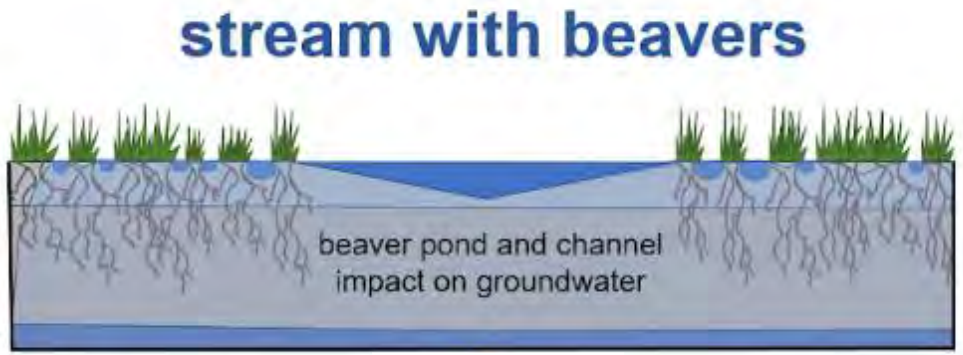
Beavers Buffer Droughts

the conceptual model

Conceptual Model: Beavers and Drought

Fairfax and Small (2018)

Conceptual Model: Beavers and Drought



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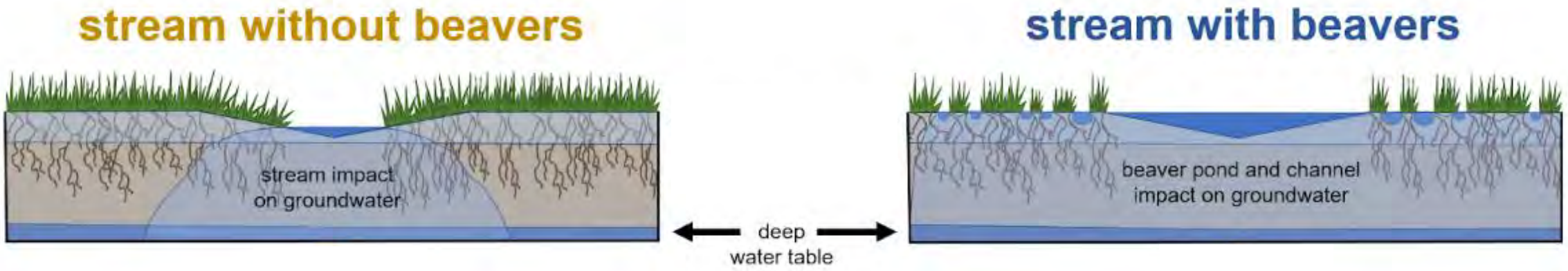
Conceptual Model: Beavers and Drought



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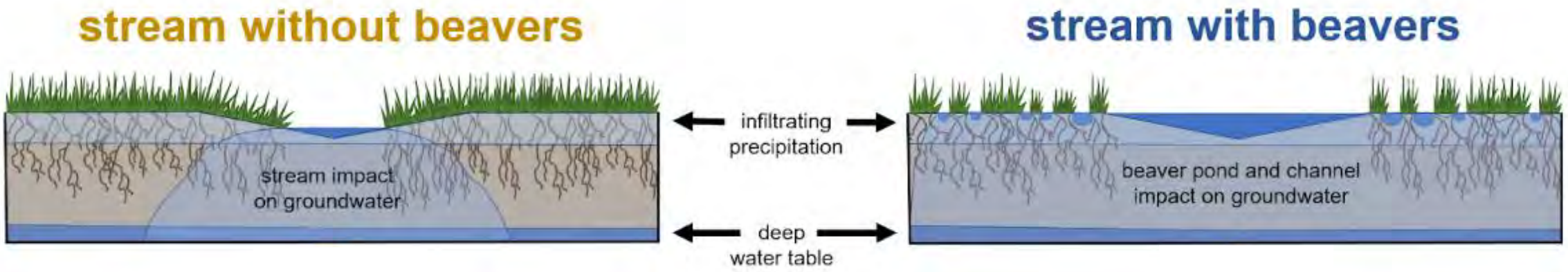

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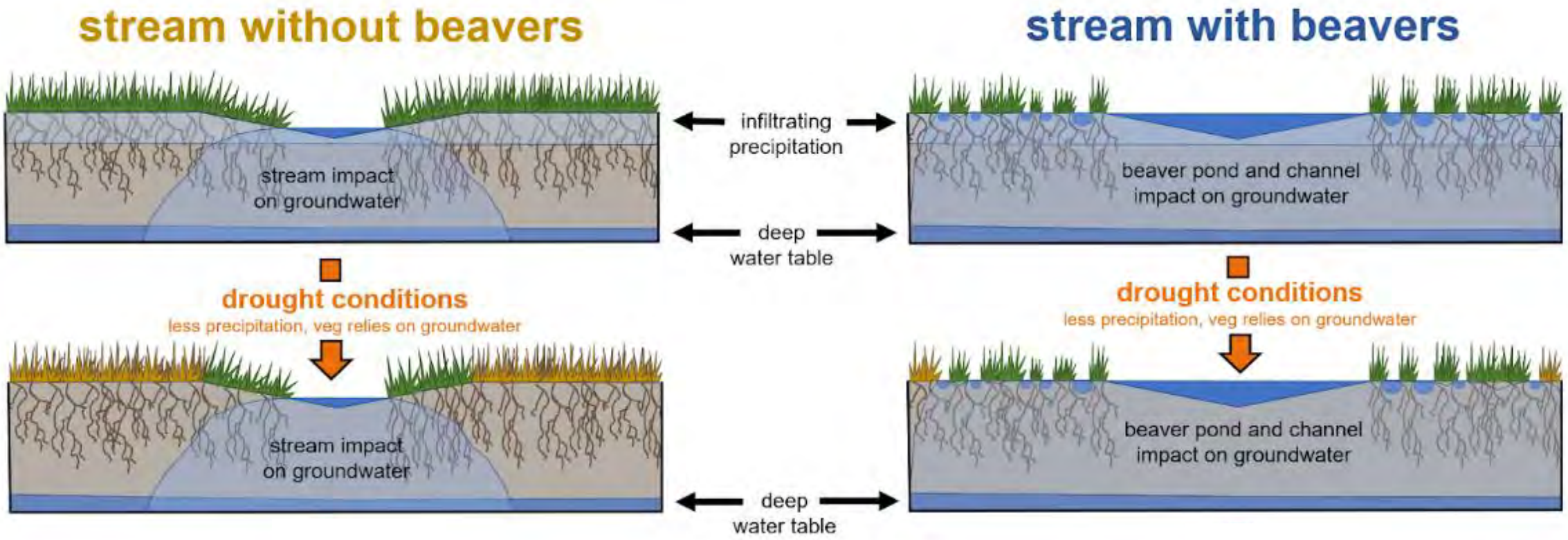

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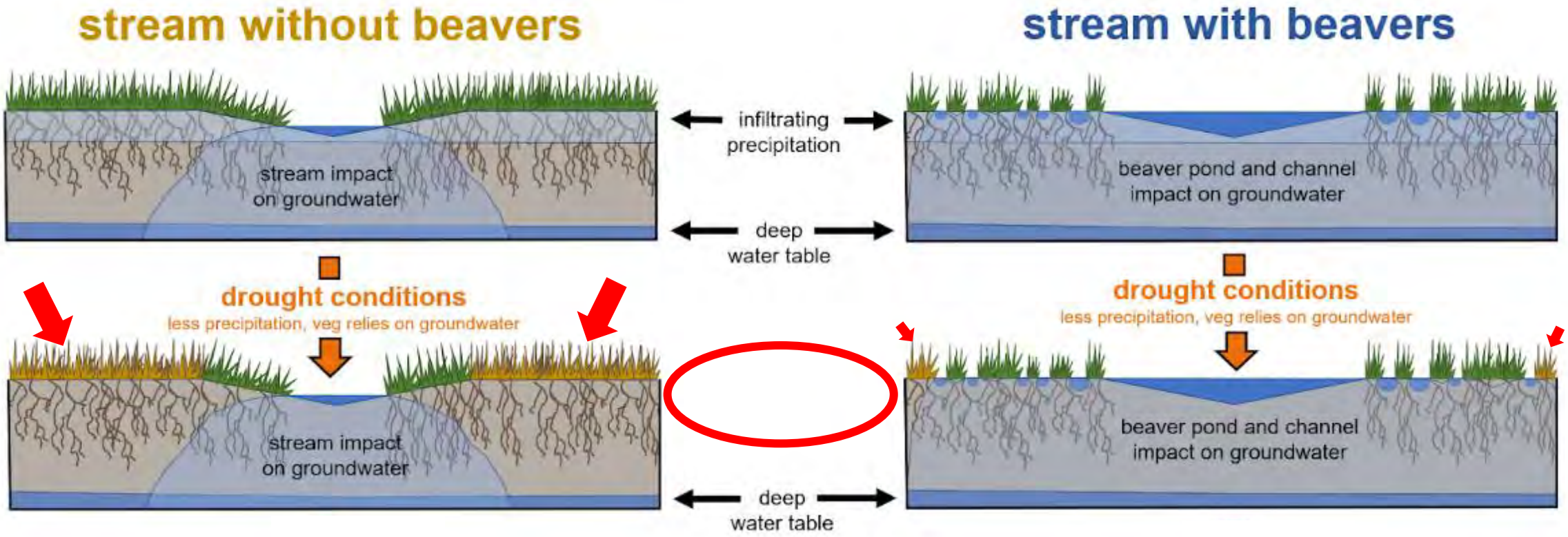


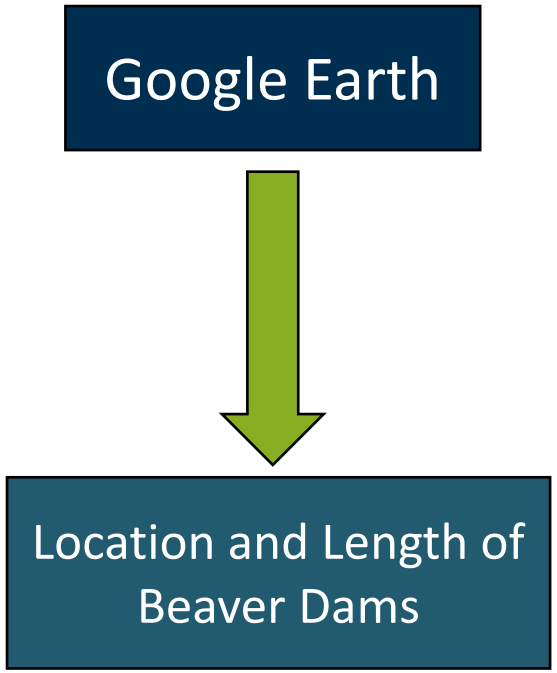
Fairfax and Small (2018)

Beavers Buffer Droughts

the science and data

From Fairfax & Small (2018)

How can we observe and quantify drought resistance?



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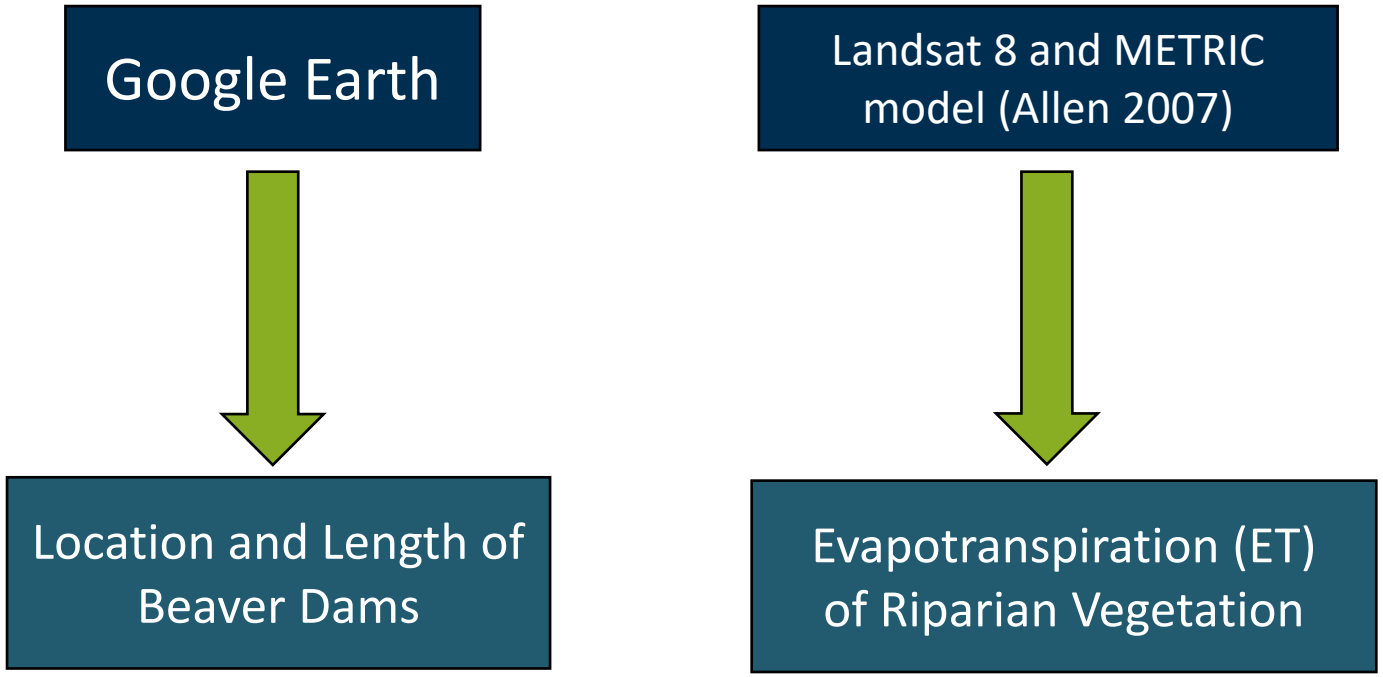
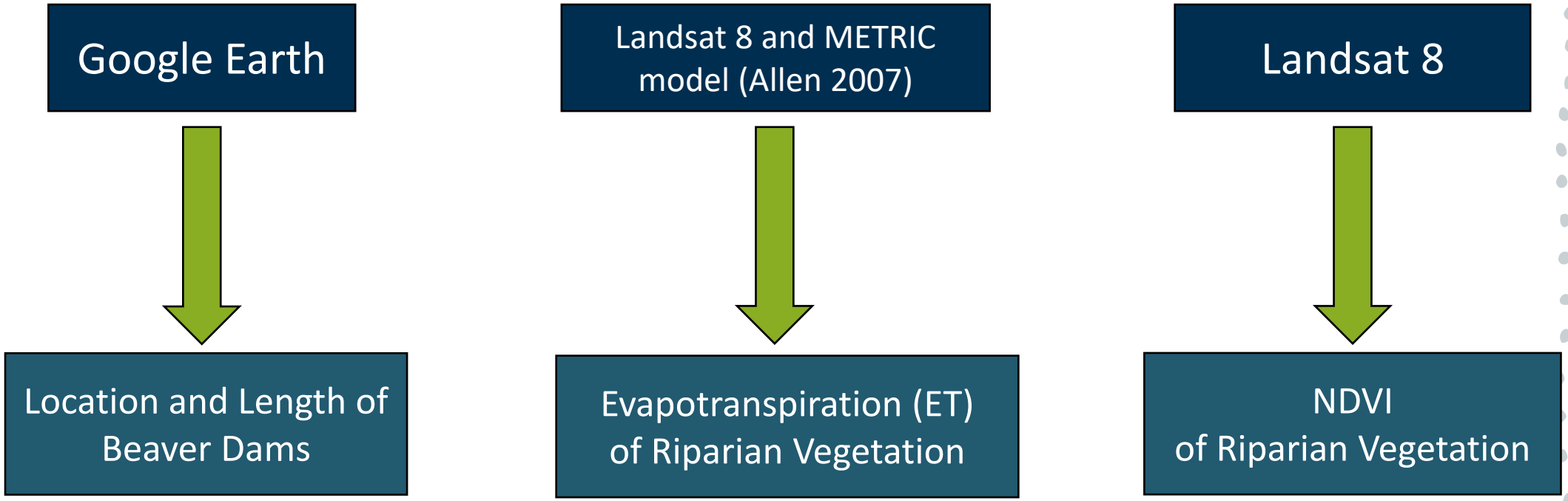


From Fairfax & Small (2018)

How can we observe and quantify drought resistance?



From Fairfax & Small (2018)

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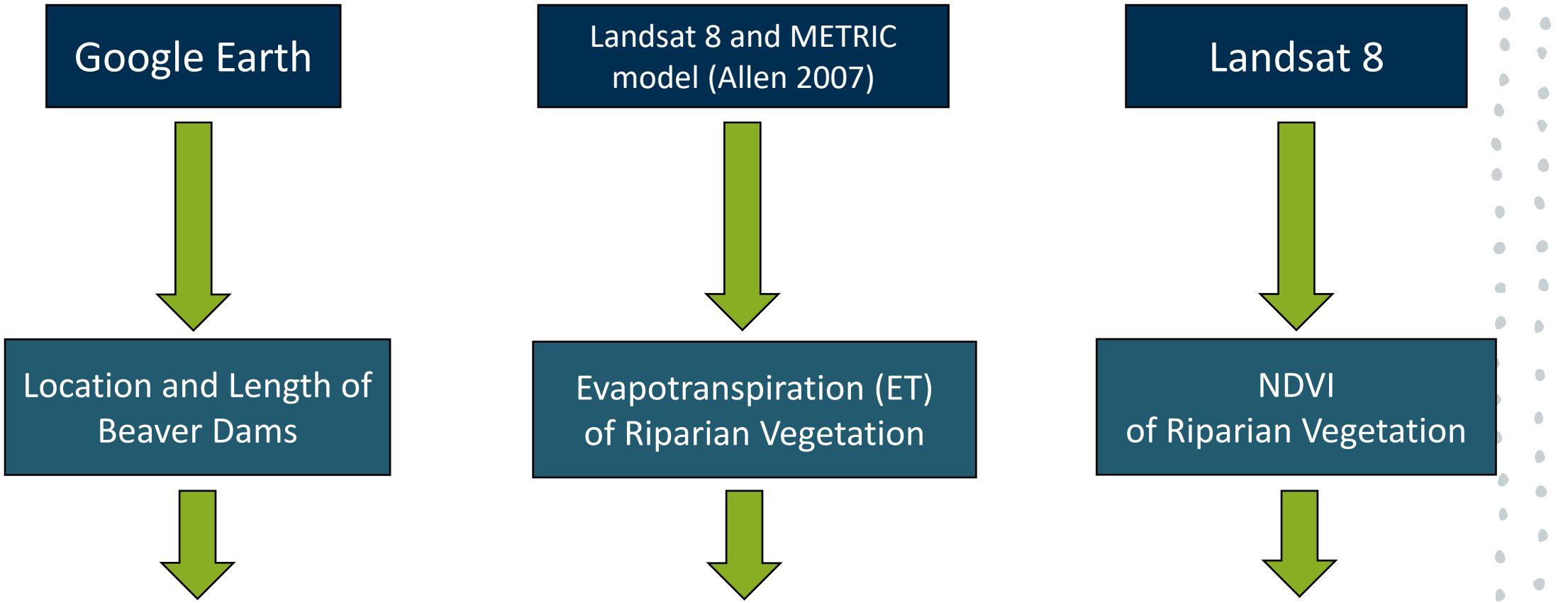
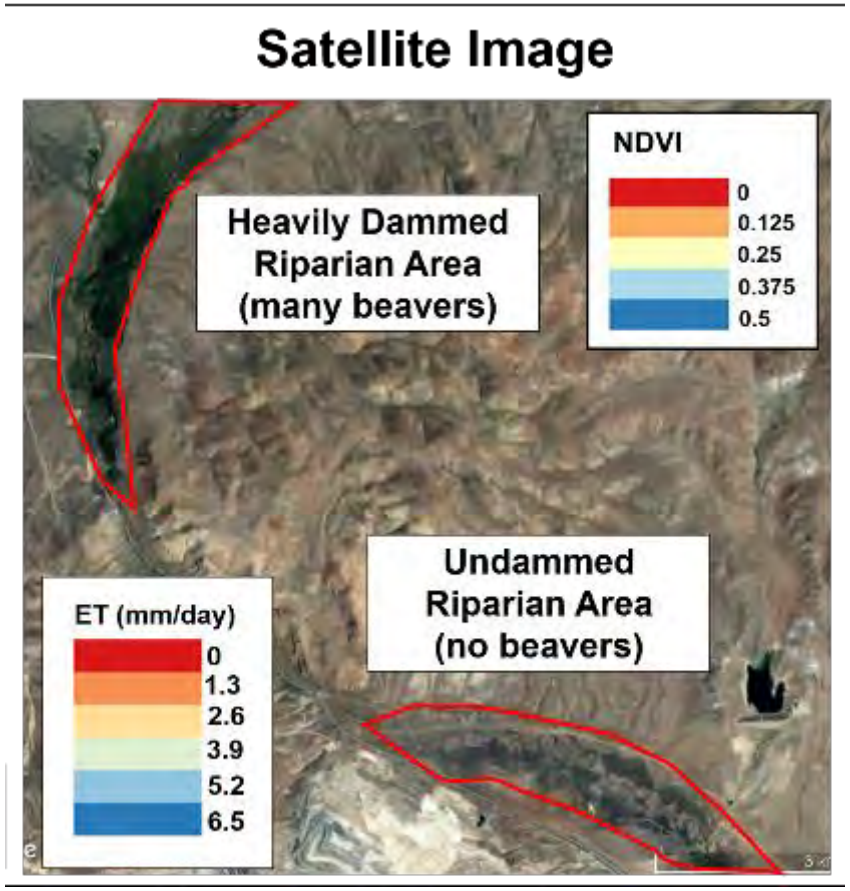


Goal: Compare the vegetation health in dammed vs undammed areas throughout study area (near Elko, NV)

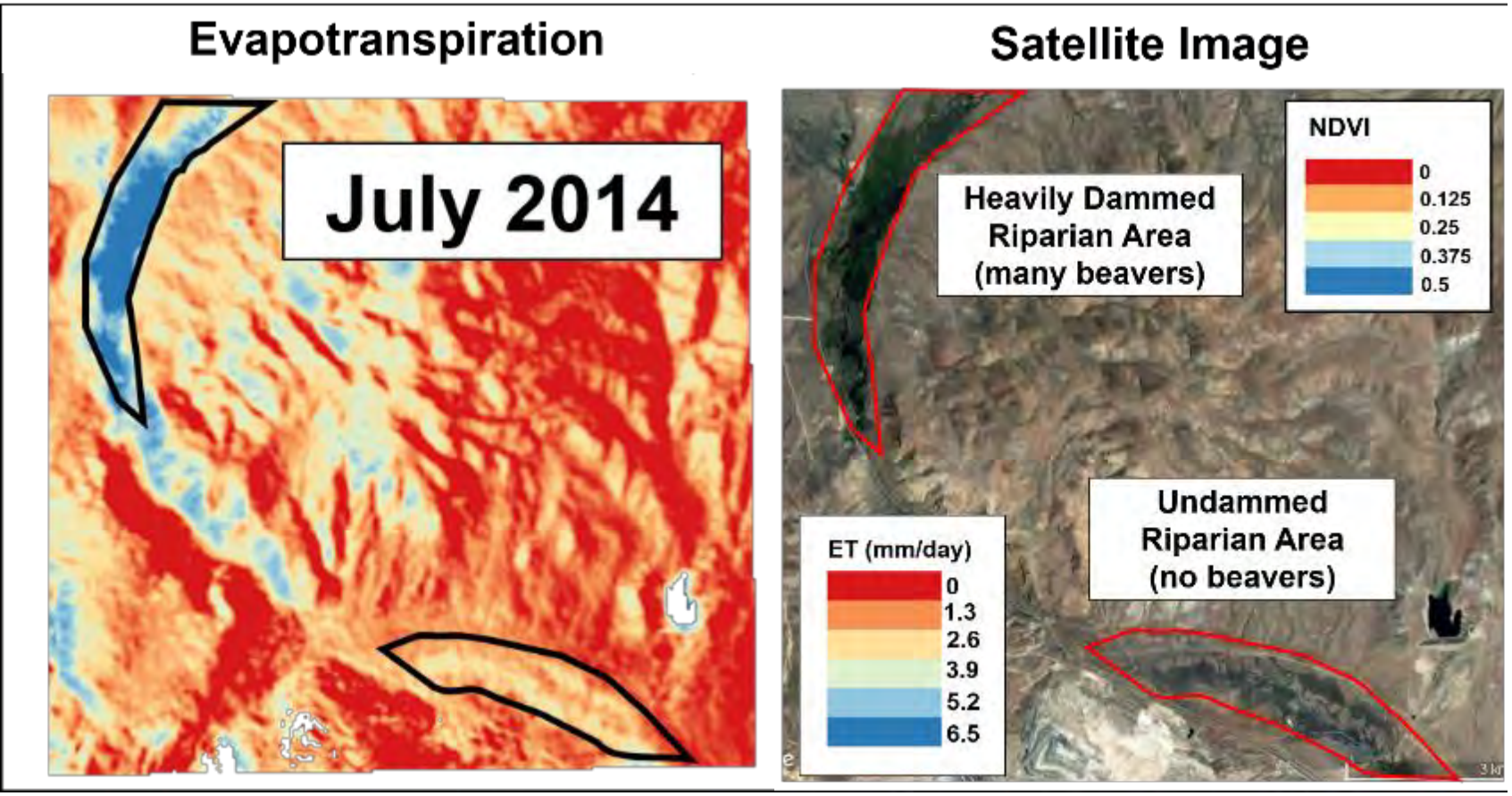
From Fairfax & Small (2018)

Data Example: Maggie Creek, NV



From Fairfax & Small (2018)

Data Example: Maggie Creek, NV



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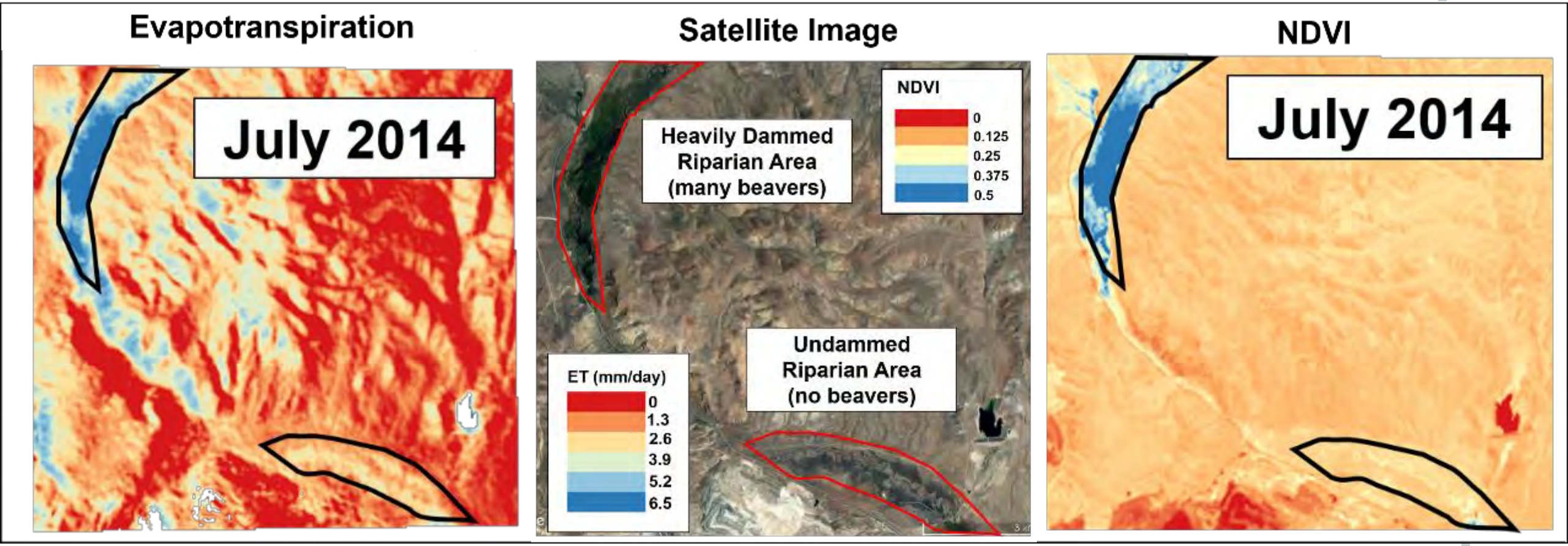
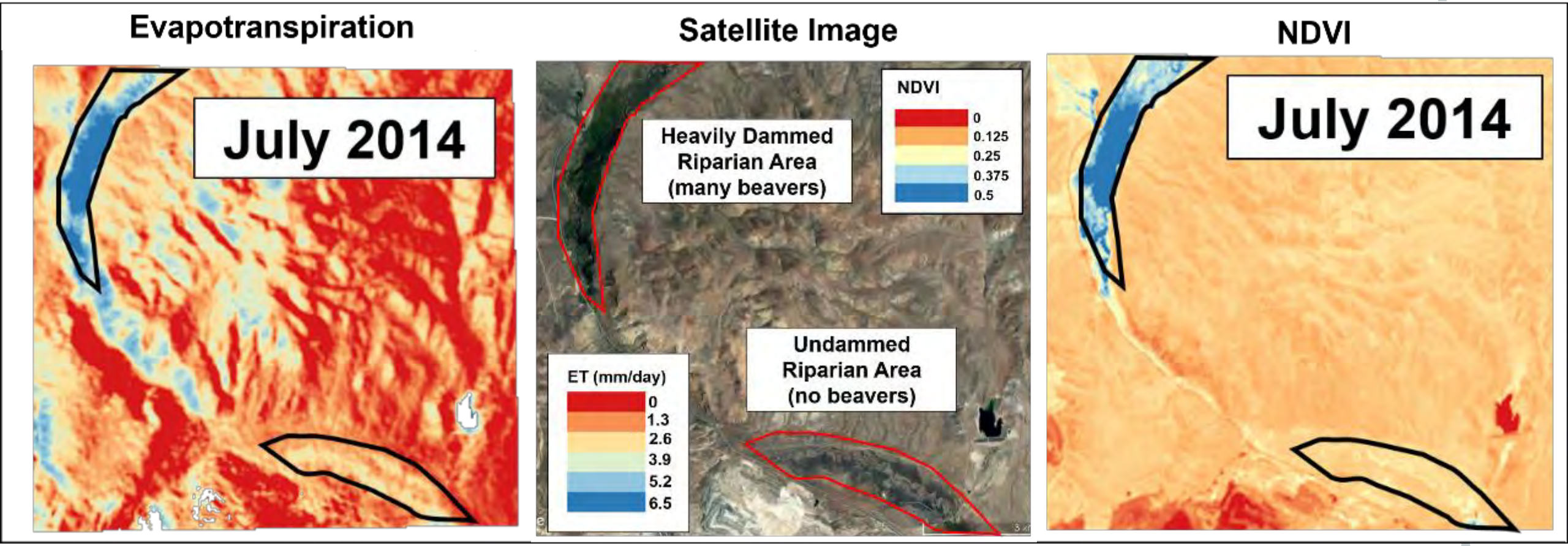


From Fairfax & Small (2018)

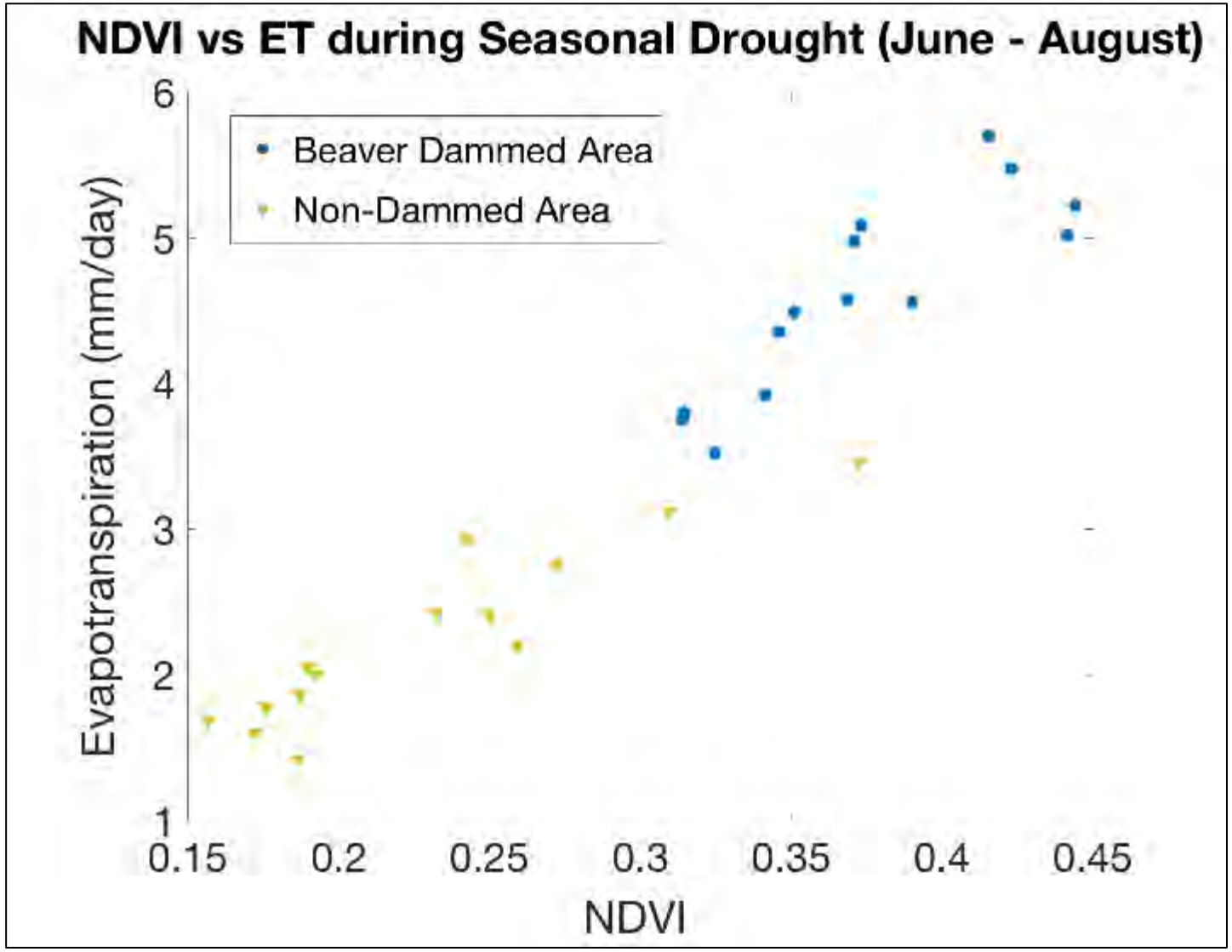
Data Example: Maggie Creek, NV



This was in the middle of TWO droughts: seasonal and multi-year

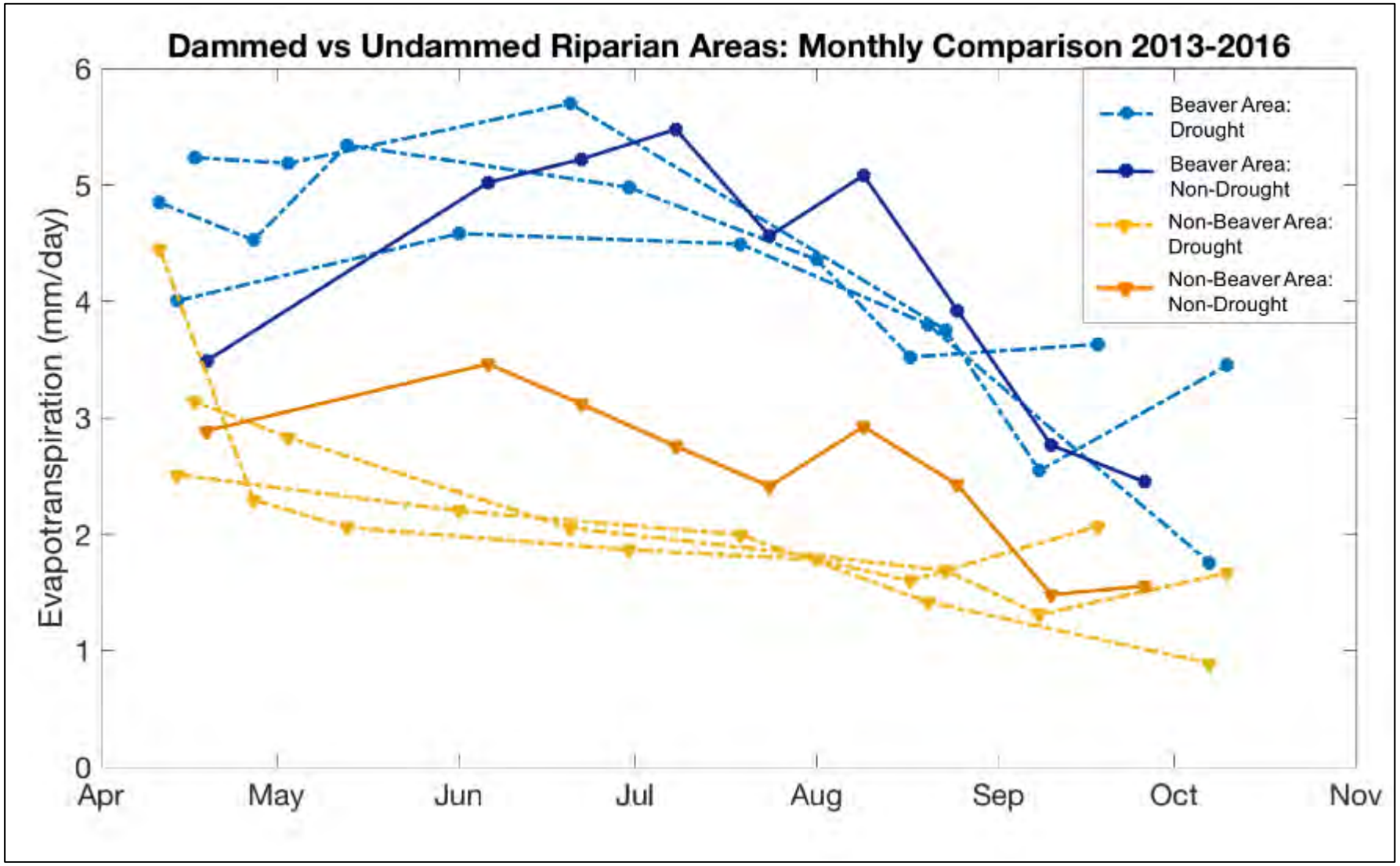
Precipitation is extremely limited, but the beaver-dammed areas are staying green, plants are productive, and that portion of the landscape doesn't "feel" the drought like the undammed riparian areas do.

Observed ET is driven by plant productivity, not open-water evaporation.



From Fairfax & Small (2018)

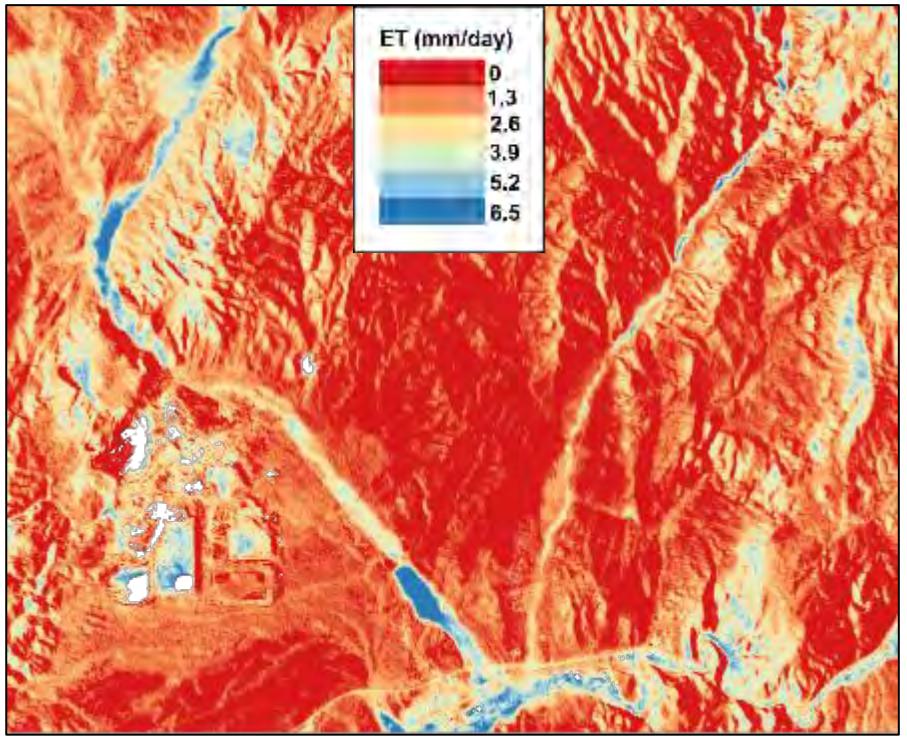
Beaver-dammed riparian zones don't "feel" drought effects, year after year. Undammed riparian zones do.



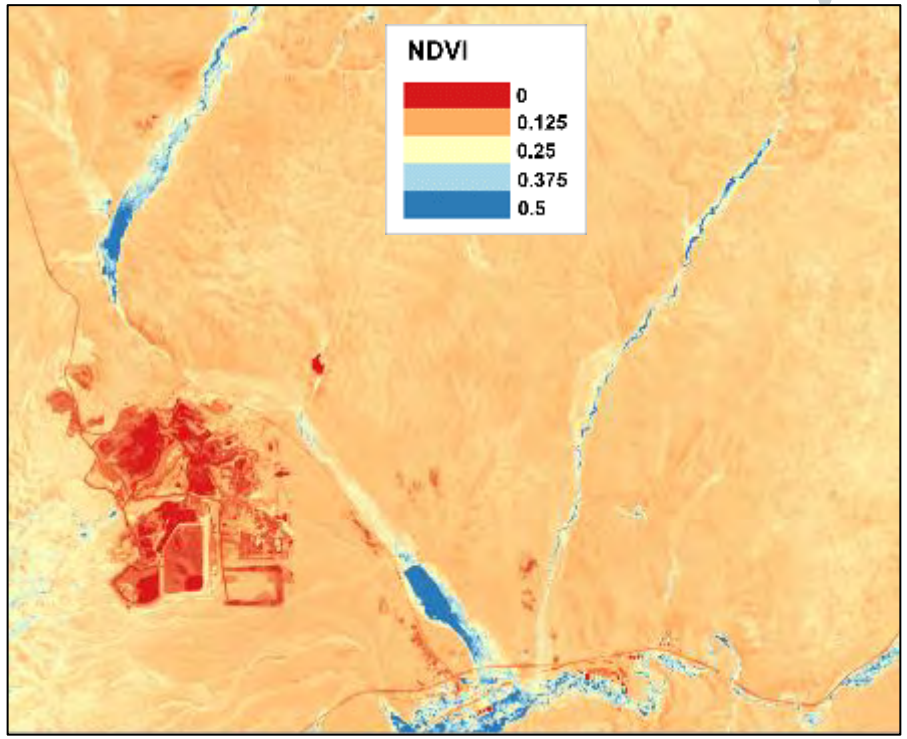
From Fairfax & Small (2018)

Beavers irrigate the landscape. So do we. How do we compare?

July 2014: ET

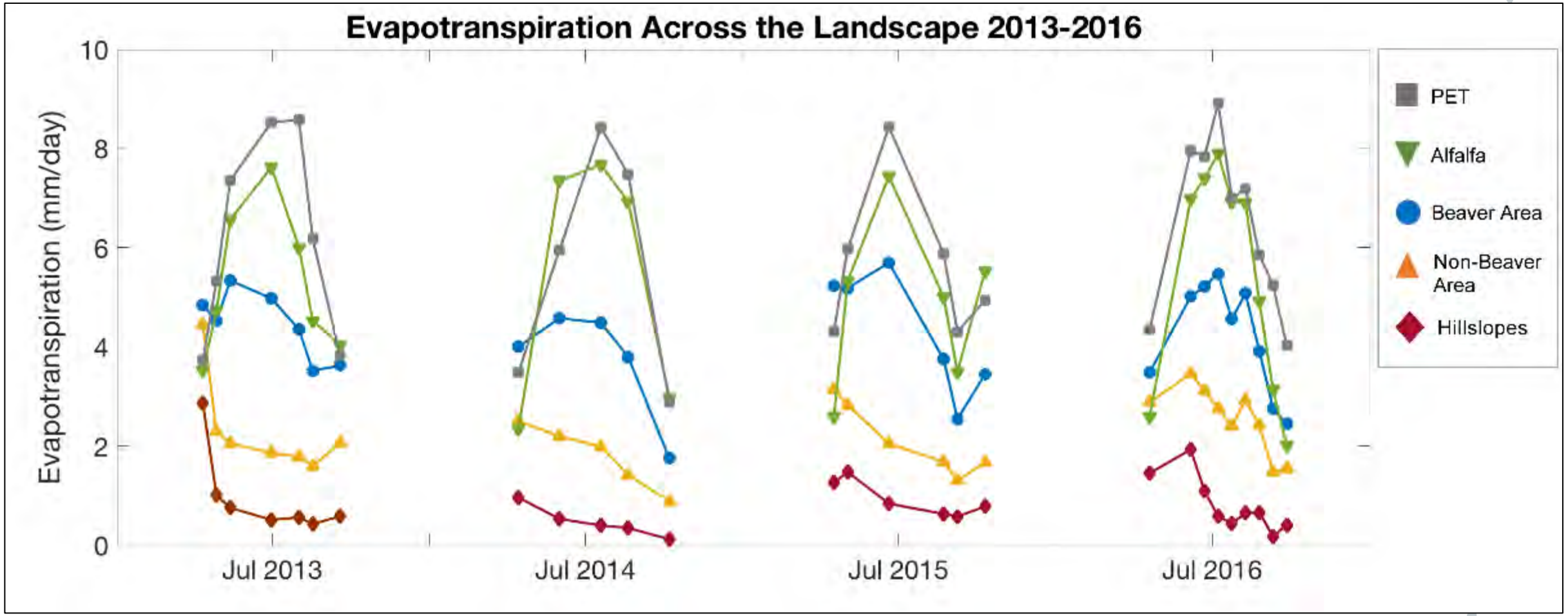


July 2014: NDVI



From Fairfax & Small (2018)

Beavers are a close second at “managing” plant irrigation.



From Fairfax & Small (2018)

Beavers and Drought: the take home messages

Stream with Beavers

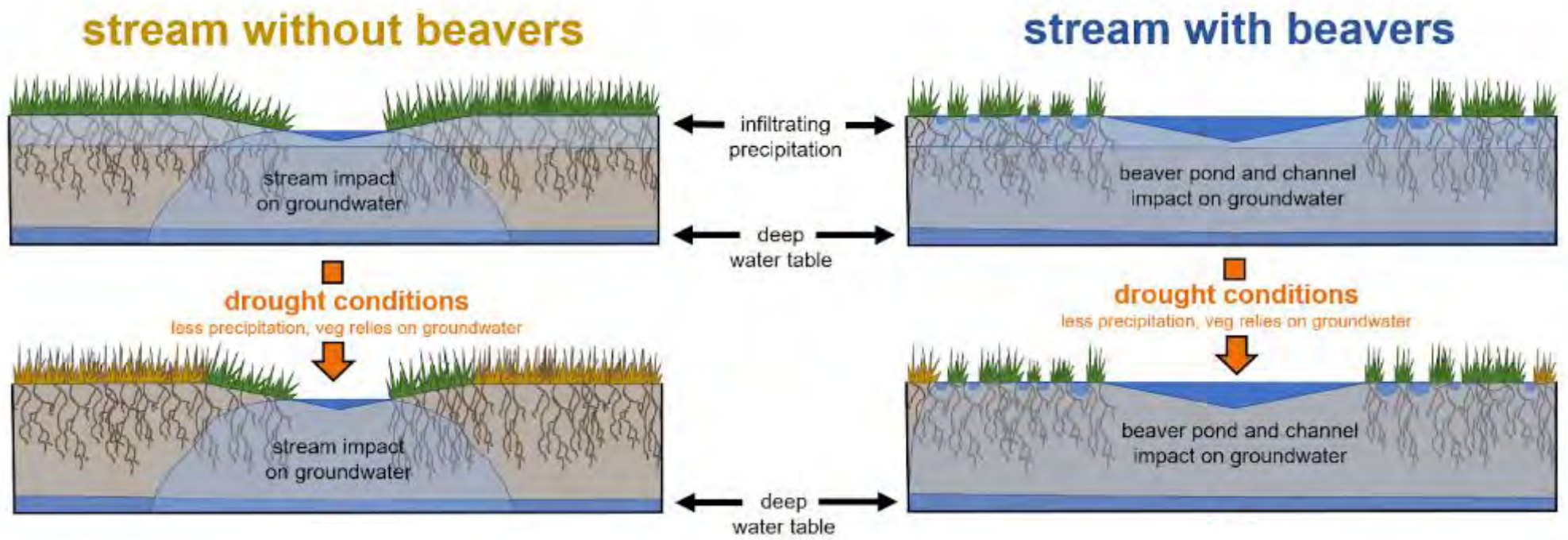
- **Higher** overall ET
- **Not sensitive** to long- or short-term drought
- Similar ET pattern to **irrigated** crops

Stream without Beavers

- **Lower** overall ET
- **Sensitive** to long- and short-term drought
- Similar ET pattern to **hydrologically disconnected** hillslopes

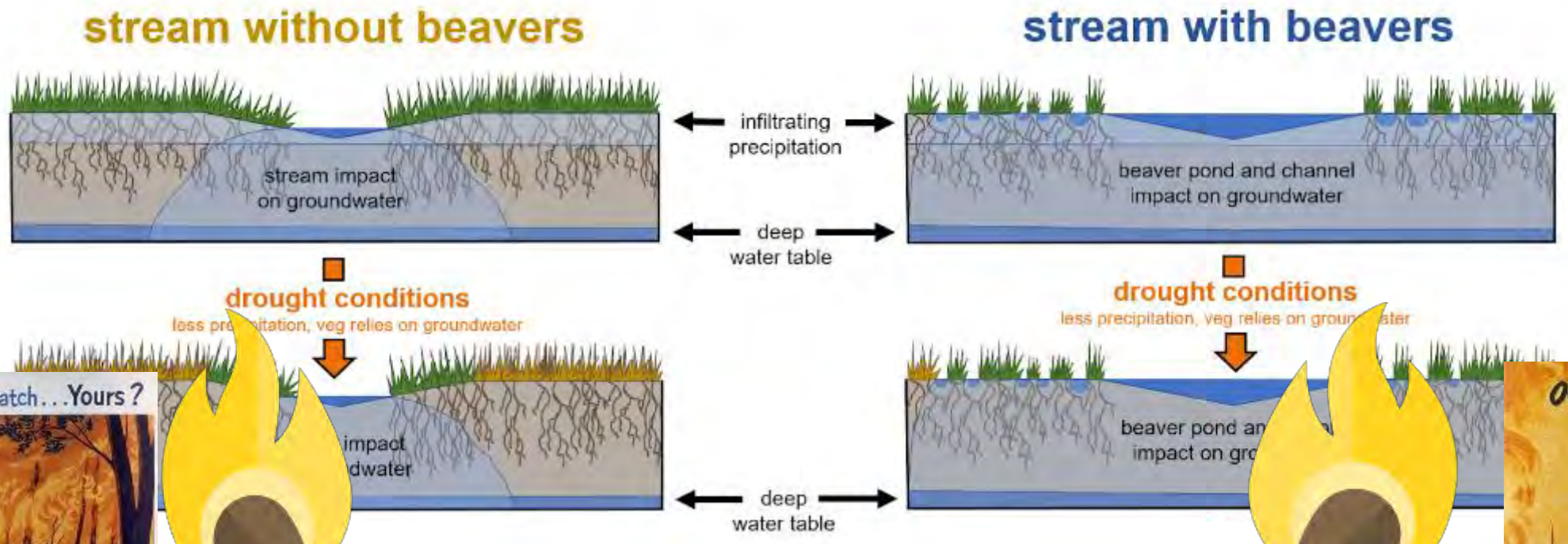
From Fairfax & Small (2018)

Think back to the conceptual model.



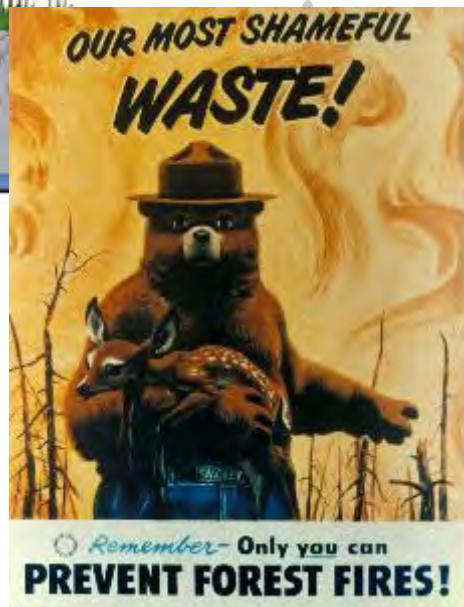
Fairfax and Whittle (2020)

What happens if there is an ignition event?



ONE CARELESS MATCH!

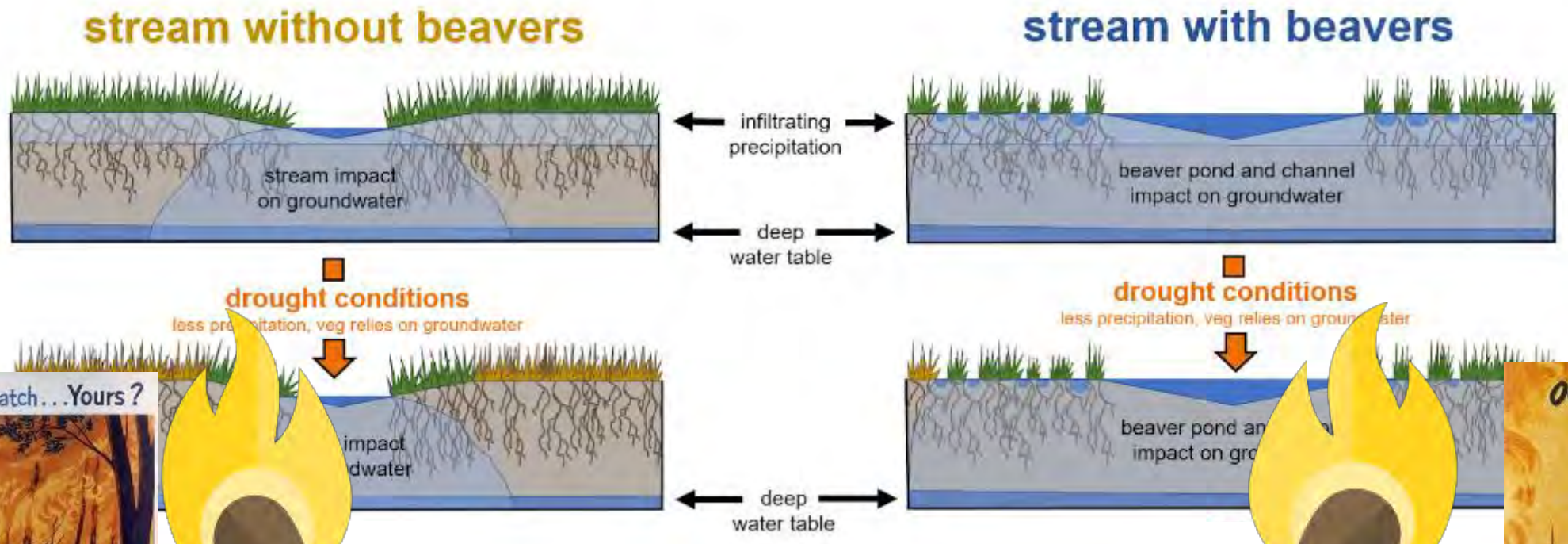
(or power line)



Beavers Fight Fire

the conceptual model

What happens if there is an ignition event?



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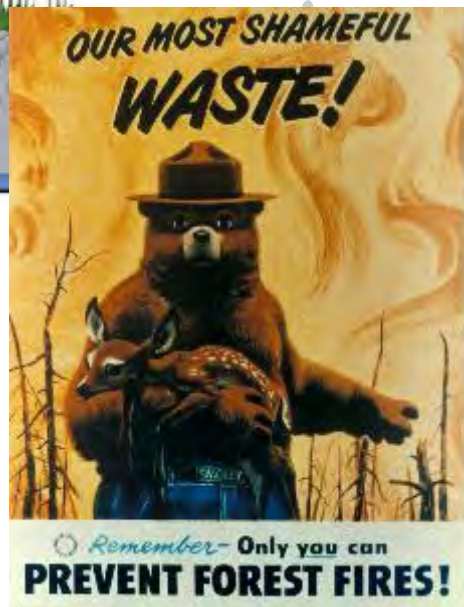
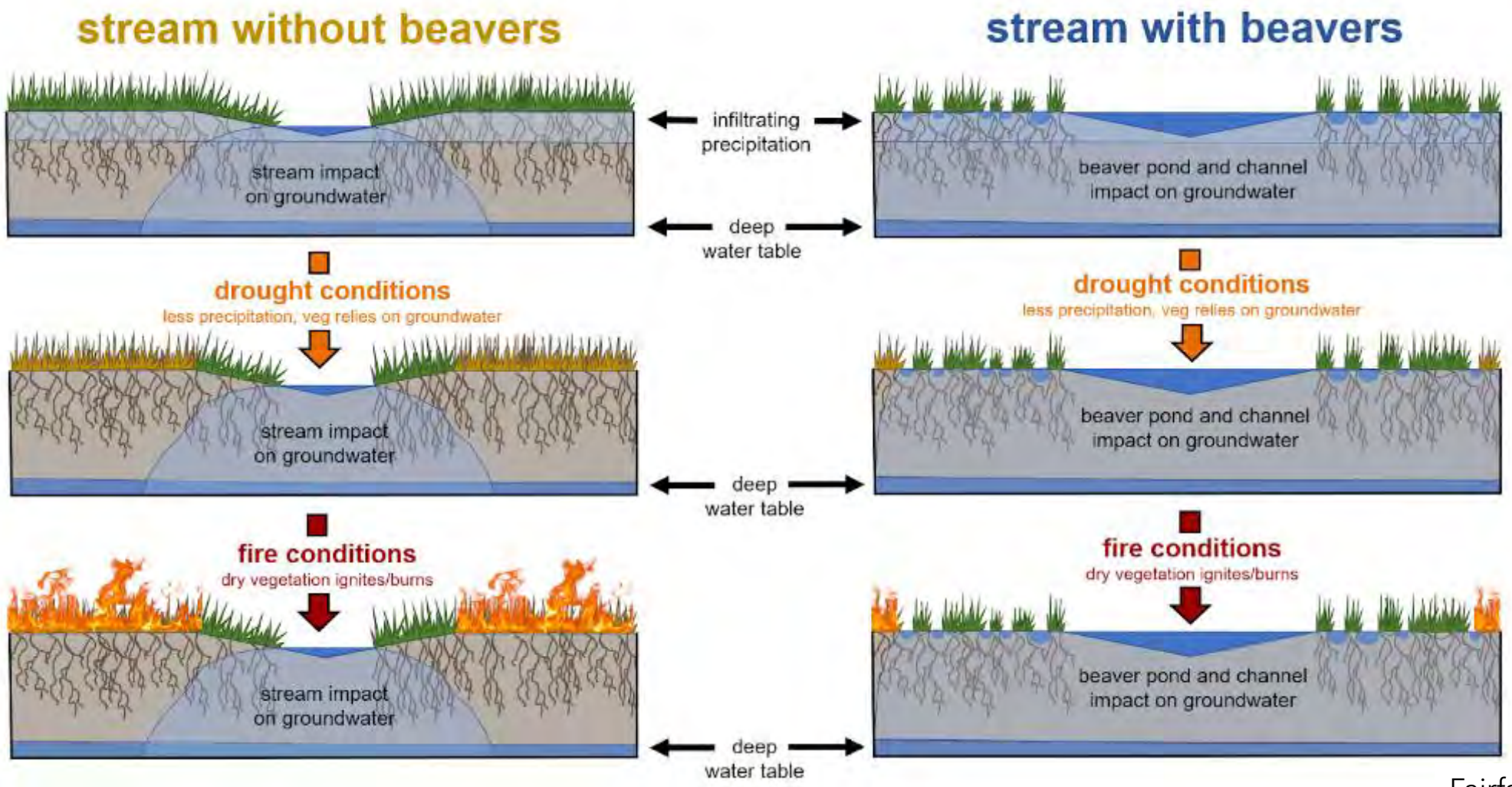
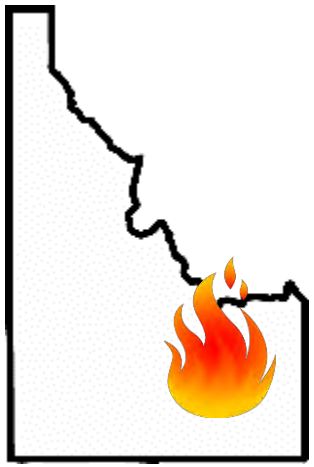


Beavers create refugia during fire.



Fairfax and Whittle (2020)

Beavers create refugia during fire, at least sometimes.



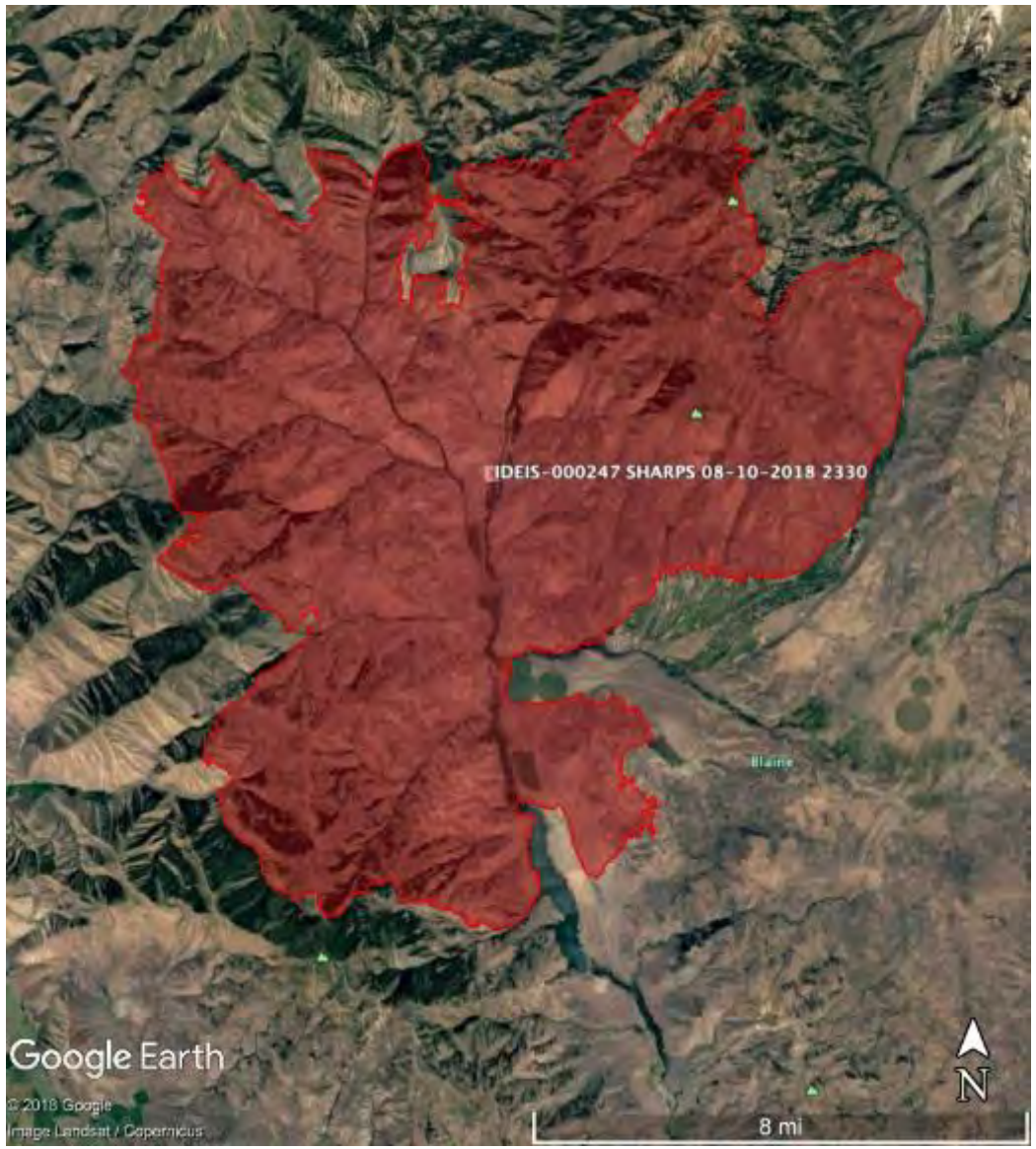


Photo by Joe Wheaton. Baugh Creek, ID

Beavers Fight Fire

the science and data

Beavers create refugia during fire.

ECOLOGICAL APPLICATIONS
ECOLOGICAL SOCIETY OF AMERICA

Communications | Free Access

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

Emily Fairfax, Andrew Whittle

First published: 02 September 2020 | https://doi.org/10.1002/eap.2225

Trends in Ecology & Evolution
Volume 35, Issue 4, April 2020, Pages 346-356
CellPress

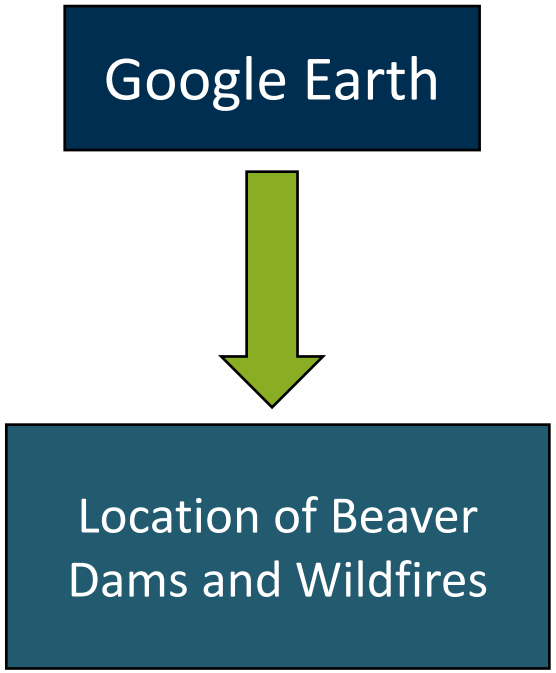
Review

Animals as Agents in Fire Regimes

Claire N. Foster [1,5], Sam C. Banks [2], Geoffrey J. Cary [1], Christopher N. Johnson [3], David B. Lindenmayer [1], Leonie E. Valentine [4]

From Fairfax & Whittle (2020)

Similar Methods; New Question



From Fairfax & Whittle (2020)

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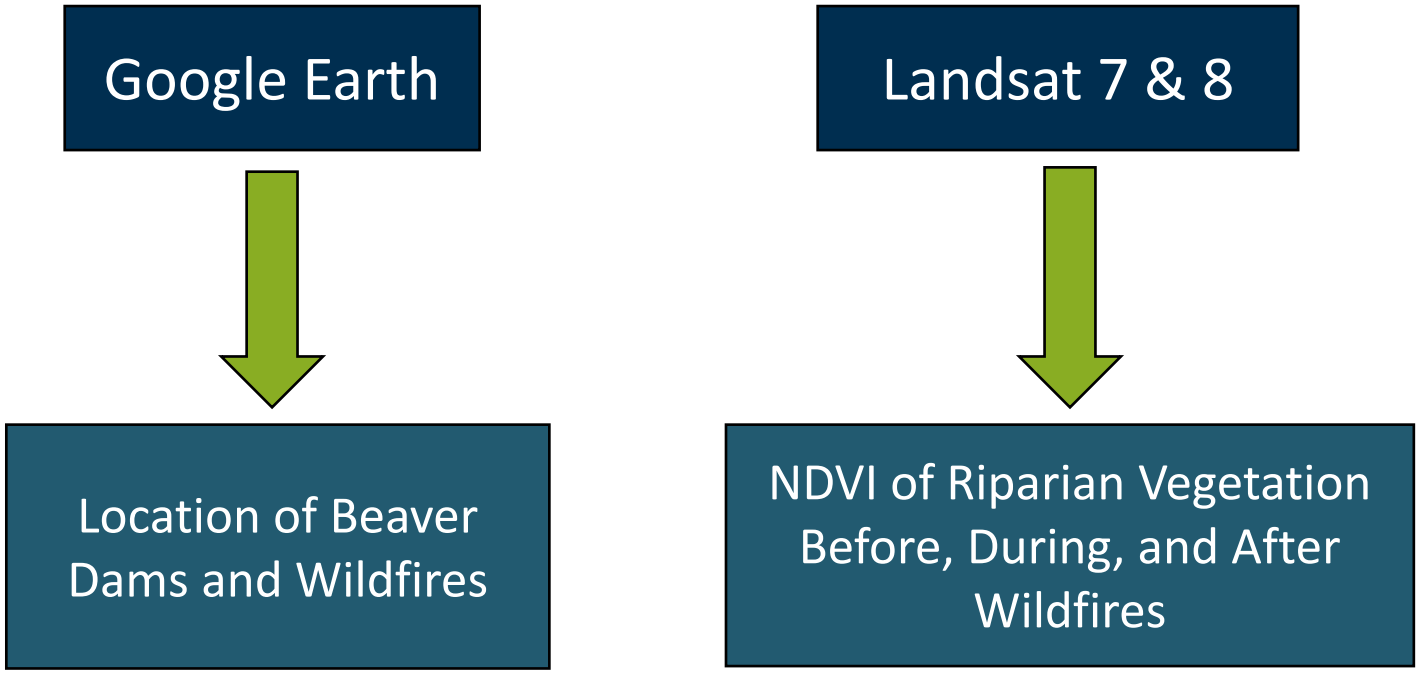

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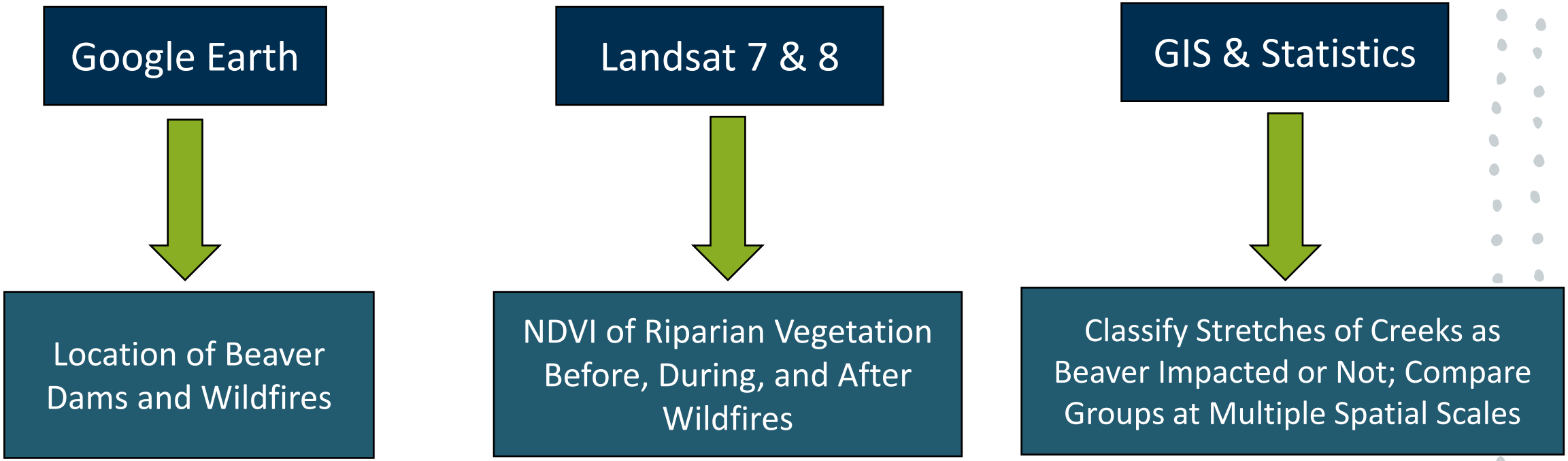

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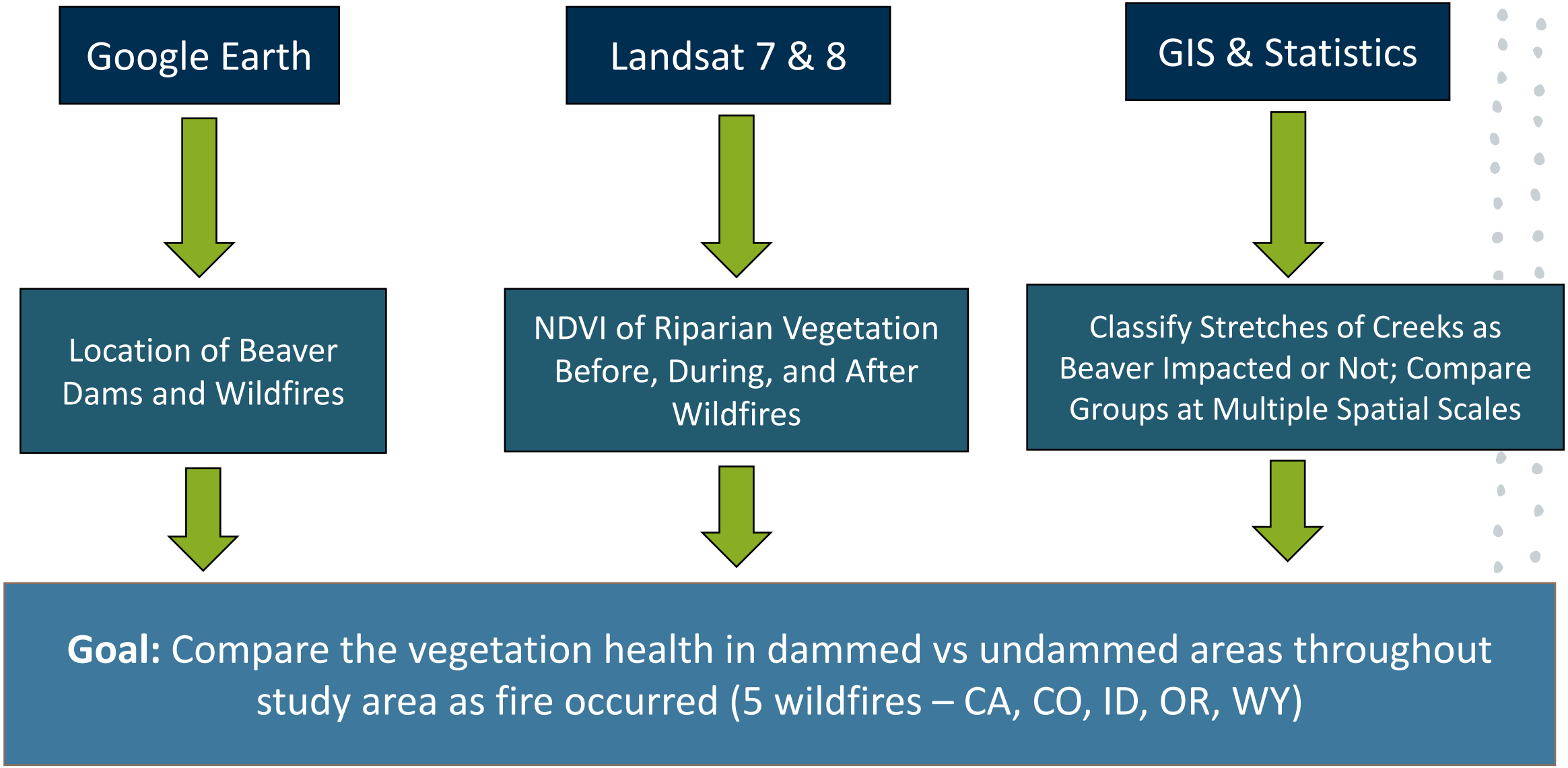
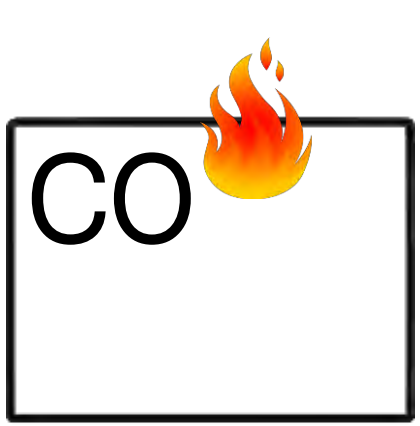


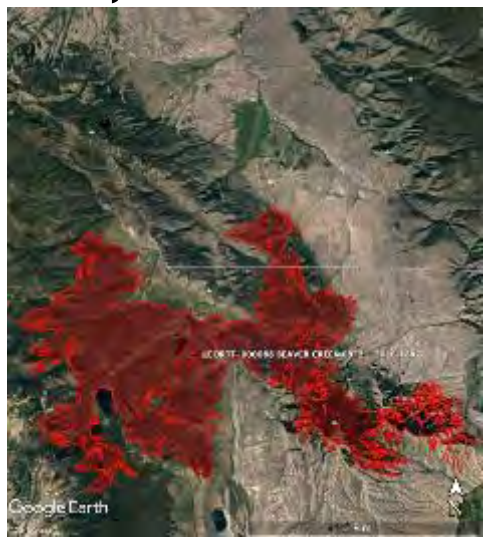
From Fairfax & Whittle (2020)

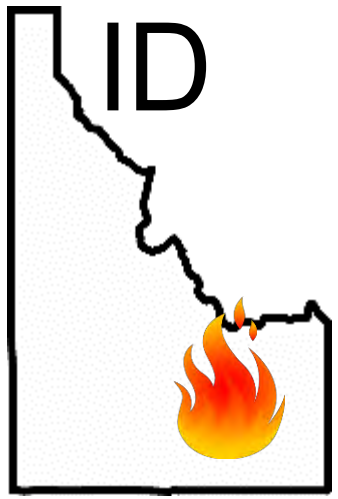
Study Areas: fires, beavers, and high-quality imagery!

79,000 acres

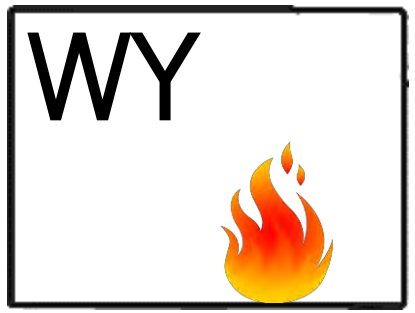


38,000 acres

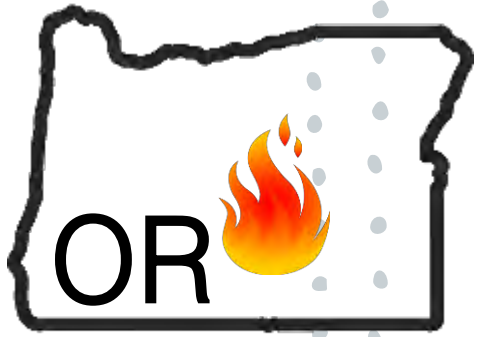




65,000 acres



21,000 acres



395,000 acres

California Manter Fire

Domeland Wilderness

part of Sequoia National Forest

Manter Fire

Burn Date: Summer 2000

Burn Area: 79,000 acres

“It is a humbling expression of nature.

Walls of flame 70 feet high, twice as high as the nearest tree.

Leaping through canyons and valleys, at times in five directions at once.

Left behind, quite literally, is scorched earth.”

-LA Times, August 2nd, 2000 on the Manter Fire in California

Profiling Creeks to Quantify Plant Greenness

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

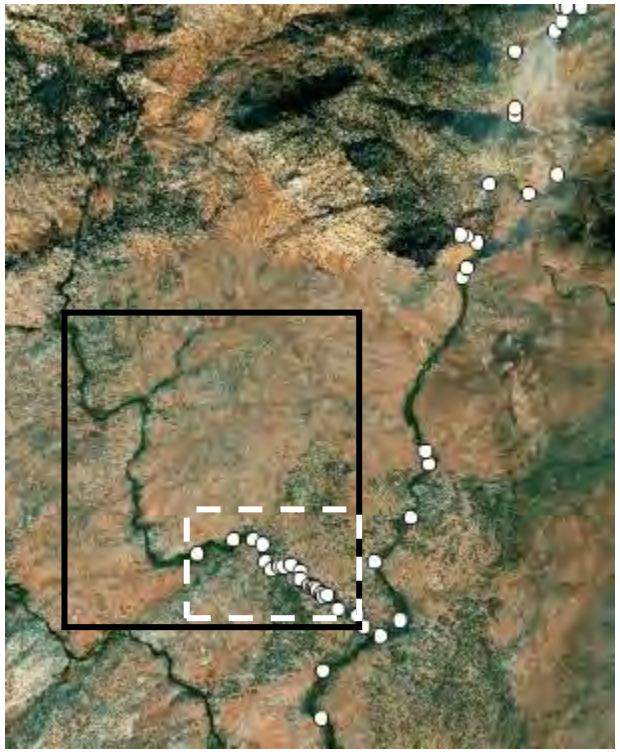
Profiling Creeks to Quantify Plant Greenness

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.

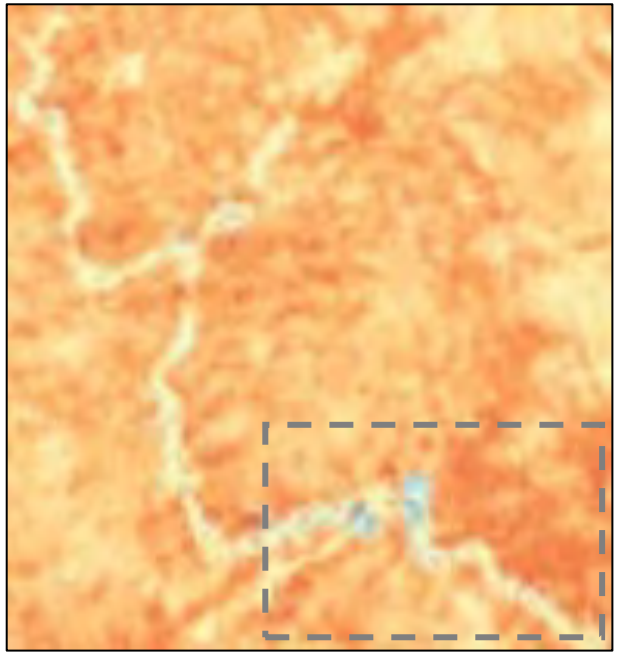
Look back into the past with satellites

Satellite Image
(dams marked)

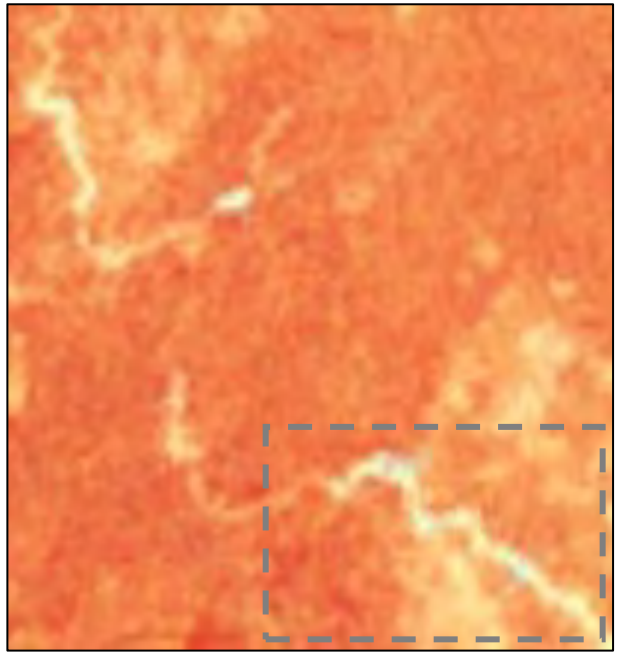


◯ = beaver dams

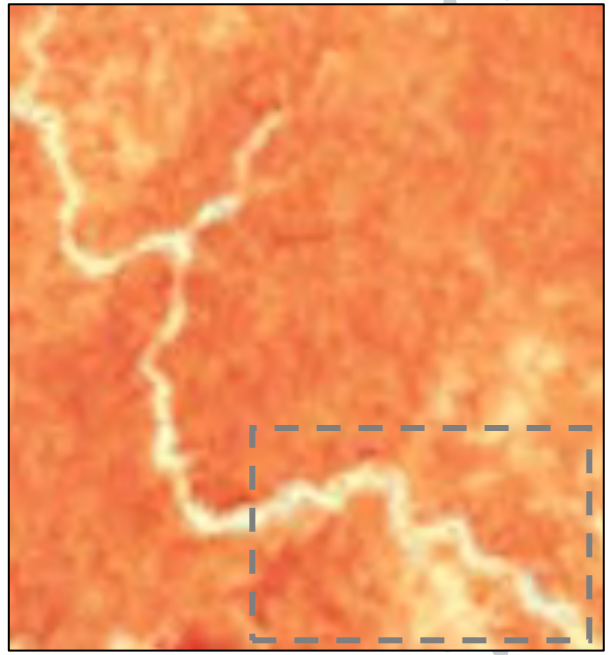
July 1999
(before fire)



July 2000
(during fire)



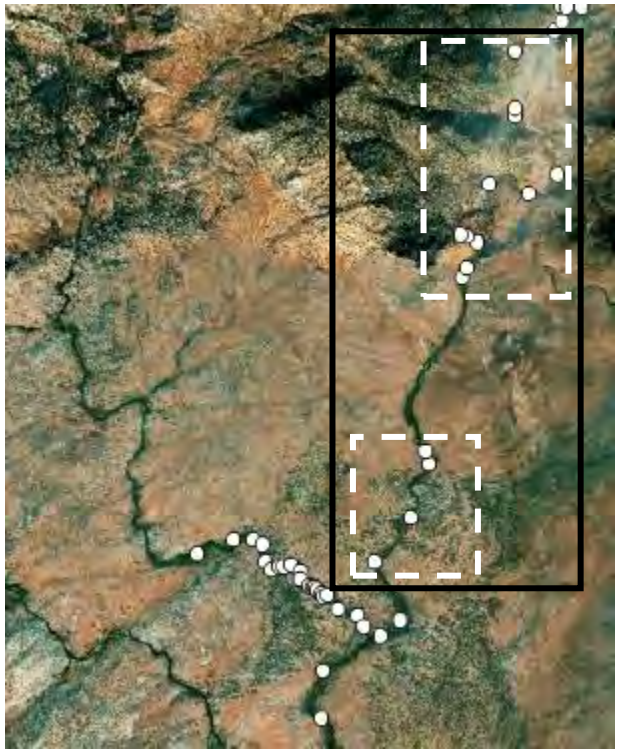
July 2001
(after fire)



From Fairfax & Whittle (2020)

Look back into the past with satellites

Satellite Image
(dams marked)



◯ = beaver dams

From Fairfax & Whittle (2020)

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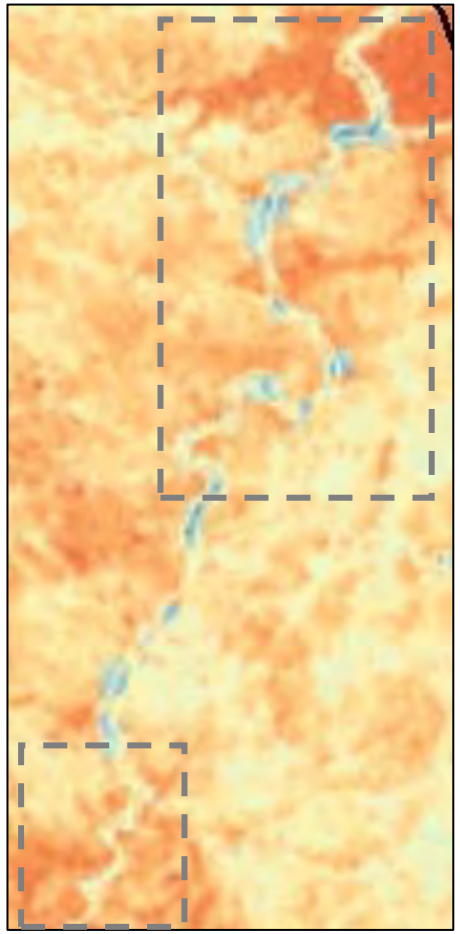
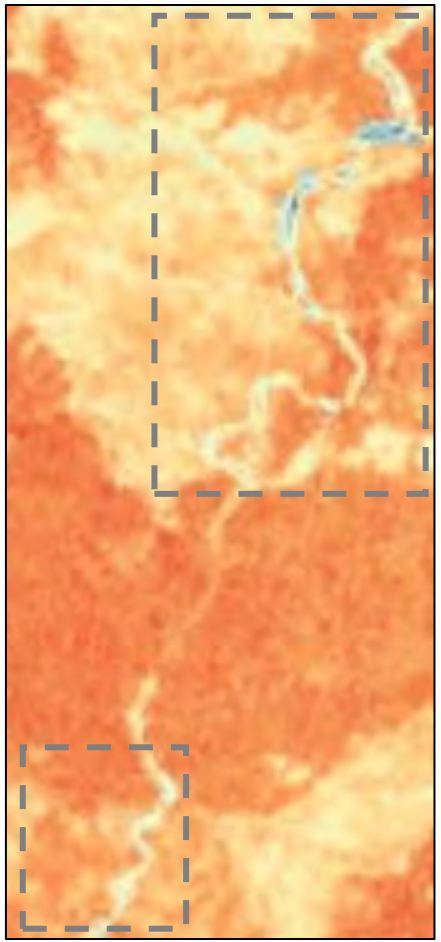
(before fire)



July 2000
(during fire)



July 2001
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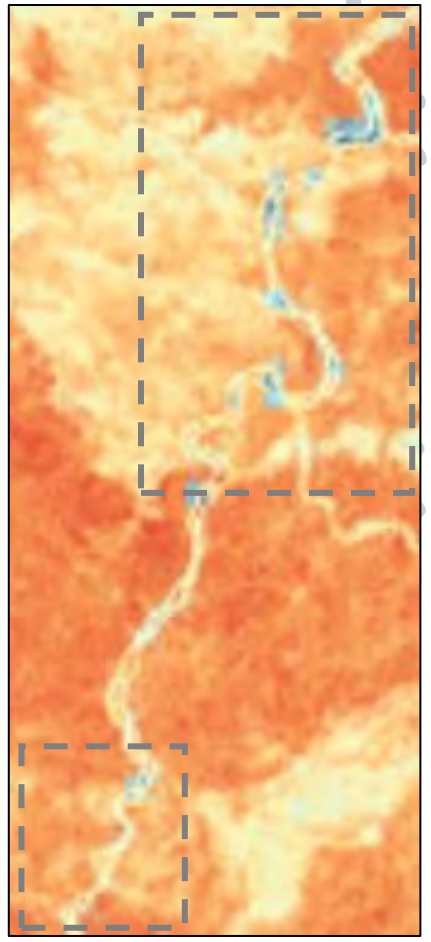
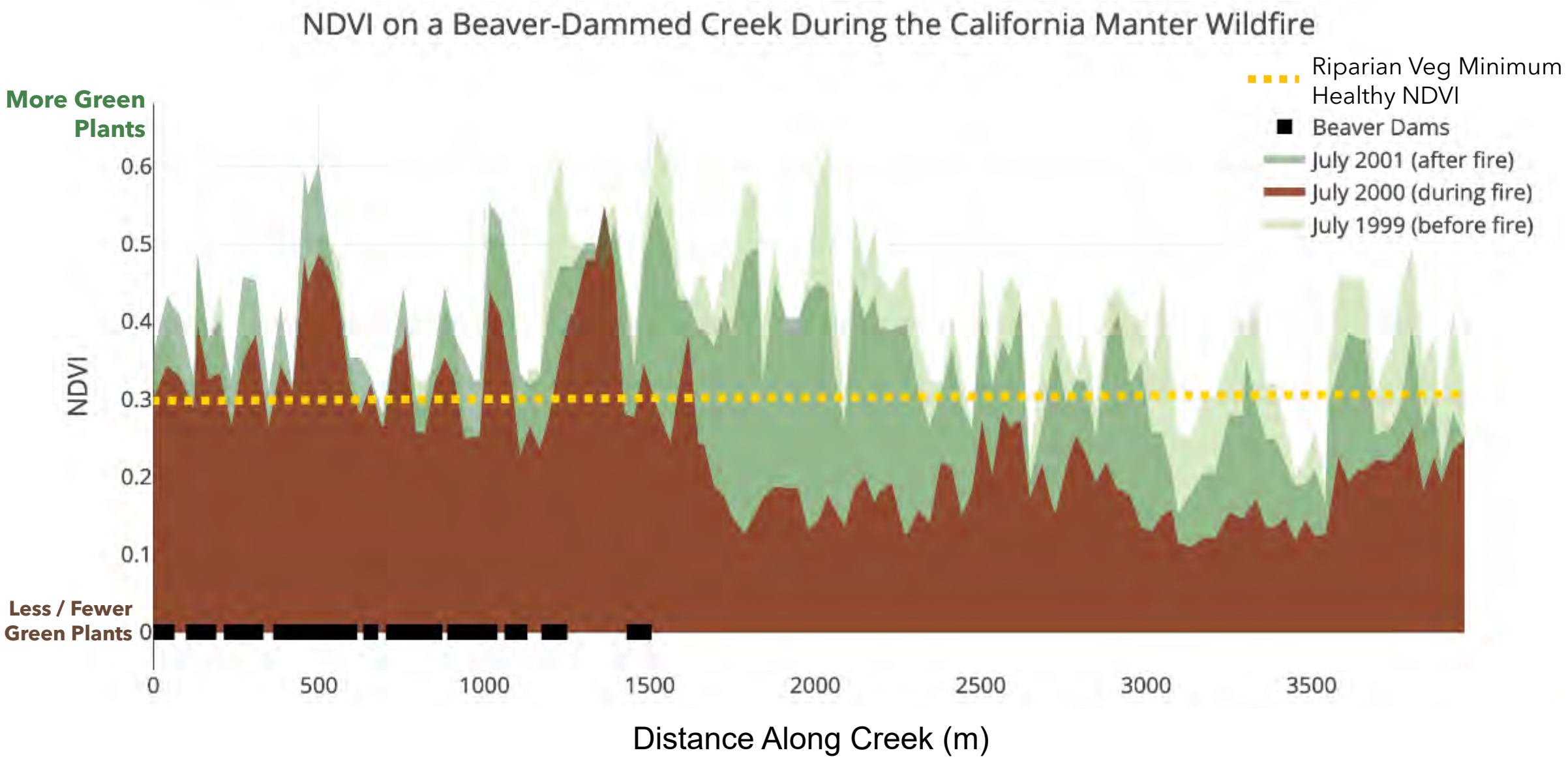


Beaver dams appear to reduce impact of fire on plants.



From Fairfax & Whittle (2020)

From Fairfax & Whittle (2020)

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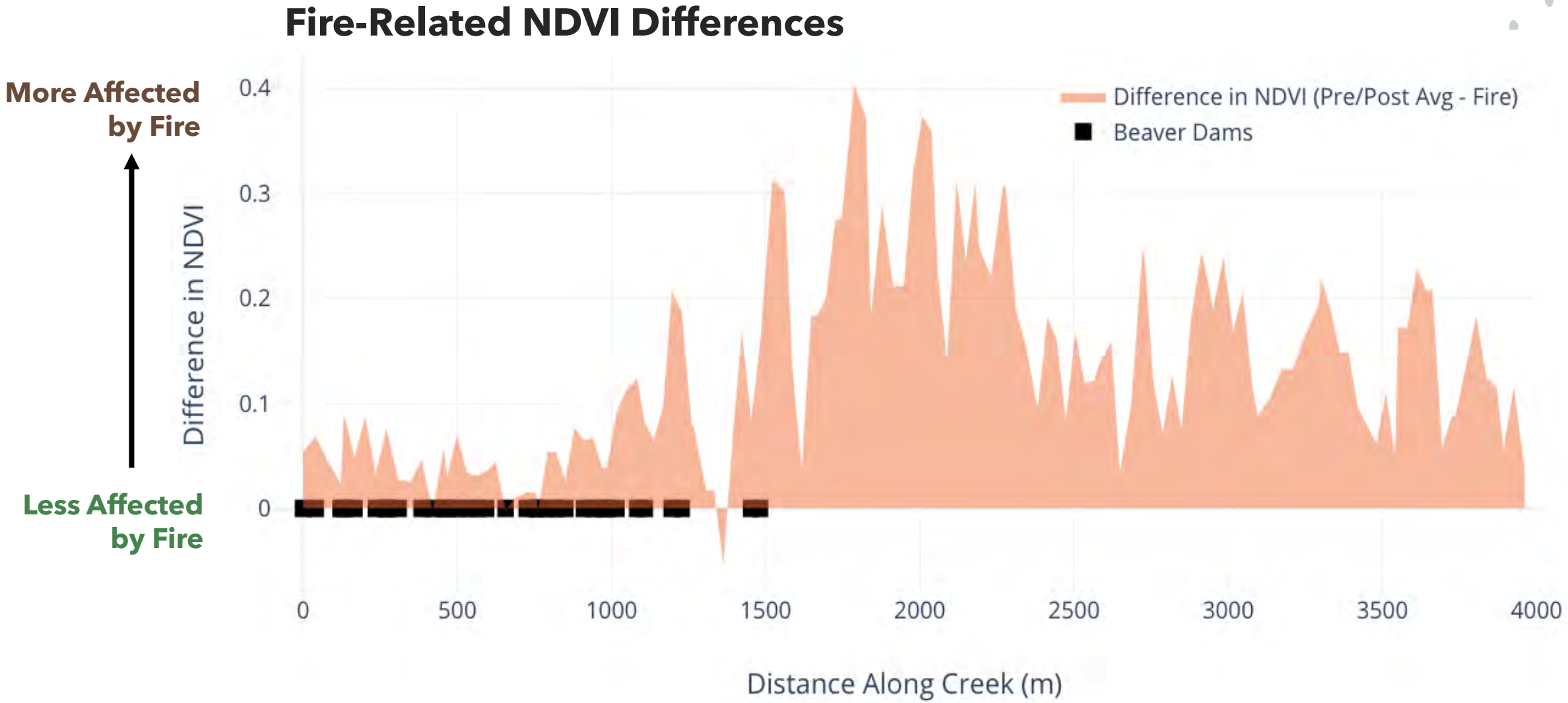


From Fairfax & Whittle (2020)

Beaver-driven fire resistance is not an isolated event.

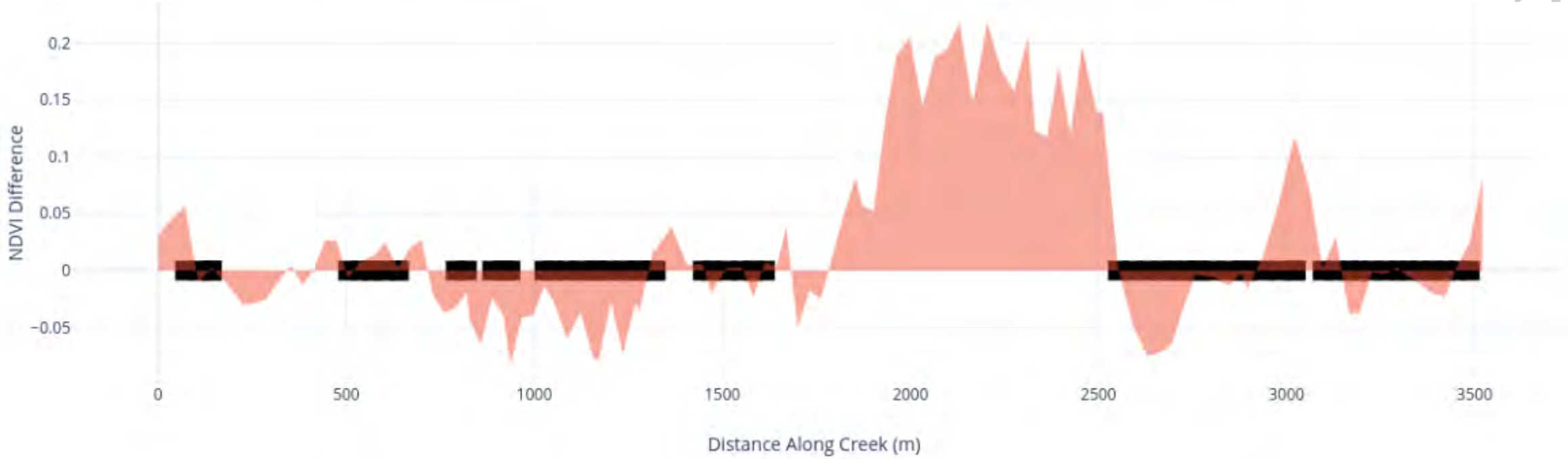
From Fairfax & Whittle (2020)

Beaver-driven fire resistance is not an isolated event.

...but there is a better way to visualize that.

From Fairfax & Whittle (2020)

Quantifying fire resistance in all studied fires.



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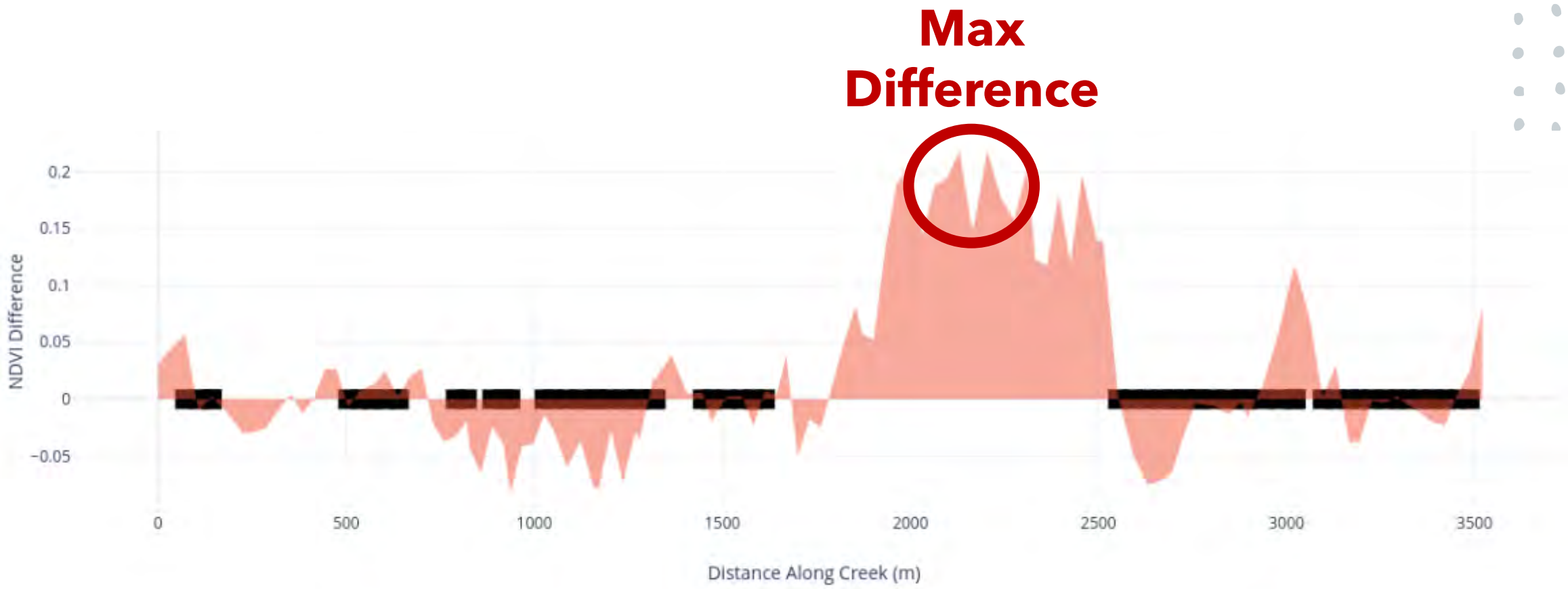
Quantifying fire resistance in all studied fires.



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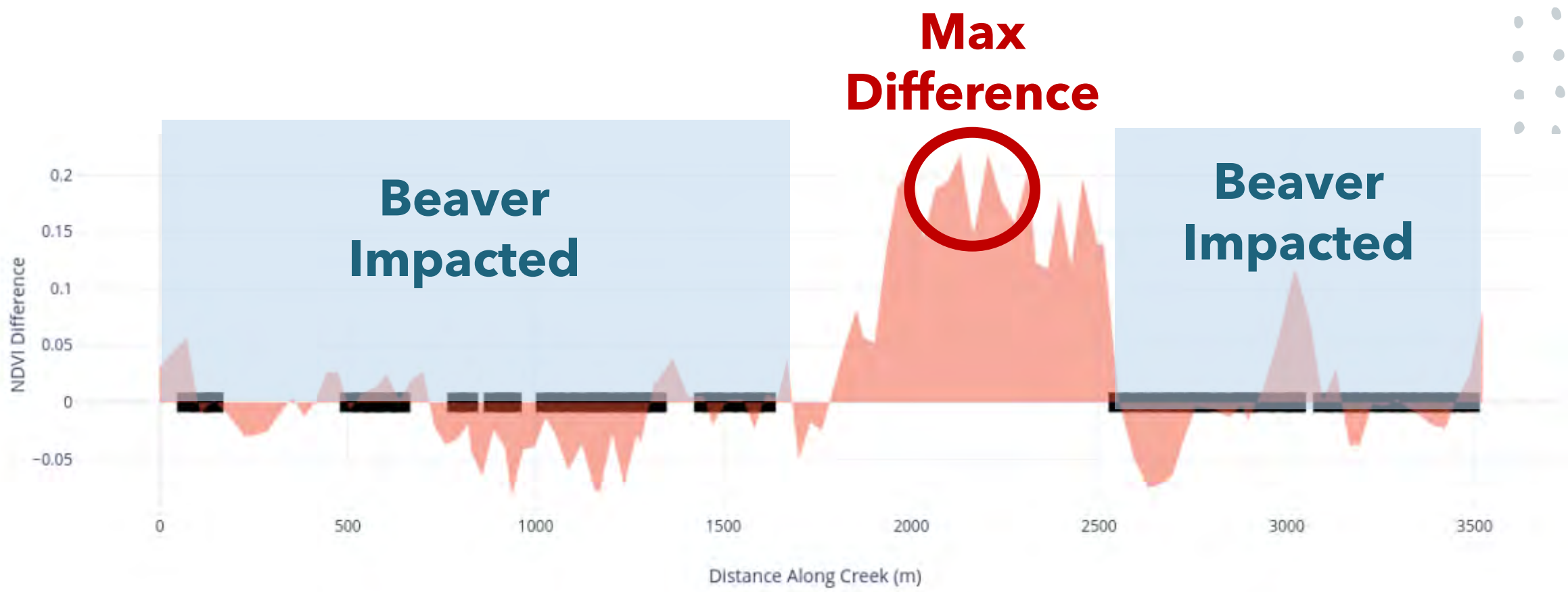

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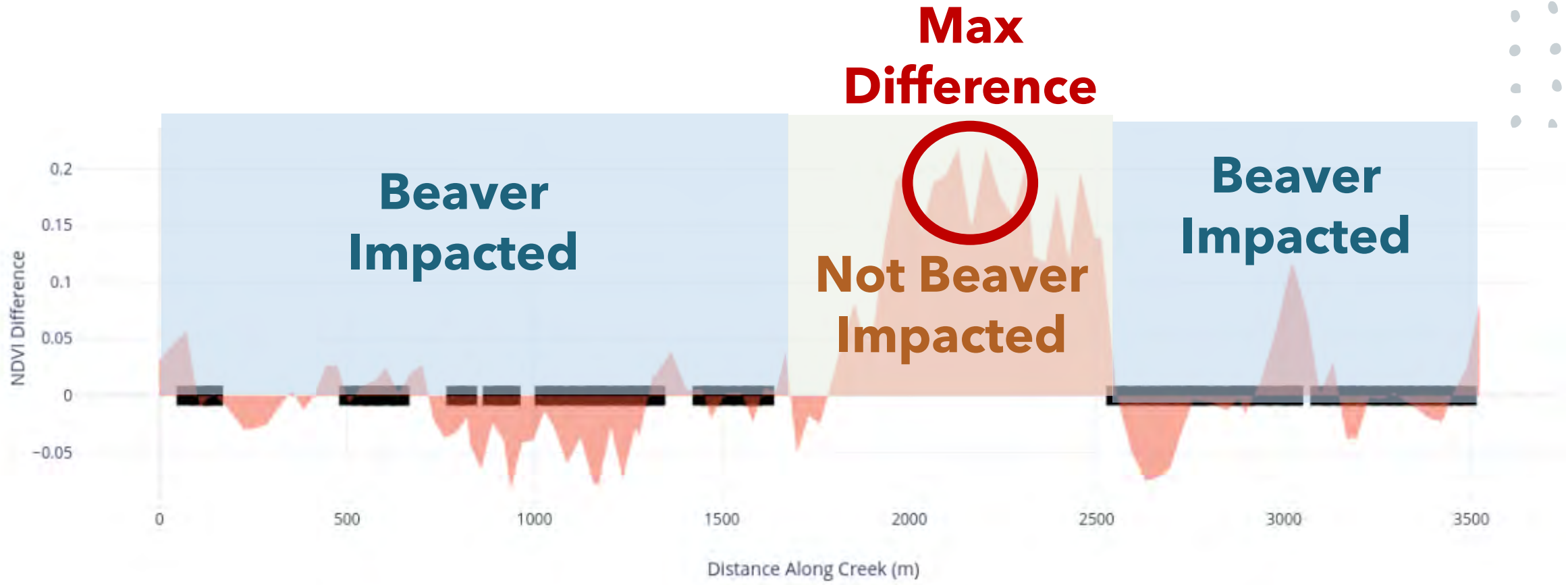


From Fairfax & Whittle (2020)

Quantifying fire resistance in all studied fires.

$$\frac{\text{NDVI Difference at each pixel along creek profile}}{\text{Max NDVI Difference on that Creek}} = \text{Scaled NDVI Difference}$$

In plain English, please…

$$\frac{\text{How much did veg actually burn within a pixel?}}{\text{How much could riparian veg have burned given the fire characteristics?}} = \text{Percent of max burning that actually occurs in a given pixel}$$

From Fairfax & Whittle (2020)

Quantifying fire resistance in all studied fires.

$$\frac{\text{NDVI Difference at each pixel along creek profile}}{\text{Max NDVI Difference on that Creek}} = \text{Scaled NDVI Difference}$$

Why scale the NDVI?

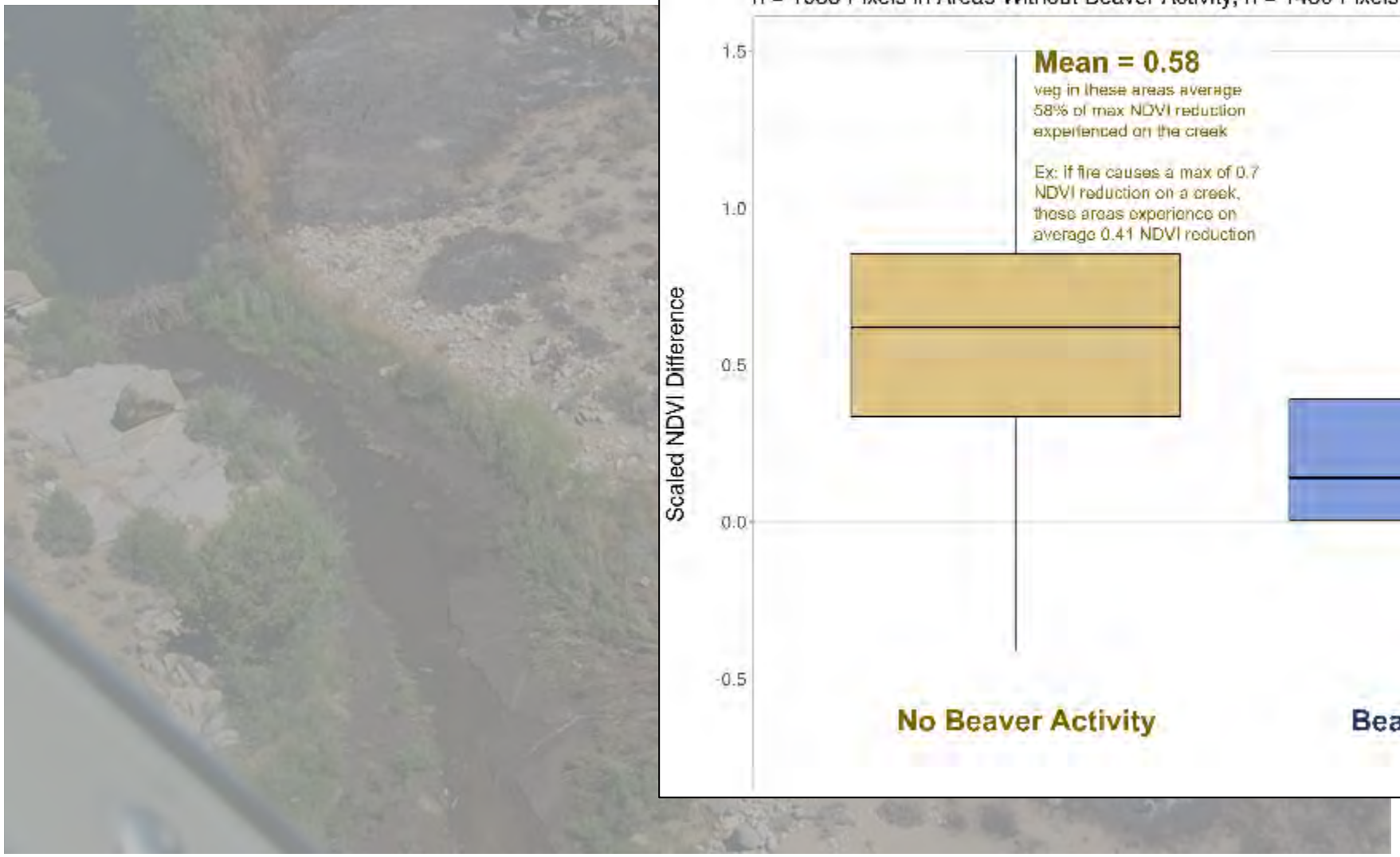
- easier to conceptualize: think of it as % of max vegetation burning that happened in each pixel based on the max burning a given fire was capable of

- it lets us generalize between varying fire intensities, land covers, etc. and talk about beaver-related fire resistance as a general process instead of only in the context of a specific case study

Beavers repeatedly create refugia during fire.

Fairfax and Whittle (2020)

Beavers repeatedly create refugia during fire.



Fairfax and Whittle (2020)

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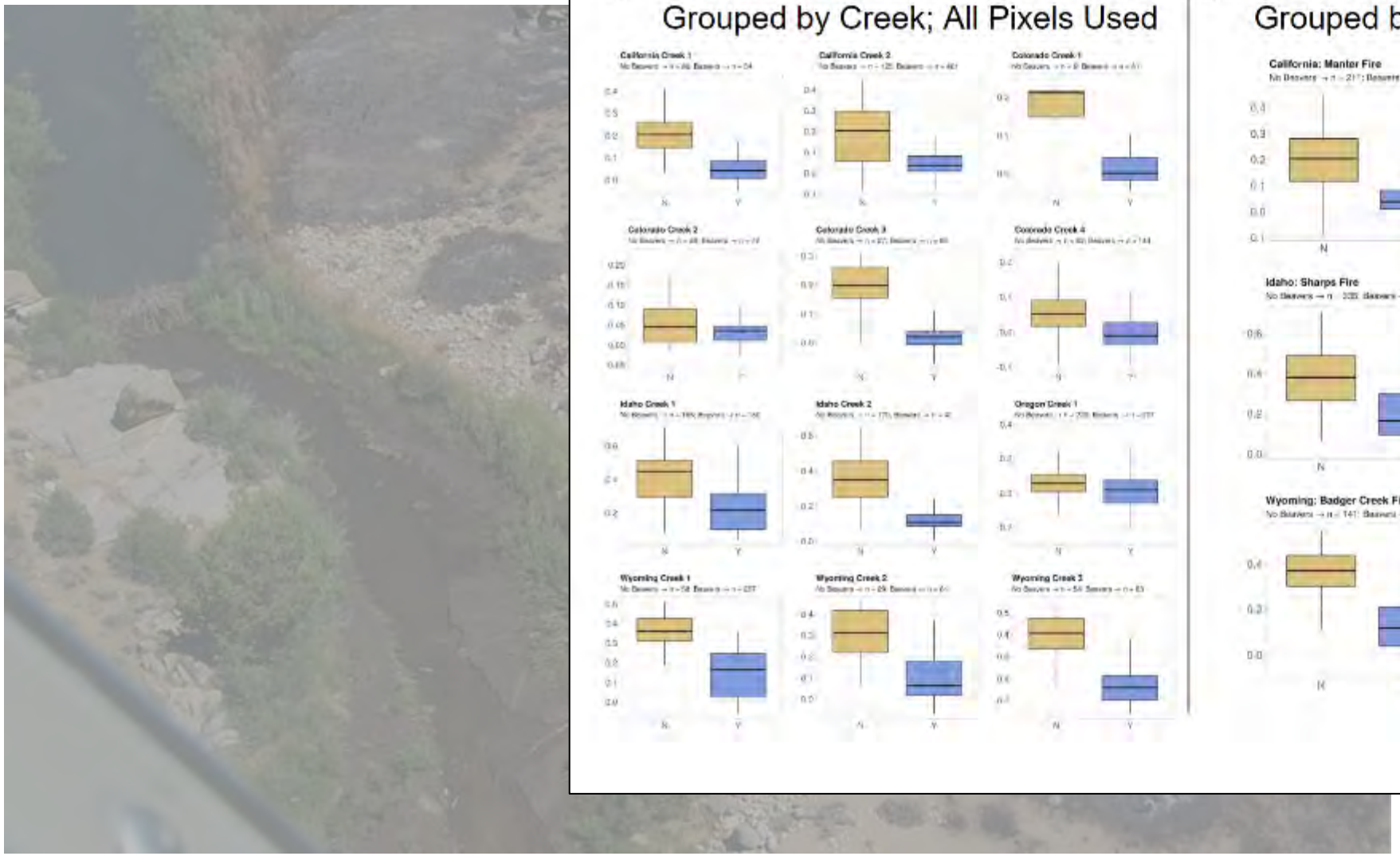

Fairfax and Whittle (2020)

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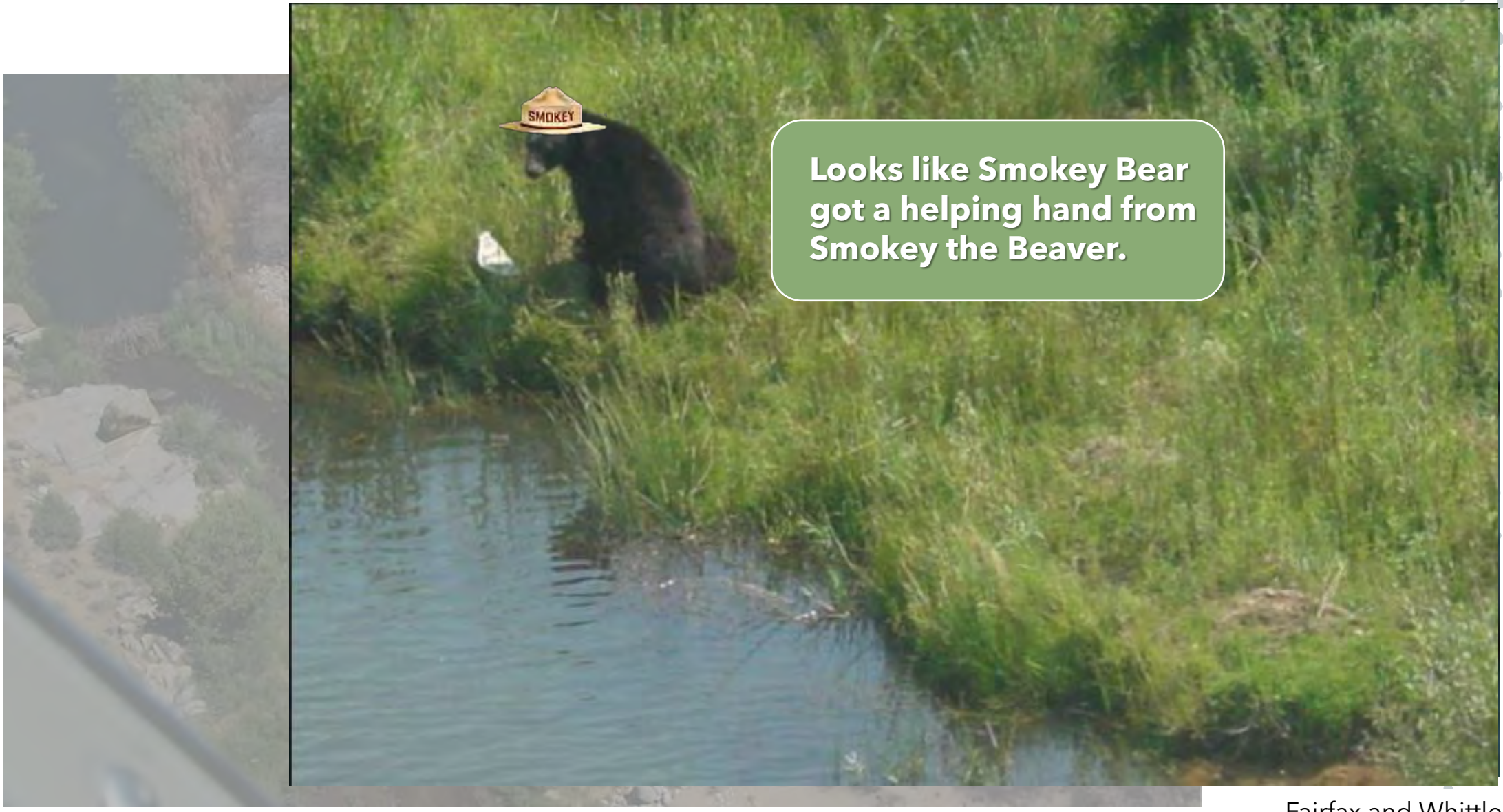

Fairfax and Whittle (2020)

Beavers and Fire: the take home messages

Stream with Beavers

- **19% NDVI reduction** on average
- Satellite and aerial images show **green patches** during fires
- Effect occurred in varying climate, landcover, and antecedent conditions
- Potential for green patches to protect sensitive flora and fauna during fires, harbor native plants
- Potential for preserved patches to attenuate post-fire runoff and debris flows

Stream without Beavers

- **58% NDVI reduction** on average
- Satellite and aerial images show **burned vegetation** during fires
- Increasingly large burn areas and spread rates make escaping fire challenging
- Invasive plants often recolonize burned sites
- Highly burned areas often followed by uncontrolled debris flows and flooding

From Fairfax & Whittle (2020)

The Role of Beavers
in a changing climate

a final summary

Beavers create and maintain resilient landscapes.

They're doing climate adaptation and mitigation.

Mammal Review

Review | Full Access

Ecosystem services provided by beavers *Castor* spp.

Stella Thompson, Mia Vehkaoja, Jani Pellikka, Petri Nummi

First published: 01 October 2020 | https://doi.org/10.1111/mam.12220

Ecosystem service	Ecosystem service category	Number of value estimates
Moderation of extreme events (FloodDrought)	Regulating	11
Greenhouse gas sequestration (GHG)	Regulating	8
Water purification (Quality)	Regulating	28
Water supply (Supply)	Provisioning	6
Recreational hunting and fishing (HuntFish)	Provisioning	3
Habitat and biodiversity provision (HabBio)	Supporting	8
Nutrient cycling	Supporting	9
Non-consumptive recreation (Recreation)	Cultural	11
Historical value	Cultural	0

They're doing climate adaptation and mitigation.

$ $ $ $ $

1 ha = 0.01 sq km

Mammal Review

Review | Full Access

Ecosystem services provided by beavers *Castor* spp.

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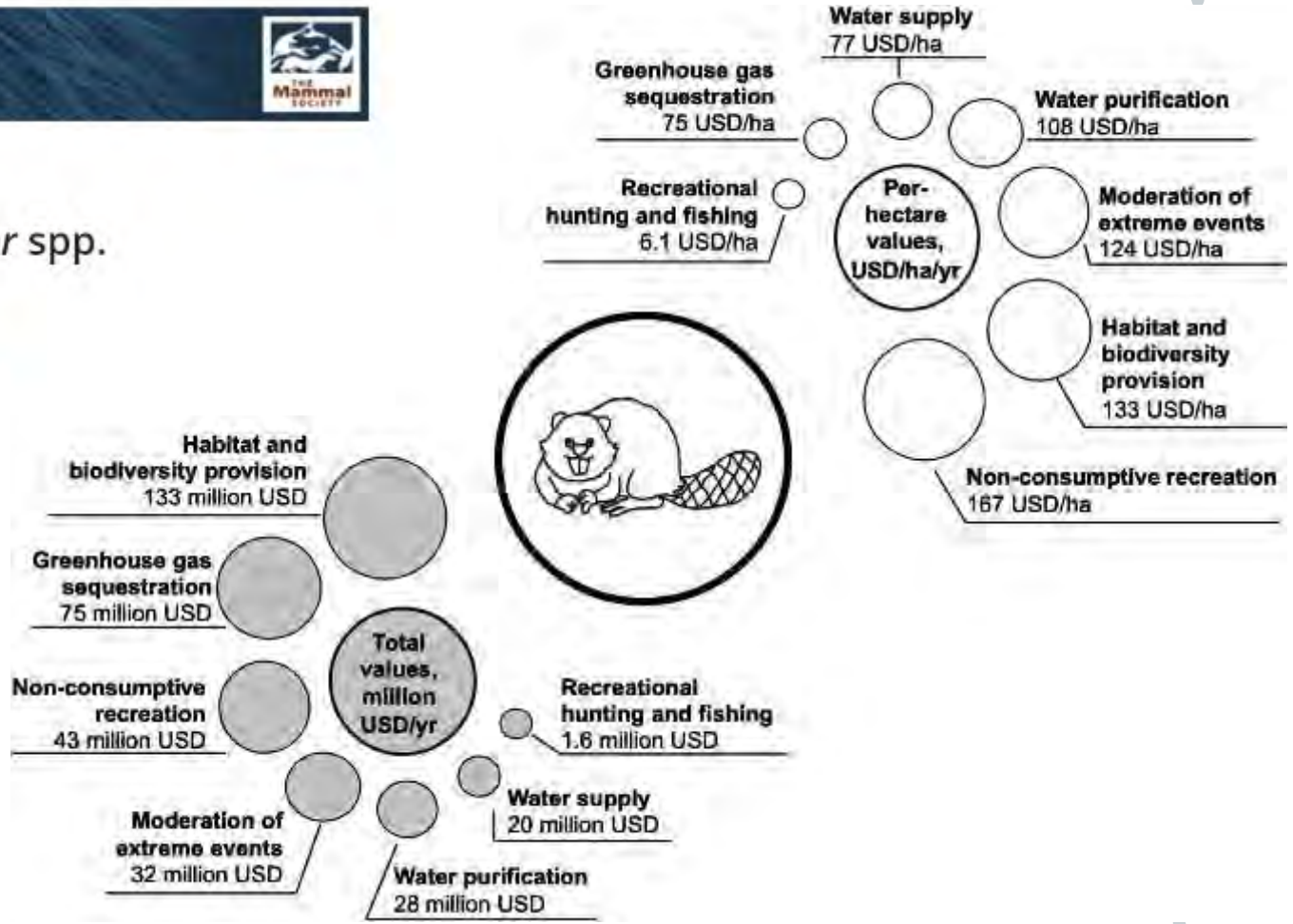

QUESTIONS?

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