Researchers, basalt suppliers, and U.S. environmental associates visit a basalt-treated miscanthus field at the Illinois Energy Farm in August 2018.

LC3M Progress in 2018-19

iSEE partners with the Leverhulme Centre for Climate Change Mitigation (LC3M) at the University of Sheffield, UK, to investigate methods for removing CO_2 from the atmosphere. Since 2016, crushed basalt rock has been applied to corn, soy, and miscanthus fields at the University of Illinois Energy Farm to investigate the potential of Midwestern croplands to act as sinks for atmospheric CO_2, while still supporting the agriculture critical to the region. A pilot study in all three crops was expanded to field scale in maize in 2017, and maize and miscanthus in 2018 and 2019. Early results from the project show that in Illinois, a large effect of this CO_2-capture project is observed in the agricultural nitrogen cycle.

In the 2018 research season — after the second basalt application and tillage into maize occurred, and basalt was surface-applied to for the first time to a miscanthus field — measurements of greenhouse gas production from soils, soil carbon and nitrogen, and plant biomass and yield were carried out through the growing season, while eddy covariance towers monitored gas exchange for each of the crops. Water samples (tile drain water, soil pore water, and rain) were collected throughout the year and analysed for pH, electrical conductivity, alkalinity, major cation and anion concentrations, dissolved organic carbon concentrations, total dissolved nitrogen concentrations, and radiogenic Sr isotope ($^{87}Sr/^{86}Sr$) ratios, which indicate the presence or absence of basalt.

Basalt is applied for the third time to harvested corn fields in November 2018. The fields were planted in soybeans in 2019.

Measurements in 2018 confirmed that, like maize, soils under miscanthus respond to basalt application with increased pH and reduced soil N_2O production, though total N_2O production from control and treated miscanthus is only a fraction of that produced by heavily-fertilized maize. As the cornfields of Illinois are heavily nitrogen-fertilized to maximize yields, losses of N as N_2O indicate both an inefficient use of the supplied fertilizer, and the release of a potent greenhouse gas to the atmosphere, so reduced soil N_2O production is a benefit to the ecosystem. Computer-generated biogeochemical models use productivity and greenhouse gas data collected in the field to validate the model, which makes estimates of the basalt effect

for the surrounding region, and can be scaled for the larger Midwest. The models indicate that basalt-induced pH change is the major driver of differences in N_2O production, with a smaller effect from basalt-supplied phosphorus.

Measurements of $^{87}Sr/^{86}Sr$ ratios of 2018 miscanthus water and aboveground biomass reservoirs from the control and experimental plots encompass a narrow range of values and are statistically identical to their corresponding 2017 values when no basalt was applied. This suggests little basalt weathering occurred in the miscanthus plots after basalt application in 2018. Similarly, $^{87}Sr/^{86}Sr$ ratios of maize water reservoirs in the control and experimental plots are statistically identical to their corresponding 2017 values, suggesting little to no additional basalt weathering occurred in the maize plots during 2018 (Fig. 2). Future work will measure $^{87}Sr/^{86}Sr$ ratios of soil exchange sites as a possible reservoir for weathered basalt cations.

The 2019 season began with basalt application to maize/soybean fields in November 2018 and continued with basalt application to miscanthus and the first full-scale planting of basalt-treated soybeans in May 2019.

ISEE Director Evan DeLucia heads the Illinois Leverhulme research team, with Plant Biology and Crop Sciences Associate Professor Carl Bernacchi, Crop Sciences Professor Steve Long, ISEE Postdoctoral Research Associate Ilsa Kantola, Department of Plant Biology Technician Michael Masters, and two field technicians, Haley Ware, an undergraduate student in Natural Resources and Environmental Sciences, and Konrad Taube, a 2015 U of I graduate in Molecular and Cellular Biology — who recently left to begin graduate studies at DePaul University. This project includes international collaborators in the UK, Australia, and Malaysia.

Team members made four conference presentations in 2018-19:

- Andrews, M.G., Pearce, C.R., James, R.H., Masters, M.D., Kantola, I.B., DeLucia, E.H., and Beerling, D.J. “Enhanced Rock Weathering in Agroecosystem Field Rrials, Illinois, USA.” Goldschmidt Conference, Boston, August 2018.
- Blanc-Betes, E., Kantola, I.B., Hartman, M. Gomez-Casanovas, N., Beerling, D.J., and DeLucia, E.H. “Potential of Basalt Amendments to Increase Nitrogen Use Efficiency and Reduce the N_2O Emission Factor of Agriculture.” American Geophysical Union Annual Meeting, Washington, D.C., December 2018.
- Kantola, I.B., Masters, M.D., Blanc-Betes, E., Bernacchi, C.J., Beerling, D.J., Long, S.P., and DeLucia, E.H. “Application of Basalt Reduces Nitrous Oxide Evolution from Annual and Perennial Crops.” American Geophysical Union Annual Meeting, Washington, D.C., December 2018.
- DeLucia, E.H., Kantola, I.B., Blanc-Betes, E., Bernacchi, C.J., and Beerling, D.J. “Basalt Application for Carbon Sequestration Reduces Nitrous Oxide Fluxes from Cropland. European Geosciences Union General Assembly, Vienna, Austria, April 2019.

Team members had six invited talks in 2018-19:

- DeLucia, E.H. “Managing Perennial Crops for Improved Greenhouse Gas Emissions.” Plenary Speaker, International Symposium on Bioenergy, Hokkaido University, Japan, February 2018.
- DeLucia, E.H. “Conversion from Row Crop Agriculture to Perennial Bioenergy Feedstocks Provides a Double Benefit to the Atmosphere.” Danforth Center for Plant Sciences, St. Louis, Mo., September 2018.
- DeLucia, E.H. “The Connection Between How We Use Land and Our Climate System.” University of Illinois Alumni Association, Thornybush, South Africa, October 2018.
- James, R.H. “Putting the Brakes on Climate Change: Carbon Capture and Storage and Enhanced Weathering.” University of Southampton, November 2018.
- Andrews, G. “Keeping the Earth a Happy Home: How Chemical Weathering Controls Long-Term Climate and Could Combat Modern Climate Change.” University of Minnesota – Twin Cities, February 2019.
- DeLucia, E.H. “Land Use and the Potential to Mitigate Climate Change.” Chicago Botanic Garden, May 2019.