How do fires impact the relative abundance of bacterial- and fungal-feeding nematodes in chaparral ecosystems?

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BACKGROUND + MOTIVATION:

Microbial communities are an essential component of ecosystems, in part because of their impact on both biogeochemical cycles and ecosystem productivity. These communities can be drastically altered by fires, which expose them to extreme temperatures and shift the soil's abiotic components (i.e. nutrient availability, soil moisture, etc.). Fires can therefore alter the competitive relationships between microbial communities (Pérez-Valera, 2019). In particular, they can shift the ratio of major groups of soil microorganisms and cause massive extinctions, especially in the topsoil. Active mycelium, for instance, almost entirely disappears after burning while bacteria populations tend to increase (Butenko, 2017). In their 2005 study, D'ascoli et al observed a 19-61% reduction of the fungal fraction of microbial carbon in burned soils and a 29-41% increase in microbial biomass carbon (D'ascoli, 2005).

Changes lower in lower trophic levels, such as fungi and bacteria, have broader effects on the entire food web. Nematodes, for instance, are impacted by changes in bacteria and fungus abundance because they feed on fungi and/or bacteria, depending on the particular species (Butenko, 2017). Logic suggests that there would be a relatively higher abundance of bacterial-feeding nematodes in burned soils compared to fungal-feeding nematodes. The scientific literature, however, is not yet conclusive on this point. According to Čerevková et al (2013), there was a decrease in bacterivorous nematodes three years after a fire. They were replaced by nematodes with different primary food sources, mainly those who eat fungus. Other studies, such as the one conducted by Butenko et al. (2017), observed the opposite.

Figure 1. *Nematodes are roundworms in the Phylum Nematoda. They're typically 5 to 100 µm thick and 0.1 to 2.5 mm long. Depending on the species, they have a broad range of diets, including ones based on fungi and/or bacteria.*

As fires increase in frequency and intensity due to climate change, it is increasingly important to understand their full impact on both natural resource management and the environment more broadly. This is especially true in the chaparral regions of California, where wildfires threaten human life and reduce the ecosystem's natural resistance to invasion by non-native species (Park, 2018).

HYPOTHESES:

Burnt sites will have 1) a significantly lower overall nematode abundance and 2) a significantly higher ratio of bacterial- to fungal-feeding nematodes relative to unburnt sites. As explained in "Background + Motivation" (see above), fires can drastically reduce microbe populations by altering the soil's abiotic factors. Because fungal populations tend to decrease after fires and bacterial populations tend to increase, nematodes who consume bacteria will have a more abundant food source than those who consume fungus.

The null hypothesis is as follows: there is no relationship between fires and the abundance or feeding patterns of nematodes.

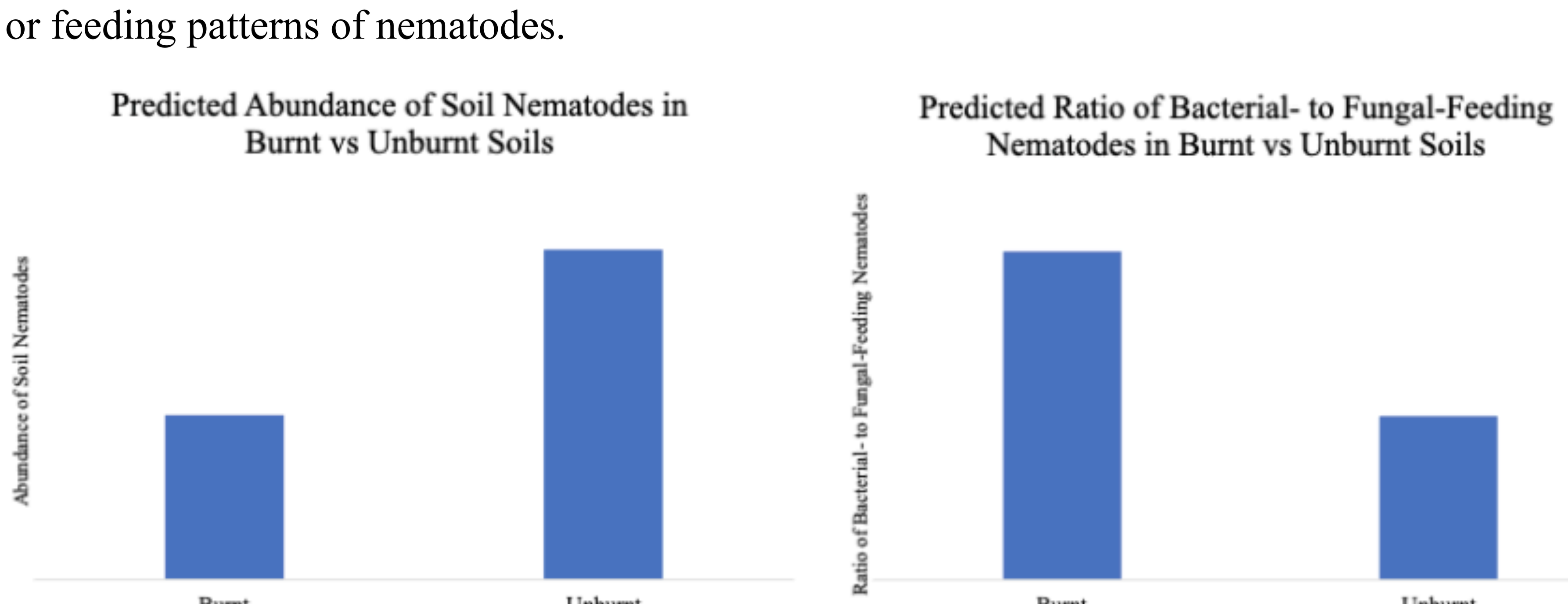

Figure 2. *The graphs above illustrated the general relationships predicted by the two hypotheses. On the left, a higher abundance of soil nematodes is predicted in unburnt soils. On the right, a higher ratio of bacterial- to fungal-feeding nematodes is predicted in burnt soils. These graphs are intended to show the broader relationship and are therefore not to scale.*

METHODS:

This study will be a field experiment conducted across 20 locations chosen at random from un-inhabited chaparral in California. Two sites will be chosen, again at random, at each location. One of the two will remain unburned, serving as the control. The other will be treated using a controlled burn. After the fire has been extinguished, five samples (100-200 g each) will be taken from each treatment. New samples will be taken every six months for five years in order to track changes over time. Data from each sample will be averaged out into a mean value for the site.

In the lab, nematodes will be removed from the samples using a variation of the Baermann Method of water extraction. They will then be identified by taxa and categorized by their primary food source (i.e. bacterial-feeding, fungal-feeding, neither). Nematode abundance will be calculated by dividing the number of individuals by grams of dry soil. The number of individuals in each group will be compared in the ratio of bacterial- to fungal-feeding.

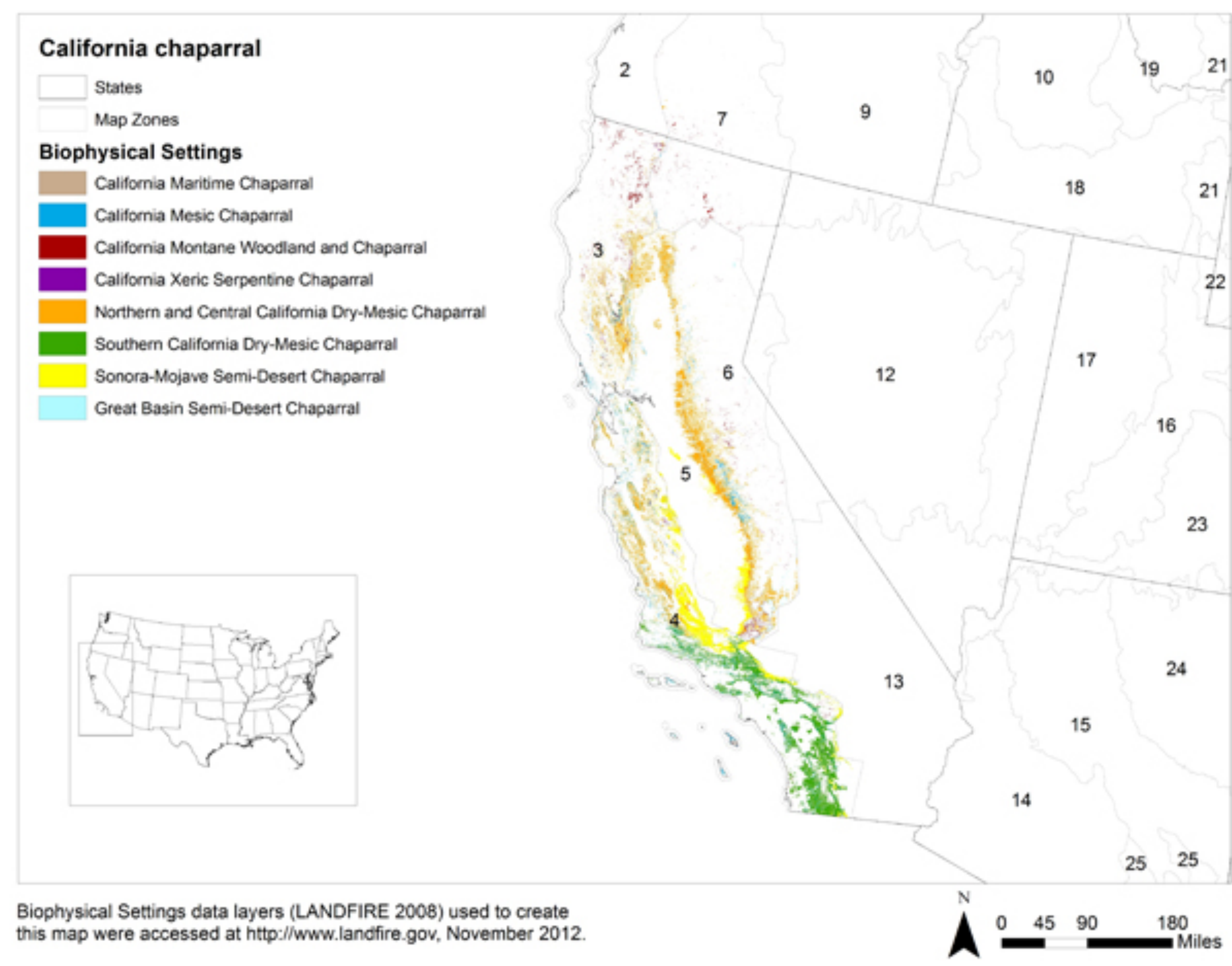

Figure 3*. The above image shows the spatial distribution of California chaparral based on LANDFIRE Biophysical Settings (BpS) data.*

INTENDED ANALYSIS:

Collected data will be used to demonstrate the relationship between fires and the abundance and feeding patterns of nematodes. In this experiment, the independent or predictor variable is the plot's treatment (burned or unburned) and is therefore categorical. There are two dependent or response variables: the nematode abundance in individuals/gram dry soil (a continuous variable) and the ratio of bacterial-feeding to fungal-feeding nematodes in soil (also continuous). Because of the categorical predictor and two continuous response variables, an ANOVA statistical test will be conducted. If the test results in a p-value less than 0.05, the observed relationship would occur only 5% of the time if there was in fact no relationship between fires and nematode abundance and diet. Because this study focuses specifically on the California chaparral, it will likely have a limited ability to be generalized.

MANAGEMENT IMPLICATIONS:

The expected results of this research have clear natural resource management applications. If there is indeed a clear link between fire and nematode abundance and diet, fire will be implicated as a driver of nematode biodiversity and community structure. Managers could therefore promote soil biodiversity by using controlled burns to create a mosaic of burned and unburned areas within an ecosystem. This allows for fungus- and bacteria-dominated communities to coexist in close quarters (Rutigliano, 2013). Along with their utility for reducing high-intensity wildfires, this support of biodiversity provides further incentive for natural resource managers to use controlled burns as part of their strategy.

LITERATURE CITED

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