Herbaceous Biomass Production Research at the Northern Great Plains Research Laboratory to Conserve Soil, Land, Water, and Energy Resources

The Northern Great Plains Research Laboratory (NGPRL) in Mandan, ND consists of nine scientists with diverse backgrounds ranging from soil science to agronomy to animal science. The scientists primarily involved with bioenergy research are Jon Hanson, Kris Nichols, and Dave Archer. However, the projects discussed below involve teams of scientists beyond these four personnel. The mission of the NGRPL is to develop environmentally sound practices and add value to agricultural systems in the Great Plains in terms of food, feed, and biomass by conducting team-focused, systems-oriented research and technology transfer. With this goal in mind, research at NGPRL strives to provide information applicable to producers giving options to maintain soil and water resources and increase productivity, energy efficiency, and profitability. With about 3 million acres of CRP land and abundant resources for wind, hydroelectric, and coal generated electricity, North Dakota has a large potential for renewable and alternative energy production. In addition, North Dakota has over 7 million acres of highly erodible land that would benefit from conversion to a perennial crop production system. The objective of bioenergy research as NGPRL is to develop dynamic cropping systems to help meet bio-energy production needs and increase economic returns while enhancing natural resource quality.

Biomass Energy Accomplishments at NGPRL

The NGPRL and North Dakota State University (NDSU) Research Experiment Stations in Streeter and Dickinson, have conducted research on switchgrass production. This research has identified cultivars, such as Sunburst with the greatest biomass production potential for this region. An evaluation of switchgrass stands compared with nearby croplands in the northern Great Plains and northern cornbelt indicated switchgrass stands store more carbon at depths below 12 inches where it may be sequestered. Research results also have shown that about 80% of the biomass in switchgrass is belowground indicating that it has a tremendous potential to sequester carbon as well as improve soil quality by increasing soil organic matter content. Greenhouse trials have determined that the optimal germination temperature for switchgrass is 77^{o}F and optimum pH is 6.0. Other trials have identified big bluestem as a crop with higher ethanol production potential.

Switchgrass biomass production and interactions with mycorrhizal fungi using regionally adapted mycorrhizal fungi (native inoculum), commercially produced (introduced) inoculum, and a mix of both inoculum sources were evaluated under ambient (365 ppm) and elevated (730 ppm) CO_2 conditions. Results showed that aboveground biomass was significantly higher under elevated CO_2 and the combined amount of above- and belowground biomass was significantly higher with the introduced inoculum source.

Current and Future Projects

1. A follow-up experiment to the growth chamber experiment using native, introduced, and a mix of native and introduced inoculum sources under ambient (365 ppm) and elevated (730 ppm) CO_2 conditions is determining the effects of drought and defoliation stress on switchgrass with the three inoculum sources. The culturing phase of this experiment is complete and above- and belowground data is currently being collected. The SYs involved in this project are John Hendrickson, Holly Johnson, and Kris Nichols.

2. NGPRL scientists are currently cooperating with five NDSU Experiment Stations on a ten year biomass evaluation of perennial herbaceous biomass crops to determine the appropriate bioenergy crops for maximizing biofuel production capacity. This research involves both warm and cool season grasses and mixes, including mixes with alfalfa and clover. Carbon sequestration and soil

quality parameters are being evaluated. The SYs involved in this phase of the project are Mark Liebig, Jason Gross, and Kris Nichols. The second phase will be to repeat these evaluations at NGPRL with additional aboveground measurements on net photosynthetic rates, soil properties, soil water, economic returns, and ethanol production capacity being made. In addition, some biomass material collected from this and other bio-energy projects will be subjected to a pyrolysis process to collect bio-char. This bio-char will be compared to crushed coal from North Dakota lignite in a series of pot culture studies to determine if either or both of these materials can increase switchgrass biomass and the production arbuscular mycorrhizal fungi and soil aggregation to improve soil quality. The SYs involved in this phase of the project are Jon Hanson, John Hendrickson, and Kris Nichols.

3. Monocultures of switchgrass, intermediate wheatgrass and alfalfa and binary mixtures of switchgrass-alfalfa and intermediate wheatgrass-alfalfa will be compared to a continuous spring wheat control. This project will develop economically feasible management systems that reduce input requirements for transitioning into and out of bioenergy crops. Changes in soil properties over time will quantify cumulative treatment impacts on soil quality. Variables measured will be biomass, stand counts, soil parameters, soil moisture and economic returns. The SYs involved in this project are John Hendrickson, Mark Liebig, Don Tanaka, and Dave Archer.

4. A 20-ha field used for traditional annual crop production and a native range site at the Northern Great Plains Research Laboratory will be used to determine how conversion from traditional annual crop to perennial biofuel production systems influences ecosystem carbon flux. Net ecosystem exchange of carbon will be measured continuously for four years. Cumulative annual net carbon uptake for the annual and perennial crops will be compared with native perennials. We will report how conversion from annual to perennial grasses affect ecosystem carbon flux compared to native range under variable conditions. The SY involved in this project is Rebecca Phillips.

5. Enterprise budgets will be constructed for bioenergy crop production alternatives, based on ongoing field studies at Morris, MN and Mandan, ND to evaluate farm- and region-level economic and environmental impacts of increased biofuel crop production including utilizing crop residues for bio-energy production. Data from these studies will be used in calibrating and validating the EPIC simulation model, which will be used to evaluate the long-term environmental impacts and economic performance of each of the scenarios. This will provide information useful for farmers making cropping decisions at the field level, and will feed into the ESAFE and REAP national projects. These results will also be compared with results obtained using the minimum-data tradeoff analysis approach to quantify the supply of C sequestration services supplied by agriculture as the value of biomass increases. The SY involved in this project is Dave Archer.

6. A previously cropped site will be selected for the study, and each phase of three crop rotation treatments will be seeded in strips. The crop rotations will be: (i) spring wheat-field pea, (ii) spring wheat-field pea with a millet cover crop seeded after pea harvest, and (iii) spring wheat-field pea-corn. Four biomass harvest treatments will be imposed as split-plots within each crop strip: (i) no harvest; (ii) mechanical harvest of wheat straw; (iii) mechanical harvest of wheat straw, cover crop and corn stover; and (iv) mechanical harvest of wheat straw and grazing cover crop and corn stover. Variables measured will be grain yield, biomass yield, soil properties, soil water, and economic returns. The SY involved in this project is Dave Archer.