Long-term Agroecosystem Research Network

Northern Plains (Mandan, ND) Site Conceptual Plan

Overview

The Northern Great Plains Research Laboratory (NGPRL; www.ars.usda.gov/plains-area/mandan-nd/ngprl) has a 100-year legacy of addressing critically important natural resource issues affecting agricultural sustainability. The NGPRL has 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 adaptive and integrative practices for sustainable crop, livestock, and rangeland systems through team-focused, systems-oriented research and technology transfer. To achieve this mission, research is currently conducted through two CRIS projects: Agricultural System Competitiveness and Sustainability (NP216), and Pasture, Forage and Rangeland Systems (NP215).

The NGPRL is one of 18 Long-Term Agroecosystem Research (LTAR) network sites in the United States (Walbridge and Shafer, 2011). Within the network, NGPRL is referred to as the Northern Plains LTAR site. This conceptual plan provides a synopsis of NGPRL attributes and activities as they apply to goals of the LTAR network.

Site Attributes

The Northern Plains LTAR site is centrally located within the Northern Great Plains farm resource region (latitude 46.77, longitude -100.95; 1942 ft asl) (Fig. 1). The site is situated within the Temperate Steppe Ecoregion of the United States, which has a semiarid continental climate, with evaporation typically exceeding precipitation. Average annual precipitation at the site is 18 inches and long-term growing season precipitation (Apr – Sep) is 14 inches. Average annual temperature is 39°F, though daily averages range from 70°F in summer to 12°F 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 have a silty loess mantle overlying Wisconsin age till. Predominant soil types include Temvik-Wilton silt loams. In contrast, a small area

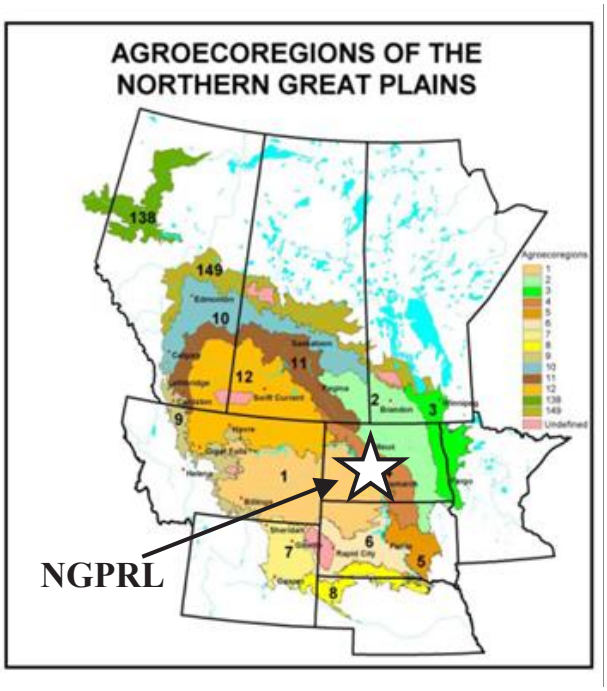

Fig 1 (Padbury et al., 2002).

(<125 ac) of alluvial outwash near the NGPRL campus is dominated by Parshall fine sandy loam. The site is within the Missouri river water resource region (HUC Region 10) near the mouth of the Lower Heart Watershed, corresponding to National Ecological Observatory Network (NEON) eco-climatic domain 9 - Northern Plains.

Agricultural land use in the area includes a diverse mix of annual crops, hay, and grazing lands. This is reflected throughout the 2,396 ac of land available for research at NGPRL, including rangeland, cropland, and pastures. Approximately 1,900 ac are available for rangeland research. Numerous small (6.2 ac) and mid-sized (18.5 ac) paddocks comprise a significant portion of rangeland, though extensive areas (>74 ac) are available for larger-scale, landscape-oriented studies. All rangeland paddocks are fenced, and most have livestock shelters supplied by underground water lines. 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 feature of the NGPRL land base includes the lease of 380 ac 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 issues associated with dryland cropping systems. All crop production is under no-till management, and a broad portfolio of crop diversity treatments are evaluated in plots of varying size (0.02 to 27 ac) and duration (13 to 34 years). Since its inception, the SCD research farm has served as a catalyst for customer outreach and technology transfer activities at NGPRL.

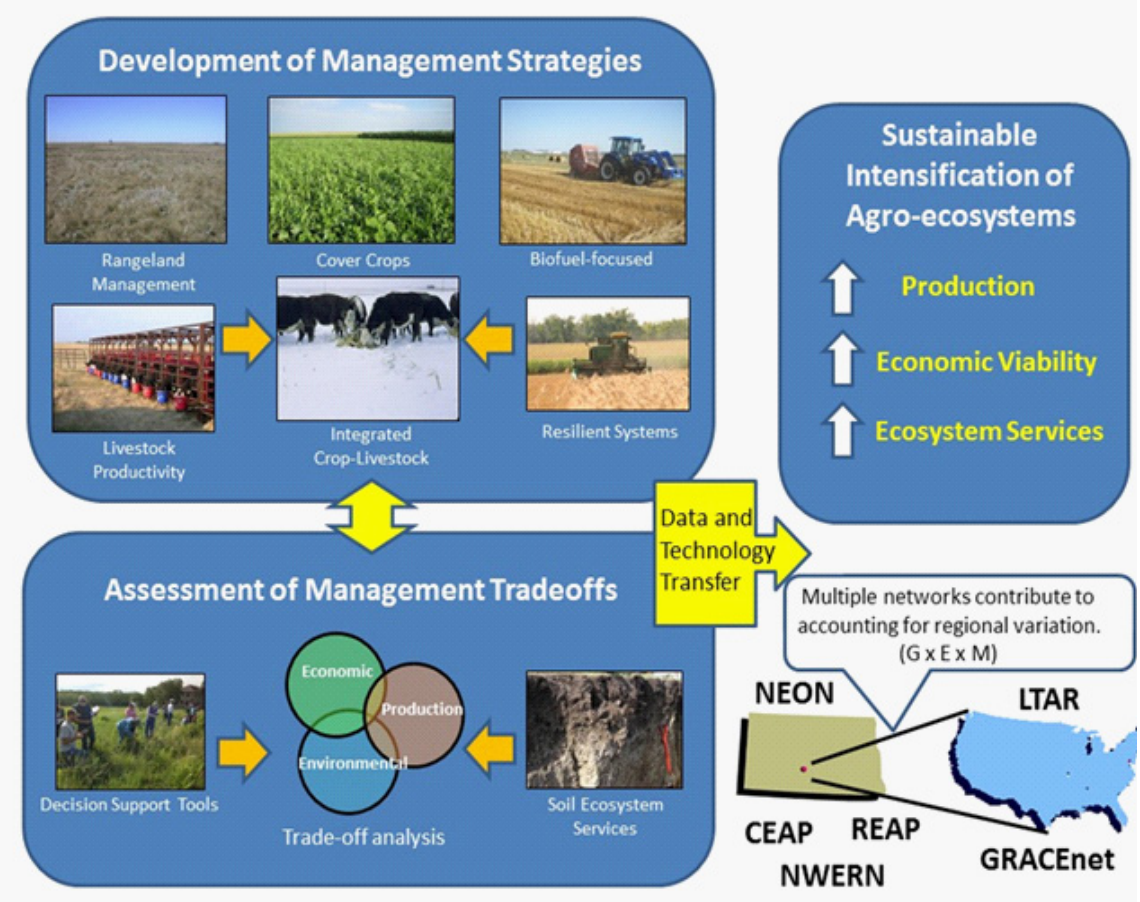

Fig 2. NGPRL research framework. Project acronyms: CEAP, Conservation Effects Assessment Project; GRACEnet, Greenhouse Gas Reduction through Agricultural Carbon Enhancement Network; LTAR, Long-Term Agroecosystem Research Network; NEON, National Ecological Observatory Network; NWERN, National Wind Erosion Research Network; REAP, Resilient Economic Agricultural Practices.

NGPRL Research Framework

Throughout its 106 year history, NGPRL has focused on improving the sustainability of farms and ranches throughout the northern Great Plains. Current NGPRL research reflects this continuing challenge by developing novel management practices to sustainably intensify agroecosystems through increased production, economic viability, and ecosystem service delivery (Fig. 2). Data collected at NGPRL provides the basis for tradeoff analyses and decision support tool development, and concurrently contribute to multiple cross-location research efforts with national scope.

LTAR Research Portfolio

Principal research emphases at NGPRL related to LTAR goals include:

- Quantifying the ability of integrated crop-livestock systems to sustainably increase food production.
- Developing cost-effective and environmentally sound strategies to address land-use change.
- Developing dynamic agricultural systems that include food, fiber, and biofuels.
- Assessing agroecosystem trajectory through key soil- and vegetation-based metrics at multiple scales.
- Quantifying potential changes in soil functions resulting from anticipated climate effects.

Research efforts are addressed through assessments of historical data, on-going studies, and a forthcoming 'Common Experiment'.

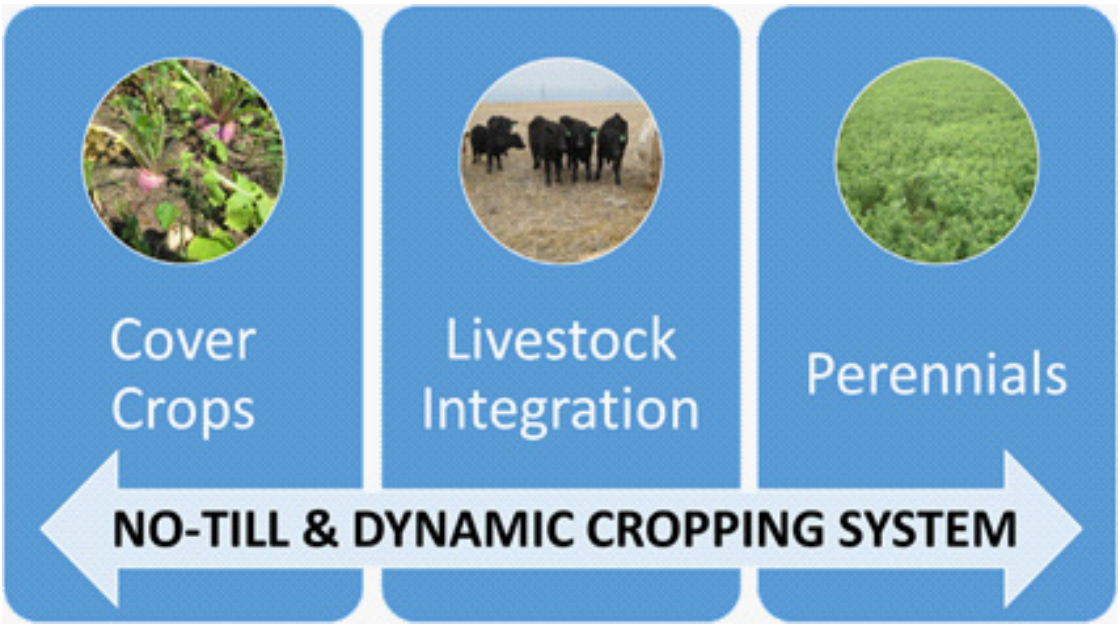

Fig 3. Practice portfolio for aspirational management

Historical Assessments – NGPRL has unique long-term data sets for grazing management (>100 year) and cropping system (>30 year) treatments that link to on-going studies. Longitudinal analyses have been conducted using soil, vegetation, and/or animal performance data to elicit key insights arising from long-term responses to management and effects of extreme drought. Additionally, over 5000 samples are included in the NGPRL soil archive, thereby providing unique opportunities for evaluations of long-term soil change.

On-going Studies – Long-term grazing management, dryland cropping, and integrated crop-livestock studies are conducted at NGPRL. Two native vegetation pastures differing in stocking rate have been maintained since 1916, with one pasture currently serving as a NEON relocatable site (DO9; NOGP). Additional long-term rangeland paddocks at NGPRL investigate effects of invasive plant species on ecosystem function, and also serve as sites for the development of rangeland health indicators. Multiple long-term dryland cropping system studies have been conducted since 1984 on the Area 4 SCD Cooperative Research Farm. These studies, conducted at plot- and field-scales, resulted in the development of adaptive management strategies related to cropping intensity, cropping system diversity, and cover crop use. A bioenergy cropping systems study established in 2009 provided key information regarding residue removal effects on soil and crop metrics, while an integrated crop-livestock study established in 1999 is a key experiment testing hypotheses related to sustainable intensification. The latter study is included in a multi-state NIFA CAP grant including South Dakota State University, South Dakota School of Mines, North Dakota State University, University of Nebraska, and the LTAR site in Lincoln, NE (Platte River/High Plains Aquifer).

Common Experiment – The Common Experiment at NGPRL will seek to address key issues of sustainable intensification for dryland cropping systems in the northern Great Plains. The experiment will contrast common standard cropping practices for

Table 1. Focal areas associated with aspirational treatments included in 'Common Experiment' (adapted from Common Experiment Synthesis Project; Spiegel et al. (2018)).

Production
• Provisioning
• Nutritious food
Socioeconomic
• Profitability
• Rural opportunity
• Resilience to market volatility
• Adaptive capacity
• Animal welfare
Environmental
• Resilience to climate variability and change
• Resilience to environmental degradation
• Soil quality
• Water quality
• Air quality
• Minimize GHG footprint
• Beneficial insects

central North Dakota ('Business as Usual'; BAU) with dynamic/adaptive cropping practices using no-till management, integrated cropping, cover crops, livestock integration, and perennials ('Aspirational'; ASP) (Fig. 3 & 4). Focal areas associated with aspirational treatments are diverse, and classified broadly pertaining to production, socioeconomic, and environmental attributes deemed important for improving agricultural sustainability (Table 1).

The Common Experiment will be deployed at field and plot-scales on the Area 4 SCD Cooperative Research Farm. Treatments at the field-scale will occupy 50 ac/field, while plots will be 0.75 ac/plot in size, with plot-scale treatments replicated four times. In order to maintain relevance over time, treatments will be updated every six years (two 3-year rotation cycles) using multiple sources of information, including National Agricultural Statistical Service (NASS) crop survey data, outcomes from on-going studies, and input from the NGPRL Customer Focus Group. Continuity over time will be facilitated by adherence to goals established for BAU and ASP treatments.

A spectrum of agronomic and environmental assessments will be conducted at both spatial scales on sub-annual, annual, three-year, and six-year cycles. Carbon and water balance will be measured using eddy covariance methodology in BAU and ASP field sites, with complementary assessments of soil moisture, temperature, O_2 concentration, and meteorological variables. Data streams from field sites, including phenocam images, will be transferred by telemetry to the main NGPRL campus on 30-min intervals. Wind erosion will be assessed on the BAU field following protocols developed by the National Wind Erosion Research Network (Webb et al., 2016). Soil-atmosphere gas flux (CO_2, CH_4, N_2O) will be assessed using static chamber methodology following Greenhouse Gas Reduction through Agricultural Carbon Enhancement Network (GRACEnet) protocols. Measurements of soil properties will align with recommendations developed by the LTAR Soils Workgroup. Assessment of predaceous and beneficial insects, including pollinators, will be done in collaboration with ARS-Fargo and USGS-Jamestown. Crop/forage yield and livestock production will be assessed using established protocols. Economic outcomes will be determined annually using production data (crop yield; livestock gain) and costs for land, inputs, and labor.

LTAR Network Linkages

Since 2014, NGPRL has actively expanded LTAR research collaborations throughout the northern Great Plains. Using LTAR goals as a template for collaboration, annual meetings among ARS (Lincoln,

	Component	Description
Prevailing Regional Practices ('Business as Usual')	Crop rotation	Spring wheat-corn-soybean
	Cover crop	None
	Tillage	No-till/minimum-till
	Nutrient management	NDSU recommendation; Uniform application
	Pest management	Proactive herbicide/insecticide use
	Other	Residue removal following spring wheat phase; Chisel tillage following corn.
Practices Delivering Site-Prioritized Ecosystem Services ('Aspirational')	Crop rotation	Cool season grass-warm season grass-broadleaf (3-yr dynamic/adaptive annual crop selection)
	Cover crop	Incorporated post-harvest and/or as intercrop
	Tillage	No-till
	Nutrient management	Precision/variable rate technology
	Pest management	IPM and precision/variable rate technology
	Other	Post-harvest livestock grazing of crop residue and/or cover crops.

Fig 4. Generalized treatment descriptions for 'Common Experiment'.

Brookings, Fargo, Sidney), university (NDSU, SDSU, UNL, UND), federal (USGS-Jamestown), and NSF (NEON) partners have contributed to new and expanded research efforts. The regional partnership currently includes 30 scientists representing >15 research locations.

The NGPRL regularly collaborates with partners at NDSU, SDSU, Sitting Bull College, as well as other universities, federal agencies, and ARS locations on grant funded research aligned with LTAR goals. The NGPRL is complemented by NDSU faculty, research associates, and graduate students who conduct research to provide engineering-related solutions for the harvest, collection, storage, transport, and pre-processing of biofeedstocks. Research collaboration with NDSU has recently been formalized through a Specific Cooperative Agreement (SCA) to support phenocam image analysis of LTAR field sites.

Scientists at NGPRL are key contributors to multiple cross-location research efforts, including GRACEnet, Resilient Economic Agricultural Practices (REAP), Conservation Effects Assessment Project (CEAP), and National Wind Erosion Research Network (NWERN).

LTAR Working Groups

LTAR working groups facilitate cooperation, uniformity, and efficiency across the network.

Staff at NGPRL are actively involved in multiple LTAR working groups within Information (Data Management; GIS and Remote Sensing), Common Experiment (Croplands), and Common Measurement (Meteorology; CO_2 Flux; Non CO_2 Flux; Hydrology; Soils) categories.

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