Carbon Sequestration and Gaseous Emissions in Perennial Grass Bioenergy Cropping Systems in the Northeastern US

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Northeast Bioenergy Context

Unique regional bioenergy potential

- Large available marginal land base
- Abundant water resources
- Close production-to-use proximity
- Integration with existing farm systems
- Multiple end uses, including potential offsets of heating oil
- Rising interest among growers and potential end users

Trend: Land in NY Farms (10^6 ac)	
1950	30.6
1978	9.5
2007	7.2

Unfortunately, the research base on perennial grass bioenergy crop production (yields, soil tolerance) and impacts (carbon cycling, GHG emissions) on marginal soils is very thin, especially for the Northeast.

Project Objectives

Overall goal: assess crop yields, soil carbon impacts and soil emission impacts for switchgrass (*Panicum virgatum* Shawnee) and reed canarygrass (*Phalaris arundinacea* Bellevue) on marginal soils

Objective 1 Establish and monitor a large replicated field-scale perennial grass trial in order to determine effect of species (switchgrass vs. reed canarygrass), N loadings, and soil moisture status/variability on yield, C sequestration and trace gas emissions.

Objective 2 Conduct a broader range of regional field-scale perennial grass trials (including new and established stands as well as mixed seeding stands) to further determine the effects of marginal soil characteristics on yield, carbon sequestration and trace gas emissions.

Objective 3 Develop spatial tools to scale up our field results of relative yield, C sequestration and emissions for biofuel crop production on marginal soils of the Northeast US.

Project Team

Cornell Investigators and Researchers include Brian Richards*, Cathelijne Stoof, Cedric Mason, Tammo Steenhuis, Todd Walter, Larry Geohring (Department of Biological & Environmental Engineering – Soil & Water Group), and Hilary Mayton, Ryan Crawford, Julie Hansen, Don Viands (Department of Plant Breeding & Genetics), and a host of dedicated undergrad assistants.

Collaborators Doug Goodale & John Kowal (SUNY Cobleskill), Ben Ballard (SUNY Morrisville), Jon Warland (University of Guelph), and John Osborn (Beneterra Agritech). Switchgrass seed donated by Ernst Conservation Seeds.

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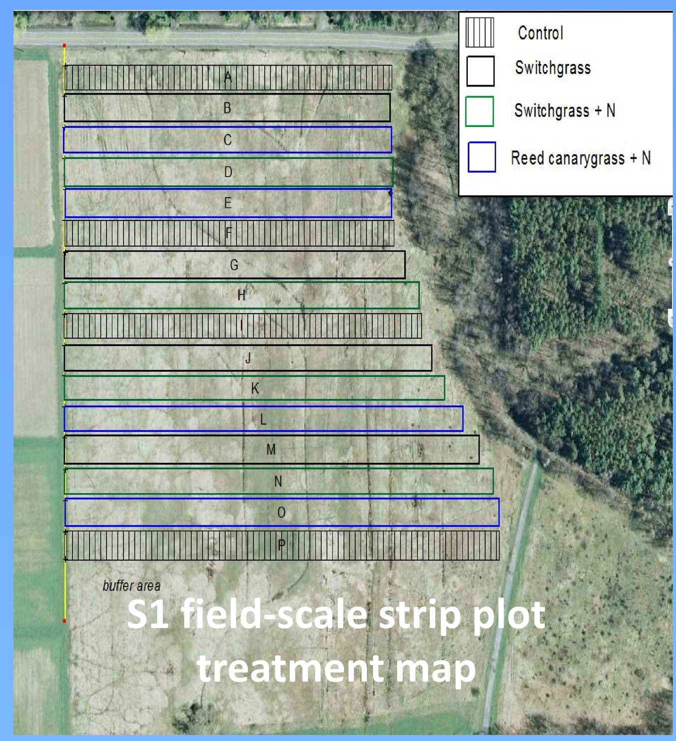
Primary Field Site

The Objective 1 site (S1, Ithaca NY) represents many marginal soils in the Northeast. Seasonal wetness has prevented intensive use for at least 50 years despite surface drainage measures in the 1960's. Prior management has been occasional mowing or hay harvest when possible. S1 was dominated by reed canarygrass, goldenrod, and mixed grasses with patches of multiflora rose and shrubs. The existing surface drainage was supplemented at key points with surface inlets and underdrains to address the worst points to help ensure fall harvestability. Nevertheless, the site remains clearly marginal.

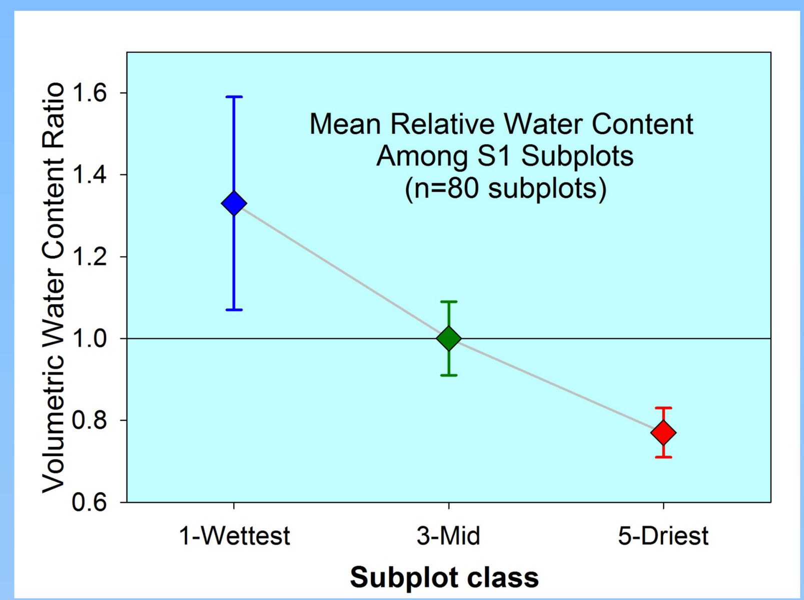


S1 field-scale strip plot treatment map

Cropping treatments consist of sixteen ~1 acre strip plots in randomized quadruplicate blocks

Switchgrass	Switchgrass + 78 kgN/ha	Reed Canarygrass +78 kgN/ha	Fallow Control

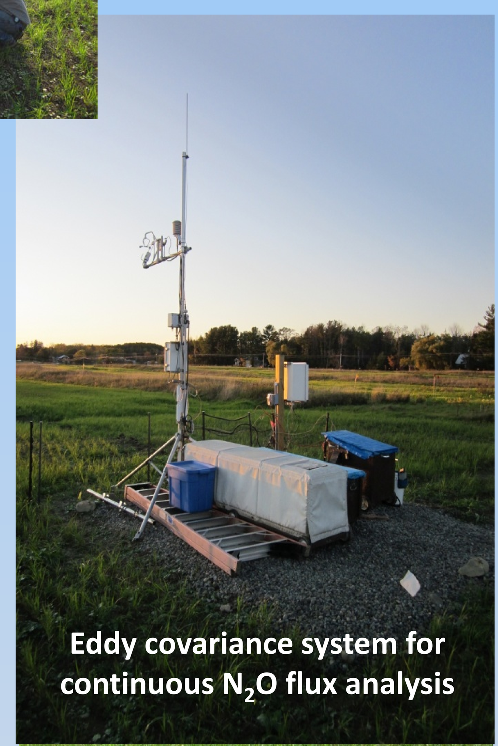
Soil moisture regime (i.e. drainage class) constitutes another "treatment" assessed using 5 intensive sampling subplots along *natural soil moisture gradients* in each strip plot. Subplot locations (80 total) were laid out using a soil moisture survey. Soil moisture is monitored via periodic TDR and shallow well measurements, coupled with continuous soil moisture loggers at 12 locations. Cumulative 2011-2012 data *(right)* show the water contents of wettest and driest subplots relative to the field average for subplots in all 16 strips.




Shallow well installation for perched water table monitoring

Trace gas emissions

We are using a coupled approach for trace greenhouse gas flux monitoring at S1. *Chamber campaigns* on the subplots are used for determining treatment effects (crop and moisture regime) on CH_4 and N_2O fluxes. Large scale monthly campaigns consist of 120 chambers (duplicate chambers on all 5 subplots on 12 strip plots) monitored for 30 minute flux testing. These are supplemented with weekly 36-chamber campaigns on short steep soil moisture gradients on 6 strips. Given the temporally variable nature of N_2O emissions, we couple periodic chamber campaigns with continuous *field-scale eddy covariance* determinations to determine overall trends in N_2O fluxes. We have recently demonstrated this approach (*SSSAJ* 75:1829). Midfield placement of the trace gas analyzer (Campbell Sci. TGA100A) allows sampling of key wind directions.


Eddy covariance system for continuous N_2O flux analysis


Chamber sampling

Soil carbon

Soil C is being monitored by periodic soil coring, with samples at each of 80 subplots composited from four replicate cores. Samples are taken for intervals of 0-5, 5-15, 15-30, 30-60, 60-90, and 90-120 cm. Samples are dried, milled, screened for coarse fragments and hand-picked to separate and weigh roots. Analysis includes loss on ignition (total organic matter) and direct total C measurements.


Soil coring at subplots for soil C profiles

Crop Establishment

Switchgrass and reed canarygrass were planted in July 2011. Emergence and establishment for both grasses were good, but the abnormally warm winter/early spring of 2011-2012 led to early switchgrass emergence from dormancy, preventing early herbicide sprays. Severe thinning of switchgrass stands was noted after late spring snows (also at S3 site below), and we used no-till reseeding to help ensure good stands. Chopping (above crop grass height) and subsequent broadleaf control sprays were needed for weed control. Despite near-drought summer 2012 conditions, switchgrass stands appear to have recovered well.


Chopping above grass height to control yellow rocket

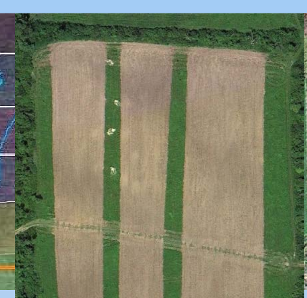

No-till reseeding


Mid-October switchgrass stand

Satellite Field Sites

We are also carrying out similar but less intensive monitoring at three satellite field sites yielding a wider range of soil and landscape conditions. Sites include an N-loading study at Cornell (S2, Shawnee), a farm site in Sherrill NY (S3, Shawnee, Reed Canarygrass) operated by Beneterra Agritech and SUNY Morrisville, and a field site at SUNY Cobleskill (S4, Cave-in-Rock, Sunburst). Emissions monitoring is limited to chamber campaigns.

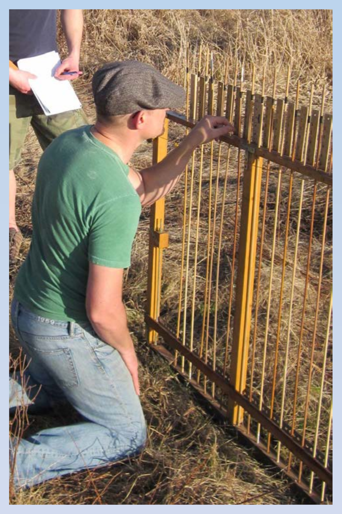
S2 treatments are 0, 50 & 100 lbN/ac on 3 soil catena


S3 replicates S1's treatment map


S4 has two upland varieties at two N rates

Collaboration & Outreach

Expanded testing being carried out with Hatch Federal Formula Funds awarded by Cornell to enable tracking of multiple *soil health* indicators. A pending Hatch grant will fund investigation of perennial grass interactions with *marginal soil hydrology*. Project data will be integrated with the USDA NEWBio project. Additional collaboration is invited.


Paul Richards (SUNY Brockport) uses a clinometer to track hydrologic parameters

Project site tours have included AFRI Bioenergy education cadres, and the National Agricultural Air Quality Task Force *(right)*.

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