Solar Energy | Water | Environment

Nexus IN NEVADA

Innovative research to achieve water efficient and environmentally friendly solar power

SOLAR ENERGY-WATER-ENVIRONMENT NEXUS PROJECT

Stress Tolerance of Biological Soil Crust

Introduction and goal

Biological soil crusts, also called cryptogammic crusts, are formed by living organisms (cyanobacteria, lichens, or mosses) and their by-products, creating a crust of soil particles bound together by organic materials. Crusts play an important role in the desert environment by providing soil stability and erosion, atmospheric nitrogen-fixation, nutrient contributions to plants, soil-plant-water relations, infiltration, seedling germination, and plant growth.

Cryptogamic crusts are extremely fragile and vulnerable to physical disturbance caused by solar farm installations and maintenance activities. It has been suggested that the crust could be harvested prior and used afterward to inoculate the soil to effect crust restoration. To evaluate this strategy, we studied the viability of crust-forming cyanobacteria and lichens from the Mojave Desert that have been in storage over different time periods. We also investigated their tolerance for ultraviolet light (UV), desiccation-wet cycles, and photochemical oxidation. Data indicate that these organisms can be stored up to three years without losing viability. They are effectively protected from UV and desiccation, but relatively sensitive to photochemical oxidation.

Where does this research fit within the NEXUS project?

This research will improve our understanding of the impacts that large scale solar farms will have on a fragile desert ecosystem and to the development of mitigation strategies. It is one of the research strategies under Objective 2 of the NEXUS Research (Goal 1): Understand environmental impacts of solar energy projects.

Why is this research important and what knowledge gap does it fill?

The implications of our work go beyond restoration biology. The species compositions of biological soil crust in some parts of the southwestern United States have shifted in the last few decades, possibly due to climate change. Our work provides a mechanistic explanation as to why this shift occurred.

What is the originality of the approach?

Previous studies on the stress tolerance of crust-forming organisms considered only UV and desiccation. Our work showed that photochemical oxidation presents a more severe stress than UV and desiccation. Consequently, shifts in the species composition of biological soil crust may be determined in a large part by the difference in their tolerance for oxidative stress.

Key results to date

Biological soil crust can be stored dry for up to three years without significant reduction in biological activity. All crust organisms are tolerant of UV and desiccation but tolerance for oxidation is more complicated. In the Mojave Desert, eukaryotic lichens are more tolerant than prokaryotic cyanobacteria but in the Gurbantunggut Desert in northwestern China, the reverse is true. Cyanobacteria are more tolerant than lichens.

The results suggest that the proposed crust restoration is feasible. Crust organisms can be stored for later use as inoculum. Their re-introduction can be enhanced by amending soil with antioxidants.

How is the research and/or equipment fostering collaboration now, and in the future?

As the result of the NEXUS project, we formed a collaboration with Dr. Jayne Belnap (USGS, Moab, Utah) to investigate the impact of climate change on biological soil crust. We are also collaborating with Dr. Yuanming Zhang, Xinjiang Ecology and Geography Institute of Chinese Academy of Sciences to compare biological crusts from the hot Mojave Desert with those from the relatively cold Gurbantunggut Desert.

Future plans

Many desert cyanobacteria are capable of biological nitrogen fixation. In some species, such as Nostoc commune, nitrogen fixation occurs in specialized cells called heterocysts that are nonphotosynthetic to protect the oxygen sensitive nitrogenase. Interestingly, Microcoleus, a non-heterocystous cyanobacterium, is also capable of nitrogen fixation. We plan to test the hypothesis that in this organism photosynthetic activity and nitrogen fixation are temporally separated, with the former taking place during the day and the latter occurring at night, when the organism's own heterotrophic activity depletes oxygen from its surrounding. This research will further our understanding of the biology and requirements of biological soil crusts which will inform future restoration mitigation efforts in the context of solar plant impacts.

Contact us

H. Sun, DRI, Henry.Sun@dri.edu, 702-862-5337

www.nvsolarnexus.org

This material is based upon work supported by the National Science Foundation under grant number IIA-1301726. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.