How does wildfire impact environmental metrics in forest streams and how do changes impact biota of different species and ages?

Wildfire in western Oregon increases stream temperatures, benthic biofilms, and juvenile coastal cutthroat trout size and densities with mixed effects on adult trout and coastal giant salamanders

Citation
Swartz, A. and Warren, D. (2023). Wildfire in western Oregon increases stream temperatures, benthis biofilms, and juvenile coastal cutthroat trout size and densities with mixed effect on adult trout and coastal giant salamanders. *Canadian Journal of Fisheries and Aquatic Sciences* 00: 1-14. dx.doi.org/10.1139/cjfas-2022-0053

What is the effect of fire on stream ecosystems? How do populations of fish and other vertebrates respond after fire events? The authors used a before after control impact (BACI) study to evaluate two hypotheses one-year post-fire. The first is that increased stream temperature resulting from loss of riparian cover leads to decreases in population sizes. The second is that increased light availability results in increased primary productivity, which meets increased metabolic costs, and results in population stability or increase.

How where temperature and nutrient levels impacted by fire?

- Mean daily temperature and the daily temperature range increased at burned sites, with greater increase at sites with greater burn severity. Temperature did not differ at unburned sites.
- Stream nitrate decreased significantly in burn sites post-fire while stream phosphate did not change.

What was the impact on primary productivity?

- Chlorophyll *a* increased at burn and control sites, although the increase at burn sites was significantly greater. The increase at burn sites correlated with burn severity and the magnitude of change was greater than for any other metric in the study.

How did vertebrate populations respond to the effects of fire?

- Juvenile cutthroat trout biomass and density were significantly greater post-fire in burned sites than in control sites. Size, measured as either length or as weight, was greater; however, condition did not differ.
- Differences in biomass and density of adult cutthroat trout, Pacific giant salamanders, and total vertebrates among years and streams were greater than differences pre- and post-fire.

Do the results support either of the proposed hypotheses?

- The increase in chlorophyll *a* and juvenile cutthroat trout abundance and biomass provide support for the alternative hypothesis that increased light stimulates primary productivity, increasing food availability enough to mitigate thermal stress or even positively impact population size and biomass.

- There was little evidence for the hypothesis that reduced canopy cover and resultant increased stream temperature negatively impacts vertebrate population size and biomass. Burn-affected populations of adult cutthroat trout and Pacific giant salamanders decreased in two streams and increased in the third.
- Increases in juvenile population size and biomass may compensate for decreases in adult population size and biomass in streams when post-fire thermal regimes are above optimal ranges for extended periods.

What can we do to increase our understanding of post-fire effects on stream ecosystems?

Future studies should evaluate the interaction between productivity, food availability, and thermal tolerance in stream vertebrates. The positive impact of greater productivity may outweigh the negative impact of increased thermal regime.

Additional work should be done to evaluate the effects of fire over time periods greater than one year, including whether positive responses in juvenile abundance and biomass can mitigate negative responses in adult abundance and biomass at a population scale.

Research Approach/Methods

- Researchers used six replicate streams in the McKenzie River drainage, three of which were in the perimeter of a major 2020 wildfire. All six streams had been sampled during a pre-fire study, allowing use of a BACI design.
- Before and after fire, researchers collected data on stream temperature, macronutrients, benthic biofilms (chlorophyll a), and vertebrate abundance and density. Vertebrates included two age classes of coastal cutthroat trout, coastal giant salamanders, and sculpin, when present.
- They also categorized the burn severity for each of the streams in the fire perimeter using rapid assessment data from the US Forest Service Geospatial Technology and Applications Center.
- The authors used a linear mixed-effects model to assess the effects of fire on the environmental and biotic factors sampled. To visualize changes post-fire, they also calculated response ratios by dividing the post-fire value by the pre-fire value for each metric at each stream and then averaged the response ratios for the reference and fire streams.

Keywords wildfire, stream temperature, benthic chlorophyll *α*, Pacific giant salamander (*Dicamptodon tenebrosus*), coastal cutthroat trout (*Oncorhynchus clarkii clarkii*)

Images

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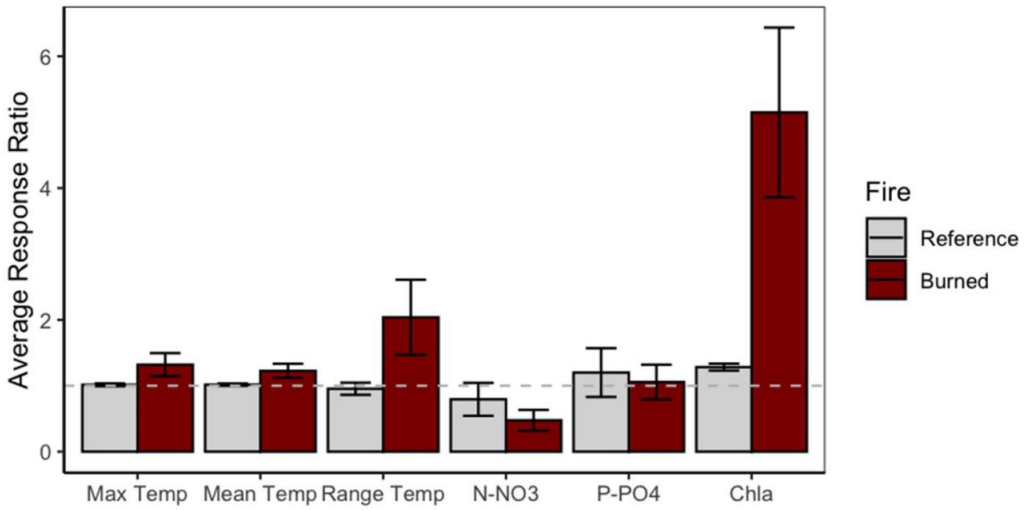

Fig. 4 in Swartz and Warren (2023). Average response ratios (from 2021 to 2018) of the burned and unburned sites for averages of the daily maximum temperatures, mean temperatures, ranges in temperatures, nitrate–N, phosphate–P, and chlorophyll *a* accrual.

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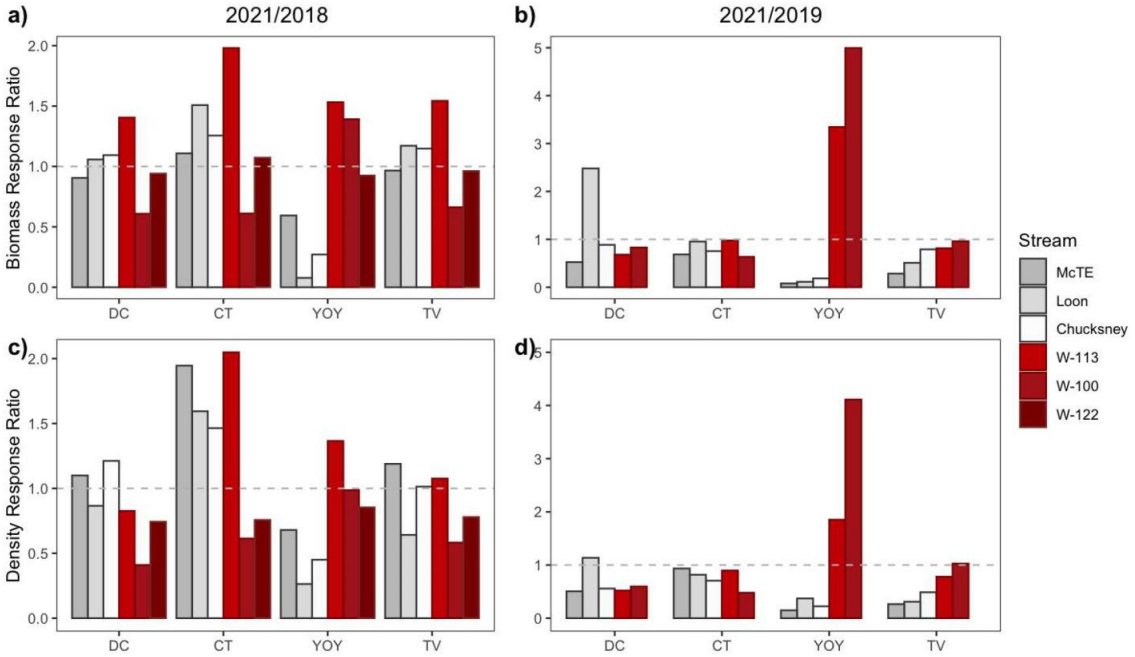

Fig. 5 in Swartz and Warren (2023). Biomass (*a*, *b*) and density (*c*, *d*) response ratios comparing the post-fire year (2021) to each of the two pre-fire years 2018 (*a*, *c*) and 2019 (*b*, *d*) at each stream for separate species groups (CT, adult cutthroat trout; DC, salamanders; TV, total vertebrates; YOY, juvenile cutthroat trout).

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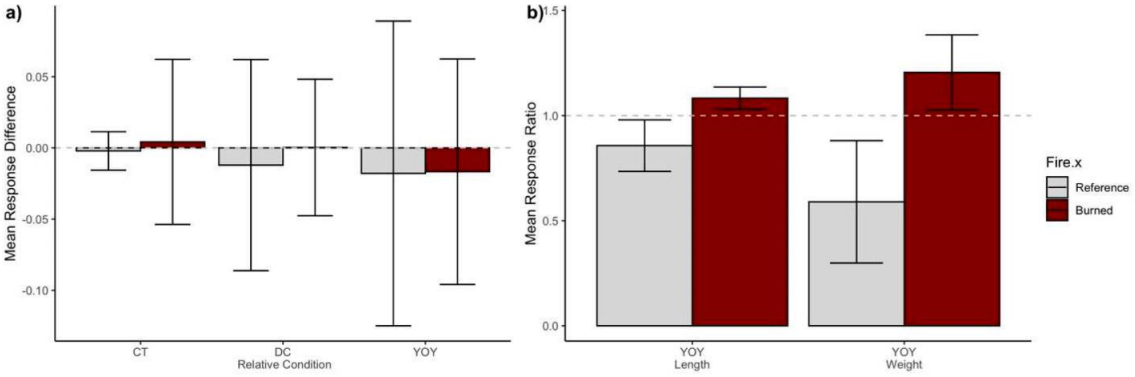

Fig. 6 in Swartz and Warren (2023). (*a*) Average differences of the post-fire year (2021) compared to the pre-fire year (2018) for mean relative condition (residuals of ln length versus ln weight relationship during each year) of adult cutthroat trout (CT), salamanders (DC), and juvenile cutthroat trout (YOY), and (*b*) average response ratios (post-fire/pre-fire) of mean length andweight of juvenile cutthroat trout.