CALIFORNIA FIRE SCIENCE CONSORTIUM

Research Brief for Resource Managers

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Reducing Fuel while Protecting Soil Biocrusts

Chiquoine, L.P., S.R. Abella, J.L. Greenwood, and A. DeCorte. 2020. Unexpected side effects in biocrust after treating non-native plants using carbon addition. Restoration Ecology 28:S32-S44. https://onlinelibrary.wiley.com/doi/full/10.1111/rec.13106

Management Implications

- Carbon addition in the form of sucrose successfully reduced soil nitrogen and non-native annual grasses
- Unfortunately, this desirable effect was accompanied by an undesirable tradeoff of reducing soil biocrust severely and persistently
- Other forms of carbon may require evaluation for their effectiveness at reducing fire risk while avoiding non-target impacts

Non-native annual grasses, such as red brome (*Bromus rubens*), have increased the amount and continuity of fine fuels in drylands of the southwestern U.S. Resource managers have a clear need for developing effective treatments to reduce hazardous, non-native annual plant fuels, while minimizing non-target effects.

Where herbicide is not allowed or may have undesirable non-target effects, one of the alternative treatments that has been proposed and used in more mesic habitats is carbon addition. The idea behind carbon addition is that adding carbon is an energy source for soil microbes, which increases their activity and makes soil nutrients, such as nitrogen, unavailable to vascular plants as the nutrients are tied up in microbial biomass. Because non-native plants are often more nutrient-demanding than native plants, the idea is that lowering soil nutrient concentrations should disproportionately harm non-natives while benefitting natives via reduced competition. Carbon addition has worked well in some mesic habitats for reducing some non-native plants within small, priority treatment areas including where using herbicide is not possible.

Fig 1. Plot (1 m^2) showing persistent reduction in biocrust cover where carbon was added intended to reduce non-native plants, Mojave Desert. Photo by S.R. Abella.

Effectiveness of carbon addition for reducing non-native plants has been little evaluated in deserts. Deserts also often contain soil biocrusts (living surficial layers including lichens, mosses, or cyanobacteria), which could interact with carbon addition in unknown ways and are not a major part of more mesic ecosystems where most of the carbon addition research has been conducted. We

conducted a field experiment in the eastern Mojave Desert by applying carbon in the form of sucrose (1,263 grams C/m^2) to 1-m^2 plots on soil surfaces with or without biocrust. We measured effects of the carbon addition on the plant community (including non-native and native annuals) and on biocrusts for up to seven years after treatment. We also conducted laboratory experiments to examine potential mechanisms for how biocrust organisms might interact with carbon addition.

In 2016 (seven years after carbon addition), biocrust plots that had received carbon had 60× less cover of biocrust than plots not receiving carbon (0.6% biocrust cover with carbon addition, 36.5% cover without). Adding carbon did reduce non-native plants, including red brome, while minimally affecting native plants.

The laboratory experiments suggested that sucrose at the concentrations tested may have negatively affected biocrust organisms via cell damage, as shown in the image below.

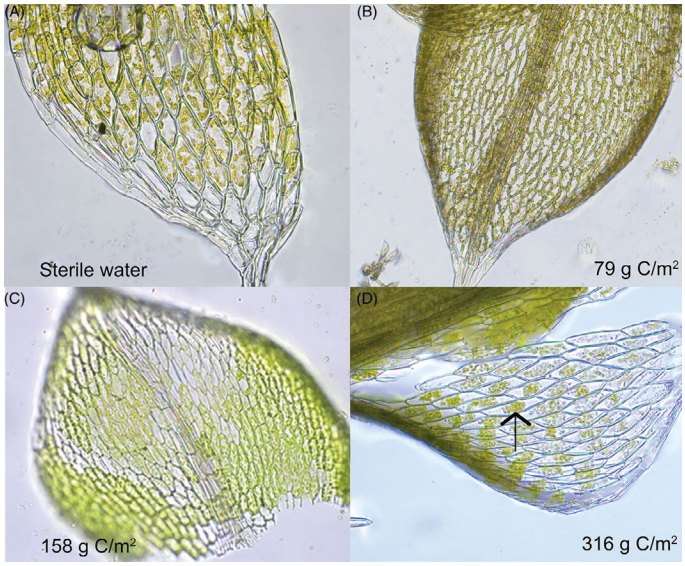

Fig. 2 Images of tissue of the moss Funaria hygrometrica at 400x magnification, 144 hours after submersion in sucrose solutions of different concentrations. In the bottom right photo, the arrow indicates clustering of chloroplasts at the center of cells in the highest sucrose addition treatment.

Results illustrate that while carbon addition successfully reduced non-native grass fuels, the undesirable tradeoff was that biocrusts were sharply and persistently reduced. It is important to note, however, that the effectiveness and tradeoffs of carbon addition can vary with the form of carbon used and the concentration and frequency at which it is applied, in addition to interacting with site conditions. It is possible that lower concentrations of sucrose might not have affected biocrust as negatively, but they might also have not reduced non-native grass fuels.

The research highlighted that carbon addition may still have potential for reducing non-native grass fuels in drylands, but that at least where biocrust is present, using other forms of carbon might be important. For example, glucose could be evaluated as a carbon source that may not negatively impact biocrust while still lowering soil nitrogen and reducing non-natives. Sets of candidate reliable treatments, with minimal non-target effects, still need to be developed for treating non-native annual fuels at broad and fine scales in the Mojave Desert.

Suggestions for further reading:

Steers, R.J., J.L. Funk, and E.B. Allen. 2011. Can resource-use traits predict native vs. exotic plant success in carbon amended soils? Ecological Applications 21:1211-1224.

Chiquoine, L.P., S.R. Abella, and M.A. Bowker. 2016. Rapidly restoring biological soil crusts and ecosystem functions in a severely disturbed desert ecosystem. Ecological Applications 26:1260-1272.