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.

Overview of a typical native grass plot. Observe, soil temperature probes, litter decomposition bags, and soil respiration collars.

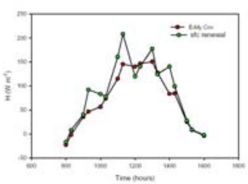
At Tennessee Valley, in the Golden Gate National Recreation Area, we have also established two sets of micro-meteorological sensors: one in the annual and one in the perennial- dominated grassland. We use the surface renewal and the eddy covariance methods to measure the components of the surface energy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

Micro-meteorological station among Native Perennial Grasses, Tennessee Valley, Marin County, CA.

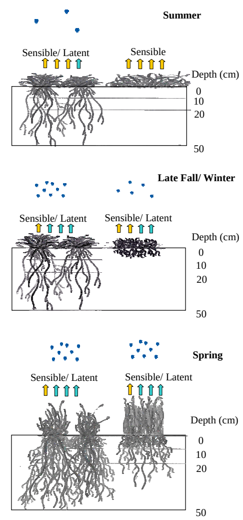
We hypothesize that differing lifecycle strategies between annual and perennial grass species have led to key differences in plant morphology, phenology and tissue quality that, in turn, impact material exchange at the land surface. Long-lived perennial species produce deep roots, have a bunchy structure, 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.

Native Grasses and Exotic Grasses change in color and morphology over the course of the year. a. Native grasses (Spring), b. Exotic Grasses (Spring), c. Native grasses (Summer), d. Exotic grasses (Summer).

To determine the surface energy balance components, we Use both the Surface Renewal Method and the Eddy Covariance Methods. The Surface Renewal Method is a robust alternative to the more commonly used, but more expensive technique for determining surface fluxes.

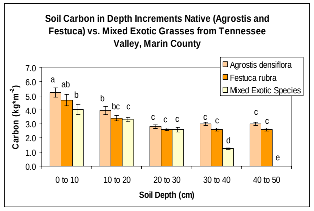


Surface Renewal and Eddy Covariance Methods for Estimating Sensible Heat Flux at the Vaira Ranch, Day 346, 2001. Baldocchi, pers. comm.

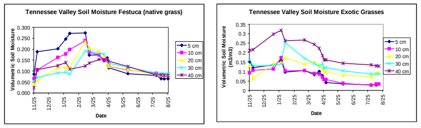


Schematic of Changes in Native and Exotic Grasses with the seasons. Native Grasses (left) and Exotic Grasses (right.)

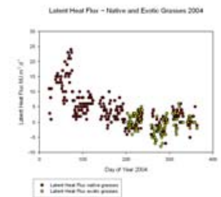
Some Preliminary Results



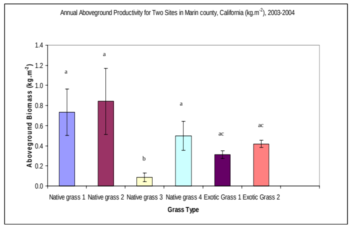
Soil carbon at the Tennessee Valley field site. At some depths, there is greater storage under the native grasses. This is most pronounced at lower soil depths, where the root system for exotic annual grasses is scarce and well-developed under native perennial grasses.



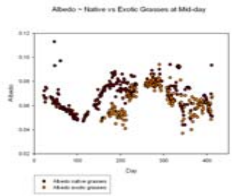
Soil Moisture Profile under the native perennial grasses (left) and exotic annual grasses (right.) The top soil layers are driest under the annual grasses. In contrast, the bottom soil layers become the driest under the native perennial grasses during the onset of summer drought, as depicted here.



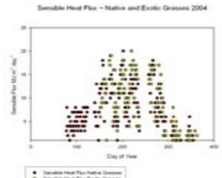
Preliminary latent Heat flux is found to be similar for annual and Perennial grasses. However, we estimate that transpiration is higher Under perennial grasses and evaporation higher under annuals. The Data set for the perennial grasses started in February 2004. The dataset for the annual grasses began in June 2004.



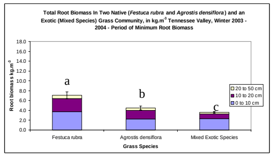
Native grass 1 = *Agrostis densiflora*, Native grass 2 = *Festuca rubra*, Native grass 3 = Mix of *Bromus carinatus, Nassella pulchra* and *Danthonia californica*, Native grass 4 = *Elymus glaucus* and *Bromus carinatus* Exotic grass 1 = mix of exotic grasses from Tennessee Valley field site, Exotic grass 2 – mix of exotic grasses from Bolinas Lagoon Preserve field site.

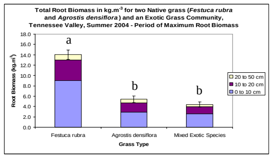


Albedo for annual and perennial grasses. The data set for perennial grasses began February 2004. Data set for annuals began in June 2004.



Preliminary sensible heat flux for annual and perennial grasses. The data set for perennial grasses began February 2004. Data set for annuals began in June 2004.





Root biomass at the Tennessee Valley site at Period of minimum (winter) and maximum (summer) root biomass.

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