

2022 GLBRC Standard Sampling Report

Biofuel Cropping System Experiment (BCSE)

Soil

Soil was sampled from all the BCSE plots once in 2022. Some treatments were sampled more frequently alongside gas sampling (see BCSE Gas section below). Soil samples were taken November 16 from all blocks or replicates (R) 1-5 of all treatments (G) 1-10. Soil was sampled using 2cm (0.75") diameter push corers. Three cores (0-25cm) were taken from each of the three sampling stations and all 9 cores composited for each plot. On November 14, soil was sampled from the BCSE subplots. Nine cores (0-25cm) were composited from each subplot. Soil was also sampled from rainout sheltered areas of G5R2-5 (see Rainfall Manipulation Experiment) on November 14. Four cores (0-25cm) were composited from each of those areas.

Inorganic nitrogen extractions and soil moisture determinations were done on subsamples from all soil sampled. Analysis of the extracts for nitrate and ammonium should be completed by Alyssa Trethewey during winter 2022-2023. All samples will be air-dried and archived. Subsamples of G1-3 main soil only were sent to A&L Great Lakes Laboratories for their S1 soil analysis package which includes pH, buffer pH, P, K, Ca, Mg, CEC, and percent base saturation of cation elements. The entire set of BCSE plots and subplots is analyzed every three years and due next in 2024.

Deep soil cores (1m depth, 7.6cm diameter) were sampled from all BCSE plots between November 14 and December 2. One core was taken about 5m north and 1m west of each station, so three cores were sampled from each main plot (150 cores total, no subplots were sampled). The cores were stored in a walk-in refrigerator until they can be cut open and the soil sectioned into 0-10, 10-25, 25-50 and 50-100cm depths. Bulk density of each section will be calculated. Subsampling is planned for moisture determination, carbon and nitrogen analysis, archive and to supply individual researcher requests.

Gas

Greenhouse gases were sampled from cylindrical static chambers installed in replicates 1-4 of G1-5 beginning March 24. Gas samples were put into Labco exetainers and transported back to the lab for analysis. They were analyzed for nitrous oxide, carbon dioxide and methane by Kevin Kahmark, using the Agilent/Gerstel automated GC in Academic 330. These samples were taken seventeen times between March 24 and November 29. Soil samples (0-25cm depth) were collected from each plot as well. The soil was sampled simultaneously with most gas sampling and taken from two of the three sampling stations in each plot. Soil was sampled fifteen times in 2022. Inorganic nitrogen extractions and soil moisture determinations were done on subsamples of the soil sampled. Analysis of the extracts for nitrate and ammonium should be completed by Alyssa Trethewey during winter 2022-2023.

The automated gas sampling trailer measures N₂O, CH₄, CO₂, and NO from six chambers in G5R1 and six chambers in G1R1. A LI-COR CO₂/CH₄/H₂O trace gas analyzer was installed in spring 2022. Sampling started in early spring and continues into 2023 with a brief shutdown from December 22, 2022 to January 6, 2023 due to a snowstorm and holiday break. Incubations were continuous throughout the day and night. NO_x measurement was removed for a period to see if this

impacted the system N₂O results, no evidence was found, and the NO_x system was reestablished. All data is collected via Gashog web application created by Sven Bohm.

Water

In May 2022, a final collection of 33 water leachate samples were taken from the BCSE and Switchgrass Nitrogen Rate Experiment lysimeters. These were all analyzed for anions, cations, and NH₄-N via ion chromatography. The Switchgrass Nitrogen Rate Experiment samples were also processed and analyzed for Non-purgeable organic carbon (NPOC), Total dissolved nitrogen (TDN), and may be analyzed for Total dissolved phosphorus (TDP). Sampling and analysis was completed by Dave Weed.

Plants

Plant biomass samples were taken from the BCSE plots at their peak to measure above-ground net primary production (ANPP) or just prior to agronomic operations. No species separations were completed on samples taken in 2022. Plots were sampled as follows: G3 cover crop on May 16 ahead of harvest; G8 understory on June 23-24 ahead of mowing; G4, 5, 7, 9, 10 ANPP September 6-20; G3 (soybean) ANPP on October 4; G2 (sorghum) ANPP October 5-6; G6 ANPP October 7-10 and G1 ANPP on October 13. Species composition and plant heights were measured with three transects per plot following the line-point intercept protocol. Transects were completed around the same time that each treatment was sampled for ANPP, except for G1 and G3 where no transect data was collected. On November 10, the residue remaining following machine corn stover collection was sampled from the ground in G1 to evaluate collection efficiency. Two ground traps were deployed in each G8 plot on July 29 to collect leaf litter as leaves fell from the trees. Litter from the traps was collected every two weeks until the trees were bare, and traps were pulled from the field on November 17. On December 5, to track poplar growth, ten trees were randomly chosen from each G8 plot and the main stem diameter measured at 15cm above the ground. All plant samples were dried at 60°C for at least 48 hours. The dried biomass will be weighed, ground and archived. Combustion analysis for carbon and nitrogen determination will be completed by Stacey VanderWulp.

Switchgrass stand frequency was determined in May with stand counts done in all replicates of G5 main plot only, no microplots.

Plant phenological development was tracked using cameras positioned on each plot in block 1 of the BCSE. These cameras were programmed to take a picture about every 30 minutes between 5am and 9pm. Photos from the current year are stored locally until they are moved to a server at UW for long-term storage. A subset of the images will be stored in the LTER database. Images no longer go to the PhenoCam network.

Cheyenne Lei, graduate student with Jiquan Chen, had albedo towers installed in G1, 2, 5, 6, 7, 9 and 10 of block 1 of BCSE. These towers functioned continuously since May 2018. Instruments on these towers measured solar radiation, near infrared radiation, albedo, air temperature, precipitation, soil moisture, wind speed, wind direction, barometric pressure, relative humidity and recorded images of vegetative growth. Personnel from the Chen lab also measured leaf chlorophyll concentrations periodically using a SPAD meter and instantaneous measurements of solar radiation for the calculation of albedo using a survey pole at BCSE blocks 1, 2 and 4. These measurements

were completed biweekly. On November 3, 2022, the Chen Lab dismantled all seven albedo towers to wrap up the GLBRC BCSE albedo project.

Around twelve drone flights were completed over the BCSE from early April to November 2022. Flights collected albedo data from each plot on sunny to hazy days between 10am and 2pm. All flights concluded with a 30 second to one-minute flight over a white tarp as reference. All flying was done by Kevin Kahmark. Data collection was on a raspberry pi computer developed by Sven Bohm. See also the Scale-up section for information regarding Basso Lab drone flights on the BCSE.

Yield data was collected from all plots and subplots during mechanical harvest. A sub-sample from the machine harvest of these plots was saved. This biomass was dried and will be ground, archived, and analyzed for carbon and nitrogen.

BCSE Subplots and Microplot

Stover non-removal subplot (G1 R1-5): This is a 15-foot-wide strip along the west edge of each G1 plot where corn stover is not collected. The corn stover in the rest of the plot is collected after harvest. Besides the surface soil samples collected in November (see BCSE soil), there was no other routine sampling done here. Yield data was collected from mechanical harvest.

Unfertilized subplot (G2-7, 9 R1-5): This is a 15-foot-wide strip along either the east or west edge of each G2, G3, G4, G5, G6, G7 and G9 plot where no nitrogen fertilizer is applied while the rest of the plot received fertilizer. Besides the surface soil samples collected in November (see BCSE soil), there was no other routine sampling done here. Yield data was collected from mechanical harvest.

Fertilized subplot (G10 R1-5): This is a 15-foot-wide strip along either the east or west edge of each G10 plot where nitrogen fertilizer is applied while the remainder of the plot receives none. Besides the surface soil samples collected in November (see BCSE soil), there was no other routine sampling done here. Yield data was collected from mechanical harvest.

Rainfall Manipulation Experiment (G5 R2-5): Beginning in 2018, rainout shelters were installed in G5R2-5 during the growing season. The shelters are 12' long x 12' wide. Initially the shelters excluded about 60% of rainfall. In April 2019, the exclusion was increased to nearly 100% with full roof panels installed. In 2022, shelters were put in place on May 24 and removed for the season on August 30. The area under the rainout shelter and a comparable unsheltered area nearby were harvested by hand just prior to machine harvest in these plots. Surface soil samples were collected from the sheltered area in November (see BCSE soil).

Scale-up Experiment

Soil

Soil was sampled on November 29 in all the GLBRC scale-up fields at Lux Arbor and Marshall Farms by Thelen lab personnel. Soil was sampled using 2cm diameter push corers. Ten cores were taken to a depth of 25 cm at each of the 10 stations in each plot. Inorganic nitrogen extractions and soil moisture determinations were done on subsamples from all soil sampled. Analysis of the extracts for nitrate and ammonium should be completed by Alyssa Trethewey during winter 2022-2023.

All samples will be air-dried and archived. Subsamples of L1, M1 soil only were sent to A&L Great Lakes Laboratories for their S1 soil analysis package which includes pH, buffer pH, P, K, Ca, Mg, CEC, and percent base saturation of cation elements. The entire set of Scale-up plots is analyzed every three years and due next in 2024.

Gas

Each of the seven fields has a CO₂ Eddy Covariance flux tower that measures the flux of carbon dioxide into and out of the canopy/soil and allows for development of a complete carbon budget based on rates of carbon sequestration and loss from these different systems. Static chambers were not sampled in 2022.

Plants

Plant biomass samples for ANPP were not taken from any scale-up plots in 2022. Transects through the switchgrass, prairie and reference fields were used, following the same line-point intercept protocol as on the BCSE, to collect data on species composition and plant height. This data was collected September 29-30.

The Basso Lab used a DJI M600 Pro to fly the GLBRC Scale-Up fields from May to November 2022. Approximately every two weeks the corn, switchgrass and prairie fields were flown (L1, L2, L3, M1, M2, M3) as well as the GLBRC BCSE and Marginal Land Experiment at Lux Arbor. The UAV flew at 122m (400ft) and was equipped with a visual camera and a Micasense Altum-PT sensor. Over the course of the season at least 6 NDRE, NDVI, RGB and Thermal images per field were collected.

Yield data was collected from all sites when mechanically harvested. At the time of this report (January 2023), corn stover had been collected from L1 but not M1.

Marginal Land Experiment (MLE)

Soil

Soil samples were taken by Thelen lab personnel from all MLE sites in October 2022. They were sampled in this order between October 3 and October 27: MN (Escanaba), WN (Rhineland), WC (Hancock), MC (Lake City), and MS (Lux Arbor). Each half of the split plots (fertilized and unfertilized) was sampled separately with six 0-25cm cores/split plot composited. Beginning in 2018, as on the BCSE, rainout shelters were installed in each G5 plot at all the MLE sites during the growing season. The shelters are 12' long x 12' wide, exclude nearly 100% of rainfall and are installed on the fertilized split plot. Shelter were put in place May 23-27 and removed for the season August 17-31. Soil was sampled in the sheltered areas on the same day as the split plots. Four cores (0-25cm) were taken from each sheltered area. Inorganic nitrogen extractions and soil moisture determinations were done on subsamples from all soil sampled. Analysis of the extracts for nitrate and ammonium should be completed by Alyssa Trethewey during winter 2022-2023. These soil samples will be air-dried and archived. Subsamples will not be sent for analysis. Soils were analyzed in 2021 and are due next in 2024.

Plants

Plant biomass samples were taken from all MLE sites for ANPP between August 15 and September 1. Samples were not sorted to species. Plant species composition and height data was collected in

all plots, at all sites in September using a line-point intercept protocol. Species were identified and height measured along two transects in both the fertilized and unfertilized split plots.

Yield data was collected from all of the mechanically harvested plots (G5-7, 9, 10) separately in the fertilized and unfertilized split plots. G11 was not harvested, so hand samples were taken there to measure productivity. Additionally, the area under each G5 rainout shelter and a comparable unsheltered area nearby were harvested by hand. Subsamples of all harvested materials (with the exception of the G5 unsheltered comparison area) were saved and will be ground, cataloged and stored on MSU main campus. The majority of this work was done by personnel from Kurt Thelen's lab, led by Todd Martin. Species composition transects were completed by a four-person crew from the Robertson lab.

In August 2022, one drone flight was completed over each MLE site. Visual and spectral images were collected. All flying was done by Kevin Kahmark. See also the Scale-up section for information regarding Basso Lab drone flights over the MLE plots.

Weather

A weather station is installed at each MLE site. Each weather station collects air temperature, precipitation, solar radiation, relative humidity, soil moisture and temperature at 10cm and 25cm depths, and wind speed. Two replicates of G5 at each site have loggers to measure soil moisture and temperature at 10cm and 25cm depth within the shelter footprint and in a nearby ambient subplot. Water profilers installed in switchgrass, poplar, and native prairie plots allow researchers to study the dynamics of water and water use efficiency in MLE soils.

Switchgrass Nitrogen Rate Experiment (formerly Nitrogen/Harvest)

Soil

After initially having a split plot design with half of each plot harvested once per season (H1) while the other half was harvested twice (H2), the entire experiment has been under one cut management since 2013. Soil samples were collected on January 11, 2023 for the 2022 season. Four cores were taken to a depth of 25 cm in each plot, 2 cores from the H1 half of the plot were combined with 2 cores from the former H2 half. Samples were sent to A&L Great Lakes Laboratories for their S1 soil analysis package which includes pH, buffer pH, P, K, Ca, Mg, CEC, and percent base saturation of cation elements. Soil is sampled every three years, so is due next in 2025.

Water

See BCSE Water section.

Plants

Switchgrass stand frequency was determined in May with stand counts done in all plots.

Yield data was collected from all plots during mechanical harvest. A sub-sample from the machine harvest of these plots was saved. This biomass is dried and will be ground, archived, and analyzed for carbon and nitrogen.

Switchgrass Variety Experiment

This experiment was decommissioned in 2021 and no longer sampled. It was replaced with the Switchgrass Variety Experiment II.

Switchgrass Variety Experiment II

This experiment was established in 2021. Soil was not sampled in 2022. Soil is sampled every three years and is due next in 2023. Switchgrass stand counts were not done in 2022. Yield data was collected from mechanical harvest. Samples were taken from the harvested material for calculating moisture content and were sent to the GLBRC Bioenergy Analytics Facility.

Ilya Gelfand Bait crop Experiment

In early November 2022, eight 2m x 2m plots were installed in the bait crop north of BCSE plot G4R3. All eight plots are separated by two meters. The area was tilled and finished just prior to installing plots. Each plot was rototilled. Four of the eight plots had approximately 100lbs (wet weight) sorghum residue incorporated into each with the rototiller. In the spring of 2023, the plots will be rototilled once again, and four rates of nitrogen fertilizer will be added in quadrants across each plot.

Written by Stacey VanderWulp with contributions from Sven Bohm, Kevin Kahmark, Cheyenne Lei, Todd Martin, Ruben Ulbrich and Dave Weed

Archived Material

Experiment	sample type	2008	2009	2010	2011	2012	2013	2014	2015
GLBRC BCSE	plants								
GLBRC BCSE	surface soil								
GLBRC BCSE	deep core soil								
GLBRC Scale-up	plants								
GLBRC Scale-up	surface soil								
GLBRC Scale-up	microplot surface soil								
GLBRC Scale-up	deep core soil								
GLBRC Scale-up	microplot deep core soil								
GLBRC MLE	deep core soil								
GLBRC Switchgrass Gradient	plants								
GLBRC Switchgrass Gradient	deep core soil								
Experiment	sample type	2016	2017	2018	2019	2020	2021	2022	
GLBRC BCSE	plants								
GLBRC BCSE	surface soil								
GLBRC BCSE	deep core soil								
GLBRC Scale-up	plants								
GLBRC Scale-up	surface soil								
GLBRC Scale-up	deep core soil								
GLBRC MLE	plants			campus	campus	campus	campus	campus	
GLBRC MLE	surface soil								
GLBRC MLE	deep core soil								
GLBRC Switchgrass Gradient	plants								
GLBRC Switchgrass Gradient	deep core soil								

Agronomic Soil Analysis

Experiment	2008	2009	2010	2011	2012	2013	2014	2015
LTER MCSE								
LTER Resource Gradient								
GLBRC BCSE main								
GLBRC BCSE micro								
GLBRC BCSE deep core								
GLBRC Scale-up								
GLBRC MLE								
Experiment	2016	2017	2018	2019	2020	2021	2022	
LTER MCSE								
LTER Resource Gradient								
GLBRC BCSE main				G1-3	G1-3		G1-3	
GLBRC BCSE micro				G1-3	G1-3			
GLBRC BCSE deep core								
GLBRC Scale-up				L1, M1	L1, M1		L1, M1	
GLBRC MLE								
GLBRC Switchgrass Gradient								