Site-specific Climate-Friendly Farming

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The uniform application of nitrogen to spatially variable farms leads to unnecessary nitrogen losses. These losses result in a financial cost to growers and an environmental cost to society. Nitrogen fertilizers are expensive, and their manufacture contributes to global climate change. Agricultural nitrogen can be lost in the form of nitrous oxide (N_2O), a potent greenhouse gas, or nitrate (NO_3^-), a surface and groundwater pollutant. It is in the interest of both growers and society to find ways to mitigate agricultural nitrogen losses through precision management.

IMPACT

Nitrogen losses can result in a financial cost to growers and an environmental cost to society. Precision agricultural technologies can help wheat growers better understand their fields and manage N fertilizers more efficiently across non-uniform landscapes and reduce losses.

The Site-Specific Climate-Friendly Farming (SCF) project team is tackling these problems in two primary ways: (1) we seek to improve our understanding of the spatial and temporal variability of nitrogen cycling, N_2O emissions, and related processes for wheat-based cropping systems on complex Palouse landscapes (Figure 1); and (2) we are constructing site-specific management tools to help farmers reduce nitrogen losses, improve nitrogen use efficiency, and increase profits. The availability, uptake, and movement of water, as controlled by topography and soil properties, is the driving force behind the spatial variability of the nitrogen cycle, so mapping the agrohydrology of the Palouse is central to improving management.

SCF project activities can be loosely grouped into three areas: mapping, modeling, and experiments (Figure 2). Using a variety of crop, soil, and moisture sensors, we are developing approaches to inexpensively map and monitor soil, water, and nutrient variability over space and time. We are also refining and linking models to simulate crop response to a variety of climatic and management scenarios, and evaluate the economic consequences of grower decisions. These models are informed by a variety of experiments: (a) cropping systems experiments evaluating the effects of seeding density and nitrogen fertilizer levels for different landscape positions; (b) automated chamber experiments to measure greenhouse gas fluxes (CO_2 and N_2O) under different carbon, fertilizer, and water treatments; and (c) field and laboratory experiments to characterize the spatial and temporal variability of soil microbial processes and nitrogen cycling in Palouse wheat fields.

Advances in crop and soil sensing and mapping techniques are particularly important for growers wanting to adopt site-specific management. Mapping advances allow us to transfer the knowledge gained from experiments and modeling to new fields, without having to extensively sample and analyze crops and

Figure 1. *Research site near Colfax, WA with highly variable soils, hydrology, topography and crop productivity. Photo by Dave Brown.*

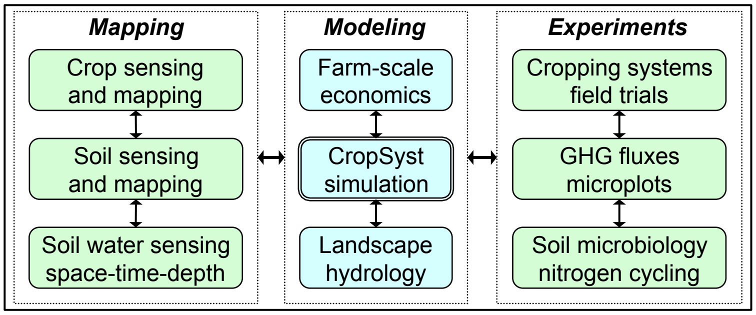

Figure 2. *Site-Specific Climate-Friendly Farming project overview.*

soils. Two main soil sensing devices are being refined for use on the Palouse: a visible and near-infrared (VisNIR) penetrometer and an electromagnetic induction (EMI) sensor. The VisNIR penetrometer allows us to probe down into the soil and measure reflectance without sampling, while simultaneously measuring the physical resistance of the soil. The VisNIR reflectance data can be used to estimate clay, mineralogy, and organic matter, while tip resistance is related to bulk density and clay content. An EMI survey estimating apparent soil electrical conductivity (ECa) can be used to map clay and water content and salinity. Figure 3 provides an example soil map for a research site near Leland, ID, showing soil resistance by depth, important for mapping root- and water-restricting soil layers. We generated this map using a detailed VisNIR penetrometer survey (50 meters [164 feet] grid) that was interpolated using EMI data. A map of estimated nitrogen balance for the same field was derived from a RapidEye satellite image (Figure 4). The availability of the red-edge band with RapidEye, allowing the computation of the Normalized Difference Red Edge (NDRE) index, has proven particularly valuable for estimating and mapping crop nitrogen content.

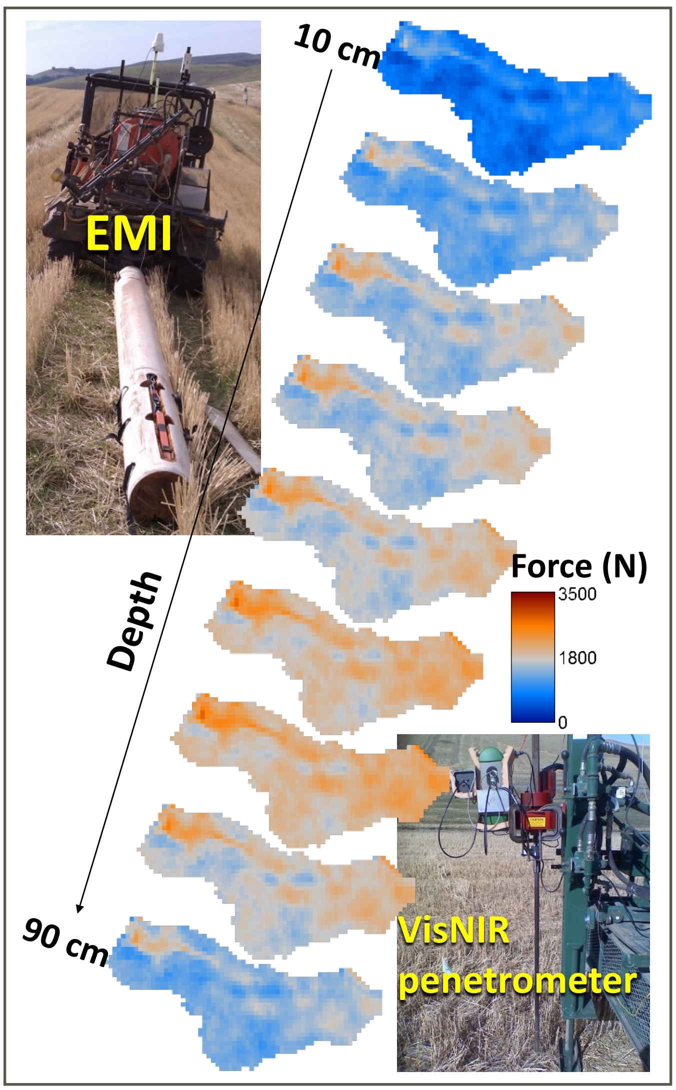

Figure 3. *Soil resistance by depth for Leland site, mapped using Visible and Near-Infrared (VisNIR) penetrometer and Electromagnetic Inductance sensor. Figures by Matteo Poggio and Caley Gasch.*

There is substantial collaboration between REACCH and SCF researchers. Both projects are funded by the same U.S. Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA) Climate Change program, both projects are funded over the same five-year period, and a number of co-investigators contribute to both the REACCH and SCF project teams. The projects have shared expenses and expertise in conducting joint experiments with automated chambers to measure greenhouse gas fluxes under variable levels of nitrogen fertilization, carbon amendments, and water applications (see "Nitrification and denitrification pools of N_2O: Acetylene inhibition study" on page 66 of this report). SCF remote sensing scientists have contributed instrumentation and expertise to monitor a REACCH experimental site. Perhaps most importantly, the REACCH project has the funding and personnel to disseminate SCF findings to growers and the general public. For example, in the past year SCF and REACCH have collaborated on a precision agriculture field day and an article highlighting research on the farm of SCF cooperator Eric Odberg. We anticipate ongoing collaborations on research and dissemination of SCF knowledge through REACCH education and outreach capabilities.

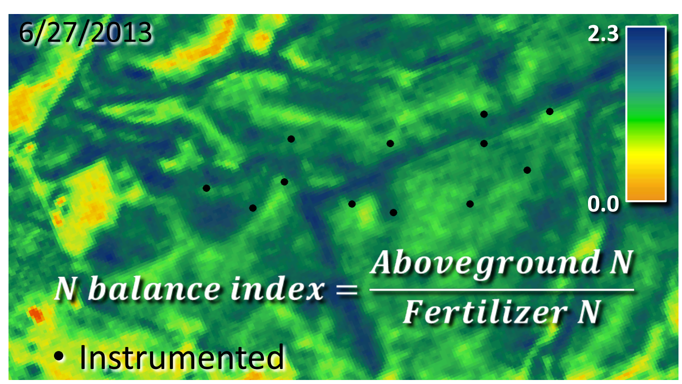

Figure 4. *Map of nitrogen balance estimated from June 27, 2013 RapidEye Normalized Difference Red Edge (NDRE) index for a field near Leland, ID (Image courtesy of Troy Magney). Notice the high nitrogen balance (blue) along old fence lines only recently removed with a right angle in the middle of the image. The red dots highlight instrumented locations within the study catchment. Figure by Troy Magney.*