A Comparison of Carbon Cycling and the Surface Energy Balance Between Native Perennial and Exotic Annual Grass Ecosystems in Northern Coastal California

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Abstract

This research is a comparative look at the cycling of carbon, water and energy in native perennial and exotic annual grass ecosystems. California’s native perennial grasses have been almost completely replaced by exotic annual grasses across the state’s ten million acres of grassland habitat. The comparison is being carried out at two field sites in Marin County, California where remnant perennial grass communities are found on the same soils and slopes as exotic annual grasses. This research makes use of a number of biogeochemical and micro-meteorological methods. The primary objectives are:

1. To observe and understand the biotic and abiotic processes that affect the cycling and storage of carbon, water and energy among the soil, plants and the atmosphere in native perennial and exotic annual grass ecosystems in northern coastal California.

2. To apply our observations towards understanding ways that changing ecosystems affect surface climate and meteorology, and how they may impact the magnitude and direction of global climate change.

We have set up research plots at each of the two field sites, in locations of relatively pure native perennial and exotic annual grass communities. In each plot, we are measuring plant and soil carbon storage, above and belowground annual productivity and rates of tissue turnover, soil temperature, soil moisture and soil respiration, to understand the mechanisms by which differences in ecosystem carbon storage arise.

At Tennessee Valley, in the Golden Gate National Recreation Area, we have also established two sets of micro-meteorological sensors: one in the annual and one in the perennial-dominated grassland. We use the surface renewal and the eddy covariance methods to measure the components of the surface energy balance.

Some Preliminary Results

We hypothesize that differing lifecycle strategies between annual and perennial grass species have led to key differences in plant morphology, phenology and tissue quality that, in turn, impact material exchange at the land surface. Long-lived perennial species produce deep roots, have a bunchy structure, construct complex tissues and transpire over most of the year. By contrast, annual species are shallow-rooted, evenly-distributed, build tissues to last a single wet season, and die with the onset of summer drought. We expect that these structural and functional differences have led to differences in the cycling of carbon, energy and water by affecting soil temperature, soil moisture, radiation capture and energy partitioning into latent and sensible heat fluxes.

Soil carbon at the Tennessee Valley field site. At some depths, there is greater storage under the native grasses. This is most pronounced at lower soil depths, where the root system for exotic annual grasses is scarce and well-developed under native perennial grasses.

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