Land-use Impacts on Regional Biogeochemical Cycles in Arid and Semi-arid Ecosystems

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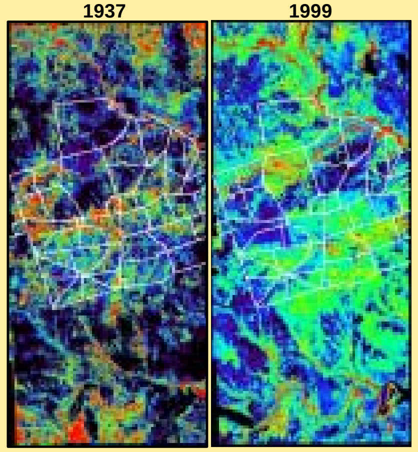
(1) Woody Encroachment in Texas

Impacts on Carbon Stocks and Nitrogen Trace Gas Emissions from Soils

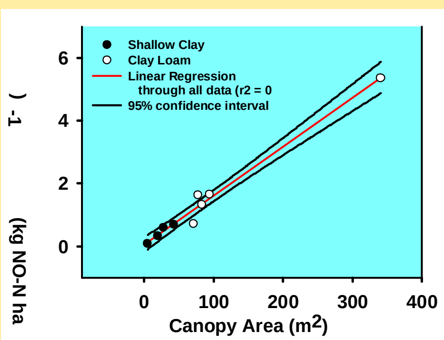
400 km^2 North Texas Rangelands

1937 **1999**



<10% Woody Plant Cover >90%

Many semi-arid, sub-tropical ecosystems have undergone woody vegetation expansion in areas once dominated by herbaceous land covers. Woody encroachment is thought to result from over-grazing, fire suppression, and climate change. However, the rates, spatial patterning, and biogeochemical consequences of this land-cover change are poorly understood. We are using large mosaics of historical aerial photography and modern Landsat 7 image analysis (spectral mixture analysis) to estimate net changes in woody vegetation cover over 60-70 yr timeframes. In the most productive regions of the sub-tropical Southwest U.S., woody vegetation cover has increased by 30%, despite intensity efforts to clear land.

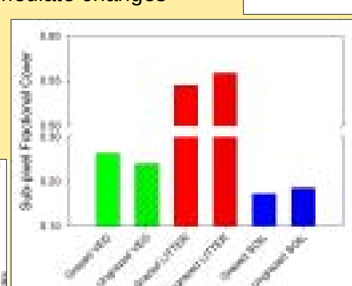


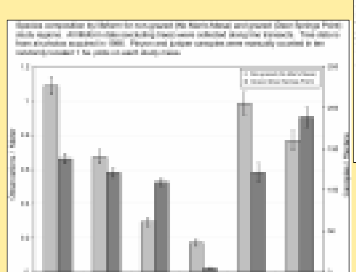
We have found that woody encroachment increases aboveground carbon stocks by 15-25% over 63 yr in these regions. This expansive form of land-cover change also greatly impacts nutrient and water cycling. Our field studies indicate that increased canopy area of woody vegetation results in major soil carbon and nitrogen stock increases, and it subsequently increases emissions of atmospherically important nitrogen trace gases such as nitric oxide (NO). NO is a precursor for tropospheric ozone formation and it acts as a downwind source of nitrogen to areas that have not undergone woody encroachment.

(2) Historical Land-use Impacts on Ecosystem Structure

Imaging Spectroscopy Provides Unique Insights

Despite government programs to protect western U.S. ecosystems, most of the Southwest has experienced land use (primarily cattle ranching) in the past few centuries. What imprint has land use left in today's protected areas, such as in the National Parks and Monuments? We are using imaging spectroscopy and field studies to answer this question, and to develop linkages to the biogeochemical processes that mediate changes in the region.





We used AVIRIS data to analyze differences in vegetation structure and composition in historically grazed and ungrazed mesas of Escalante National Monument. We found striking differences in live and dead vegetation cover, bare soil extent, and species functional groups. These results indicate that past land use has dramatically altered ecosystem structure in this region, leaving a clear mark on the landscape for decades and centuries.

Background

Despite the central role of arid and semi-arid ecosystems in global agricultural and cattle production, the effects of land-cover and land-use change on biogeochemical processes in these regions are poorly understood. Current limitations to studying these changes arise from difficulties in: (1) measuring key land-surface properties from satellites, (2) modeling the biogeochemical processes central to regional ecological assessments, and (3) linking field studies to remote sensing and modeling activities.

The NASA NIP and LCLUC programs support our lab in developing and applying remote sensing, modeling and field studies needed to make regional-scale, high-resolution assessments of biogeochemical changes that occur with land use in the Southwest U.S. and Northern Mexico. A wide range of simultaneous activities are summarized here,with highlights of some of the major findings produced to date.

AsnerLab Participants

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Project Collaborators

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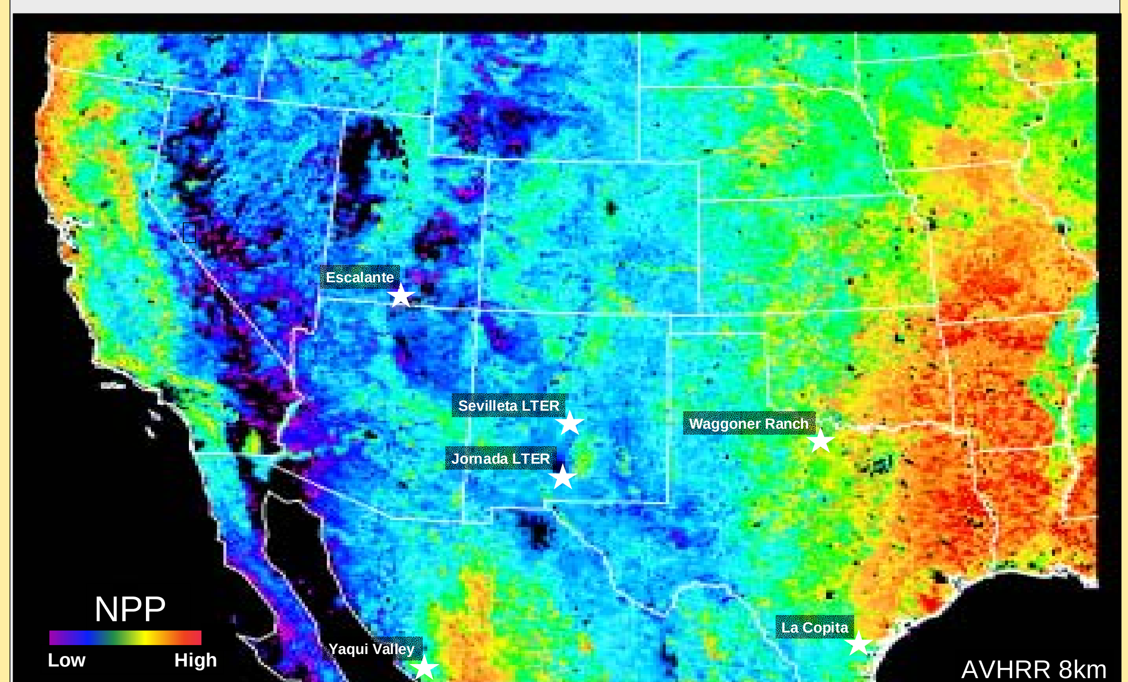

Satellite- and Model-Derived Net Primary Productivity in the Southwest U.S. and Northern Mexico

A strong precipitation gradient sets the basic limitations on vegetation production and ecosystem carbon storage throughout the region. Our studies cut across this gradient using multiple satellite sensors, the CASA and TerraFlux biogeochemical models, and an array of field projects at the six locations shown.

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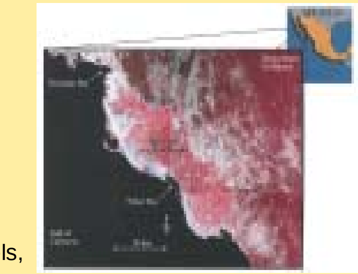
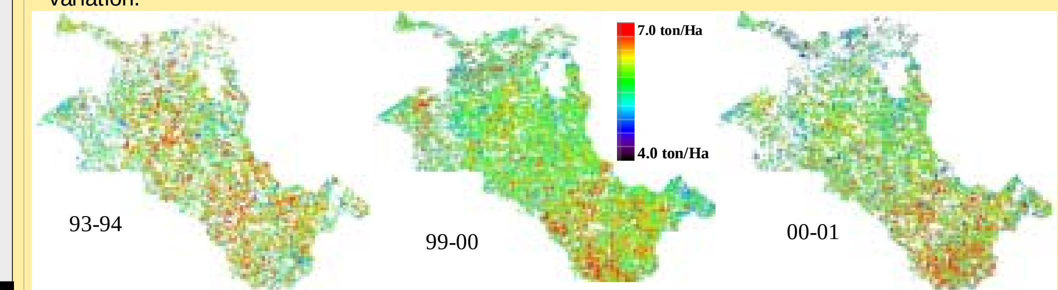
Visit: http://asnerlab.colorado.edu for more information, data and on-line publications.

(3) Carbon Cycling in Intensive Agriculture

Inter-annual Variability in Mexico's Breadbasket



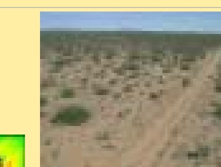
Agriculture is less expansive than cattle ranching in sub-tropical ecosystems, but its affect on biogeochemical processes is more dramatic. We are studying the seasonal and inter-annual dynamics of biogeochemical cycles in one of the most intensively managed agricultural valleys in the world: The Yaqui Valley of Western Mexico. We are using a combination of Landsat 7 and Terra-ASTER imagery, with biogeochemical models, to study spatial and temporal variation in carbon uptake and storage. We have found that even in one of the world's most intensively managed agricultural regions, cropland productivity varies spatially and inter-annually. Spatial variation is also common among soil carbon and nutrients stocks. Sources of this variation are field-level management decision-making, soil chemical and physical properties and inter-annual climate variation.



Crop Productivity estimates derived using Landsat data

(4) Desertification in New Mexico

Resolving Spatial Patterns of Biogeochemical Processes Using Imaging Spectroscopy



While woody vegetation encroachment is common in the mesic ecosystems of the Southwest (Central Texas), land use and climate variability has promoted even greater changes in woody-herbaceous vegetation partitioning in arid ecosystems, such as in south-central New Mexico. These systems have be prone to desertification, where woody vegetation completely replaces grasslands, rather than adding new vegetation to them. Regional measurements of the biophysical and biogeochemical impacts of desertification have been tenuous due to the high spatial heterogeneity of land covers in these regions. We have tested several traditional and newer remote sensing technologies, and have found that imaging spectroscopy provides the only consistent and reliable means to measure the abundance of surface constituents considered key to desertification studies. These measurements include live vegetation, bare soil and dry carbon (senescent vegetation), a combination that provides clear indication of biogeochemical function and desertification status.