Fish and Fire, what do we know?

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Traditional Perspective

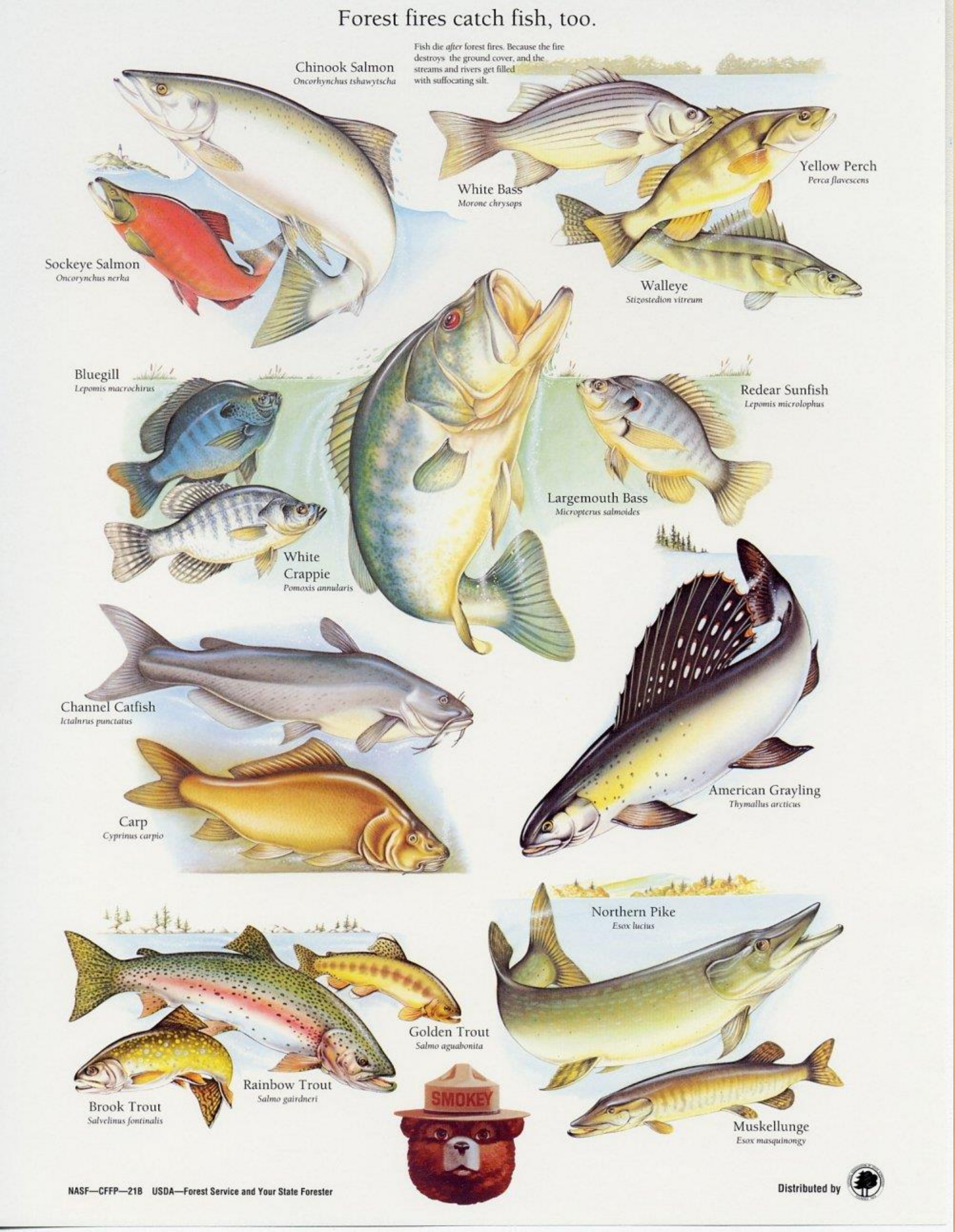
"Forest fires catch fish, too.

Fish die *after* forest fires. Because the fire destroys the ground cover, and the streams and rivers get filled with suffocating silt."

Fire continues to be seen in the media and broader culture as only a negative effect on the landscape that should be managed. This perspective is extended to riparian areas and concerns regarding aquatic habitat quality.

What are the relationships among wildfire, riparian areas, native fishes, and aquatic habitat over time?

Emerging research that is often opportunistic in nature, has begun to paint a complex picture of the effects of wildfire on riparian areas, native fishes and aquatic habitats.



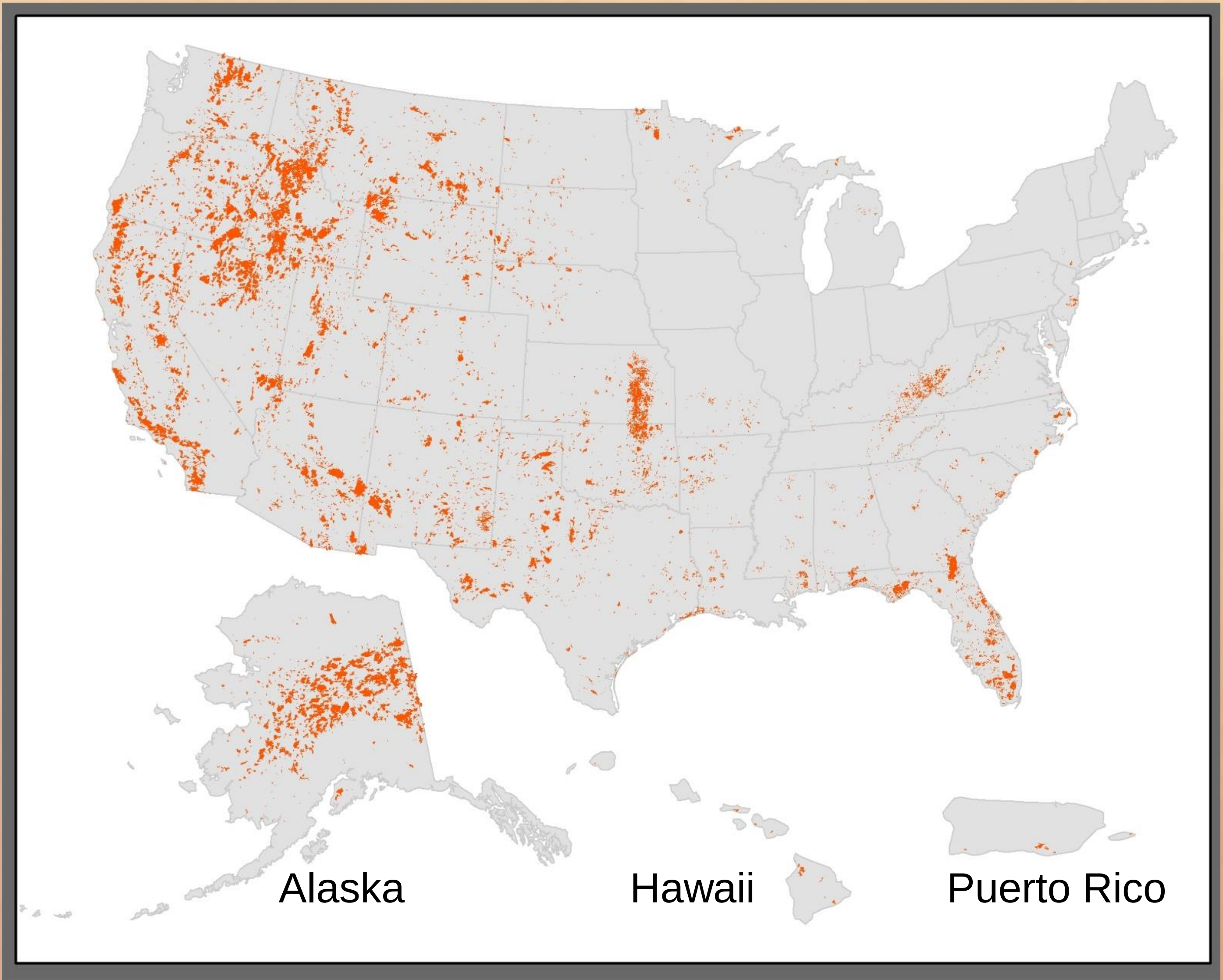
Alternate Perspective

Wildfire is a natural process.

Riparian zones need disturbance to maintain dynamic aquatic and terrestrial habitat conditions.

Fish populations have persisted for millennia in fire- and disturbance-prone landscapes.

Mapped fire boundaries from 1984-2015 by MTBS



As we know, fire continues to be a significant disturbance at landscape scales. In the west, it was probably the principle large-scale disturbance process effecting upland and riparian community structure at varying spatial and temporal extents.

The “Great Fires of 1910”


St. Joe Idaho, 1910

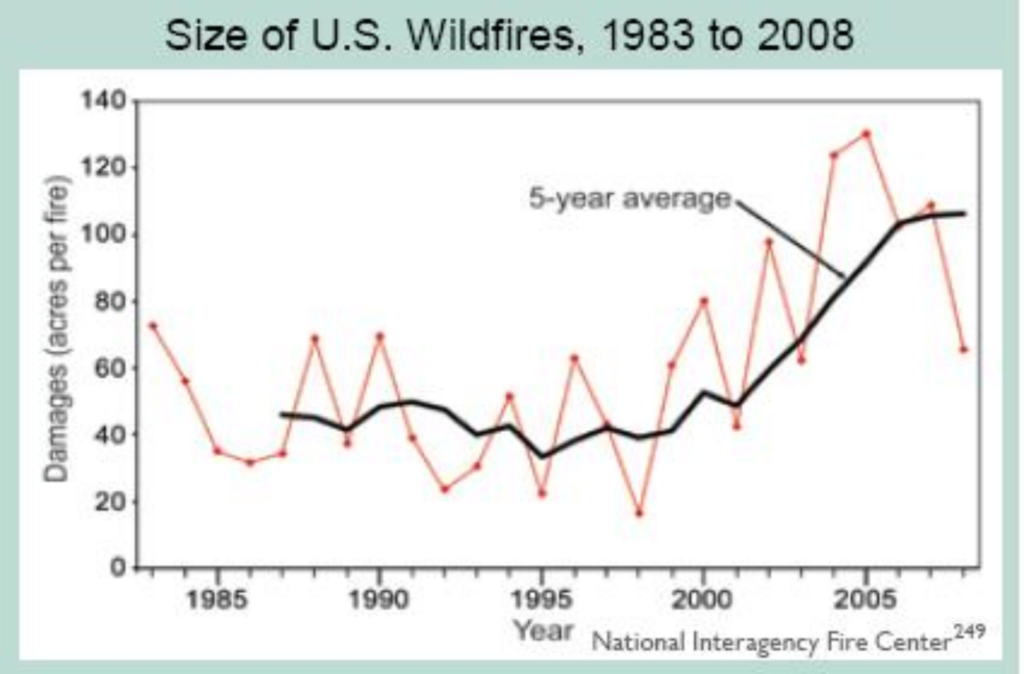
Clean and Sparkling Water (1986)

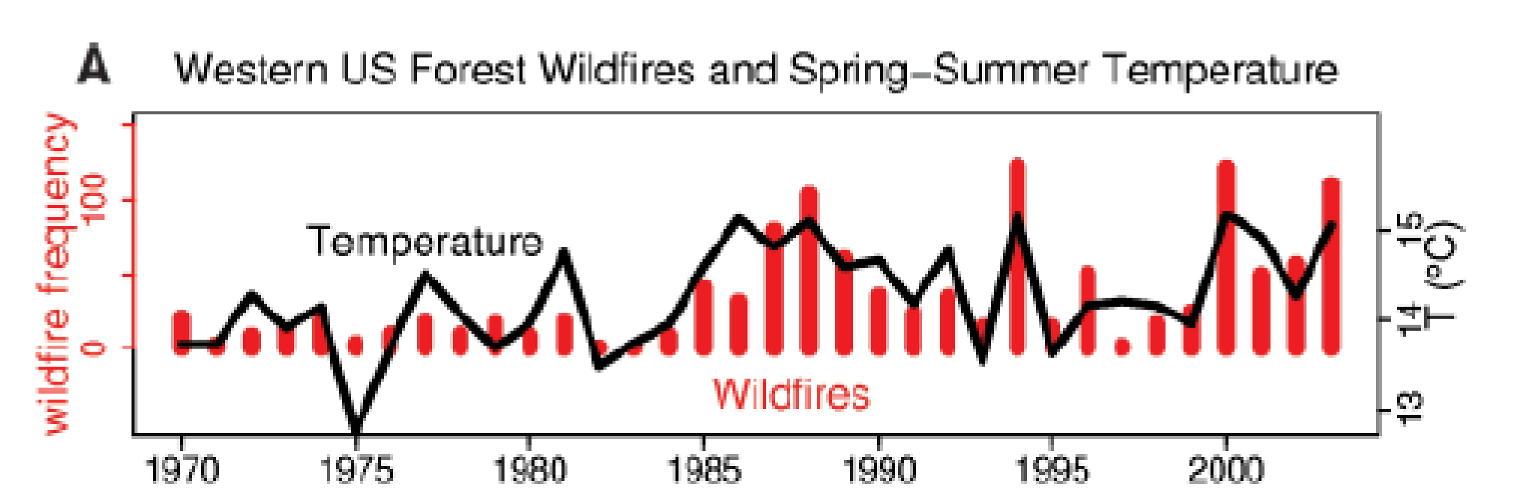
Arguments against fighting of fires went up in smoke with the Great Fires of 1910. Approximately 3 million acres of forest burned in NE Washington, N Idaho (the panhandle) and W Montana. The fires killed 87 people including 78 firefighters.

Fire size, and recurrence interval have changed over time.

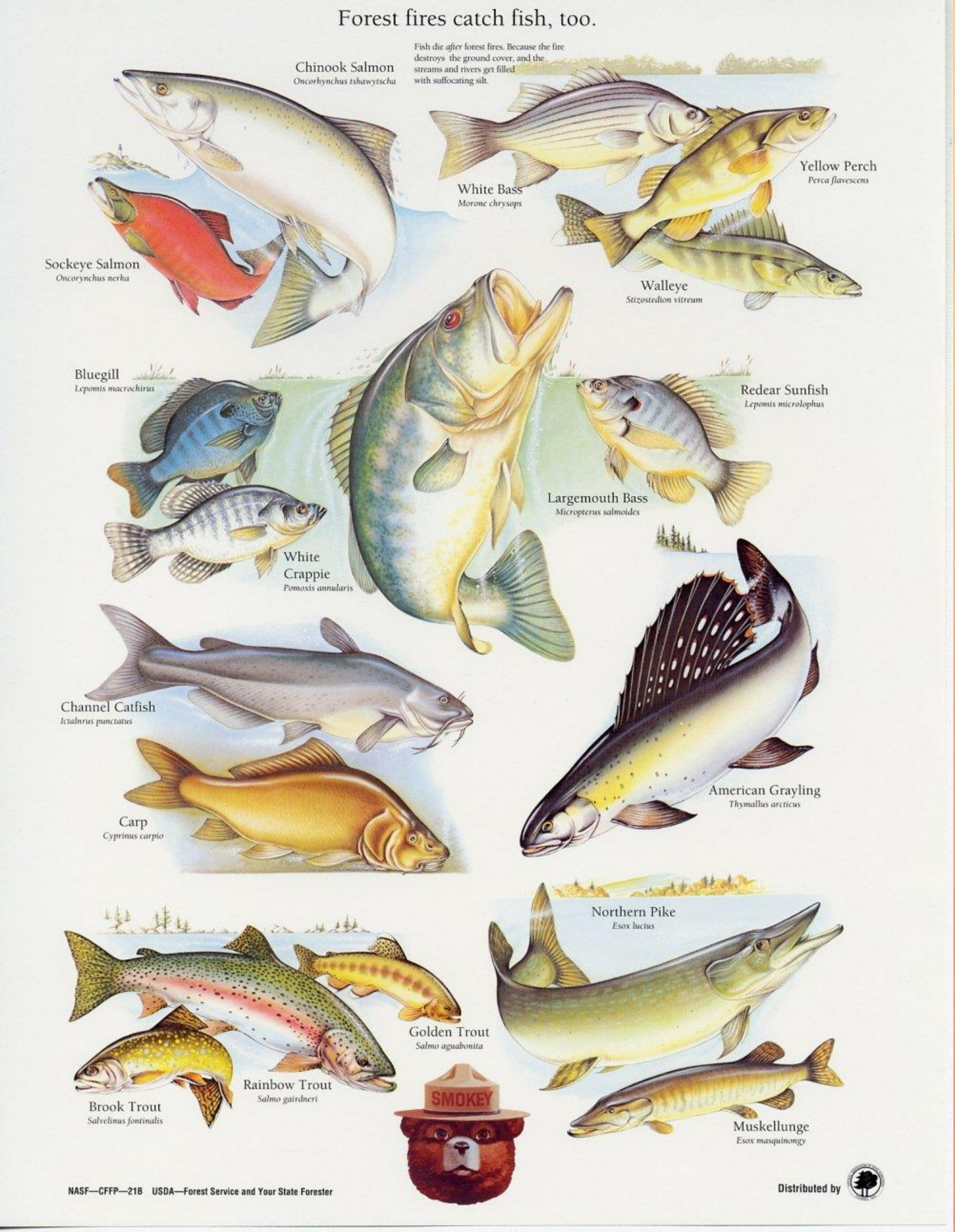
Since 1980's

- Higher frequency
- Larger
- Longer season





Westerling et al. 2006



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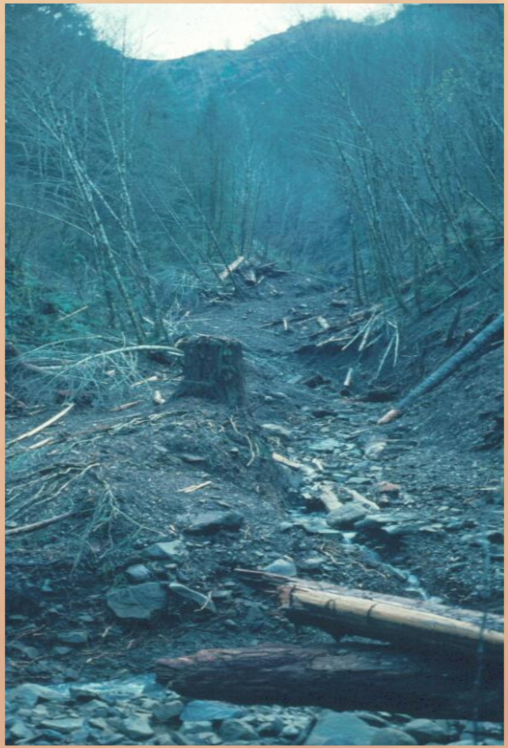
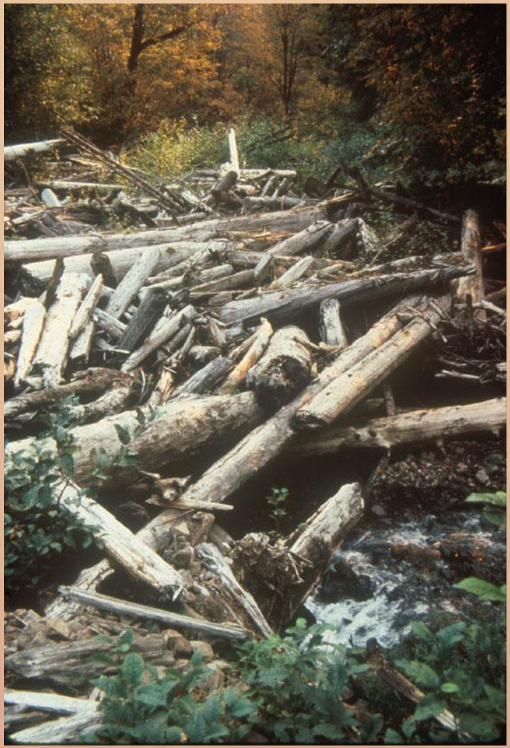
Riparian areas are zones of dynamism reflecting cyclical disturbance.



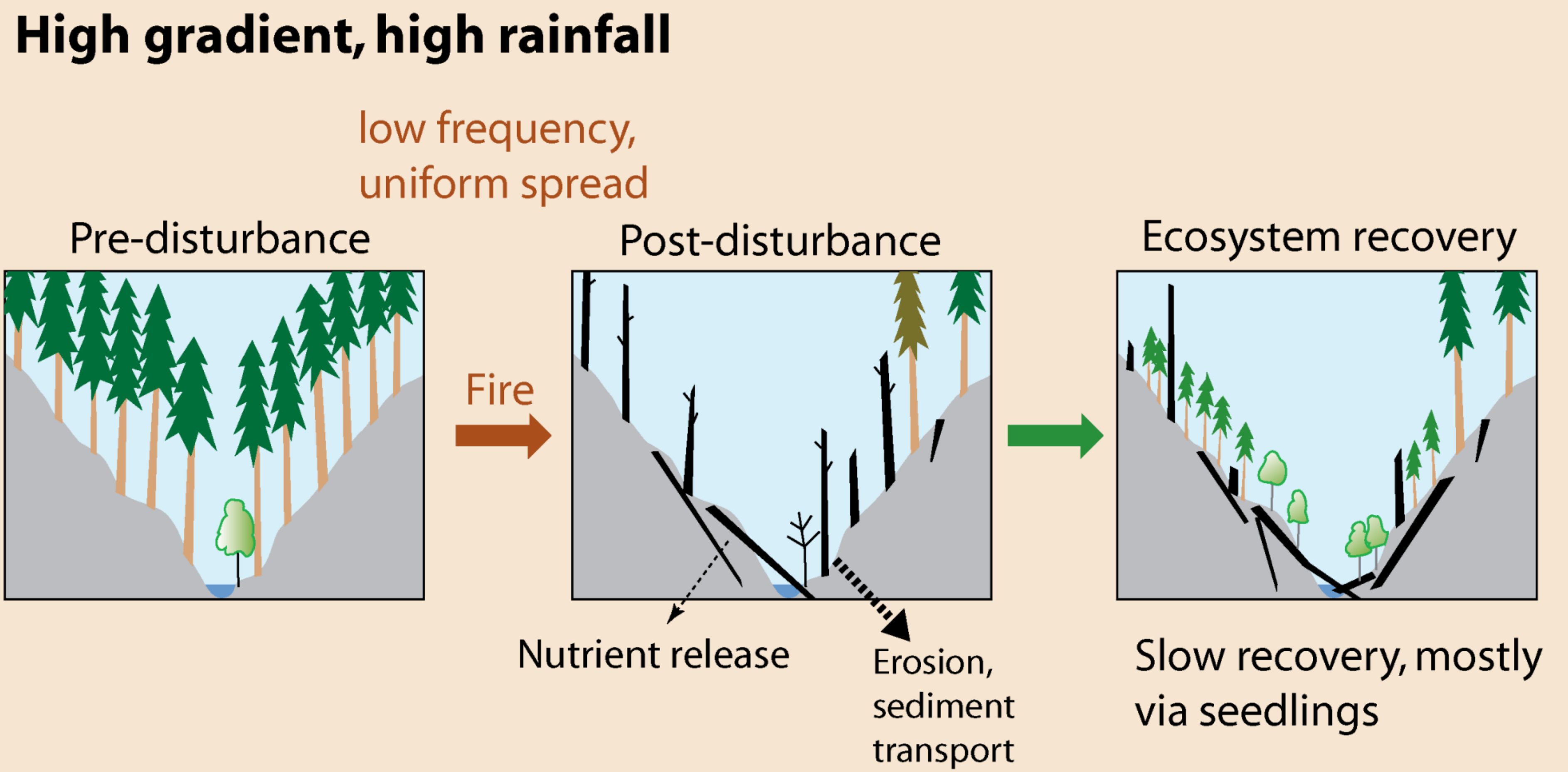


Common events in riparian zones include flooding, debris flows, and landslides that contribute to habitat diversity. This habitat diversity translates into generally higher species diversity in riparian areas compared to uplands, and dynamic in-stream habitat conditions.

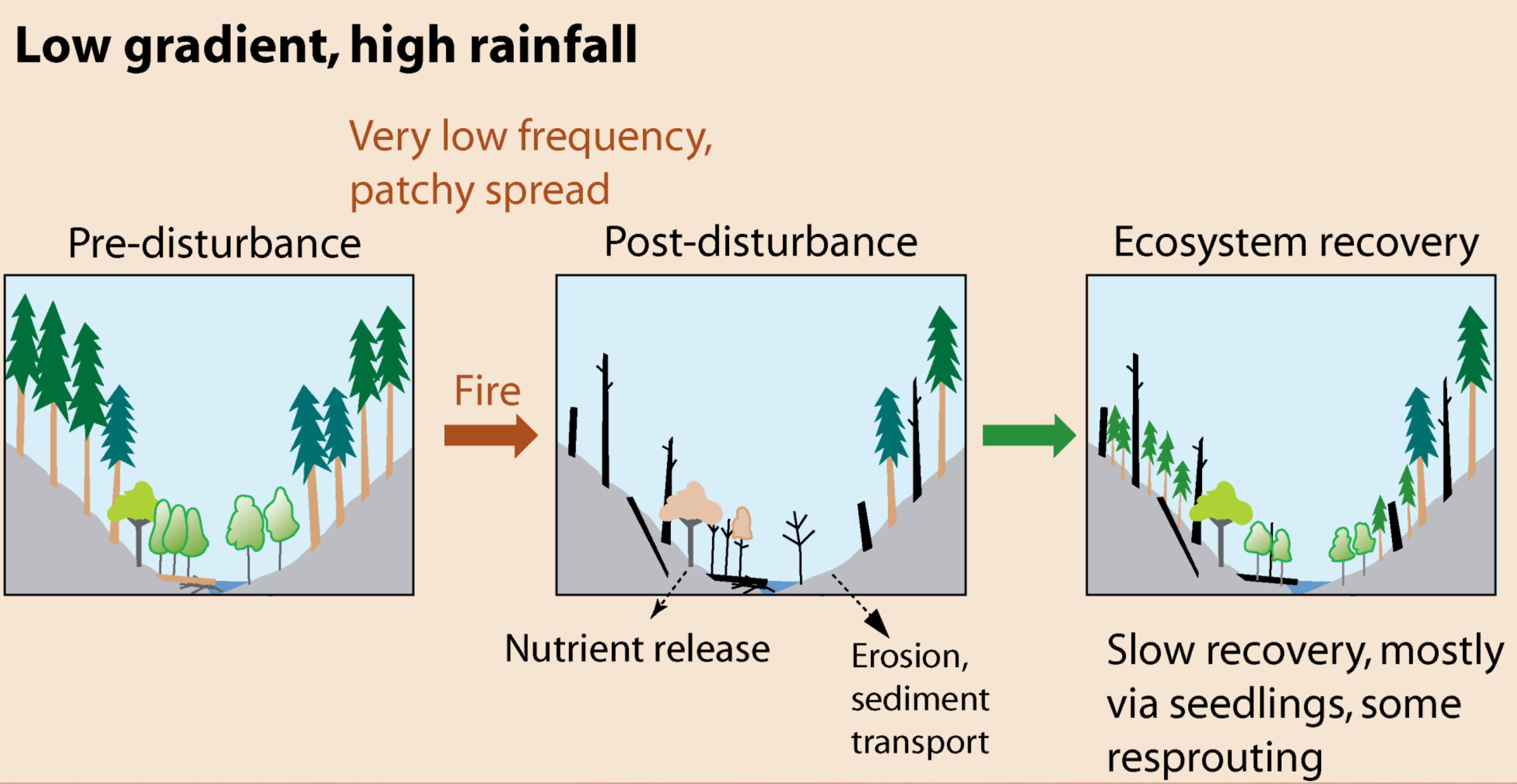
Wildfire in riparian areas.

Study	Location	Results
Hemstrom and Franklin (1982)	Mt. Ranier, WA	Fire in riparian areas **more moderate** than those in adjacent upslope areas
Barrett (1988)	E. Idaho	Fire return interval **48 years in riparian areas compared to 30 years** in adjacent uplands
Morrison and Swanson (1990)	W. Cascade Mountains, OR	Fire in riparian areas **less frequent and severity more moderate** than uplands
Camp et al. (1997)	E. Cascade Mountains, WA	Areas **least likely to burn were near confluences** with perennial streams
Barrett (2000)	Central Idaho	**Fire return interval** 10-14 years in riparian areas and **similar** to upland forest.
Everett et al. (2003)	E. Cascade Mountains, WA	**Less frequent, but potentially more severe fires in riparian** than upland forest, but apparent continuity in events shared by both.
Skinner (2003)	Klamath Mountains, CA	Fire return interval **lower in riparian areas** with perennial streams compared to adjacent uplands.
Kobziar and McBride (2006)	Sierra Nevadas, CA	Riparian areas act as **natural fire breaks**, with **faster regeneration** in riparian areas compared to adjacent uplands.
Arkle and Pilliod (2010)	Salmon River Mtns, ID	**Controlled burns** in riparian areas did not significantly alter in-stream habitat and resulted in **lower riparian fire intensity** after wildfire.

Riparian areas often differ from upslope areas in terms of vegetation composition, microclimate and fuels. This leads to potentially different fire environments and return intervals.



Pettit and Naiman 2007



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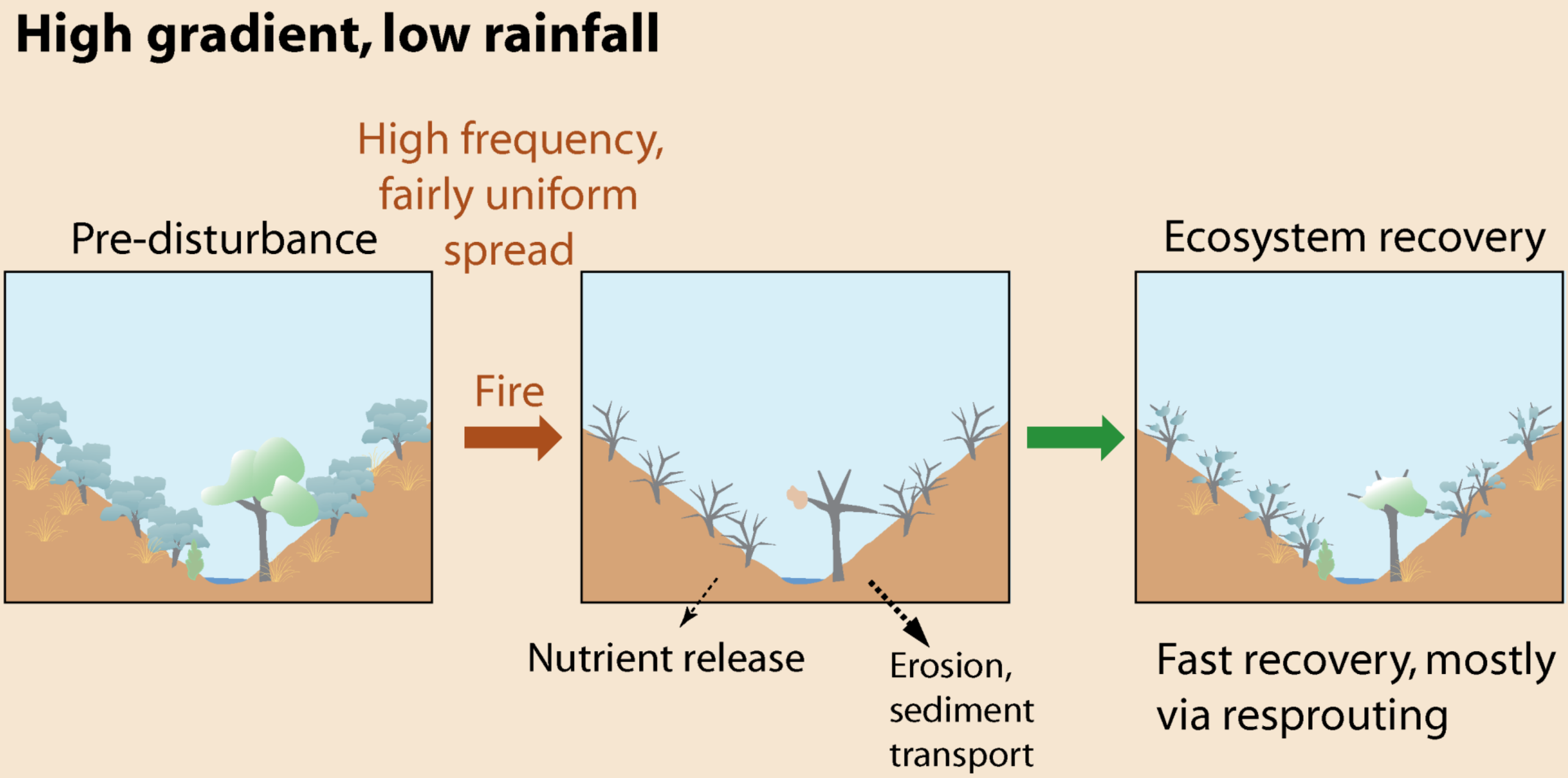

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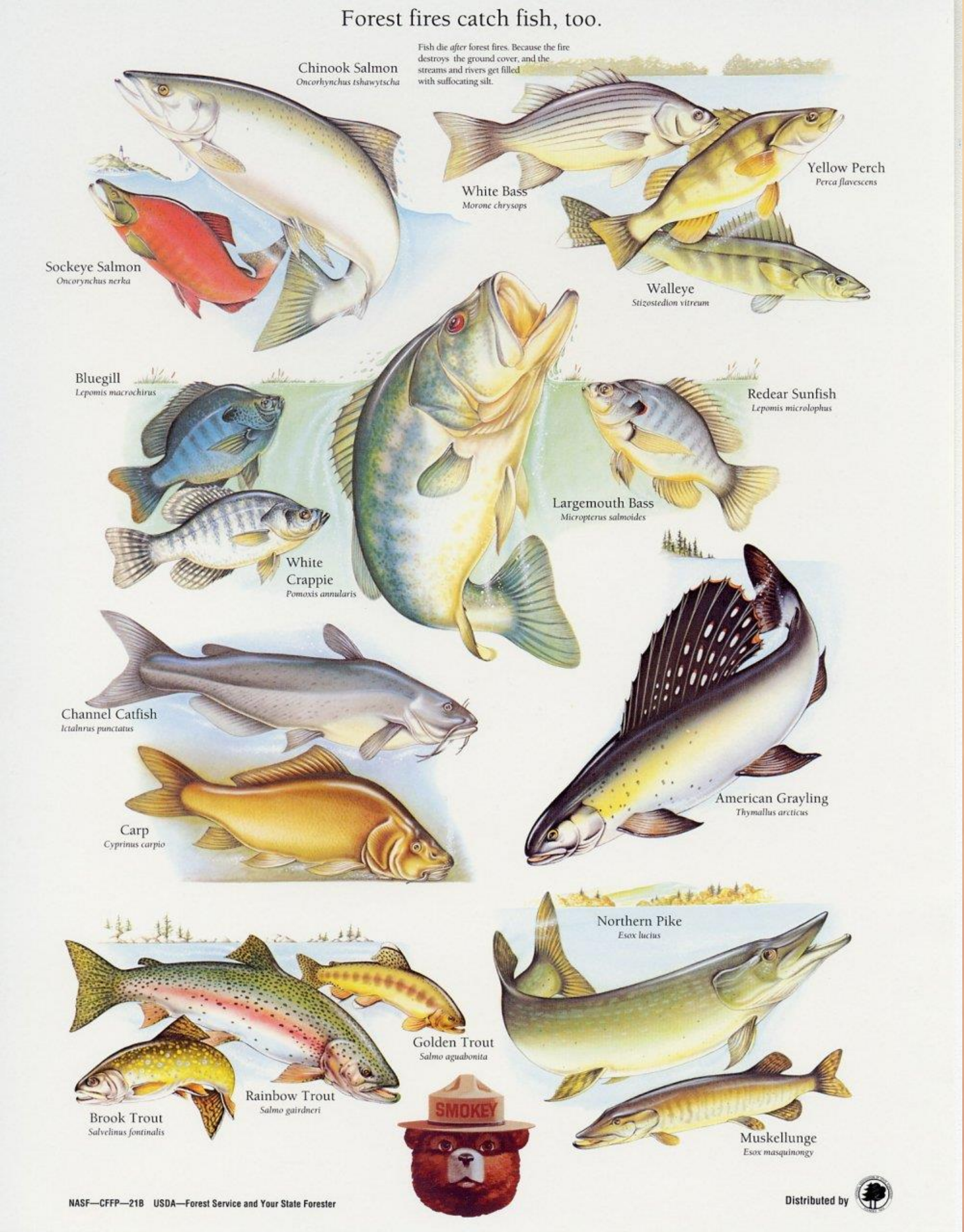

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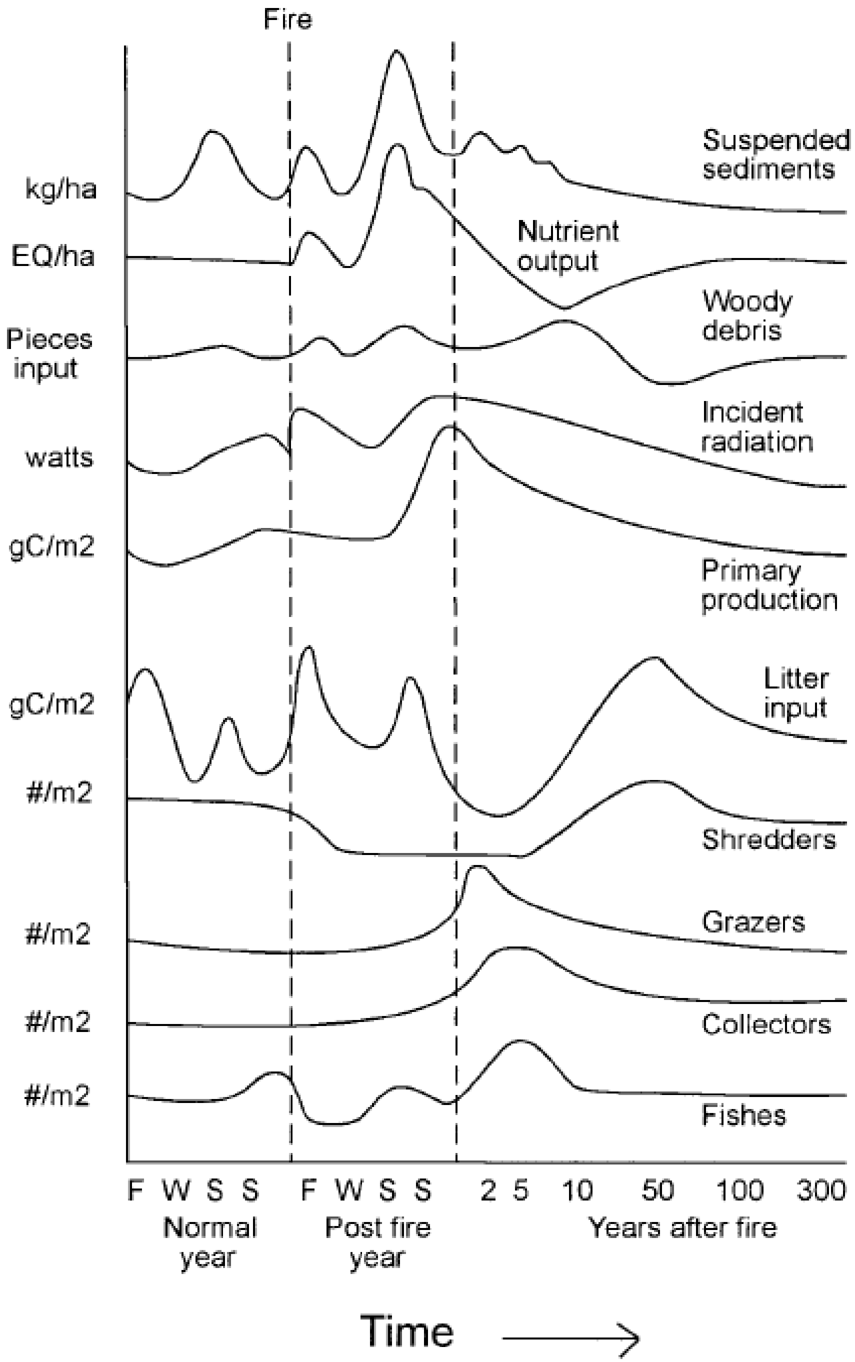
Post-wildfire effects on aquatic systems change over time.



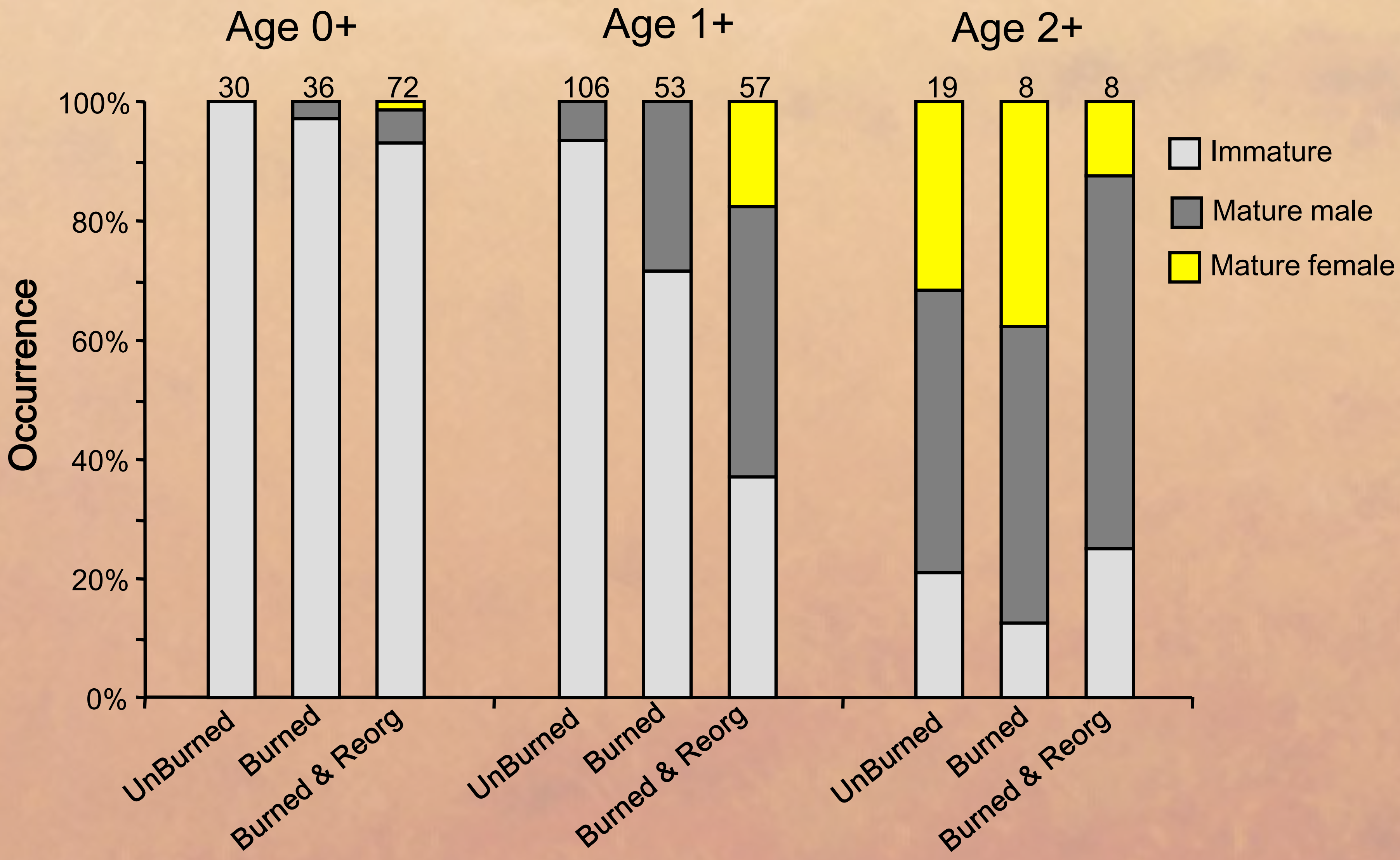
Gresswell 1999 adapted from Minshall et al. 1989

Consideration of post-wildfire effects on aquatic habitat has often focused on the immediate changes associated with shade, stream temperature, sedimentation, landslides, and fish kills. It is important to consider how streams process disturbance over time.

Native fishes of the Western US are adapted to dynamic disturbance processes.

Resilience mechanisms of native fishes to disturbance include mobility, phenotypic variability, and high fecundity.

Life history expression in Rainbow Trout post-fire in Idaho



Emergence of previously unobserved life history diversity was found in native Rainbow Trout post-fire.

Rosenberger et al. 2012

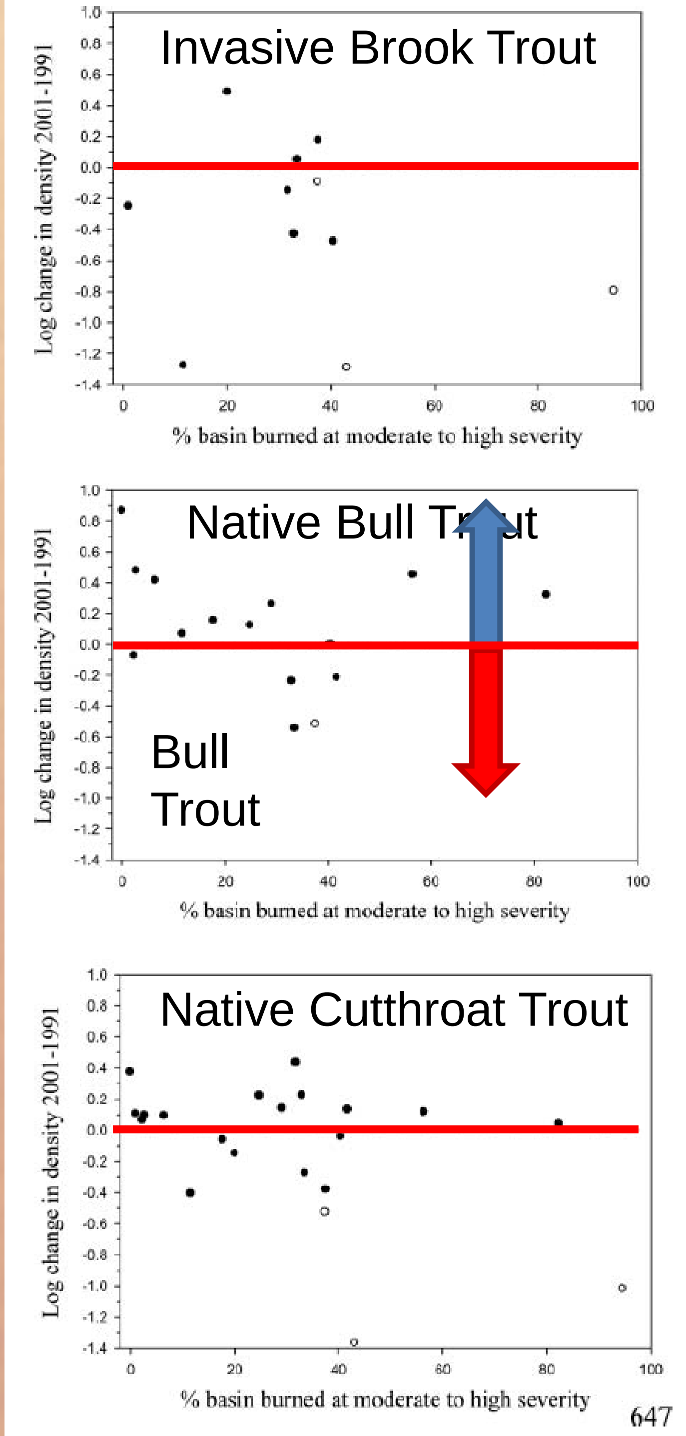
Wildfire intensity and associated habitat alterations altered life history behavior and physiology of native Rainbow Trout.

	Unburned	Burned	Reorganized
			
>60 mm	**ND**	ND	ND
Age 1+	**High**	Intermediate	Low
Growth	**Slow**	Intermediate	Fast
Age at maturity	**2y**	1-2y ♂	0-2y ♂ ♀

Strategy? **Save your strength** → **Live fast, Die young**

Rosenberger et al. 2012

Observance of physiological and life history adaptation has relied on opportunistic studies. What else don't we know?

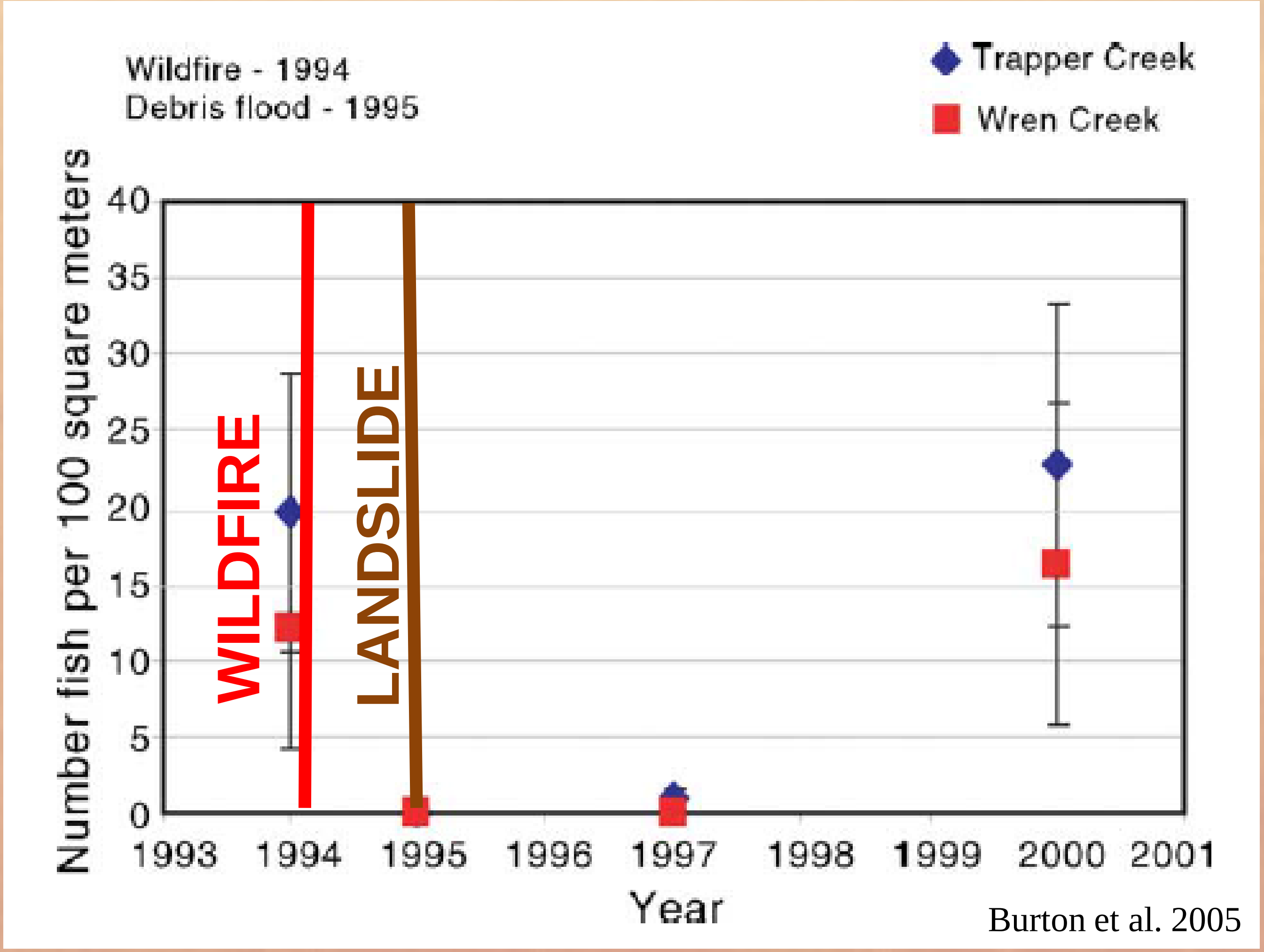


Native fishes may respond more favorably to wildfire than non-native fishes.

Post-fire population density of Brook Trout was lower at most sites compared to higher observed post-fire population densities at most sites for Bull Trout Cutthroat Trout.

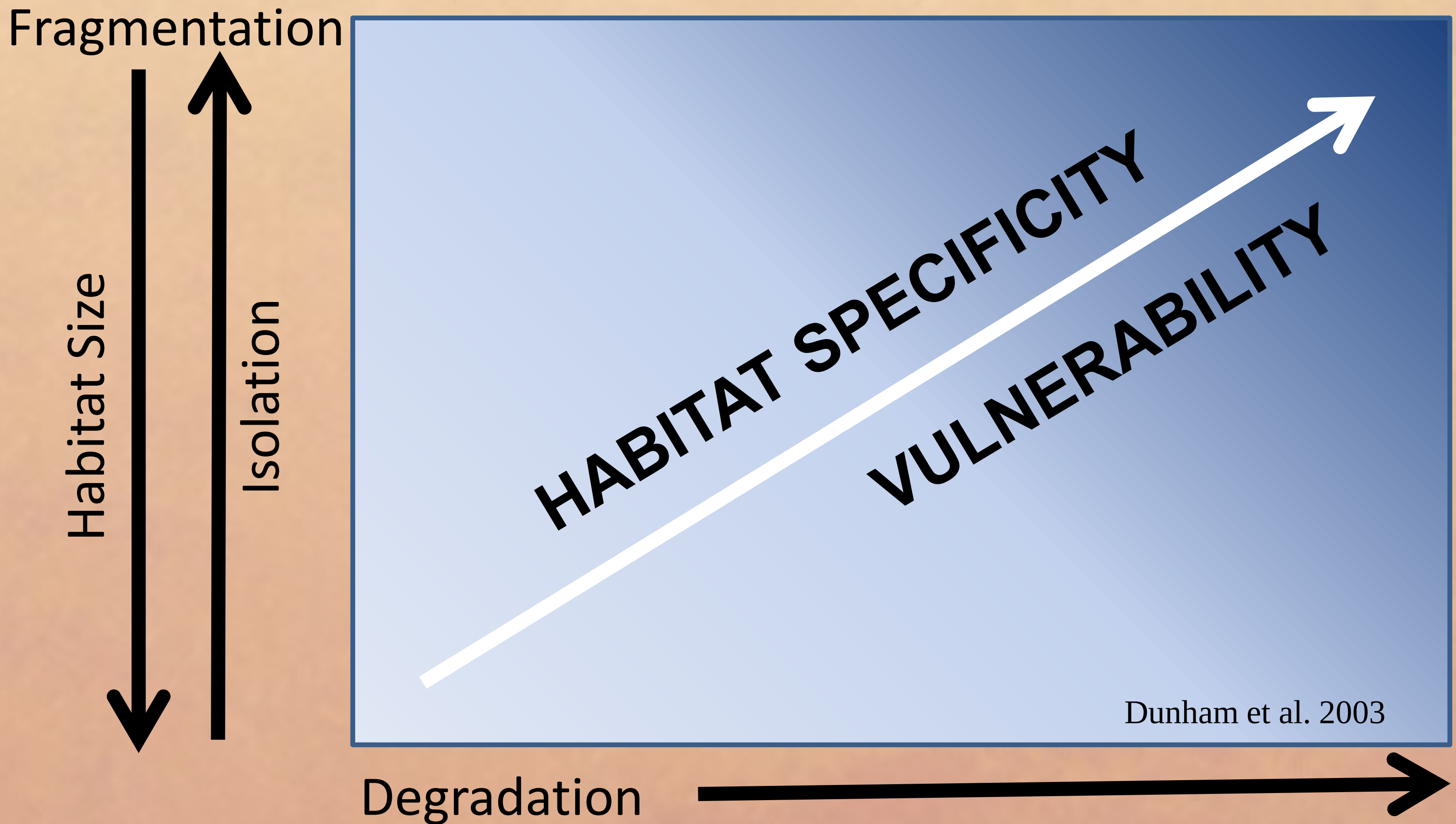
Sestrich et al. 2011

Response to Redband Trout to wildfire and landslide.



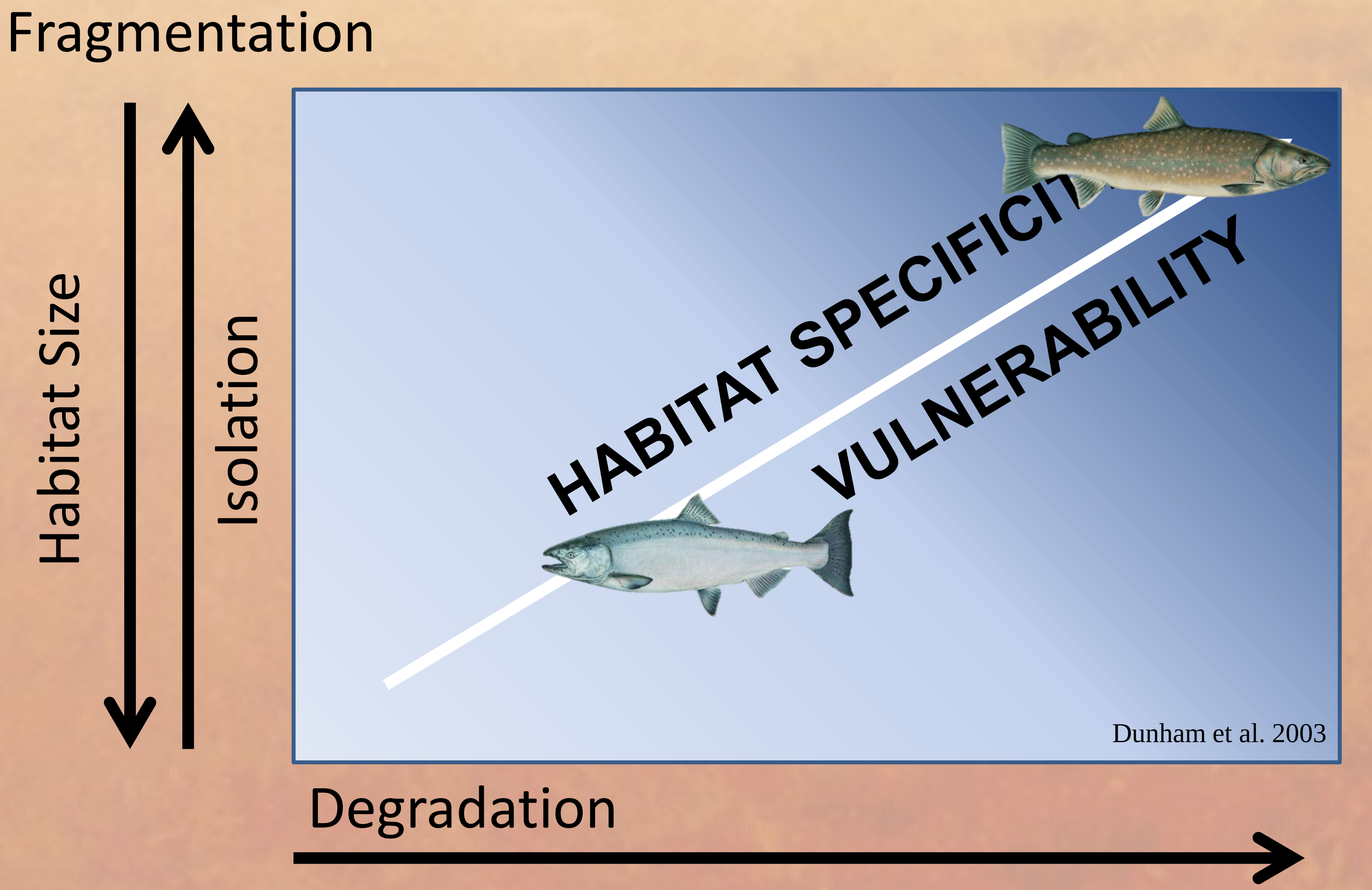
Redband Trout populations and habitat conditions improved within 5-10 years post-fire with rejuvenated aquatic habitats.

"Axes" of Fish Population Vulnerability to Fire

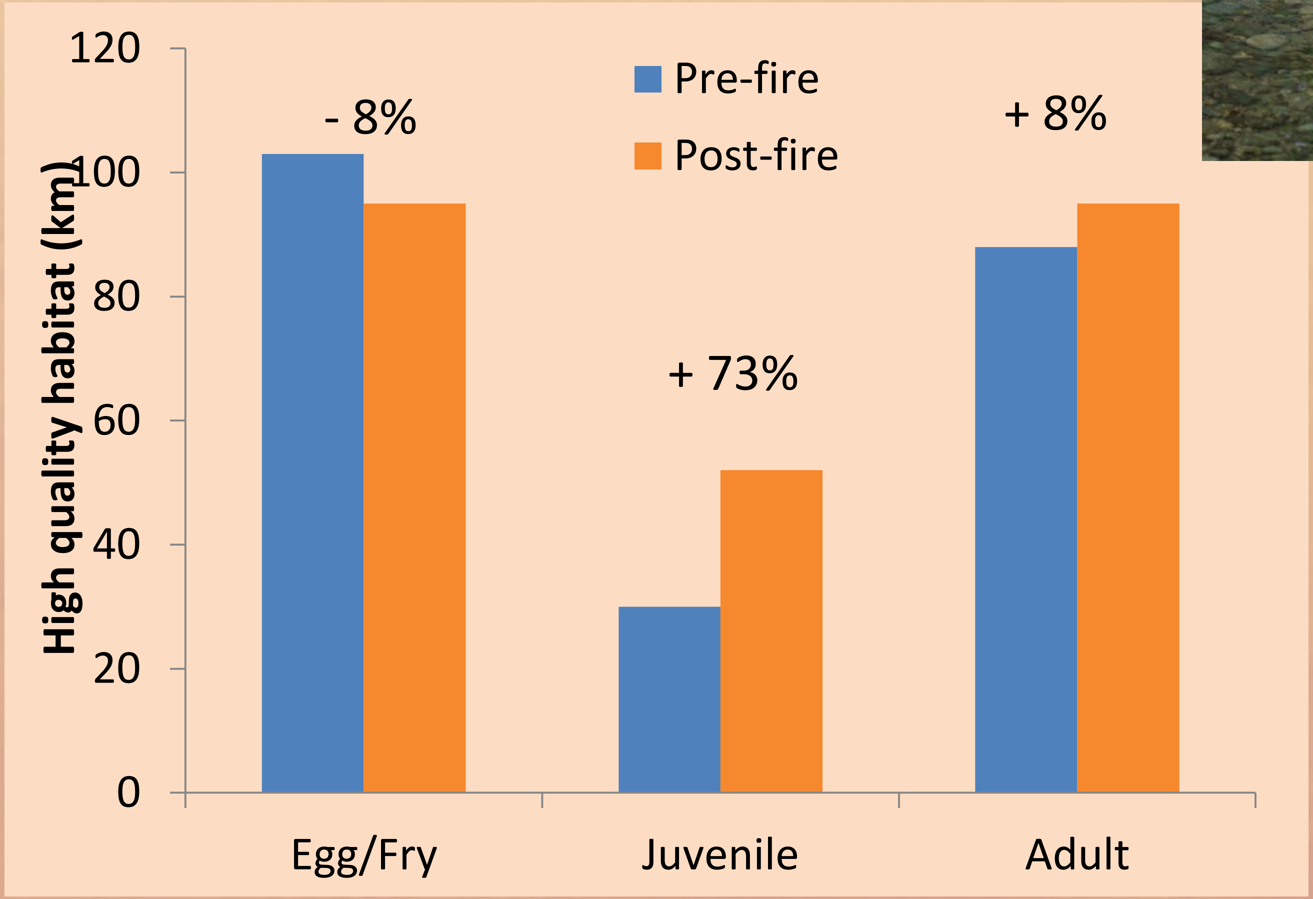


At population scales, species vulnerability depends on the size and quality of available habitat patches, and the specificity of habitat needs.

“Axes” of Fish Population Vulnerability to Fire

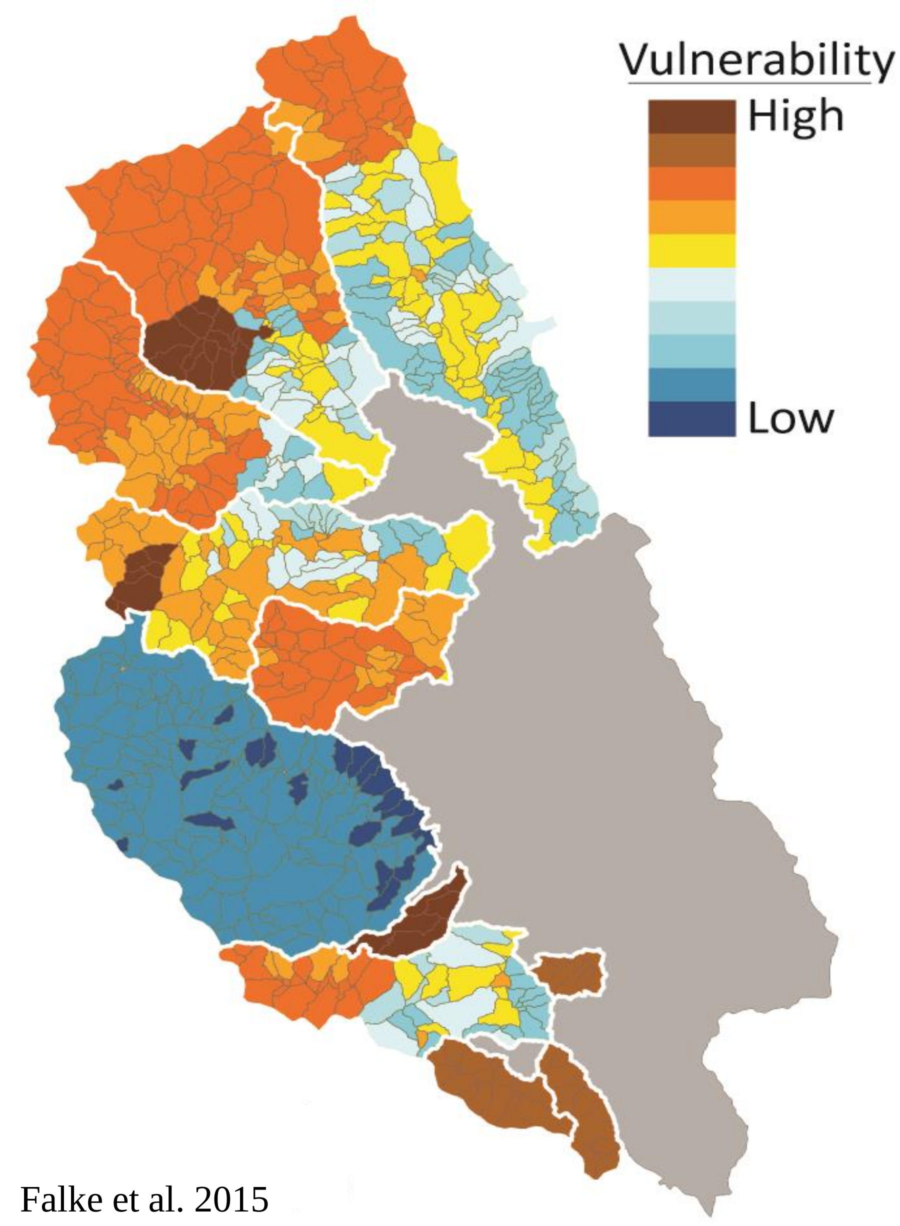


Effect of wildfire on Spring Chinook Salmon by life stage.



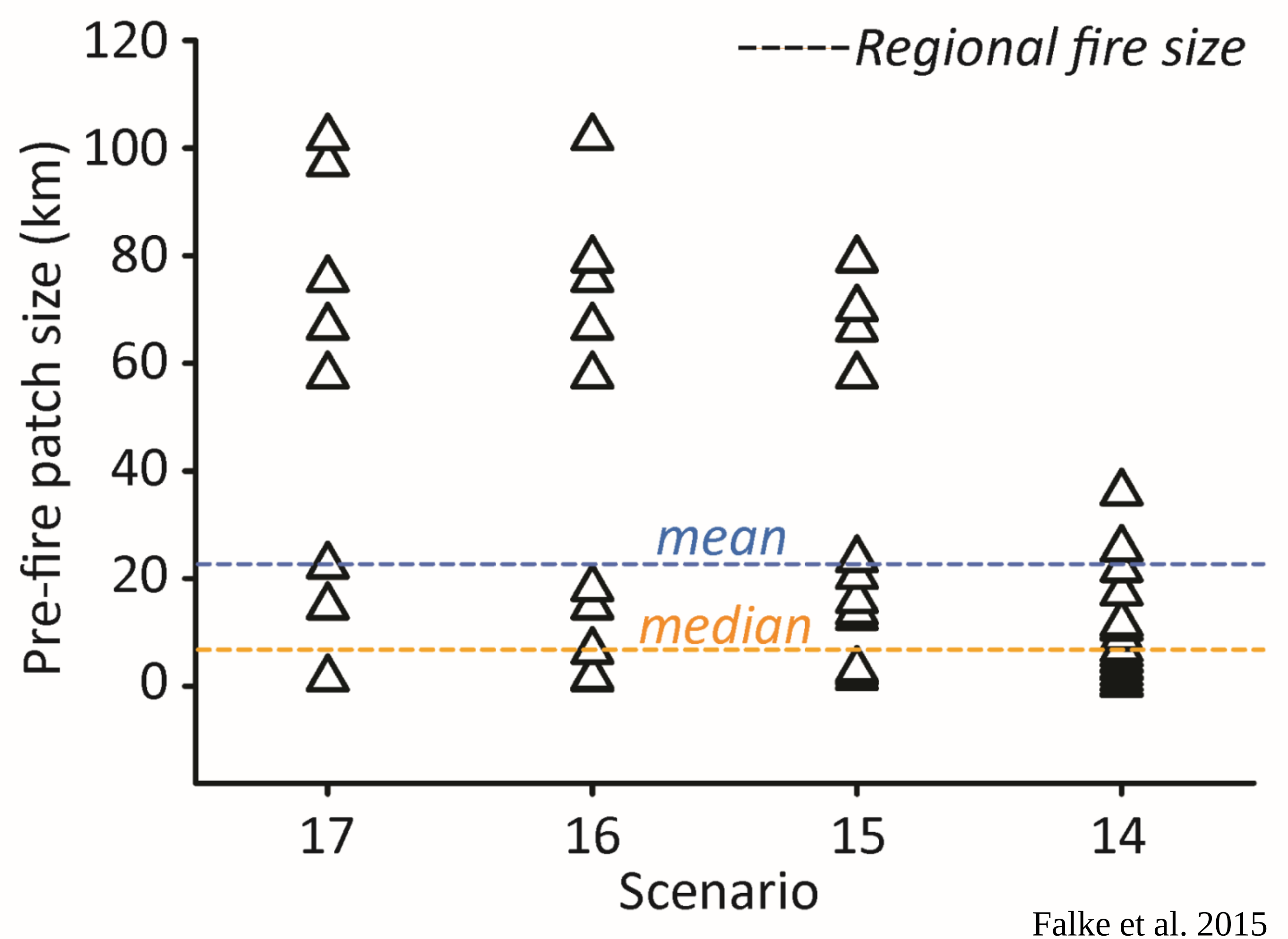
Modeled effects of wildfire show positive or negative effects on Spring Chinook Salmon by life stage.

Population-scale vulnerability of Bull Trout to wildfire.



Bull Trout population-scale vulnerability depends on the size and connectivity among available habitat patches.

Patch and Fire Size



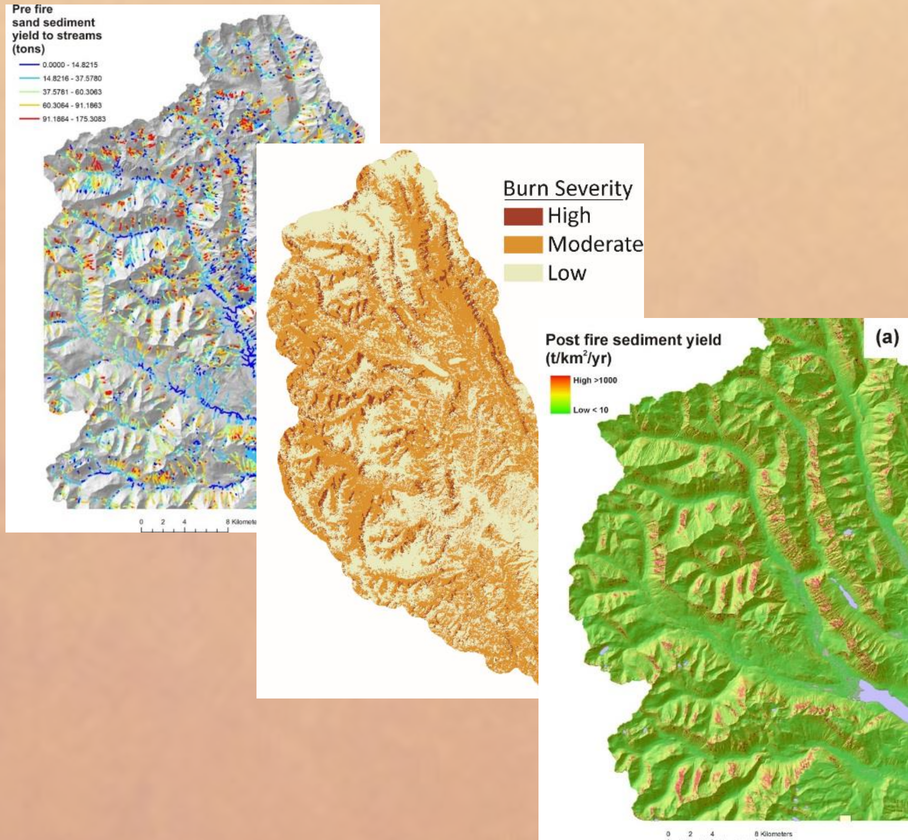
Falke et al. 2015

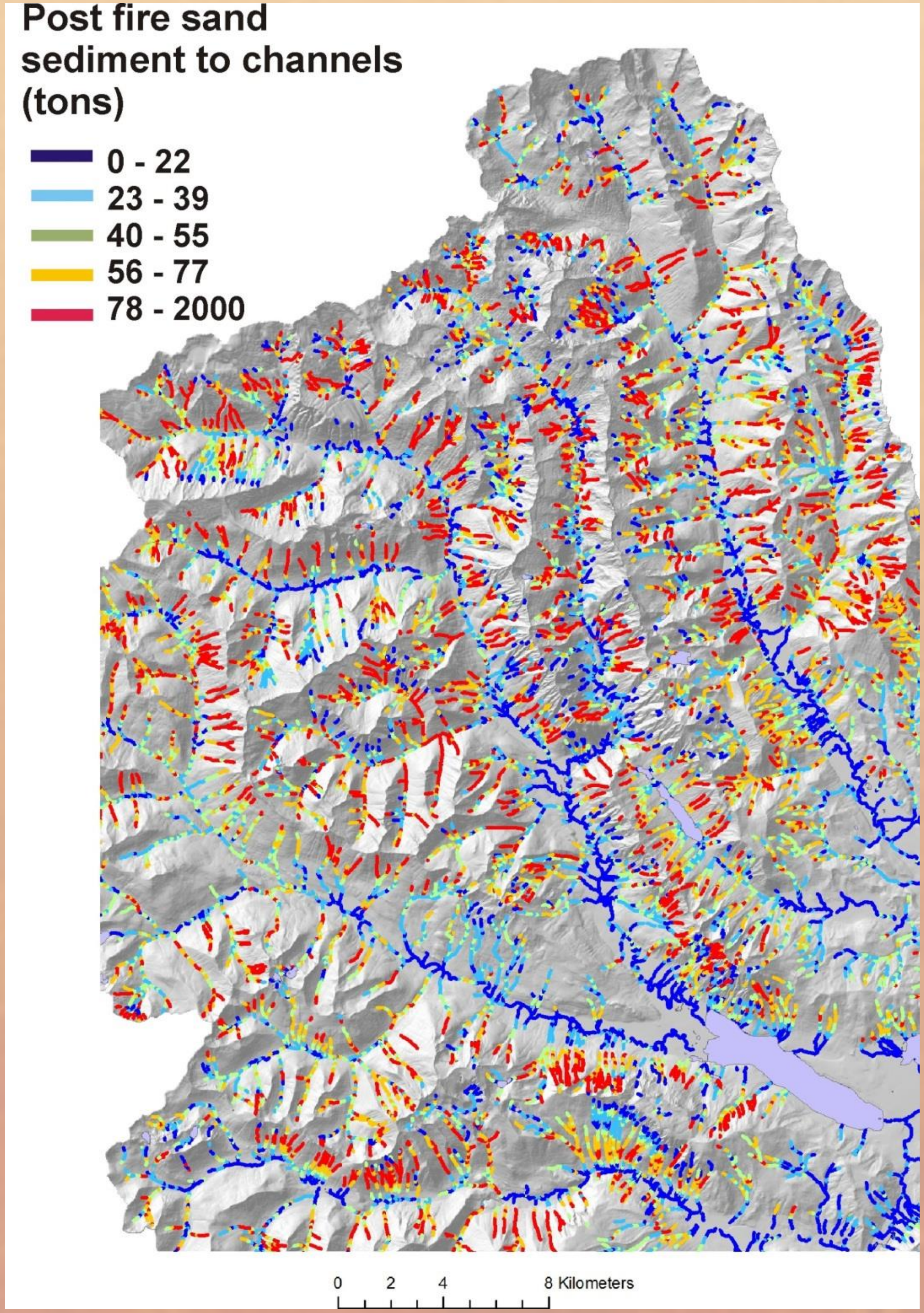
Due to the Bull Trout dependence on cold water, climate change has the potential to further isolate these fishes by shrinking the size of habitat patches and increasing patch isolation. This may enhance the negative effects of wildfires.

Aquatic habitat considerations when managing for resilience

Tools to help identify catchments or reaches most vulnerable to negative effects of fire in the short-term.

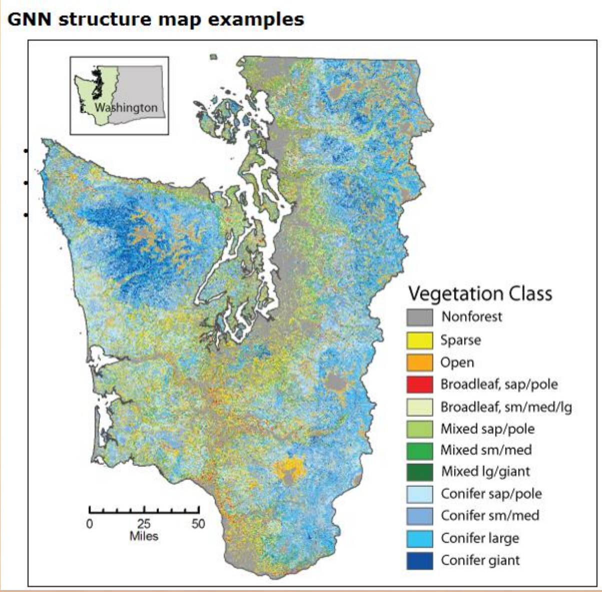
Post-fire fine sediment delivery modeling.

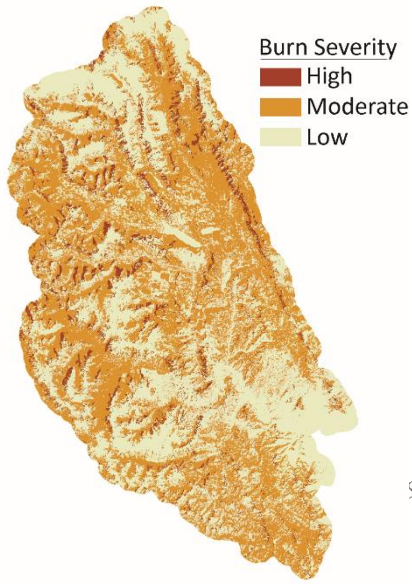


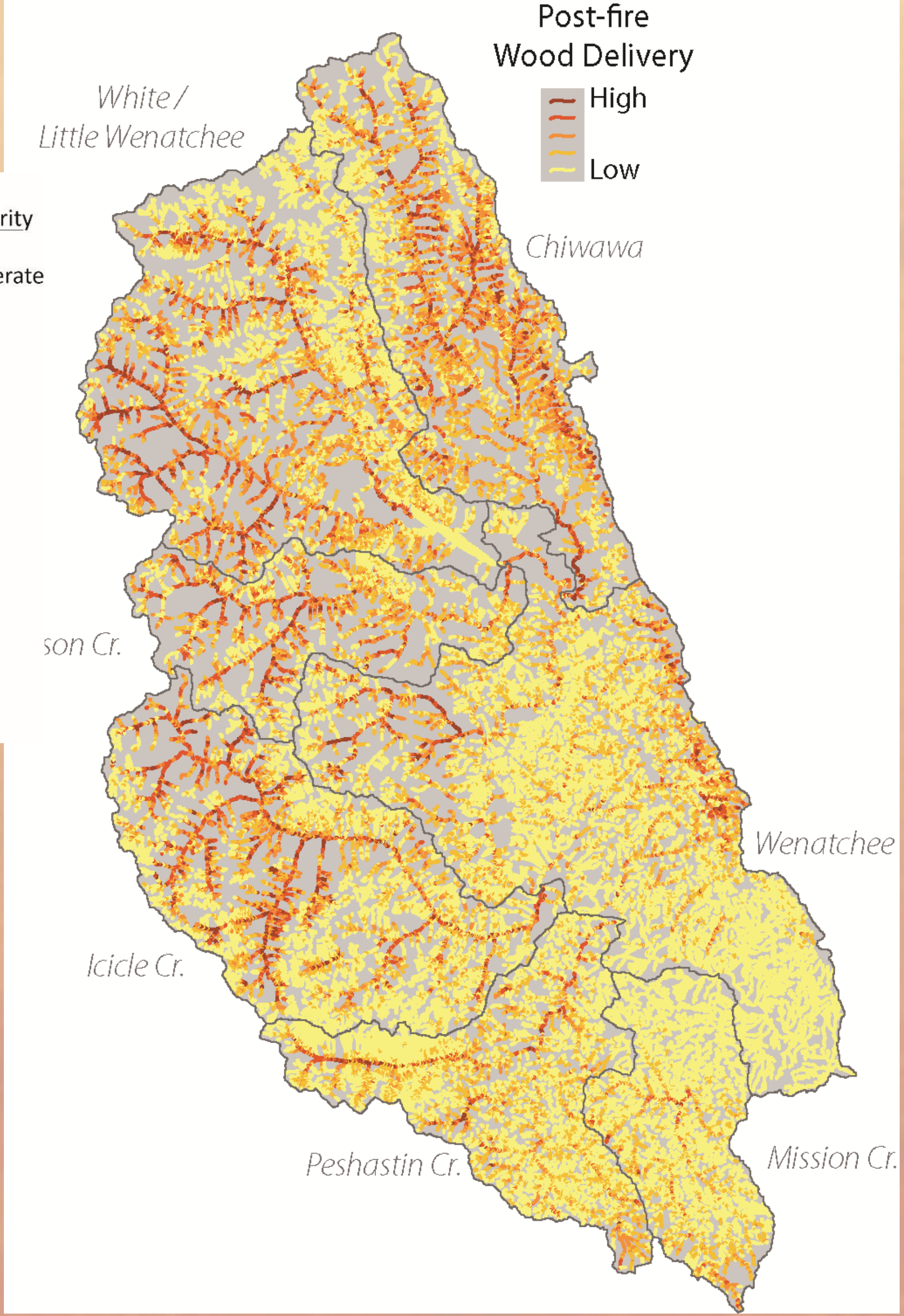


Sand sediment yield to stream channels is calculated with estimated fire intensity to generate probable post-fire sediment yield.

Post-fire wood delivery prediction.

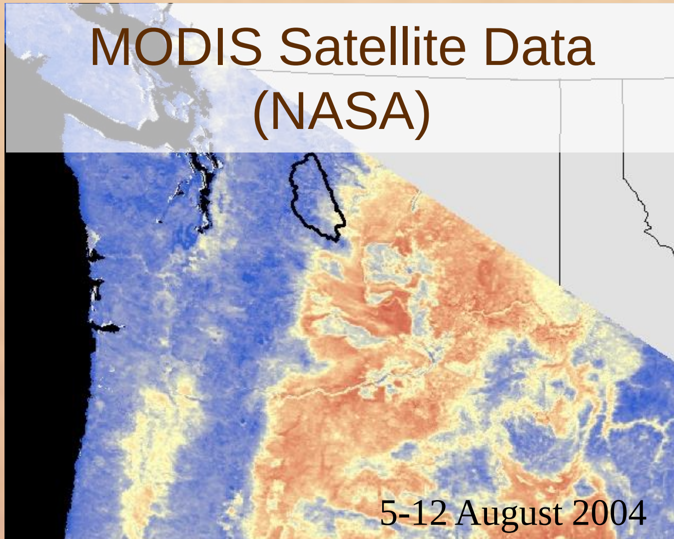


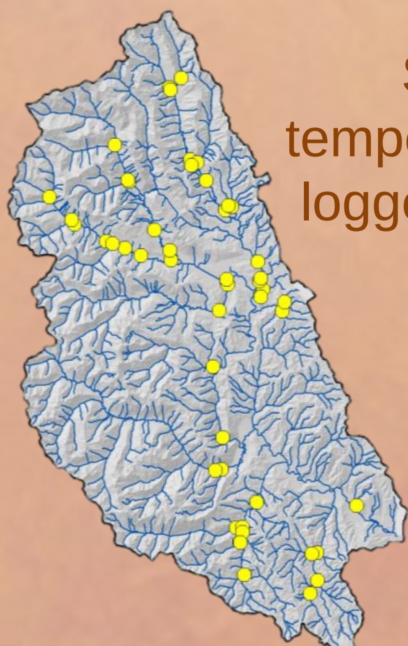




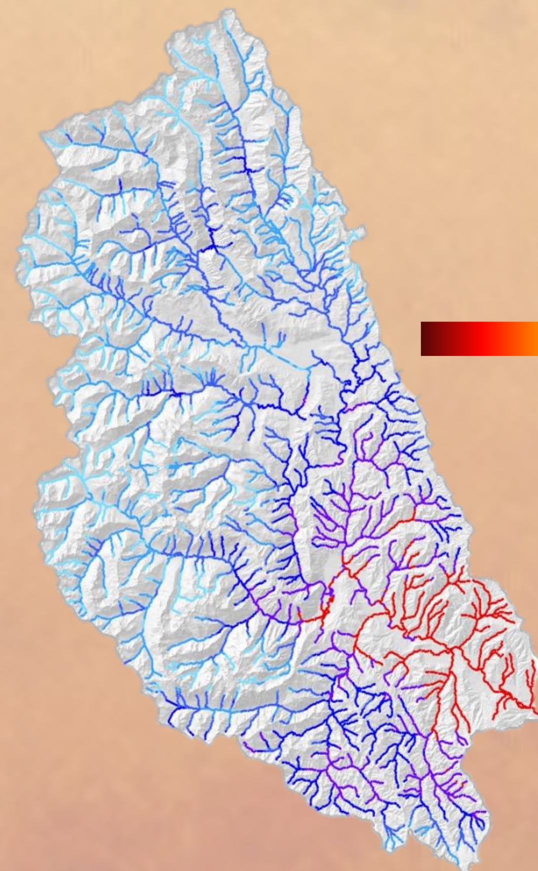
Fire severity (flame length)	% Mortality
Low (< 4 ft)	10
Medium (4-6 ft)	32.5
High (6-8 ft)	57.5
Very high /severe (>8-20 ft)	85
Severe /crown fire (> 20 ft)	100

Post-fire stream temperature at 8-day increments through the year.

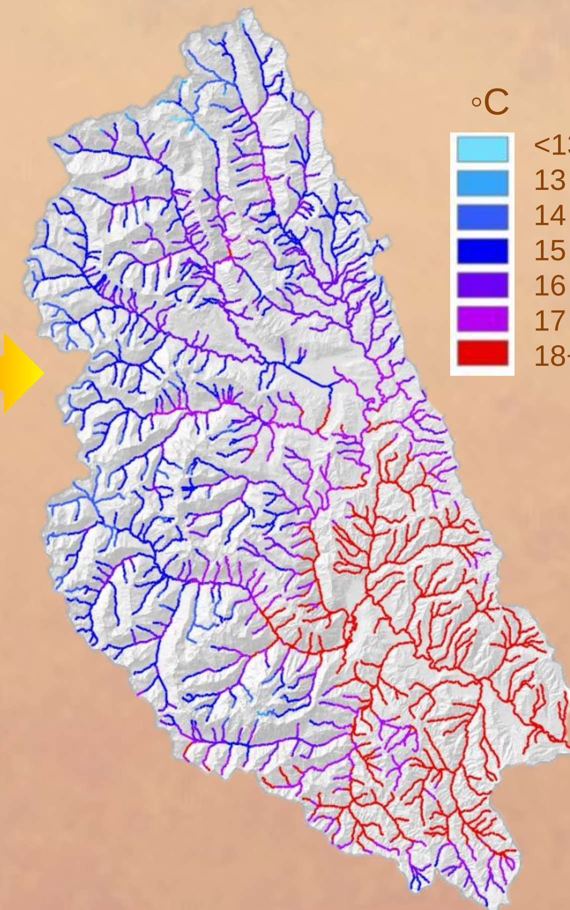




Stream temperature logger sites (n=50)

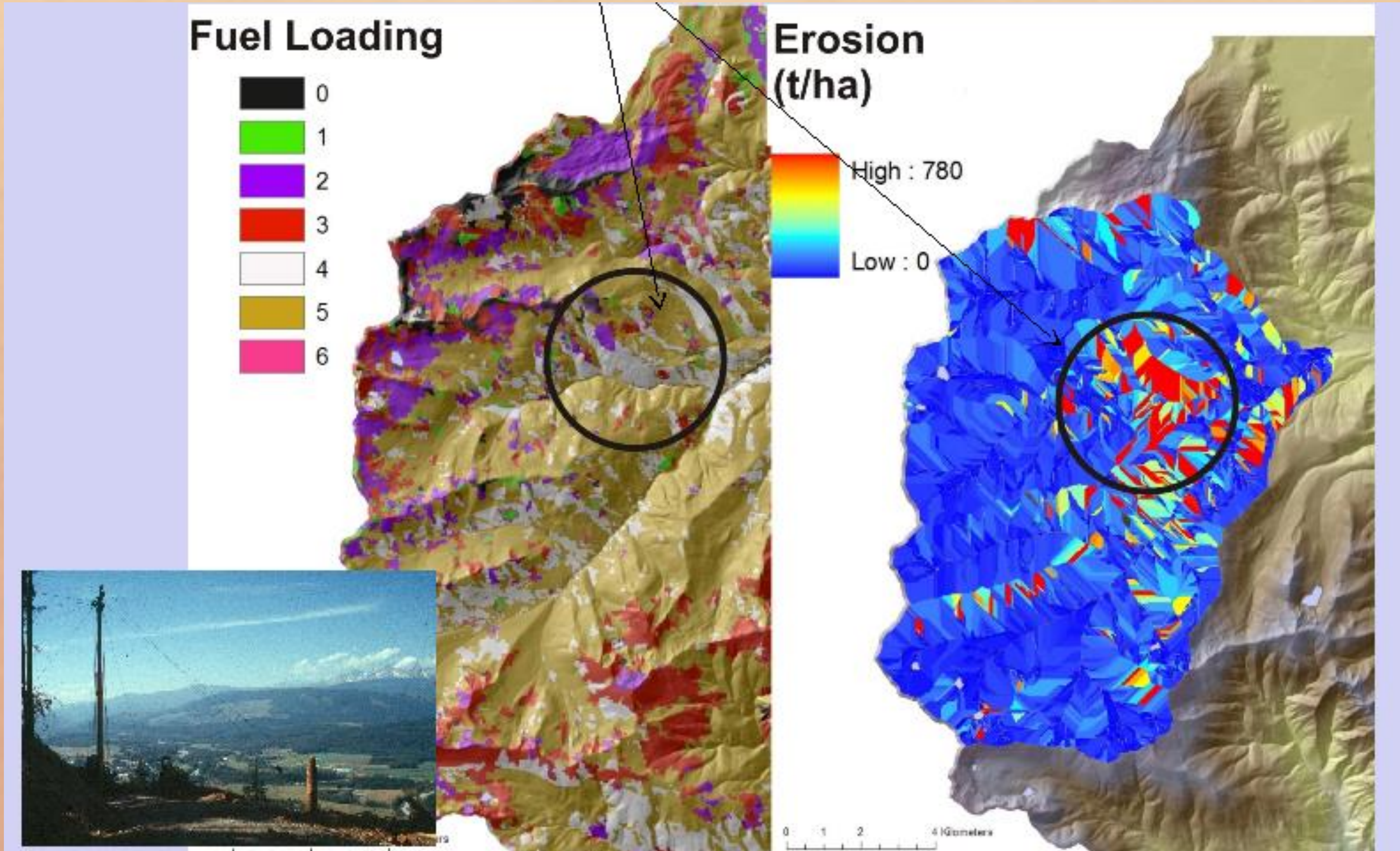


Current condition 10 year Max Mean Max



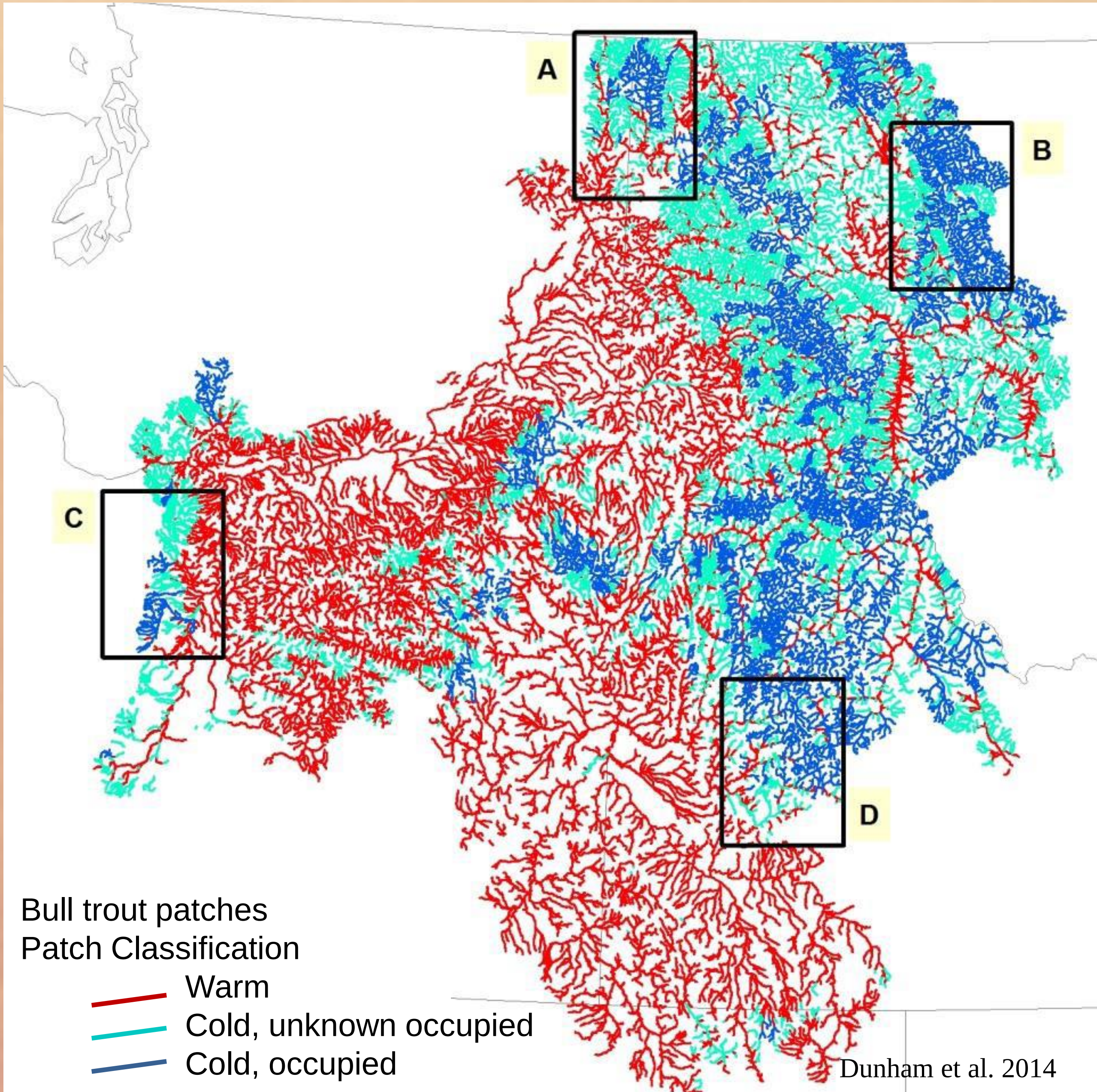
Post fire, high severity 10 year Max Mean Max

Combining model outputs to prioritize treatment locations.



High fuel loads and intense erosion zones prioritize areas of potential concern on the Shasta Trinity National forest for downstream municipal water sources.

Range-wide vulnerability assessment of Bull Trout.



Dunham et al. 2014

Assessments of population distribution, and connectivity can inform assessments of potential wildfire effects at multiple spatial extents.

Conclusions

- Effects of wildfire depend on the ecology of fish species.
- Native fishes have built-in adaptation to dynamic habitat conditions.
- Uncharacteristic wildfire, combined with human alteration of rivers that has reduced habitat complexity and connectivity, may be particularly challenging for resilience into the future.

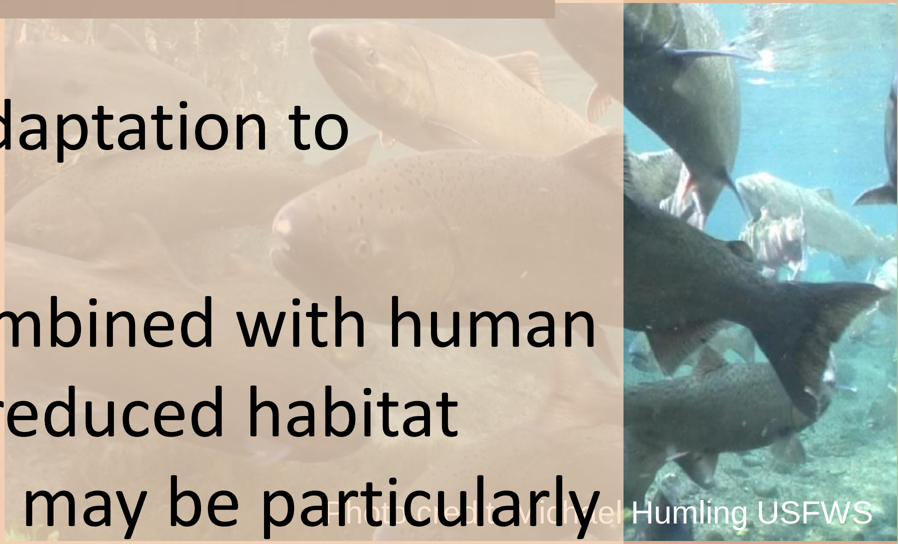


Photo credit: Michael Humling USFWS

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Research, Development & Applications

Thanks!

Photo: Joel Sartore, National Geographic