A Century of Change:
Capitalizing on Long-Term Agroecosystem Research at the Northern Great Plains Research Laboratory, Mandan, ND

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Overview

The Northern Great Plains Research Laboratory (NGPRL; www.mandan.ars.usda.gov), one of the premier long-term agricultural research locations in the Nation, offers several unique attributes that make it an ideal site for the Long-Term Agroecosystem Research Program. Strategically located in the center of the northern Great Plains, the NGPRL has a 100-year legacy of addressing critically important natural resource issues affecting agricultural sustainability. NGPRL is one of the few ARS laboratories with crop, soils, rangeland, and livestock research capacity at the field and herd scale complemented by a multidisciplinary scientific team with expertise in ecology, economics, agronomy, and rangeland and soil science.

The mission of the NGPRL 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. Research is conducted in three CRIS projects: Rangeland and livestock resource management (5445-21310-001-00D), Soil and gas flux response to improved management in cold, semiarid agroecosystems (5445-11120-002-00D), and Integrated agricultural systems for the northern Great Plains (5445-21660-002-00D). The research is primarily associated with national programs 212, 215, and 216 and also affiliated with programs 211 and 306.

NGPRL has unique long-term data sets on: (i) grazing management effects on soils and plants (>70 years); (ii) a soils archive dating back 90 years; (iii) a 12-year integrated crop-livestock project, and (iv) an 18-year cropping systems trial. Scientists at the 970-ha research facility participate in the GRACEnet, CEAP, and REAP ARS national projects and are key contributors to NSF's NEON project. NGPRL actively collaborates with partners at land grant and tribal colleges in ND and surrounding states, as well as with other national institutions and ARS locations, to leverage institutional strengths to achieve research goals. Partnership with North Dakota's Area 4 Soil Conservation Districts provides field-scale research at the Area 4 SCD Cooperative Research Farm, a 154-ha working farm, and extensive opportunities for technical transfer of research results to farm and ranch customers.

1. Productivity The scientific team at NGPRL is highly productive and diverse with expertise in soil carbon dynamics and greenhouse gas fluxes (Liebig), soil microbiology (Nichols), dynamic cropping systems (Tanaka), rangeland ecology (Hendrickson), livestock nutrition and ingestive behavior (Kronberg), agricultural economics including tradeoff analyses (Archer), unique expertise in plant physiology focused on multiscale measurements of greenhouse gas fluxes and remote sensing (Phillips), and grassland agronomy and ecology (Sanderson). During the last 5 years, the research team at Mandan has published 143 peer-reviewed journal articles (see selected articles listed in item 9), given more than 200 invited presentations to national and international research user groups, released two unique decision support tools for farmers and advisors, and garnered more than $1.5M in extramural research support. The scientific team is supported by two headquarters-funded post docs (Jonathan Aguilar; and one post doc vacancy), two category 3 support scientists (rangeland ecology and landscape modeling), and 10 technical support staff. The current budget is $3.4M with $40K in discretionary funds per scientist.

Recent accomplishments:

●By utilizing long-term pastures and a historical soil sample archive, NGPRL scientists estimated net global warming potential (GWP) for three grazing management systems located in central North Dakota. Summing across factors, net GWP was negative for native vegetation pastures, implying net removal of

GHGs from the atmosphere. This finding underscored the value of grazed, mixed-grass prairie as a viable agroecosystem to serve as a net GHG sink in the northern Great Plains.

●Developed a method for determining the net exchange of ecosystem carbon using ground and satellite-base data and observed 1500 North Dakota Conservation Reserve Program (CRP) fields over a 10-year contract. We observed more than 20,000 ha managed under the CRP and found these grasses removed 643,000 metric tons of atmospheric carbon during the 1997 to 2006 growing seasons. Results of this spatiotemporally explicit, ground data-calibrated model track year-to-year and field-to-field variation for accurate assessment of conservation practices on grassland carbon uptake.

●Analyzed the relationship between economic returns and greenhouse gas emissions for contrasting tillage, crop rotation, and nitrogen fertilizer management systems for the Great Plains. Developed strategies to profitably transition to more diverse, less-tillage intensive, and less input-intensive cropping systems.

●Developed a one-of-a-kind soil archive containing more than 5000 samples ranging in age from 4 to 90 years. Samples were derived from both grazing and cropping studies throughout the Great Plains. The archived soil samples are an important resource for quantifying changes in soil attributes over decadal time scales. Scientists and collaborators around the world have been informed about this unique resource and access is open to the public.

●Collaboration with the US Forest Service resulted in modeling remote sensing-based data to estimate forage quality and quantity at the plant leaf scale and has moved up to pasture and ecoregions scales. Because of this research, USFS has funded NGPRL on a project to assess and monitor rangeland on the 61,000-ha Grand River National Grassland. The intensive field campaign was initiated in 2010 and preliminary results indicate the utility of space-borne and aerial optical data for estimating rangeland forage quality, quantity, and structure is excellent. The model being built will have wide implications for rangeland management. The technology will be transferred to the USFS in 2011, and field operations personnel are expected to pilot this management model at the Grand River National Grassland.

●Research at NGPRL has been instrumental in developing cropping systems that efficiently use limited precipitation. Through extensive research on the combined use of no-till and annual crop sequencing, we have designed cropping systems that minimize soil water loss by evaporation and increase crop yields. Research approaches created by NGPRL scientists for developing appropriate crop sequences in dry climates have been adopted throughout world, including Australia and Finland.

●NGPRL scientists recognized that certain crop species left significantly less residue on the soil surface relative to traditional cereal grain crops, thereby compromising resistance to erosion, water infiltration and storage, and nutrient conservation within dryland cropping systems. By quantifying crop residue coverage for predominant crops in the northern Great Plains (buckwheat, canola, chickpea, corn, dry pea, grain sorghum, lentil, sunflower, proso millet, and spring wheat), NGPRL scientists were able to develop crop sequencing recommendations that minimize potential negative agronomic and environmental impact associated with the use of low residue producing crops.

●Defined key management practices to control invasive species in native rangeland and natural grasslands. This information will help public land managers and producers develop more effective strategies to control invasive species.

●Pioneered an innovative research process to identify the (i) social/political, (ii) economic, (iii) environmental, and (iv) technological factors that have the greatest impact on shaping agricultural

systems, the mechanisms by which these factors affect agriculture at the farm level, and regional differences among these factors.

●Developed novel and intuitive decision aids to assist agricultural producers in making cropping decisions that mitigate production risks. The release of the 'Crop Sequence Calculator' and development of six key factors for dynamic cropping systems provide producers with a conceptual and practical basis for cropping decisions. Nearly 14,000 copies of the 'Crop Sequence Calculator' have been distributed to farmers, extension agents, crop advisors and college instructors (available at www.mandan.ars.usda.gov). ARS scientists at Mandan, ND also developed a novel decision aid to assist agricultural producers select appropriate cover crops for addressing production and natural resource concerns. The decision aid, entitled 'Cover Crop Chart' (CCC; available at www.mandan.ars.usda.gov), includes information on 46 crop species that may be planted individually or in cocktail mixtures to address critical production and/or natural resource issues on working farms. Using an appealing visual aid patterned after the periodic table of elements, the CCC contains specifics on growth cycle, relative water use, plant architecture, forage quality, pollination characteristics, and nutrient cycling for most crop species. Since release of version 1.1 of the CCC (June 2010), it has been downloaded more than 1,100 times by users in 18 countries**.** The decision aids have contributed to increased diversification of cropping systems in semiarid regions, and brought international recognition to the NGPRL research team for their expertise in cropping system design.

2. Infrastructure Capacity

NGPRL possesses excellent land, facility, and equipment resources for conducting long-term research. Approximately 970 ha of land, including rangeland, cropland, and introduced pastures, are available for research at NGPRL (see page 15). Moreover, the NGPRL land base includes on-going long-term trials addressing grazing management (est. 1916) and cropping system diversity (est. 1984). Facilities at NGPRL support a broad research capacity, and include fully-equipped laboratories, animal handling facilities, greenhouses, growth chambers, soil and plant processing and storage facilities, mechanical maintenance and carpentry shops, and meeting rooms. NGPRL has a full complement of field equipment for farm and ranch operations, along with modern laboratory and computer equipment. Additional detail describing NGPRL land, facilities, and equipment is provided below.

Land

NGPRL is situated within the Temperate Steppe Ecoregion of the U.S. This ecoregion has a semiarid continental climate, with evaporation typically exceeding precipitation in any given year. Specifically, land managed by NGPRL is located within the Missouri Plateau, approximately 6 km south of Mandan, ND (46º 46' 12" N, 100º 55' 59" W). Average annual precipitation at the site is 410 mm and long-term growing season precipitation (Apr – Sep) is 330 mm. Average annual temperature is 4°C, though daily averages range from 21°C in summer to -11°C in winter. The average frost-free period is 131 days.

Gently rolling uplands (0-3% slope) characterize the prevalent topography of NGPRL land, and most soils possess a silty loess mantle overlying Wisconsin age till. Predominant soil types include Temvik-Wilton silt loams (Fine-silty, mixed, superactive, frigid Typic and Pachic Haplustolls). In contrast, a small area (<50 ha) of alluvial outwash near the NGPRL campus is dominated by Parshall fine sandy loam (Coarse-loamy, mixed, superactive, frigid Pachic Haplustoll).

Approximately 770 ha of rangeland are available for research at NGPRL. Numerous small (2.5 ha) and mid-sized (7.5 ha) paddocks comprise a significant portion of rangeland, though extensive areas (>30 ha) are available for larger-scale, landscape-oriented studies. All rangeland paddocks are fenced, and most have underground water lines and livestock shelters. Rangeland resources at NGPRL include three long-term grazing management trials, including two native vegetation pastures (est. 1916) and one seeded

forage pasture (crested wheatgrass; est. 1932). Additionally, NGPRL has one of the few long-term integrated crop-livestock studies in the U.S. (est. 1999).

A unique part of the NGPRL land base includes the lease of 154 ha by the Area 4 Soil Conservation District (SCD). Since 1984, producers within the SCD have provided this land to NGPRL scientists to address production and environmental problems associated with dryland cropping systems. All crop production is under no-till management, and a broad portfolio of crop diversity treatments are investigated varying in scale (0.01 to 11 ha) and duration (6 to 27 years).

Facilities

More than 30 buildings support research activities at NGPRL. Animal handling and crop storage facilities are located for convenient access by large vehicles. A recently renovated (2010) rain-out shelter is available for controlled, small-scale studies. Fully-equipped maintenance and carpentry shops are available on the NGPRL campus, thereby allowing for fabrication of research equipment as needed.

NGPRL has eight greenhouse bays, three with automated control of vents, exhaust fans, and temperature, and one with automated fertigation instrumentation. Growth chambers, germinators, and a large sample prep room are near the greenhouses. Soil and plant processing facilities include numerous drying ovens and grinders, as well as ample counter space for sample sorting and weighing. Sample storage facilities include a walk-in cooler (4°C), two chest freezers (-85°C), and two dedicated buildings for long-term sample archiving. Laboratory space at NGPRL is abundant and diverse in function, with dedicated space for sample preparation, wet and dry elemental analyses, and microscope evaluations.

State-of-the-art meeting, office, and administrative facilities exist at NGPRL. Meeting rooms are available for small (6-12), medium (15-30), and large (70) groups, with each room possessing web access and a full range of presentation options. Audio and video conferencing is available, and there is an on-site kitchen for food preparation. Furnished office space is available to support current staff and up to 10 visiting scientists and research associates. A centralized administrative area facilitates efficient processing of physical documents and sample shipments. A small on-site library complements online access of reference materials.

Equipment

NGPRL possesses the necessary equipment to support long-term research efforts. Daily weather data – dating back to 1913 – is collected at the NGPRL campus. This long-term record is supplemented by two weather stations near active research sites (NRCS Soil Climate Analysis Network, est. 1993; North Dakota Agricultural Weather Network, est. 1999). Additionally, three portable weather stations are available for monitoring air temperature, wind speed and direction, and precipitation. Additional real-time monitoring equipment include two CO_2 flux towers using eddy covariance techniques.

Equipment is available to support all aspects of field work related to large and diverse crop and livestock production systems. Sorting pens, portable cattle and sheep panels, squeeze chutes, and scales facilitate data collection for livestock research. Multiple tractors, no-till drills, sprayers, and combines allow for successful data collection for cropping system studies. Three hydraulically driven soil probes are available for soil sample collection. Transportation needs are met via a large motor vehicle fleet.

Laboratory equipment at NGPRL includes gas and liquid chromatographs, two dry combustion C and N analyzers, an atomic absorption spectrometer, autoclaves, centrifuges, and microscopes. Computer equipment includes three Microsoft 2008 R2 servers, numerous desktop and laptop computers, and a range of network-connected printers. The NGPRL computer network is connected via fiber optics between buildings and 10-Base T twisted pair within buildings. A T-3 line facilitates high-speed internet access.

3. Data Richness

The NGPRL is unique in having multiple long-term (>10 year) datasets covering several disciplines compiled from the same location. Long-term projects at the location range from crop production to integrated crop-livestock systems to grazing management. These long-term projects provide unique soil, vegetation and animal production data.

Long-term datasets at NGPRL:

Integrated crop-livestock project

Description -- An integrated crop-livestock study was established in 1999 at NGPRL to evaluate production, nutritional, and environmental aspects of overwintering dry bred cows on swathed annual crops. All treatments were in place by 2000. From 1999 to 2006, the annual cropping sequence applied in the experiment was oat/pea (*Avena sativa* L./*Pisum sativum* L.), triticale/sweet clover (*Triticum aestivum x Secale cereale*/*Melilotus officinalis* L.), and corn (*Zea mays* L.). Beginning in 2007, the crop sequence was changed to oat/alfalfa (*Medicago* spp.)/hairy vetch (*Vicia villosa Roth*)/red clover (*Trifolium pratense* L.), Brown midrib sorghum-sudangrass (*Sorghum bicolor* L. Moench)/sweet clover/red clover, and corn. No-till planting techniques are used to plant crops. Each phase of the three year cropping sequence is present in both pastures, which are used as replicates. Crops are swathed in early fall and creep grazed by cattle over winter.

Variables: *Soil variables:* Soil bulk density, electrical conductivity, pH, extractable N and P, total C, inorganic C, organic C, total N, potentially mineralizable N, infiltration rate; *Vegetation variables:* Grain and biomass production, grain and forage N and P concentration; *Animal variables:* Cow and calf average daily gain, condition scores

Soil quality management study (SQM)

Description-- A cropping systems study was established in 1993 at NGPRL to evaluate six cropping sequences and two tillage systems (minimum and no-till cropping) on biomass production, precipitation use efficiency, and soil properties and processes. Management variables in the experiment include crop sequence [continuous spring wheat with crop residue left on the soil surface (CSW+), continuous spring wheat with crop residue removed (CSW-), spring wheat-millet [*Setaria italica* (L.) Beauv.] (SW-M), spring wheat-safflower (*Carthamus tinctorius* L.)-fallow (SW-S-F), spring wheat-safflower-rye (*Secale cereale* L.) (SW-S-R), and spring wheat-fallow (SW-F)] and tillage [minimum tillage (MT) and no-till (NT)]. The experiment is designed as a split-plot, with crop sequences as whole plots and tillage as subplots. Treatment combinations are replicated three times, and individual plots are 9.1 by 30.1 m.

Variables: *Soil variables:* Soil bulk density, electrical conductivity, pH, extractable N, total C, inorganic C, organic C, total N, particulate organic matter C and N; *Vegetation variables*: plant population, crop yield, biomass production soil water content, components of yield.

Long-term grazing management

Description—A grazing experiment was established in 1916 to evaluate the impact of stocking rate primarily on animal performance but also on species composition and production. The experiment initially focused on native rangeland but a seeded pasture was added later. Currently, treatments include two native vegetation pastures and one seeded forage pasture. The two native vegetation pastures include a moderately grazed pasture (MGP) and heavily grazed pasture (HGP), both of which were established in 1916 along with a non-grazed exclosure. A crested wheatgrass [*Agropyron desertorum* (Fisch. ex. Link) Schult.] pasture (CWP) represents the seeded forage, which was planted in 1932 into plowed native range. The grazing treatments vary in size, with MGP, HGP, and CWP occupying 15.4, 2.8, and 2.6 ha, respectively with the exclosure occupying a much smaller area. Per standard protocol for the establishment of experimental treatments prior to widespread use of statistics, none of the grazing

treatments are replicated. The grazing season for all three pastures extends from about mid-May to early-October using yearling steers. Stocking rates for MGP and HGP are 2.6 and 0.9 ha steer^{-1} (0.39 and 1.1 animals ha^{-1}), respectively. Stocking rates within CWP are 0.4 ha steer^{-1} (2.3 animals ha^{-1}) in late-spring/early-summer and 0.9 ha steer^{-1} (1.2 animals ha^{-1}) for the remainder of the grazing season. Grazing has occurred every year since pasture establishment except during times of severe drought when forage production was inadequate to support livestock grazing. To increase forage production, CWP is fertilized in the fall of each year since 1963 with NH_4NO_3 or urea at 45 kg N ha^{-1}. Cages are placed in each pasture (four in the HGP and CWP and six in the MGP) to estimate end of season production and utilization. Species composition has been taken on an irregular basis since 1916.

Variables *Soil variables:* Electrical conductivity, pH, total C, inorganic C, organic C, total N; *Vegetative variables: E*nd of season biomass production, utilization and species composition on an irregular basis; *Animal variables:* Gain per head and per acre.

Other Datasets:

The NGPRL has other datasets that may be of interest to the LTAR effort including: (i) long-term weather data; (ii) carbon dioxide flux data; (iii) Bioenergy Cropping Systems (BCS) study, and (iv) rangeland renovation vegetation data.

Description— *Long-term weather data*. The NGPRL has been a National Weather Service (NWS) cooperator since 1913. These data are collected on a daily basis year round. Besides the NWS data, the NGPRL has been part of the North Dakota Agricultural Weather Network (NDAWN) since 1999 and NRCS Soil Climate Analysis Network (SCAN) since 1993. The NDAWN data are not collected during the winter months. *Carbon Dioxide Flux datasets.* The NGPRL has collected greenhouse gas data since the mid-1990s. Original data were collected on rangeland sites using Bowen Ratio equipment as part of the Rangeland Flux Network. More recently, data have been collected from native range and alfalfa using eddy covariance equipment. *Bioenergy Cropping Systems (BCS).* The BCS study was initiated in 2009 and is scheduled tlo be completed in 12 years. This study evaluates the economic, above-ground production, soil attributes and vegetative quality parameters of different bioenergy crops and also investigates the impact of residue removal. *Rangeland Renovation Studies*. The NGPRL has conducted multiple projects evaluating control mechanisms for Kentucky bluegrass invasions. These projects have evaluated fire, chemical use and grazing as potential control mechanisms. Most projects are < 10 years in duration but plots remain in place and are periodically resampled.

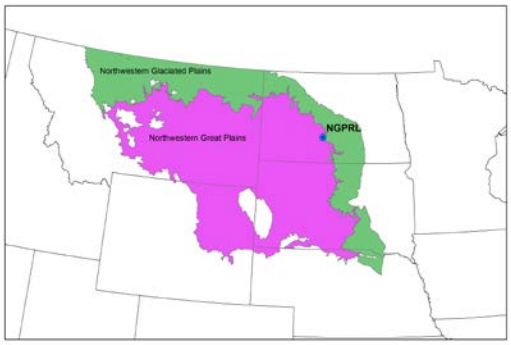
4. Data Availability (Accessibility)

All data are available through collaborations with location scientists. Data are primarily stored on common spreadsheet formats such as Excel. There are some exceptions where data are incorporated into a larger database. These include some soil data from the Long-term Grazing Management Project which is incorporated into the GRACEnet database and data from the BCS study which is provided to the REAP project. In addition, PDF files of annual reports from 1916-1970 are available in collaboration with location scientists. This reports describing the range and livestock program at NGPRL which includes information about the Long-term Grazing Management study. Long-term NWS weather data from the location can be accessed through the High Plains Regional Climate Center and NDAWN can be accessed through the North Dakota State University.

5. Geographic Coverage at Various Scales

The Mandan LTAR site is centrally located (east to west) within the Northern Great Plains U.S. farm resource region. Agricultural land use in the area includes a diverse mix of annual crops, hay, and grazing lands, and this is reflected in the land uses at the research site. The site is within the Missouri river water resource region (HUC Region 10) near the mouth of the Lower Heart Watershed (HUC 10130203). The site is centrally located within the National Ecological Observatory Network (NEON) eco-climatic

domain 9 - Northern Plains and is a candidate relocatable site for NEON. The site is in the Northwestern Great Plains Level III ecoregion and is near the boundary with the Northwestern Glaciated Plains ecoregion. The site includes land in the Missouri Plateau and River Breaks Level IV ecoregions.



6. Partnerships

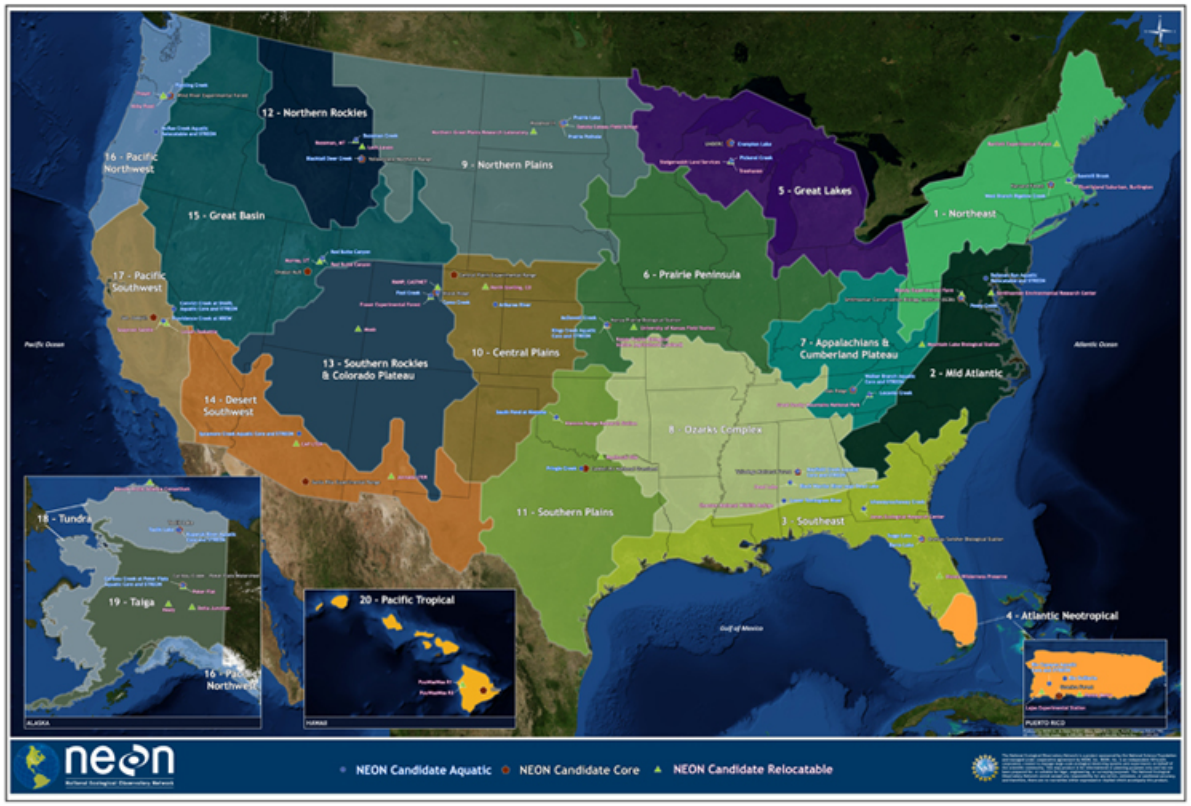
The NGPRL has strong formal partnerships (e.g., specific cooperative agreements) with North Dakota State University (NDSU), South Dakota State University (SDSU), and the University of North Dakota (UND) among several other informal collaborations with scientists at universities and ARS units across the country. There are two NDSU faculty co-located at Mandan and NGPRL and NDSU collaboratively operate a biomass testing laboratory. Scientists at NGPRL interact frequently with several tribal colleges in the region including Sitting Bull College in Ft. Yates, ND. These partnerships support unique collaborative research and education with the Standing Rock Sioux reservation, Sitting Bull College, NDSU, and SDSU to restore native rangeland, develop a natural beef enterprise, and provide an educational pathway for Native American students to gain training necessary for full time employment with the USDA-ARS.

The NGRPL also has a highly supportive and active customer focus group (CFG). The CFG is made up of 60 individuals representing individual farmers and ranchers, agribusiness, nongovernmental organizations, community leaders, commodity groups, along with state and federal agencies. The CFG meets twice yearly to review research projects at NGPRL, suggest new research directions, and inform others of the research results and their value to the northern Great Plains. The CFG and other customers and stakeholders are regularly informed of activities at NGPRL via the “Integrator” an electronic newsletter published semiannually (available at www.mandan.ars.usda.gov).

Another critical partnership at NGPRL is with the Area 4 SCD Cooperative research farm adjacent to NGPRL. The 154-ha Area 4 farm provides land to research conservation tillage and cropping systems on farmer-sized fields on a long-term basis. Established in 1984, this partnership has accomplished significant conservation research that has lead to changes in agricultural production systems throughout the region. The Area 4 SCD sponsors a “Research Results Conference” each February in Mandan, ND to transfer the research information and technology developed by NGPRL at the Area 4 farm to the public. The Area 4 farm also sponsors the annual “USDA Friends & Neighbors Day” at NGPRL. This year’s event (July 21, 2011) was attended by more than 900 family farmers and ranchers, agribusiness and community leaders, and the public from throughout the northern Great Plains region. The event was covered extensively by regional farm media, local radio and television, and newspapers. More than 80 commercial sponsors and organizations support the Area 4 SCD Cooperative Research Farm in

sponsoring this annual activity that supports tech transfer of USDA-ARS research to the public. The Area 4 farm is governed by 13 supervisors and four advisors.

The NGPRL has been chosen to be one of the **National Ecological Observatory Network (NEON)** sites. The NEON provides research infrastructure to support continental scale ecological research within specific domains located in the U.S. Research sites are geographically distributed to represent ecosystems ranging from rain forests to high deserts. Dr. Rebecca Phillips leads the effort at Mandan, which was selected as an agricultural land use site within the Northern Plains Domain. All sites are designed to collect continuous and seasonal ecological data and are instrumented similarly. Data collection protocols are rigorously reviewed and calibrated by core science staff at NEON headquarters. A state-of-the-art communications system downloads real-time data available for public and private use through the NEON web portal. Cutting-edge instrumentation networked to computational, analytical and modeling programs support hundreds of online data products. NEON will provide nationally networked research, communication, and informatics infrastructure necessary for truly collaborative, comprehensive and interdisciplinary ecological research.



Scientists at NGPRL have been actively involved in the **Greenhouse gas Reduction through Agricultural Carbon Enhancement Network (GRACEnet)** since its inception. Dr. Mark Liebig leads the effort at Mandan. Initiated by USDA-ARS in 2002, GRACEnet seeks to 1) determine the effects of agricultural management on carbon sequestration and storage, GHG flux, and environmental quality, 2) provide land managers with strategies to help mitigate GHG emissions, improve soil quality, and adapt to climate change, and 3) provide policy- and decision-makers timely and relevant information on management practices and strategies that can be used to mitigate and adapt to climate change. As a national project with more than 30 participating ARS locations, GRACEnet possesses significant geographical scope, cross-location consistency in measurement protocols and data handling, strong and effective leadership, and a clear plan for disseminating information. Scientists at NGPRL have made

significant scientific and leadership contributions to GRACEnet, including the publication of numerous journal articles, critical input on a voluntary carbon credit program, and participation in major data synthesis efforts.

The **Renewable Energy Assessment Project (REAP)** was established by the USDA-ARS to aid communication among team members, within ARS, and with clients regarding science and management issues related to biomass production from crop residues. Products from this work will be 1) guidelines for management practices supporting sustainable harvest of residue, 2) algorithm(s) estimating the amount of crop residue that can be sustainably harvested, and 3) decision support tools and guidelines describing the economic trade-off between residue harvest and retention to sequester soil C. Delivery of this knowledge and these products to farmers and the biomass ethanol industry will promote harvest of stover and crop residues in a manner that preserves the capacity our soil to produce food, feed, fiber, and fuel. Dr. David Archer leads the REAP effort at Mandan.

Dr. Matt Sanderson serves as the ARS coordinator for the pastureland CEAP **(Conservation Effects Assessment Program)** research effort. As coordinator, he works closely with ARS scientists at several locations to develop research plans and carry out research on pastureland assessment, monitoring, and modeling. He also coordinates with NRCS grazing land technical leadership on research priorities and keeps them informed of research progress and serves as a technical advisor to the National Resource Inventory (NRI) effort in protocol development for sampling pastures. The NRI database will be powerful tool in scaling grazing land research results from local to regional to national scales.

Scientists at NGPRL have partnered with the ARS units at Cheyenne, WY and Miles City, MT to form the Northern Great Plains Research Triangle to facilitate regional research on rangeland management. The initial focus of the group is organizing, analyzing, and interpreting the long-term grassland and livestock production data from the locations in relation to climate change.

Scientists at NGPRL also have strong partnerships with the US Forest Service, USDA-NRCS, US Fish and Wildlife Service, and the USGS.

7. Institutional Commitments

Scientists and staff at NGPRL are committed to long-term research as evidenced by the long-term projects described in Item 3 above and the 100 years of successful research benefiting U.S. agriculture. The three CRIS projects at the location are well integrated with most scientists serving on all three projects. This commitment is supported by the Area Office (support letter attached).

8. Scientific Staff

Category 1 Scientists

David Archer is an Agricultural Economist at NGPRL. Before coming to Mandan in 2007, he was with USDA-ARS in Morris, MN for seven years where he worked on cropping systems economics evaluating the economic feasibility of alternative cropping systems, and identifying barriers to adoption of more sustainable practices. Before joining ARS, he was a USDA-NRCS agricultural economist in Bismarck and in Spokane and Colfax, Washington. He received a Ph.D. in Agricultural Economics from Iowa State in 1995 and a B.S. in Mathematics from Rocky Mountain College in 1988. His research interests include risk management, simulation modeling, decision aid development, bioenergy economics, and decision making to achieve both economic and natural resource goals. Dr. Archer leads the REAP effort at Mandan.

John Hendrickson, a Rangeland Scientist, joined the NGPRL in 1999. Before coming to Mandan, John was a Rangeland Scientist with the USDA-ARS in Dubois, Idaho where he worked on the effects of grazing on the plant community, carbon sequestration in rangelands and using grazing to control noxious weeds. He received his B.S. from the University of Nebraska in 1984. After a term in the Peace Corps, he received his M.S. from the University of Nebraska in 1992. He received his Ph.D. from Texas A&M in Rangeland Ecology and Management in 1996.

Scott Kronberg started at NGPRL in 2000. He has graduate degrees in range science with emphasis on range animal nutrition and behavior from Montana and Utah State Universities, and a bachelor's degree in zoology from Arizona State University. He was on the faculty at South Dakota State University in the Department of Animal and Range Sciences for seven years before coming to NGPRL. He has been conducting research on nutrition and feeding behavior of grazing livestock for about 25 years.

Mark Liebig serves as a Research Soil Scientist at NGPRL. Before coming to Mandan in 1999, Mark was a Research Associate with ARS in Lincoln, NE where he conducted research to quantify the sustainability of corn-based cropping systems in the western Corn Belt. His research program at NGPRL encompasses soil quality and gas flux evaluations of crop, grazing, biofuel, and integrated management systems. Dr. Liebig leads the GRACEnet effort at Mandan.

Kris Nichols, Soil Microbiologist, began at NGPRL in 2004. Kris received a B.S. in Plant Biology and in Genetics and Cell Biology from the University of Minnesota in 1995, a M.S. in Enivronmental Microbiology from West Virginia University in 1999, and a Ph.D. in Soil Science from the University of Maryland in 2003. Since 1993, she has studied arbuscular mycorrhizal (AM) fungi – a plant-root symbiont. Her recent work involves the investigation of glomalin – a substance produced by AM fungi.

Rebecca Phillips joined the NGPRL as a Plant Physiologist in 2005. She earned graduate degrees in Ecology and Environmental Science & Engineering at Colorado State University and the University of North Carolina. Phillips received her post-doctoral training at the University of Michigan and was research faculty at the University Of North Dakota John D. Odegard School Of Aerospace Sciences. Phillips specializes in ecosystem biogeochemistry, particularly carbon and nitrogen cycling between plants and soils and the atmosphere. Dr. Phillips' research focuses on minimizing environmental impacts and designing strategies to promote sustainable use of natural resources. Dr. Phillips leads the NEON effort at Mandan.

Matt A. Sanderson is the Research Leader at the NGPRL. He has degrees from North Dakota State University and Iowa State and was a postdoctoral research associate at the University of Missouri. From 1988 to 1996 he was on the faculty of Texas A&M University Agricultural Research and Extension Center in Stephenville, TX. From 1996 to 2010, he was a research agronomist and lead scientist with the USDA-ARS Pasture Systems and Watershed Management Research Unit in University Park, PA where he did research on forage and pasture management, warm-season grasses for conservation and bioenergy, and grassland diversity. Dr. Sanderson coordinates the national pastureland CEAP component for ARS.

Donald Tanaka began with the ARS at Sidney, MT in 1980. He has been a member of the research team at NGPRL since 1991. He has advanced degrees in agronomy with a concentration in soils and soil chemistry from the University of Nebraska. He has conducted soil and water conservation research in the northern Great Plains for 30 years. Dr. Tanaka has pioneered no-till crop sequence research to take advantage of soil/crop ecology interactions, and in doing so, contributed to a significant evolution in cropping system research where production synergies lead to increased crop production, lower input requirements, and an enhanced natural resource base.

Jonathan Aguilar is a headquarters-funded postdoc with Dr. Hendrickson. His current research includes spatial and temporal analysis of crop diversity indices for the contiguous U.S. Before coming to Mandan, Jonathan was an Agricultural Engineer with the USDA-ARS in Sidney, MT exploring the use of remote sensing in quantifying crop residue. His interest includes GIS, remote sensing, database management, soil and water conservation, watershed modeling, and hydrology among others. He earned his Ph.D. in Agricultural and Biological Engineering from Kansas State University. His dissertation was regarding the changes of ecologically relevant flow parameters in Kansas' streams. He finished both his M.S. and B.S. degrees in Agricultural Engineering from the University of the Philippines Los Baños.

Category 3 Support Scientists

Holly Johnson has been on the staff since June 1999. She completed her B.A. in Biology from Concordia College, Moorhead, MN in 1996 and M.S. in Rangeland Science from North Dakota State University in 2000. Her current work at NGPRL includes a broad range of field components in grassland and cropland systems with Dr. Sanderson, including studies conducted in greenhouses and growth chambers, field collections of plant and soils, as well as laboratory analyses.

Nick Saliendra serves as an Ecologist under the leadership of Dr. Rebecca Phillips. His current research includes the study of sustainable rangeland productivity in conjunction with ground-level biometric/spectral measurements and air-borne hyperspectral imageries or remote sensing. He recently joined the NGPRL in June 2011 after working on biophysical research projects that involve measurements and modeling of carbon, water and energy fluxes at different spatial scales such as ecosystem and landscape levels. His past research has encompassed a wide range of ecosystems including suburban forests in Maryland, regenerating forests and wetlands in northern Wisconsin, and various rangelands in Utah, Idaho and Central Asia at the former Soviet republics of Kazakhstan, Uzbekistan and Turkmenistan. He obtained his Ph.D. in agronomy and soil science from the University of Hawaii in Honolulu, and M.S. in agronomy and B.S. in agriculture from the University of the Philippines at Los Baños.

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Satellite image of the land area controlled (outlined in red) by the USDA-ARS Northern Great Plains Research Laboratory, Mandan, ND. Approximate total is 970 ha.