Area 4 SCD Cooperative Research Farm
USDA-ARS Northern Great Plains Research laboratory

NGPRL

AREA 4 SCD
Cooperative Research Farm

USDA ars Agricultural Research Service

Northern Great Plains Research Laboratory
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8:00 AM	**Registration, Coffee & Trade Show**
8:30	**Welcome & Introductions** Mr. Marvin Halverson, Area 4 SCD Cooperative Research Farm Chairman Dr. Jon Hanson, Northern Great Plains Research Laboratory Director
8:40	**Jon Hanson** A Research Model for the Future
9:00	**Dave Archer** Use of Crop Residue for Biofuel: Economics and Sustainability
9:30	**Qingwu Xue** Biofuel Crops for Northern Great Plains: The Production Challenges
10:00	**Break - Coffee & Trade Show**
10:30	**Marty Schmer** Current Research Status of Switchgrass for Bioenergy - What We Know and What We Need to Find Out?
11:00	**Don Tanaka** Cover Crops: Where Do They Fit?
11:30	**Kris Nichols** The Undercover in Cover Crops.
12:00	**Lunch Complements of Area 4 & Trade Show Sponsors**
1:00 PM	**John Hendrickson** Going From Perennial Crops to Annuals: What Are Your Options?
1:30	**Mark Liebig** Winter Grazing Effects on Soil Quality
2:00	**Eric Scholljegerdes** Effects of an Integrated Crop and Livestock System for Fall Forage Production on Beef Cow Growth Performance
2:30	**Rebecca Phillips** Integration of Geospatial and Cattle Nutrition Information to Estimate Paddock Grazing Capacity in Northern U.S. Prairie
3:00	**Scott Kronberg** Adjusting the Composition of Beef and Other Foods to Meet the Emerging Market Demand for Healthier Foods
3:30	**Jon Hanson** Wrap-up
3:40	**Coffee & Trade Show**

The Area 4 SCD Cooperative Research Farm and
Northern Great Plains Research Laboratory
acknowledge and appreciate the support of many
agribusinesses and organizations
that support these research and educational activities.
Please see inside back cover.

Contents

The scientists of the Northern Great Plains Research Laboratory have included in this publication research from the Area 4 SCD Cooperative Research Farm, the USDA-ARS Northern Great Plains Research Lab, and North Dakota State University. The Area 4 SCD Cooperative Research Farm data was created thanks to cooperative agreement between the Northern Great Plains Research Laboratory and Burleigh County SCD, Cedar SCD, Emmons County SCD, Kidder County SCD, Logan County SCD, McIntosh County SCD, Morton County SCD, Oliver County SCD, Sheridan County SCD, South McLean County SCD, Stutsman County SCD, and West McLean County SCD, which are the North Dakota Area IV Soil Conservation Districts. Information The preliminary results of this report cannot be published or reproduced without permission of the scientists involved.

Message from Dr. Jon Hanson,
Northern Great Plains Research Laboratory Director
USDA Agricultural Research service

Rapid changes occurring in the agricultural environment are placing increased demands on producers. To respond to these demands, farmers need to manage their systems by reducing risk, while retaining management flexibility. Integrated agricultural systems have the potential to meet these objectives. Integrated agricultural systems are whole-farm strategies and technologies organized to help producers manage multiple enterprises in a synergistic manner to improve profitability and natural resource stewardship. In the past, American agriculture was focused solely on its ability to produce sufficient food, fuel, and fiber to meet national and global demands. Agriculture has been largely successful in meeting these production demands. While productivity will continue to be a major factor in food production systems, increased societal demands for environmentally sound management, the need for rural community viability, and a rapidly changing global marketplace are now shaping the evolution of more integrated and sustainable agricultural systems.

During the past several decades, several changes have occurred in the structure and operation of farm and ranch systems, thereby impacting the continued sustainability of American agriculture. These changes include a reduction in the number of farms and farmers, increases in farm size, and concomitantly the commercialization of farms. New policies must be developed to encourage the integration of agricultural systems. Farmers want to produce the most marketable and cost-effective products. Therefore, they logically choose to produce what they perceive as the “best” commodities resulting in increasing specialization without much regard for the environment. Actively managing for multiple services can substantially reduce agriculture’s environmental footprint and can be encouraged with production incentives that reward environmental stewardship. These incentives, whether trade-based or policy-based, must be tailored to forestall continued environmental degradation and loss of agricultural sustainability. Policies with adequate incentives must be provided for ecosystem services such as clean water and air, productive and healthy soil, habitat development and restoration, and carbon sequestration and storage.

Current American agricultural systems are dramatically different from agricultural systems at the start of the 20th century. Economic, social/political, environmental and technological drivers have all interacted to shape the current agricultural domain. To understand the structure of future agricultural systems, an understanding of how drivers have affected current agricultural systems is needed. Highly specialized systems, such as commodity crop production and supply chain livestock production appear most vulnerable to future changes. Future agricultural systems need to be developed to balance multiple goals and ensure sustainability. To this end, the USDA-ARS Northern Great Plains Research Laboratory has developed a dynamic research program that is based on strong research in soil science, animal and rangeland science, cropping systems (including cover crops and biofuels), and economics. Our ultimate goal is to provide management alternatives for agricultural professionals. As can be understood from the breadth of information provided in this document, we are attacking these agricultural issues in an attempted to develop dynamic integrated agricultural systems that will help to sustain U.S. agriculture for future generations.

History of the Area 4 SCD Cooperative Research Farm

Since 1984, Area IV SCDs have participated in a collaborative effort with the Northern Great Plains Research Laboratory of the USDA Agricultural Research Service. The purpose was to provide land to research conservation tillage and cropping systems on farmer-sized fields on a long-term basis.

Through this relationship, significant conservation research has been accomplished that has supported major changes in agricultural production systems throughout the region.

Research Farm Objectives and Goals

- Research on field-sized plots
- Improve water conservation and soil erosion control technology.
- The conservation of our soil and water resources.
- Study conservation tillage systems.
- Promote the adoption and use of research findings.
- Present information in layman's terms.
- Identify research needs through the advisory committee and agricultural community.

Administration

The Farm is administered by an Area 1V Research Advisory Committee comprised of one member from each cooperating Soil Conservation District. Research is carried out on land leased south of Mandan, near Northern Great Plains Research Laboratory. Income generated by the Farm goes into a revolving fund used for payment of the lease, farming expenses, and promotion. There is no reimbursement to officers or board members.

Personnel at the Northern Great Plains Research Laboratory carry out the research and day-to-day operations. The large areas allow the use of farm-sized equipment, and therefore greater credibility in the eyes of the agricultural community.

Prior to the Cooperative Research Farm, the USDA-ARS had leased land from Roy Nelson. When beset by health problems, Mr. Nelson presented the idea of leasing his entire farm. Area IV SCDs worked through the Lewis and Clark Resource Conservation and Development Coordinator in 1982, to obtain assistance in leasing the property. A formal proposal to establish the Cooperative Research Farm was made at the Area IV SCD meeting on June 17, 1983. It was adopted November 13, 1983. Jerry Presser, Chairman of the Area IV SCD Research Advisory Committee, signed the original lease agreement along with Mrs. Roy Nelson and Rick Nelson on December, 1, 1983 at the Nelson farmstead. The land has now passed on to Mr. Nelson's children, with a second generation committed to research.

Research Philosophy

At the Northern Great Plains Research Laboratory, open-minded scientists from multiple disciplines focus on agricultural and environmental problems. They successfully search for innovative solutions to help improve the livelihood of America's farm families while snaking the best use of our natural resources.

Research fields on the Area 1V SCD Cooperative Research Farm are evaluated for both environmental and economic stability by agronomists, soil scientists, soil microbiologists, hydrologists, plant pathologists, plant physiologists, agricultural economists, etc.

Successes

Initial research on complete, minimum, and no-till tillage systems and fertilizer rates documented the positive values of no-till, and fertilizer placement, timing and amounts.

A major cooperative research project with NDSU supported the adoption of precision agriculture in western North Dakota and was completed in 2006.

The Area IV SCD Cooperative Research Farm has provided Mandan USDA-ARS scientists the opportunity to study opportunities for remote sensing satellites to develop the capability to remotely evaluate carbon sequestration and determine crude protein from high above the Earth.

Carbon sequestration measurements and greenhouse gas fluctuation research an the Area IV SCD Cooperative Research Farm has provided support for the development of the North Dakota Farmers Union Carbon Credits program for family farmers.

Crop Sequencing Research

Intensive research into the positive and negative effects of the sequencing of commonly grown crops commenced on the Area IV SCD Cooperative Research Farm in 1999. Over 40% potential yield loss and crop limiting soil Moisture carryover has been documented from improper attention to crop planning.

The resulting Crop Sequence Calculator has been distributed to over 12,000 farmers and educators throughout the region and worldwide at no cost. The calculator provides information on production (grain and forage), economics, disease risk, soil water use, and soil quality for many crop sequences utilized throughout the region.

Producers can review the results of crop sequencing decisions utilizing barley, buckwheat, canola, chickpea, corn, crambe, dry bean, dry pea, flax, grain sorghum, proso millet, safflower, soybean, spring wheat, and sunflower on the Area IV SCD Cooperative Research Farm from 1999 to 2005.

The Mandan scientists have also included many PowerPoint® tutorials. To calculate potential economic returns from the various crop sequences, producers can use the Area IV SCD Cooperative Research Farm experimental data, or modify it for soil, weather, and local conditions that may differ from the research location.

This new CD-ROM contains both version 2.2.5 and 3.0 to assist producers predict results under various anticipated moisture conditions. Phase II research on the Area IV SCD Cooperative Research Farm (CSC 2.2.5) was completed under abundant moisture conditions while Phase III research (CSC 3.0) was completed under below-normal moisture conditions. This CD-ROM is available at no cost on the Northern Great Plains Research Laboratory website (www.mandan.ars.usda.gov).

Education

Two major events help share research with producers. The Area IV Twilight Tours first held for supervisors and staff has grown into today's "Friends & Neighbors Day" that brought out over 1000 people last year. This year's activities will be held at the USDA research campus on July 16th. Buses depart the campus at 4 PM to tour the Area IV SCD Cooperative Research Farm.

Today, the Area IV SCD Cooperative Research Farm will host the 25th annual "Research Results & Technology Conference" at the Seven Seas Inn & Conference Center. These educational events have financial support of over 80 sponsors who value the research effort of the Area IV SCD Cooperative Research Farm and USDA-ARS Northern Great Plains Research Lab scientists.

The Future

Innovation has provided new possibilities for North Dakota family farmers. The Area IV SCD Cooperative Research Farm will continue to provide major opportunities for the development and evaluation of new opportunities. From biomass bio-fuel production research, no-till tillage research remote sensing capabilities, carbon sequestration, to new cover crop research, the Area IV SCD Cooperative Research Farm provides agricultural and environmental scientists opportunities to consider impact to water, soil, production, and profitability to help keep family farmers on the land.

By LeAnn Harner,
North Dakota Association of Soil Conservation Districts Director

AREA IV SCD COOPERATIVE RESEARCH FARM SUPERVISORS

Burleigh County SCD……………………..	Gabe Brown, Bismarck, ND
	Ken Miller, Fort Rice, ND
Cedar SCD……………………..……….	Kelly Froelich, Selfridge, ND
Emmons County SCD…………………..	Leo Kiefer, Hague, ND
Kidder County SCD…………………….	Marvin Halverson, Tappen, ND
Logan County SCD…………..…………	Dallas Bakken, Napoleon, ND
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Stutsman County SCD………………….	Donald Hofman, Medina, ND
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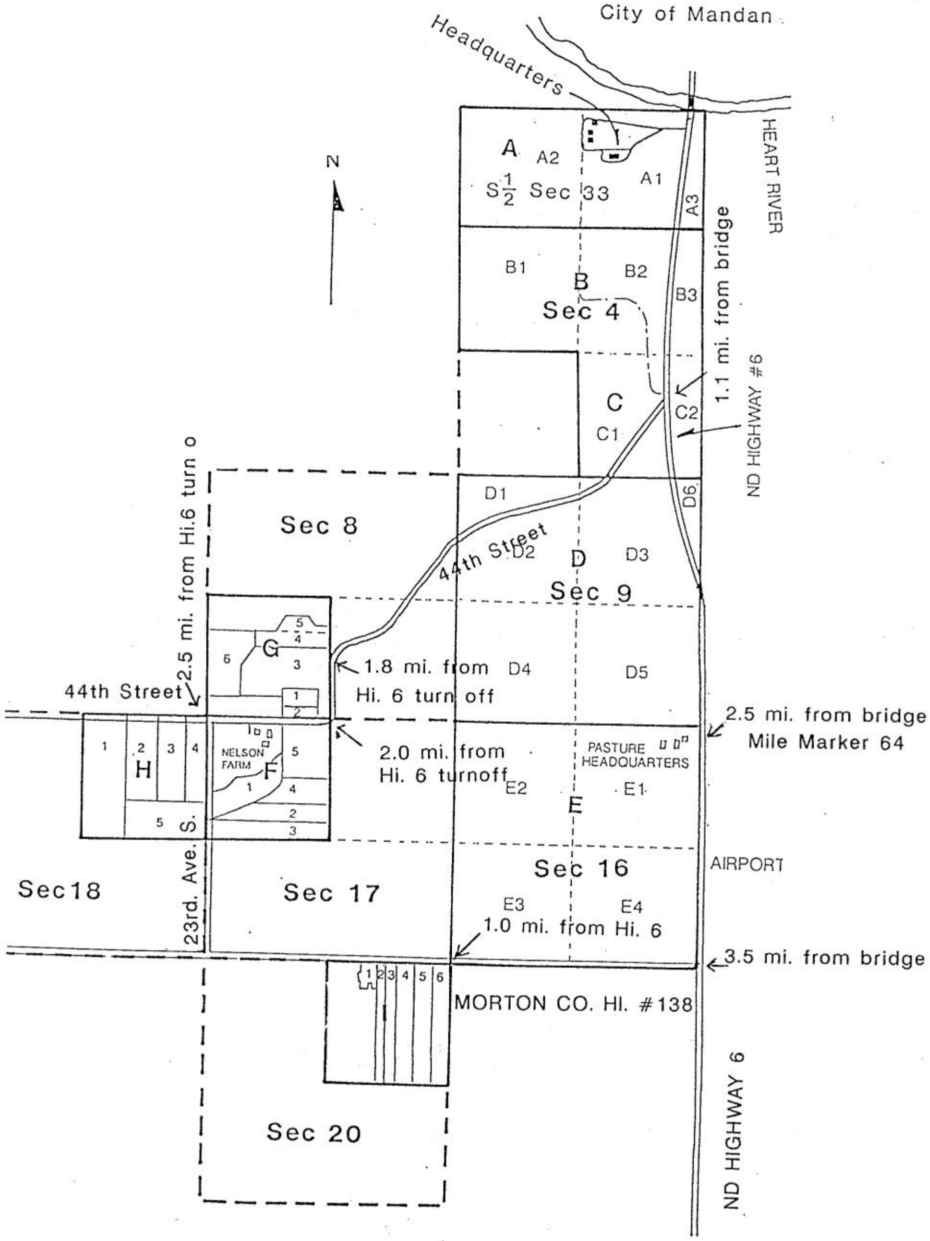
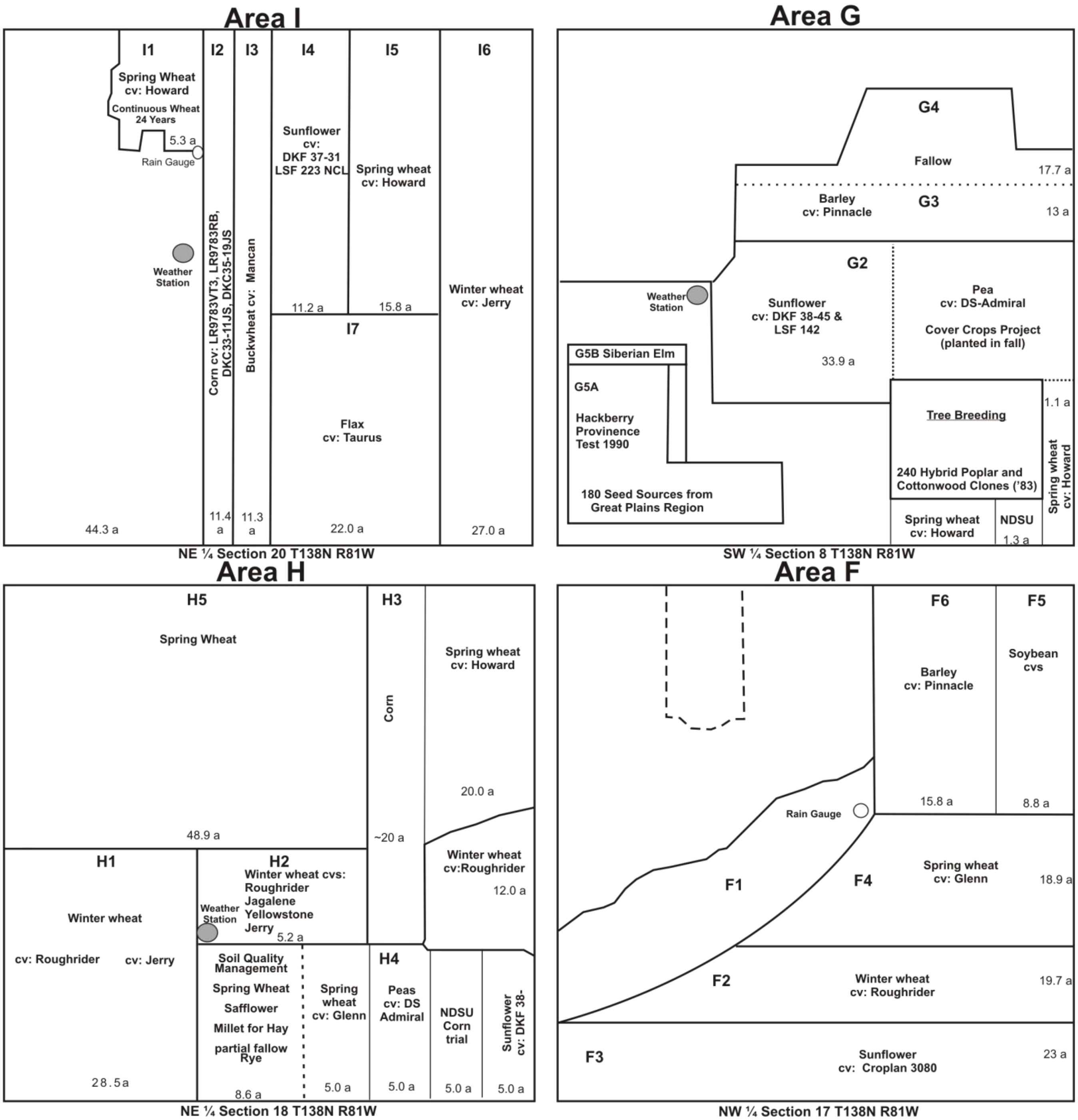
Advisors

Tom Hanson……………….……………	North Dakota Association of Soil Conservation Districts
Scott Hochholter………….…………….	North Dakota Soil Conservation Committee
Alan Ness……………………………….	Manitoba-North Dakota Zero Tillage Farmers Association
Blake Vandervorst………………………	Ducks Unlimited

USDA-ARS LAND RESOURCES (FEDERAL & STATE) A, B, C, D, AND E
AREA IV SCD COOPERATIVE RESEARCH FARM
LAND RESOURCES F, G, H, AND I



Area IV Research Farm
2008 Crop Plan



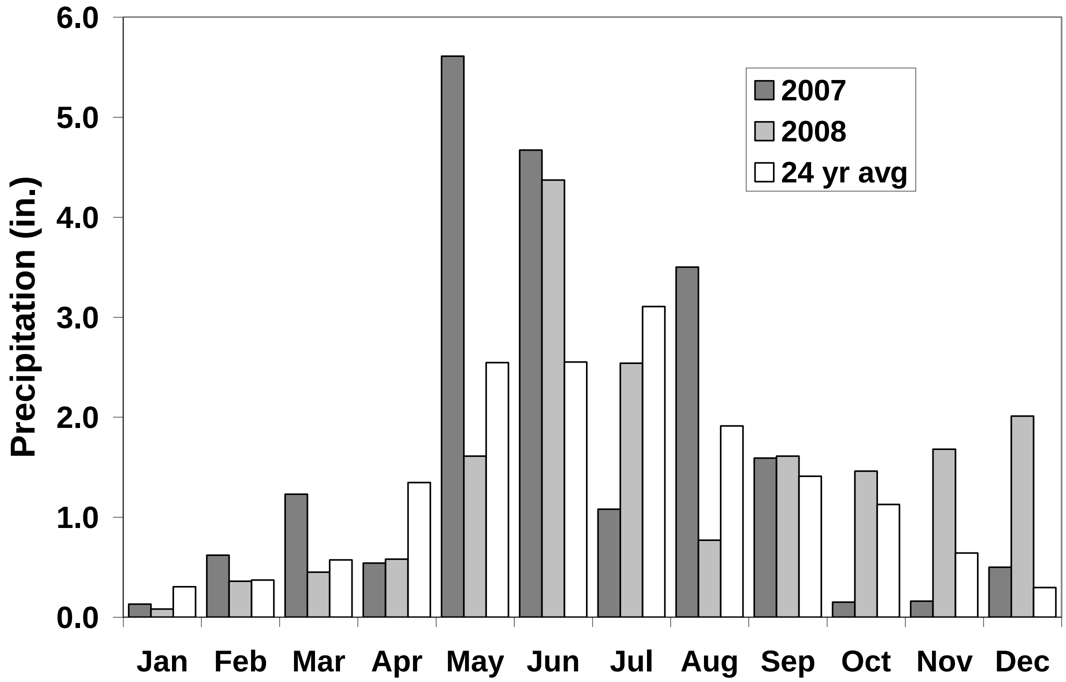


Figure 1. Average monthly precipitation (inches) for 2007, 2008, and long-term at Mandan, ND.

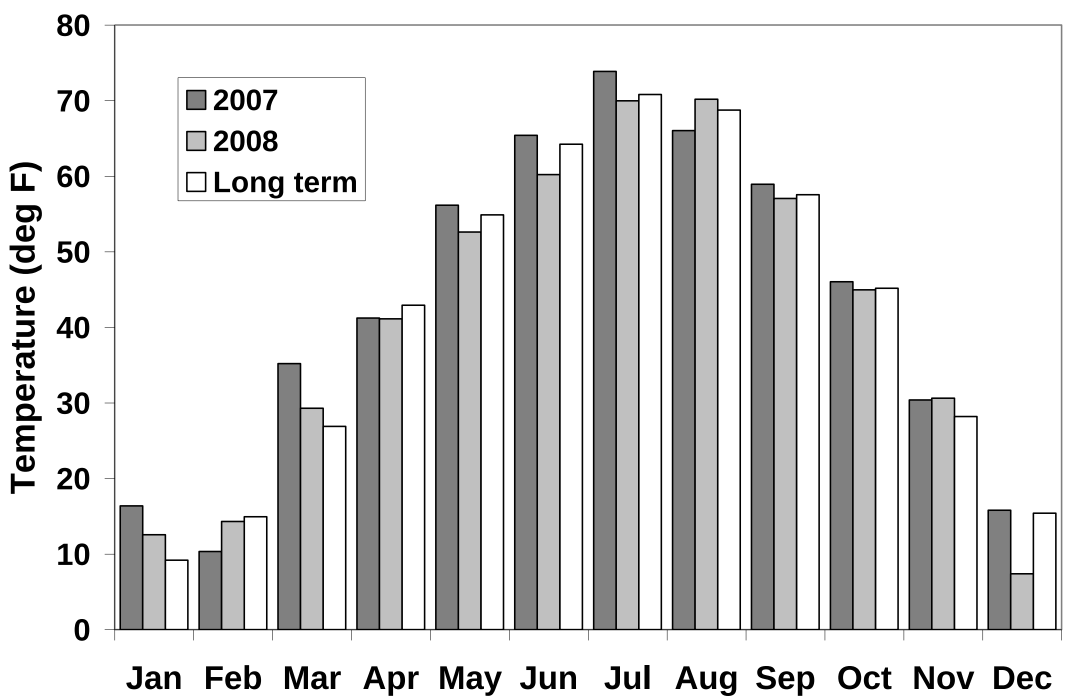


Figure 2. Average monthly temperatures (°F) for 2007, 2008, and long-term at Mandan, ND.

MANAGEMENT PRACTICES – 2008
AREA IV SCD COOPERATIVE RESEARCH FARM

<u>AREA-F FIELD OPERATIONS,</u> NW ¼ Section 17 T138N R81W

FIELD F1 This conservation bench terrace area has been excluded from the total acreage leased by AREA IV SCDs since 1987.

FIELD F2, ROUGHRIDER WINTER WHEAT

Previous crop – Parshall Spring Wheat

09/19/07 Seeded Roughrider winter wheat with Bourgault drill @ 1.3 million viable seeds/ac + 60 lbs/ac 11-52-0.
03/20/08 Contractor spread fertilizer (urea @ 80 lb N/ac).
05/18/08 Sprayed field w/2,4-D LV6 @ 24 oz/ac.
08/08/08 Field harvested with JD 6620 and straight head, (45.4 bu/ac).
09/15/08 Field sprayed w Roundup RT III @ 32 oz/ac + dicamba @ 4 oz/ac + Request @ 1 qt/100 gal.

FIELD F3, CROPLAND 3080 SUNFLOWERS (seed donated by Cropland Genetics)

Previous crop – Roughrider Winter Wheat

03/20/08 Contractor spread fertilizer (urea @80 lb N/ac).
05/15/08 Contractor sprayed field w/Roundup @ 16 oz/ac + Spartan @ 5 oz/ac + AimEW @ 0.5 oz/ac + Request @ 2 qt/100 gal.
05/20/08 Seeded w/JD Max Emerge II @ 24,000 seeds/ac Cropland 3080.
07/01/08 Sprayed with Arrow (Clethodim 2EC) @ 6oz/ac + crop oil @ 1gal/100gal.
07/22/08 Contractor sprayed field w/Assert @ 16 oz/ac + Induce @ 8.5 oz/ac.
08/14/08 Contractor sprayed for insects w/ AsanaXL @ 8oz/ac + Headline @ 6 oz/ac + Dynamic NIS @ 2 oz/ac + Crop oil @ 2 oz/ac.
09/24/08 Contractor desiccated sunflowers w/Gramozone Intene @ 24 oz/ac + Induce @ 3.5 oz/ac.
10/09/08 Field combined with JD 6620 and all crop head (1239 lb/ac).

FIELD F4, GLENN SPRING WHEAT

Previous crop - Sunflowers

03/20/08 Contractor spread fertilizer (urea @80 lb N/ac).
04/13/08 Contractor sprayed field with Glystar Plus @ 1 qt/ac + Aim @ ½ oz/ac + Request @ 2 qt/100 gal.
04/22/08 Field seeded with Sunflower no-till drill @ 1.3 million viable seeds/ac and 70lbs/ac 11-52-0.
06/10/08 Sprayed field w/Puma @ 10 oz/ac + Bison @ 1.25 pt/ac + Headline @ 3 oz/ac.
08/18/08 Field harvested with JD 6620 and straight head (30.1 bu/ac).
09/15/08 Contractor sprayed field w/Roundup RT3 @ 24 oz/ac + Rifle @ 4 oz/ac + Request @ 3 oz/ac + Induce @ 3 oz/ac.
09/25/08 Planted winter wheat w/Bourgault drill.

FIELD F5, SOYBEAN VARIETIES (seed donated by Legend Seeds and Asgrow)

Previous crop – Parshall Spring Wheat

05/07/08 Sprayed field with Roundup Ultra Max II @ 20 oz/ac + Request @ 1 qt/100 gal. (Roundup donated by Monsanto)

05/19/08 Planted varieties with JD Max Emerge II planter @ 175,000 seeds/ac in 30 in. rows. All seed was inoculated w/Tag Team and half the planter (3 rows) was inoculated with Jump Start, the other half not.

06/30/08 Sprayed varieties with Roundup Ultra Max II @ 16 oz/ac + Request @ 1 qt/100 gal. (Roundup donated by Monsanto)

11/03/08 Varieties and bulk field was harvested with JD 4420 combine w/flex head (average 18 bu/ac; see soybean variety yields, "Summary" following).

FIELD F6, PINNACLE BARLEY (seed and combining donated by Gartner Seed Farm)

Previous crop – Koto Buckwheat

03/20/08 Contractor spread fertilizer (urea @ 80 lb N/ac).

04/13/08 Contractor sprayed field with Glystar Plus @ 1 qt/ac + Aim @ ½ oz/ac + Request @ 2 qt/100 gal.

04/30/08 Field seeded with Amity drill @ 90 lbs/ac and 70 lbs/ac 11-52-0 with seed.

06/10/08 Field sprayed w/Axial @ 8.2 oz/ac + Bison 20 oz/ac + Adigor Adjuvant @ 9.6 oz/ac.

08/21/08 Harvested field by Gartner Seed Farm with straight head (74.7 bu/ac)

09/15/08 Contractor sprayed field w/Roundup RT3 @ 24 oz/ac + Rifle @ 4 oz/ac + Request @ 3 oz/ac + Induce @ 3 oz/ac.

09/25/08 Seeded winter wheat with Bourgault drill @ 1.3 million viable seeds/ac + 70lbs/ac 11-52-20 (cv: Overland).

AREA-G FIELD OPERATIONS, SW ¼ Section 8 T138N R81W

FIELD G1, HOWARD SPRING WHEAT

Previous crop – Sunflowers

03/20/08 Contractor spread fertilizer (urea @ 80 lb N/ac).

04/13/08 Contractor sprayed field with Glystar Plus @ 1 qt/ac + Aim @ ½ oz/ac + Request @ 2 qt/100 gal.

04/22/08 Field seeded with Sunflower no-till drill @ 1.3 million viable seeds/ac and 70lbs/ac 11-52-0.

06/10/08 Sprayed field w/Puma @ 10 oz/ac + Bison @ 1.25 pt/ac + Headline @ 3 oz/ac.

08/20/08 Field was harvested with JD 6620 and straight head (30 bu/ac).

FIELD G2 (WEST SIDE), DKF 38-45 (seed donated by DeKalb) **AND LSF 142 SUNFLOWERS**

Previous crop – Howard Spring Wheat

03/20/08 Contractor spread fertilizer (urea @ 80 lb N/ac).

05/15/08 Contractor sprayed field w/Roundup @ 16 oz/ac + Spartan @ 5 oz/ac + AimEW @ 0.5 oz/ac + Request @ 2 qt/100 gal.

05/21/08 Seeded w/JD Max Emerge II @ 24,000 seeds/ac (both varieties).

07/01/08 Sprayed with Arrow (Clethodim 2EC) @ 6oz/ac + crop oil @ 1gal/100gal.

08/14/08 Contractor sprayed for insects w/ AsanaXL @ 8oz/ac + Headline @ 6 oz/ac + Dynamic NIS @ 2 oz/ac + Crop oil @ 2 oz/ac.
10/01/08 Contractor desiccated sunflowers w/Gramoxone Intene @ 24 oz/ac + Induce @ 3.5 oz/ac.
10/17-30/08 Field was harvested with JD 6620 and all crop head (DKF 38-45, 1600 lb/ac; LSF 142, 1640 lb/ac).

FIELD G2 (EAST SIDE), DS ADMIRAL PEAS (seed donated by Pulse USA) (Cover Crop Project)
Previous crop – Howard Spring Wheat
04/11/08 Seeded with JD 750 drill @ 350,000 viable seeds/ac. Seed inoculated and treated with Jumpstart.
04/13/08 Contractor sprayed field with Glystar Plus @ 1 qt/ac + Aim @ ½ oz/ac + Request @ 2 qt/100 gal.
04/16/08 Rolled field.
05/31/08 Sprayed with Rezult @ 1.6 pt + 1.6 pt/ac + Raptor @ 2 oz/ac + Basagran @ 16oz/ac + Poast @ 16 oz/ac + AMS @ 5 gal/100 gal. + Crop oil @ 0.75 pt/ac.
08/5-7/08 Harvested field with JD 4420 combine w/flex head (41.6 bu/ac).
08/11/08 Contractor sprayed field w/glyphosate @ 24 oz/ac + AMS @ 5 gal/100 gal.
08/20,21/08 Seeded Cover Crops Project.

FIELD G3, PINNACLE BARLEY (seed and combining donated by Gartner Seed Farm)
Previous management - Fallow
03/20/08 Contractor spread fertilizer (urea @ 50 lb N/ac).
04/13/08 Contractor sprayed field with Glystar Plus @ 1 qt/ac + Aim @ ½ oz/ac + Request @ 2 qt/100 gal.
04/29/08 Field seeded with Amity drill @ 90lbs/ac and 70lbs/ac 11-52-0 with seed.
06/10/08 Field sprayed w/Axial @ 8.2 oz/ac + Bison 20 oz/ac + Adigor Adjuvant @ 9.6 oz/ac.
08/21/08 Field was straight combined (74.7 bu/ac).

FIELD G4, FALLOW
Previous crop - Souris Oats
05/15/08 Contractor sprayed field with Roundup @ 16 oz/ac + AimEW @0.5 oz/ac + Request @ 2 qt/100 gal.
07/22/08 Field sprayed with Glystar Plus @ 20 oz/ac + Sterling @ 8 oz/ac + 2,4-D LV6 @ 16 oz/ac + Request @ 1 qt/100 gal.
08/11/08 Contractor sprayed field w/glyphosate @ 24 oz/ac + AMS @ 5 gal/100 gal.
09/19/08 Started seeding Overland winter wheat with Bourgault drill @ 1.3 million viable seeds/ac + 70 lbs/ac 11-52-0 (seeding completed 09/25/08).

AREA-H FIELD OPERATIONS, NE ¼ Section 18 T138N R81W

FIELD H1, JERRY AND ROUGHRIDER WINTER WHEAT
Previous crop – Taurus Flax
09/19/07 Seeded Roughrider Winter Wheat (west half) with Haybuster drill & Jerry Winter Wheat (east half) with Bourgault drill @ 1.3 million viable seeds/ac + 60 lbs/ac

11-52-0.
03/20/08 Contractor spread fertilizer (urea @ 80 lb N/ac).
05/18/08 Field sprayed w/2,4-D LV6 @ 24 oz/ac.
08/06/08 Harvested field (Roughrider, 38.4 bu/ac; Jerry, 49.3 bu/ac)
09/15/08 Field sprayed w/Roundup RT III @ 32 oz/ac + dicamba @ 4 oz/ac _ Request @ 1 qt/100 gal.

FIELD H2, WINTER WHEAT VARIETIES

Previous crop – Tradition Barley
09/20/07 Seeded Roughrider, Jagalene, Yellowstone, and Jerry Winter Wheat with Haybuster 8000 drill @1.3 million viable seeds/ac + 11-52-0 @ 50 lb/ac w/seed.
03/20/08 Contractor spread fertilizer (urea @ 80 lb N/ac).
05/18/08 Field sprayed w/2,4-D LV6 @ 24 oz/ac.
08/13/08 Measured yield with Hege plot combine (see attached).

FIELD H3 WEST, CORN

Previous crop – Sunflowers
04/13/08 Contractor sprayed field w/Glystar Plus @ 1 qt/ac + Aim @ 0.5 oz/ac + Request @ 2 qt/100 gal.
04/01/08 Spread blended fertilizer (62-36-11) with Barber fertilizer spreader.
05/15/08 Seeded Legend LS9584RB with JD Max Emerge II @ 24,000 seeds/ac.
06/21/08 Field sprayed w/Glystar Plus @ 32 oz/ac + Banvel @ 16 oz/ac.
10/28/08 Field harvested w/JD 6620 w/multicrop header (40.8 bu/ac).

FIELD H3 EAST, HOWARD SPRING WHEAT

Previous crop – Soybean Varieties
03/20/08 Contractor spread fertilizer (urea @ 80 lb N/ac).
04/13/08 Contractor sprayed field with Glystar Plus @ 1 qt/ac + Aim @ ½ oz/ac + Request @ 2 qt/100 gal.
04/18/08 Field seeded with Sunflower no-till drill @ 1.3 million viable seeds/ac and 70lbs/ac 11-52-0.
06/10/08 Sprayed east side of field w/Puma @ 10oz/ac + Bison @ 1.25pt/ac + Head Line @ 3oz/ac. Sprayed west side of field w/Puma @ 10oz/ac + Husky @ 15 oz/ac + Headline @ 3oz/ac.
08/19/08 Field harvested (47.0 bu/ac).

FIELD H3 SOUTH (“waterhole”), ROUGHRIDER WINTER WHEAT

Previous crop – Sunflower/Fallow
09/19/07 Seeded Roughrider winter wheat w/Bourgault drill @ 1.3 million viable seeds/ac + 11-52-0 @ 50 lb/ac.
03/20/08 Contractor spread fertilizer (urea @ 80 lb N/ac).
05/18/08 Sprayed field w/2,4-D LV6 @ 24 oz/ac.
08/08/08 Field harvested with JD 6620 and straight head (50+ bu/ac).
09/15/08 Field sprayed w Roundup RT III @ 32 oz/ac + dicamba @ 4 oz/ac _ Request @ 1 qt/100 gal.

FIELD H4, SOIL QUALITY MANAGEMENT
See 'Management Strategies for Soil Quality' on page 20

FIELD H4, GLENN SPRING WHEAT

Previous crop - Safflower

03/20/08 Contractor spread fertilizer (urea @ 80 lb N/ac).
04/13/08 Contractor sprayed field with Glystar Plus @ 1 qt/ac + Aim @ ½ oz/ac + Request @ 2 qt/100 gal.
04/23/08 Field seeded with Sunflower no-till drill @ 1.3 million viable seeds/ac and 70lbs/ac 11-52-0.
06/10/08 Sprayed field w/Puma @ 10 oz/ac + Bison @ 1.25 pt/ac + Headline @ 3 oz/ac.
08/21/08 Harvested field (22.0 bu/ac).
09/18/08 Seeded Roughrider winter wheat with Haybuster drill @ 1.3 million viable seeds/ac + 70lbs/ac 11-52-0.

FIELD H4, DS ADMIRAL PEAS (seed donated by Pulse USA)

Previous crop - Spring Wheat

04/09/08 Field seeded with JD 750 drill @ 350,000 viable seeds/ac and 50 lbs/ac 11-52-0. Seed was inoculated with TagTeam and Jump Start.
04/13/08 Contractor sprayed field with Glystar Plus @ 1 qt/ac + Aim @ ½ oz/ac + Request @ 2 qt/100 gal.
04/16/08 Field rolled.
05/31/08 Sprayed with Rezult @ 1.6 pt + 1.6 pt/ac + Raptor @ 2 oz/ac + Basagran @ 16oz/ac + Poast @ 16 oz/ac + AMS @ 5 gal/100 gal. + Crop oil @ 0.75 pt/ac.
07/28/08 Field harvested with JD 4420 and flex head (appx. 30 bu/ac)
09/15/08 Field sprayed w Roundup RT III @ 32 oz/ac + dicamba @ 4 oz/ac + Request @ 1 qt/100 gal.

FIELD H4 NDSU CORN VARIETY TRIAL

Previous crop - Admiral Peas

03/20/08 Contractor spread fertilizer (urea @ 80 lb N/ac).
04/13/08 Contractor sprayed field with Glystar Plus @ 1 qt/ac + Aim @ ½ oz/ac + Request @ 2 qt/100 gal.
05/6&9/08 Planted experiments 1 and 2 using JD Max Emerge II planter.
06/25/08 Sprayed varieties with Roundup Ultra Max II @ 20 oz/ac + Status @ 5 oz/ac + Request @ 1 qt/100 gal. (Roundup donated by Monsanto)
10/24,31/08 Harvested corn variety experiments (hand harvest; see "Summary" for yields).

FIELD H4 EAST, DKF 38-45 DEKALB SUNFLOWERS (seed donated by DeKalb)

Previous crop- NDSU Corn Variety Trial

03/20/08 Contractor spread fertilizer (urea @ 80 lb N/ac).
05/15/08 Contractor sprayed field w/Roundup @ 16 oz/ac + Spartan @ 5 oz/ac. + AimEW @ 0.5 oz/ac + Request @ 2 qt/100 gal.
05/21/08 Field seeded with JD Max Emerge II planter @ 24,000 seeds/ac.
07/01/08 Sprayed with Arrow (Clethodim 2EC) @ 6oz/ac + crop oil @ 1gal/100gal.

08/14/08 Contractor sprayed for insects w/ AsanaXL @ 8oz/ac + Headline @ 6 oz/ac + Dynamic NIS @ 2 oz/ac + Crop oil @ 2 oz/ac.
10/01/08 Contractor desiccated sunflowers w/Gramoxone Intene @ 24 oz/ac + Induce @ 3.5 oz/ac.
10/30/08 Field harvested w/JD 6620 and all crop head (637 lb/ac).

FIELD H5, HOWARD SPRING WHEAT

Previous crop- Roughrider Winter Wheat
03/20/08 Contractor spread fertilizer (urea @ 80 lb N/ac).
04/13/08 Contractor sprayed field with Glystar Plus @ 1 qt/ac + Aim @ ½ oz/ac + Request @ 2 qt/100 gal.
04/16/08 Field seeded with Sunflower no-till drill @ 1.3 million viable seeds/ac and 70lbs/ac 11-52-0.
06/10/08 Sprayed field with Puma @ 0.5 pt/ac + Bison @ 1 pt/ac.
08/20/08 Harvested field (37.1 bu/ac).

AREA-I FIELD OPERATIONS, NE ¼ Section 20 T138N R81W

FIELD I1, HOWARD SPRING WHEAT (CONTINUOUS SPRING WHEAT 24 YRS).

Previous crop – Steele Spring wheat
03/20/08 Contractor spread fertilizer (urea @ 80 lb N/ac).
04/13/08 Contractor sprayed field with Glystar Plus @ 1 qt/ac + Aim @ ½ oz/ac + Request @ 2 qt/100 gal.
04/15/08 Field seeded with Sunflower no-till drill @ 1.3 million viable seeds/ac and 70lbs/ac 11-52-0.
06/10/08 Sprayed field w/Puma @ 10oz/ac + Bison @ 1.25pt/ac + Head Line @ 3oz/ac.
08/14,18/08 Spring Wheat harvested with JD 6620 and straight head (52.5 bu/ac).

FIELD I2, CORN (LR9783VT3, LR9783RB, DKC33-11JS, DKC35-19JS WEST TO EAST).

Previous crop – Sunflowers
03/20/08 Contractor spread fertilizer (urea @ 80 lb N/ac).
04/13/08 Contractor sprayed field with Glystar Plus @ 1 qt/ac + Aim @ ½ oz/ac + Request @ 2 qt/100 gal.
05/14/08 Seeded corn varieties @ 24,500 kernels/ac with JD Max Emerge II planter.
06/21/08 Field sprayed w/Glystar Plus @ 32 oz/ac + Banvel @ 16 oz/ac.
10/28/08 Corn harvested with JD 6620 and all crop head (see attached).

FIELD I3, MANCAN BUCKWHEAT (seed donated by MinnDak of Dickinson, ND**)**

Previous crop – Tradition Barley
03/20/08 Contractor spread fertilizer (urea @ 80 lb N/ac).
06/11/08 Field sprayed w/Roundup Ultra Max II @ 20 oz/ac + Request @ 1 qt/100 gal. (Roundup donated by Monsanto).
06/16/08 Field seeded with Bourgault drill @ 55 lbs/ac + 70 lbs/ac 11-52-0 with seed.
06/21/08 Field sprayed w/Glystar Plus @ 32 oz/ac.
09/15/08 Swathed field with 20' versatile swath

10/01/08 Buckwheat harvested with JD 6620 and pickup head (1490 lb/ac).

FIELD I4, DKF 37-31 DEKALB (seed donated by DeKalb) **& LSF223NCL LEGEND SUNFLOWERS**

Previous crop – Jerry Winter Wheat

03/20/08 Contractor spread fertilizer (urea @ 80 lb N/ac).
05/15/08 Contractor sprayed field w/Roundup @ 16 oz/ac + Spartan @ 5 oz/ac + AimEW @ 0.5 oz/ac + Request @ 2 qt/100 gal.
05/22/08 Seeded with JD Max Emerge II planter @ 24,000 seeds/ac.
07/01/08 Sprayed with Arrow (Clethodim 2EC) @ 6oz/ac + crop oil @ 1gal/100gal.
09/25/08 Contractor desiccated sunflowers w/Gramoxone Intene @ 24 oz/ac + Induce @ 3.5 oz/ac.
10/01/08 Sunflowers harvested with JD 6620 and all crop head (1816 lb/ac).

FIELD I5, HOWARD SPRING WHEAT

Previous crop – Sunflowers

03/20/08 Contractor spread fertilizer (urea @ 80 lb N/ac).
04/13/08 Contractor sprayed field with Glystar Plus @ 1 qt/ac + Aim @ ½ oz/ac + Request @ 2 qt/100 gal.
04/15/08 Field seeded with Sunflower no-till drill @ 1.3 million viable seeds/ac and 70lbs/ac 11-52-0.
06/10/08 Sprayed field w/Puma @ 10 oz/ac + Bison @ 1.25 pt/ac + Headline @ 3 oz/ac.
08/13,14/08 Spring wheat harvested with JD 6620 and straight head (30.3 bu/ac).

FIELD I6, JERRY WINTER WHEAT

Previous crop – Steele Spring Wheat

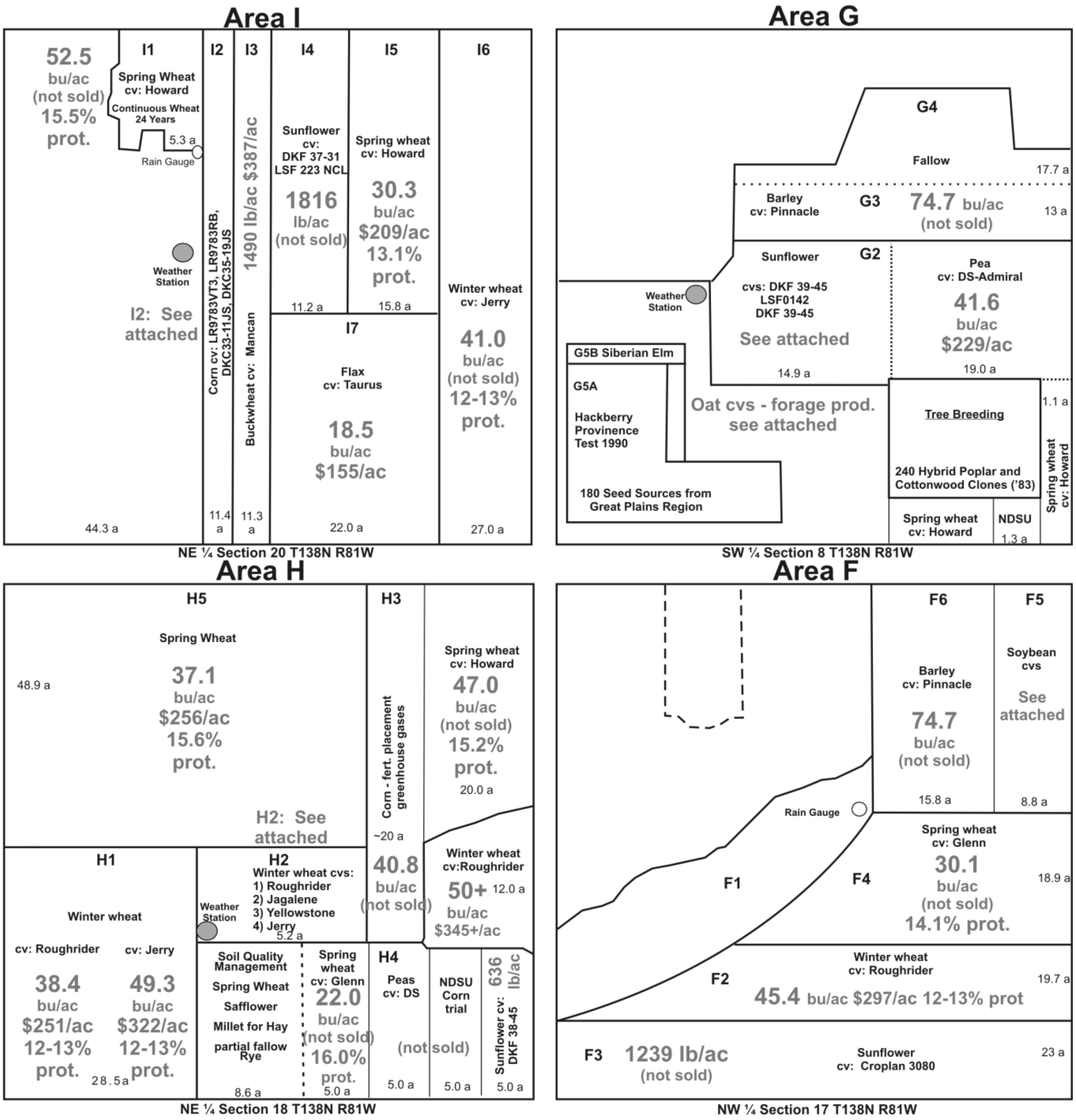
09/20/07 Seeded Jerry Winter Wheat with Bourgault drill @ 1.3 million viable seeds/ac + 60 lbs/ac 11-52-0.
03/20/08 Contractor spread fertilizer (urea @ 80 lb N/ac).
05/18/08 Sprayed field w/2,4-D LV6 @ 24 oz/ac.
07/30/08 Harvested field with JD6620 and straight head (41.0 bu/ac).
09/15/08 Field sprayed w Roundup RT III @ 32 oz/ac + dicamba @ 4 oz/ac + Request @ 1 qt/100 gal.

FIELD I7, TAURUS FLAX (seed donated Dwight Johnson seeds)

Previous crop – Corn Varieties x Conventional/Skip-Row Planting

03/20/08 Contractor spread fertilizer (urea @ 80 lb N/ac).
04/13/08 Contractor sprayed field with Glystar Plus @ 1 qt/ac + Aim @ ½ oz/ac + Request @ 2 qt/100 gal.
04/16,17/08 Field was seeded with JD 750 drill @ 45 lbs/ac
06/16/08 Field sprayed w/Poast @ 16 oz/ac + Superb @ 8 oz/ac + Bison @ 16 oz/ac.
09/16/08 Field swathed w/Versatile 4400 (20 ft. header).
09/25/08 Flax harvested with JD 6620 and pickup head (18.5 bu/ac).

2008 Area IV Research Farm Crop Yields
(Summary)



Summary (continued)

List of Crops Grown in 2008
1. Barley
2. Buckwheat
3. Corn
4. Flaxseed
5. Oats
6. Peas
7. Safflower
8. Soybean
9. Spring Wheat
10. Sunflower
11. Winter Wheat

Cover Crop Project (Field G-2 East)
1. Purple-top Turnip
2. Proso Millet
3. Spring Triticale
4. Soybean
5. Vine Pea
6. Winter Canola
7. Sunflower

NDSU Corn variety trial – Row spacing and population influences on cultivars

Company	Cultivar	Relative Maturity	Yield	Test wt.	Moisture
		(Days)	(bu/ac)	(lb/bu)	(%)
DeKalb	DK 29-97	79	64.1	57.2	13.9
DeKalb	DK 35-18	85	83.9	57.3	14.4
DeKalb	DK 43-27	93	89.7	55.1	16.1
	PH 38-N87	93	88.9	54.2	15.9
	PH 39-D85	87	78.8	55.5	15.5
Legend	LR 9584 RB	84	84.4	57.0	16.3
Legend	LR9792 RB	91	89.2	55.8	18.1
	BAXX RR	75	65.9	58.0	14.1

Summary (continued)

Attached sheet giving detailed yields of crop cultivars tested

Corn varieties (Field I2, not sold)

Company	Variety	Yield (bu/ac)	Moisture	Test wt.
Legend	LR9783VT3	39.7	15.6	53.6
Legend	LR9783RB	22.2		
DeKalb	DKC33-11	40.6	14.1	56.0
DeKalb	DKC35-19	48.0		

Sunflower varieties (Field G2 west, not sold)

Company	Variety	Yield (lbs/ac)	Location
DeKalb	DKF 39-45	1247	north
Legend	LSF 0142	1640	middle
DeKalb	DKF 39-45	1983	south

Winter wheat varieties (Field H2)

Variety	Yield	Moisture	Test wt.	Gross
	(bu/ac)	(%)	(lb/bu)	$/ac
Roughrider	50.3	11.2	55.8	$329/ac
Jagalene	62.6	11.1	57.6	$409/ac
Yellowstone	56.3	11.3	53.1	$368/ac
Jerry	55.8	11.2	53.9	$365/ac

Soybean varieties (Field F5, $7.78/bu, ~150 bu)

Company	Variety	Yield	Moisture	Test wt.	Kernal size
		(bu/ac)	(%)	(lb/bu)	Seeds/lb.
Asgrow	AG0401	20.9	11.5	56.9	4140
Asgrow	AG0604	17.9	10.5	58.5	4400
Legend	LS0746	18.4	10.5	58.6	4580
Legend	LS0528	18.4	11.5	56.9	4700
Legend	LS0406	14.8	11.3	56.8	4430

Application of Jump Start did not influence yield.

Oat forage varieties (Field G-2 west)

Variety		Oat biomass production
		(lb/ac)
Experimental	# 183.05	7146
Experimental	# 223.19	6545
Experimental	# 204	6477
Everleaf 126		6810

2008 Growing Degree Units - from NDAWN

Month	Wheat base	Avg/Normal	Corn base	Avg/Normal
May	625	735	235	292
June	873	984	370	445
July	1197	1182	625	624
August	1144	1144	619	586
Total	**3839**	**4045**	**1849**	**1947**

MANAGEMENT STRATEGIES FOR SOIL QUALITY – 2008

Drs. Donald Tanaka and Mark Liebig (Steve Merrill and Joe Krupinsky – retired)

Treatments (minimum- and no-till for each rotation):

1. Continuous spring wheat (CSW+); straw chopped and spread
2. Continuous spring wheat (CSW–); stubble left in place, straw removed
3. Spring wheat – millet for hay (SW-M)
4. Spring wheat – safflower – fallow (SW-S-F)
5. Spring wheat – safflower – rye (partial fallow, cover crop) (SW-S-R)
6. Spring wheat – fallow (SW-F)

Crop	Planting	Cultivar/ type	Planting rate – viable seeds/ac	Fertilizer – Urea & 0-44-0	Drill	Harvest
Spring wheat	4/29/08	Parshall	1.3 million	60 lb N/ac recrop; 30 lb N/ac fallow + 10 lb P/ac.	JD750	8/12,13/08 sampled & harvested
Safflower	4/29/08 6/10/08 (replantd)	Montola 2003	300,000	60 lb N/ac + 10 lb P/ac	JD750	9/22/08 hand sampled
Rye	9/28/07	Dacold	1.3 million	50 lb/ac 11-52-0	Haybuster 8000	6/16/08 sampled 6/16/08 sprayed 6/25/08 tilled
Millet (hay)	6/10/08	Manta – Siberian red	4 million	60 lb N/ac + 10 lb P/ac as 11-52-0	JD750	8/11/08 sampled 8/13/08 swathed

Residue from previous crops was uniformly distributed at harvest. All no-till plots were sprayed on April 23, 2008 with Roundup Ultra MaxII @ 20 oz./ac + Aim @ 0.5 oz/ac prior to seeding while minimum-till plots were tilled with an undercutter about 3 inches deep prior to seeding. Spring wheat, safflower, and millet were seeded with a JD 750 no-till drill with N fertilizer banded at seeding and P applied with the seed at seeding on April 29, 2008. Spring wheat was harvested on August 13. Millet was swathed for hay on August 13, and safflower was hand-harvested on September 22. Sprayed wheat and millet stubble on September 16 with Glystar Plus @ 24 oz/ac + 2,4-D ester @ 16 oz/ac.

Summary:
1. Growing season precipitation (May through August) for 2008 was about 94% of the long-term average (9.92 inches)
2. Cool May and June temperatures slowed crop development of wheat and resulted in safflower having to be replanted on June 10.
3. Spring wheat yields were lowest for CSW+ and CSW- treatments.
4. Rye biomass was 68% of the 2007 biomass production and millet for hay was 68% of the 2007 millet hay production. The lower biomass production was a combination of lack of adequate soil water and cool temperatures.

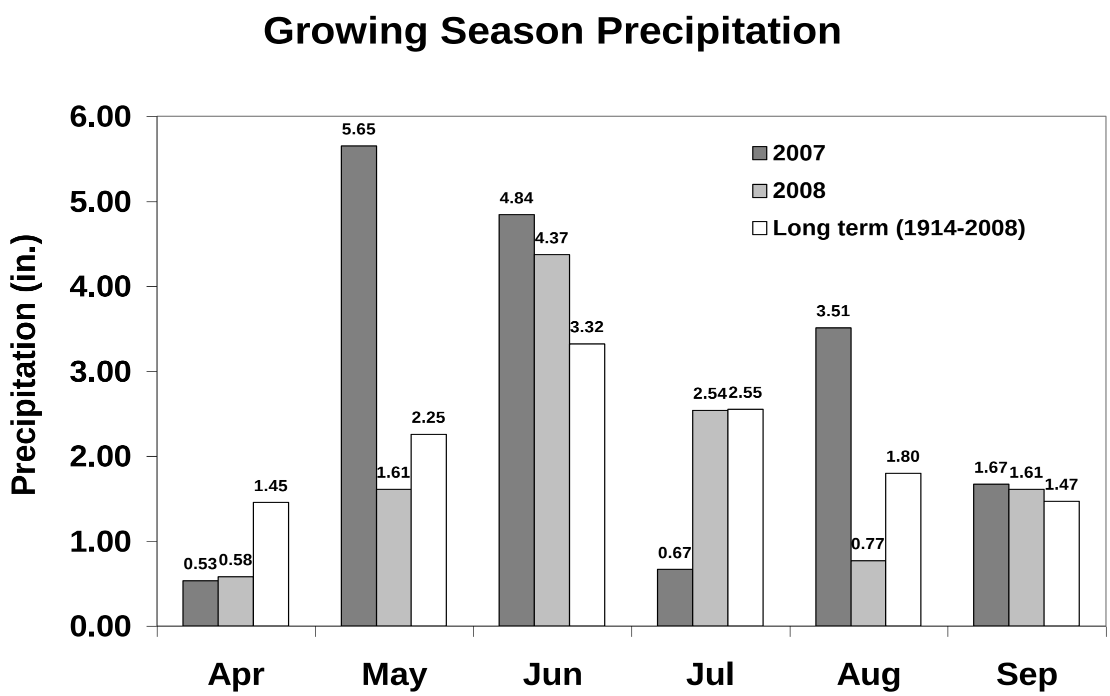


Figure 1. Growing season precipitation (April – September) for 2007, 2008, and long-term average growing precipitation at Mandan, ND.

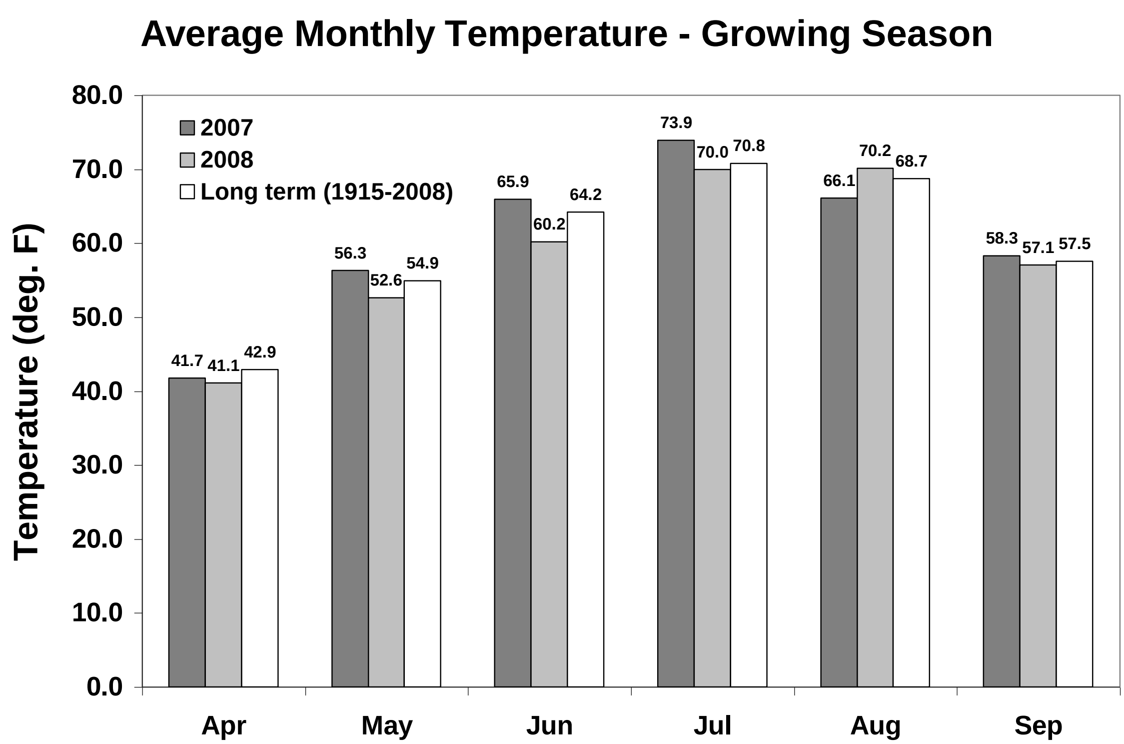


Figure 2. Growing season average monthly temperature (April – September) for 2007, 2008, and long-term average growing precipitation at Mandan, ND.

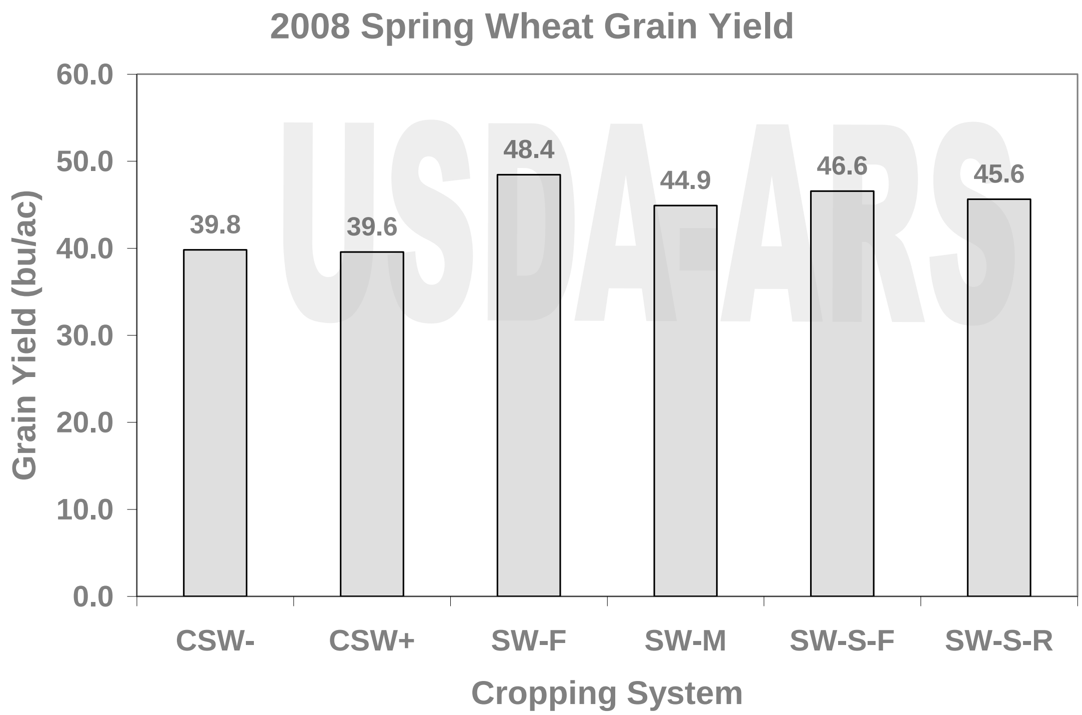


Figure 3. Spring wheat grain yield as influenced by cropping system. Yields are the estimated average of minimum and no-till.

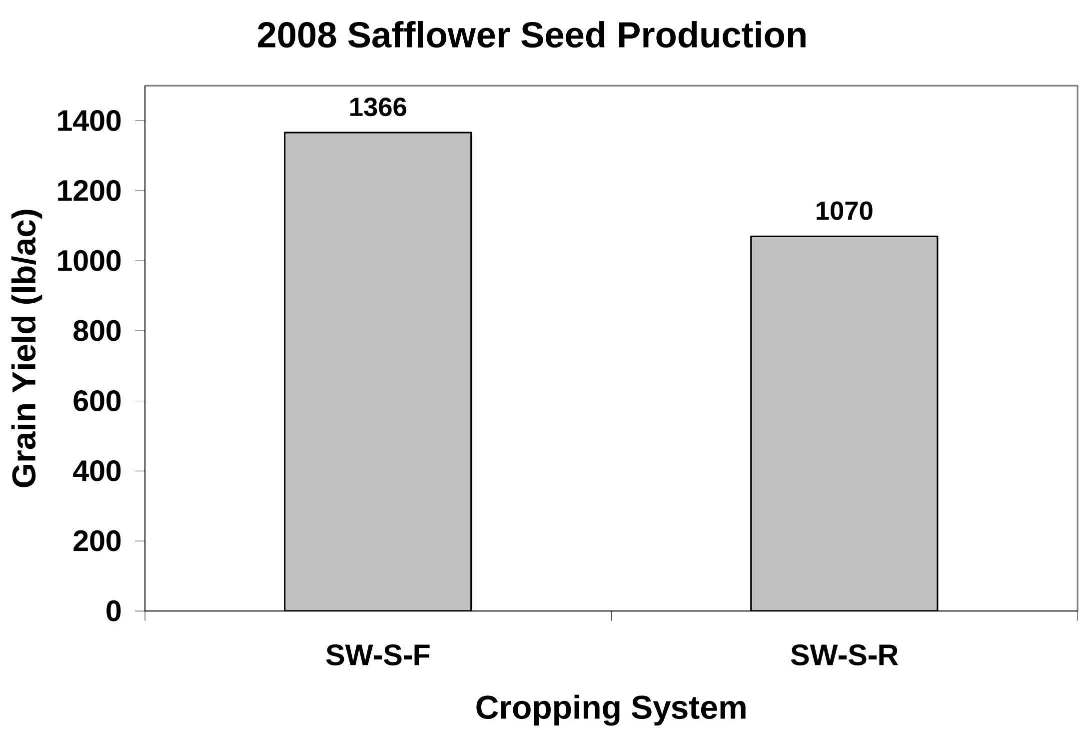


Figure 4. Safflower seed yield as influenced by cropping system. Yields are the average of minimum and no-till.

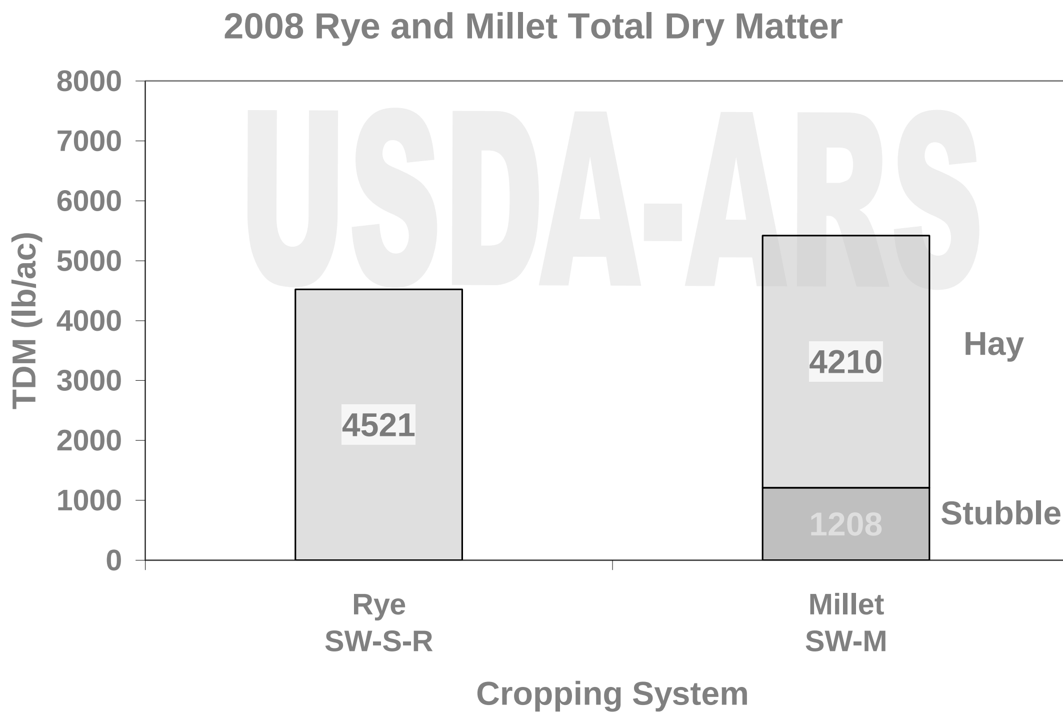


Figure 5. Total dry matter production for rye used as partial fallow and Siberian millet used for hay.

Integrated Crop / Livestock Systems – 2008 Summary

Drs. Don Tanaka, Eric Scholljegerdes, Mark Liebig, Scott Kronberg, Jon Hanson
(Jim Karn and Ron Ries – retired)

Late fall grazing (Phase 2, 1 Aug. – end of Nov.)

Phase II of the Integrated Crop/livestock systems project evaluates the second most critical time period for a cow/calf operation. This time period is from late July through November when native range may not be of adequate quality to maintain the rate of animal weight gain.

Cropping system:
1. Oat underseeded with alfalfa / hairy vetch / red clover.
2. BMR sorghum x sudan underseeded with sweet clover / red clover.
3. Corn for grain and the crop residue grazed.

Oat/hairy vetch/alfalfa/red clover was seeded on April 22 where corn was previously grown (no weeds at seeding). Oats was swathed with a 20' swather on August 6 and swath grazed from September 26 to October 29. Corn was seeded on May 13 where sorghum x sudan was previously grown. Corn was harvested on October 24 with an all-crop head and residue left in a windrow. Corn residue was grazed starting October 29. Sorghum x sudan was seeded on June 17 after two applications of glyphosate two weeks apart. Sorghum x sudan was swathed with a 12' swather on October 17 and swath grazed starting December 10. Grazing ended January 7. Cows and calves grazed oats with only cows grazing corn residue and sorghum x sudan.

Table 1. Crop parameters for 2008.

Crop	Cultivar or type	Planting	Planting rate	Fertilizer	Drill	Swathed / Harvest
Oats	Everleaf	4/22/08	1.0 million viable seeds/ac	30 lb N/ac (urea) 50 lb/ac (11-52-0)	JD750	08/06/08
Hairy vetch	Haymaker plus		7 lb/ac			
Alfalfa / Red clover	Vernal / common		3.5 lb/ac each			
BMR sorghum x sudan	Legend LSS 430 BMR	6/17/08	285,000 viable seeds/ac	60 lb N/ac (urea) 50 lb /ac 11-52-0	JD750	10/17/08
Sweet clover/ Red clover	YB / common		8-10 lb/ac total			
Corn	Legend LR9783 RB	5/13/08	25,380 seeds/ac skip-row	60 lb N/ac (urea) seed treated w/Jump Start	JD Max Emerge II	10/22/08

Table 2. Grazing length, average daily gain, and forage quality.

Cropping system	Days of grazing	ADG (lbs/day)	Protein (%)
			DM basis
Oats*	34	-0.3	11.1
Sorghum sudan	28	-2.0	6.2
Corn	42	0.0	4.8

*Calves were present while grazing oats. Stocking rate was 8 head on 12.6 acres.

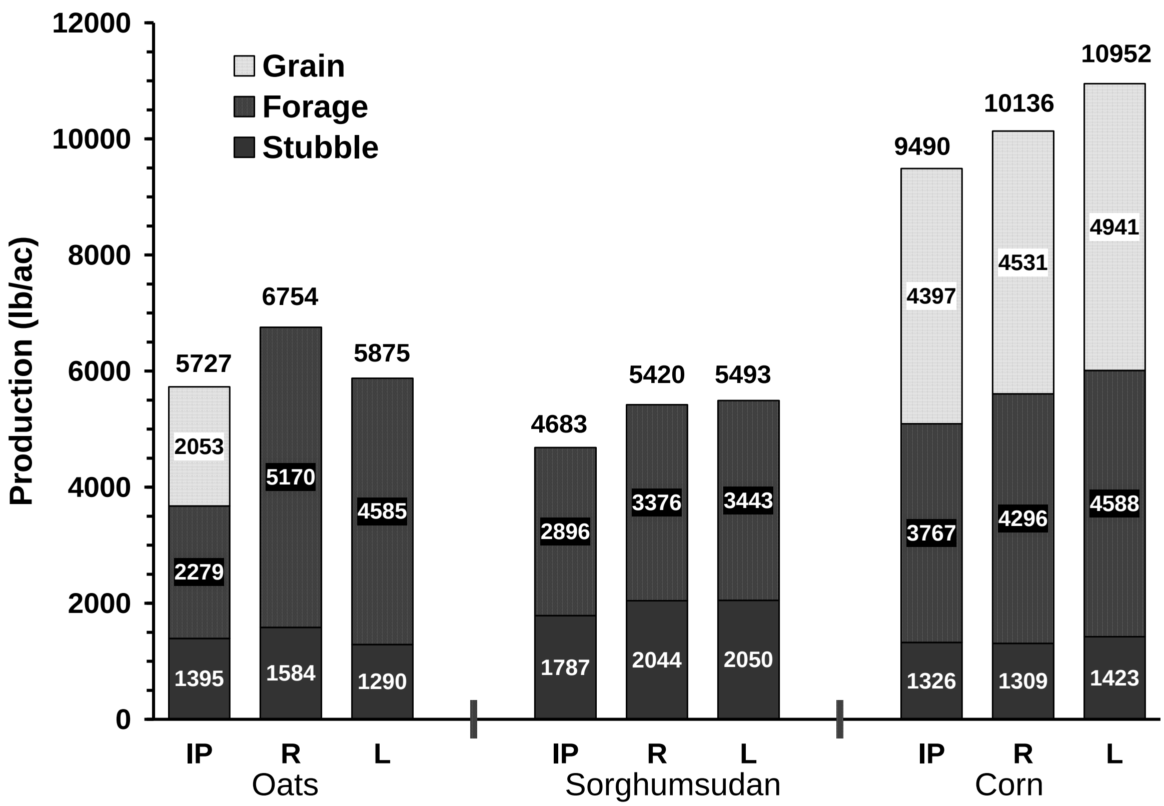
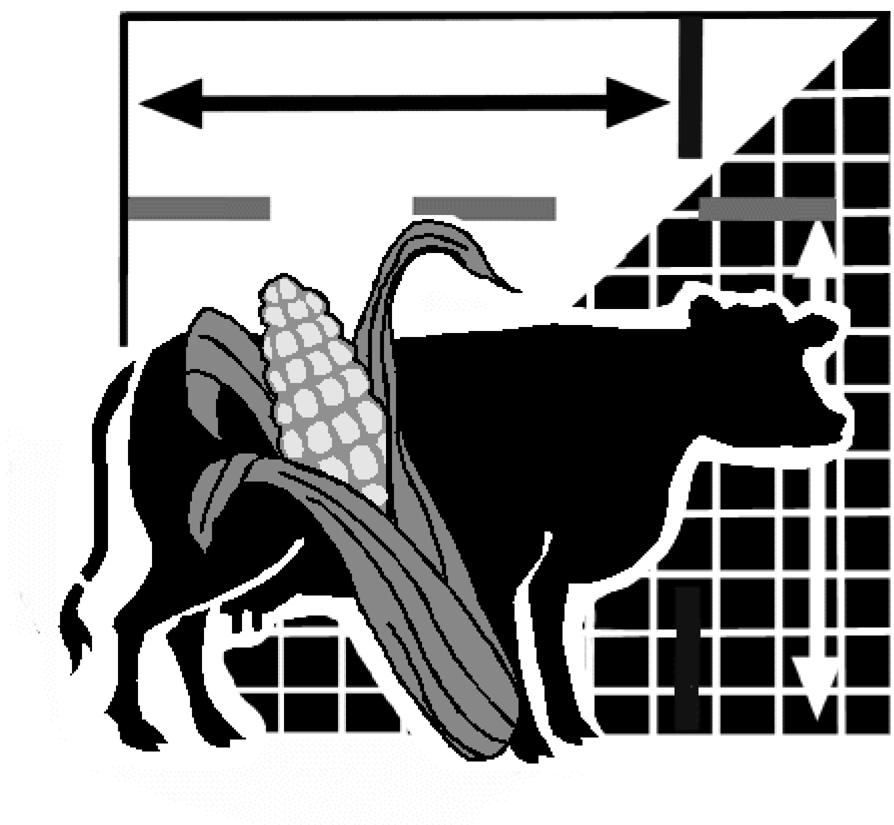


Figure 1. Grain and biomass production of three cropping systems. IP = grain harvested residue left in-place. R = grain harvested residue removed. L = residue or forage swath grazed by livestock.

Summary:
1. Growing season precipitation was 94% of long-term (9.92 inches).
2. Cool temperatures during May and June resulted in slow corn emergence and growth.
3. June rains caused multiple weed emergence patterns in sorghum x sudan and poor emergence of sorghum x sudan.
4. Later than usual frost in October delayed harvest of sorghum x sudan and corn.
5. Cattle can continue to graze through snow, as long as they can find the windrow. However, having an emergency source of forage may be needed if significant snow fall (> 15 inches) is present and cattle have a difficult time finding the windrow or the trampling of snow into the residue causes a reduction in available forage.
6. If strip grazing during cold weather, it is necessary to move fence a greater distance so that cattle will have enough forage available to satisfy the increase in intake associated with colder temperatures.
7. Calves creep grazing oats will out perform calves grazing either bromegrass or Altai pasture.
8. Body Conditioning Score (BCS) can be improved with Annual crops compared to Controls or Altai.



NDSU BioEPIC Energy and Product Innovation Center

AGROECOSYSTEM RESEARCH GROUP AT NGPRL

Sustainable Family Farms in Harmony with the Environment

NDSU BioEPIC Agroecosystems Research Group

Tim Faller, NDSU BioEPIC Agroecosystems Research Group Director

Dr. D.C. Coston, NDSU Vice President for Agriculture and University Extension, and Dr. Jon Hanson, Research Leader at the USDA-ARS Northern Great Plains Research Laboratory, have announced the creation of the NDSU Bio Energy and Product Innovation Center (BioEPIC) Agroecosystems Research Group on the USDA-ARS campus in Mandan, North Dakota.

At NDSU in Fargo, BioEPIC offers its stakeholders a reliable, high-quality, targeted research, education and technology transfer related to biomass production, harvesting, transportation, and conversion.

More than 60 faculty and staff from 15 NDSU departments and research extension centers are already involved in BioEPIC, and the program is continuing to grow. The research involves evaluating biomass species for quality and quantity under different environmental and agronomic conditions to determine appropriate bioenergy crops for biofuel production, and developing ways for farmers to add bioenergy crops to their operations.

The Northern Great Plains Research Laboratory currently collaborates with NDSU researchers in several research programs.

The current major initiative of the Mandan Agroecosystems Research Group is building conceptual awareness of long-term sustainable farming systems. "The USDA-ARS Northern Great Plains Research Laboratory is committed to developing environmentally and economically sound Agroecosystems for the northern Great Plains," says Jon Hanson, Laboratory Director. "This endeavor is too big for a single institution and for that reason our partnership with NDSU provides an outstanding means to maintain and enhance agriculture throughout this region."

The North Dakota Agricultural Experiment Station (NDAES) also will be involved. The NDAES is conducting research at its centers throughout the state, in conjunction with the Northern Great Plains Research Laboratory (see Evaluation of Perennial Herbatious Biomass Crops in North Dakota on Page 64), to develop dedicated energy crops. NDSU scientists who office at the USDA-ARS in Mandan will be committed to also work with and at the NDAES Research Extension Centers throughout the state while accessing USDA scientific expertise for NDSU research collaboration.

"This project will strengthen and enhance ongoing research efforts on dedicated energy crop production," says Coston. "This agreement continues our effort to pull together the full set of capabilities within NDSU and position ourselves to be partners with others, such as the USDA-ARS's Northern Great Plains Research Laboratory, to develop and grow biobased production."

The initial collaboration has two main objectives: (1) Determine appropriate crops to maximize biofuel production; and (2) Develop economically feasible management systems for transitioning in and out of bioenergy crop production.

"Thoughts of an Agroecosystem involve disciplines beyond production agriculture including the social sciences", says Tim Faller, Assistant Director of NDSU Agricultural Experiment Stations and Director of the BioEPIC Agroecosystems Research Group at Mandan. "A current stimulus to this way of thinking would be the emphasis being put on production of crops as feed stocks for energy generation. It is easy to envision many needs of producers as they consider this transition from food production to energy. It becomes even more dramatic when you think of all conversations currently going on over a cup of coffee someplace. That conversation is by no means over and will require much more input from science before change occurs."

According to Faller, North Dakota's northern climate lends itself to the production of many forage crops that can contribute to reduction of United State's energy dependency on petroleum from foreign sources. No one is even sure what the crop will be at the present time. "This is a huge challenge to our mindsets and to North Dakota agriculture." Our current thinking would primarily involve wheat and cattle", he adds. "We will need preparation to make this transition to being energy producers." NDSU and USDA actively collaborating and making rapid progress will positively position North Dakota and the northern Great Plains to help create this industry for family farmers and the economy throughout this region.

USDA-ARS northern Great Plains Research Laboratory CRIS (Current Research Information System) Project

SOIL RESOURCE EVALUATION OF MANAGEMENT SYSTEMS TO ENHANCE AGROECOSYSTEM SUSTAINABILITY

Scientists

Drs. Mark Liebig (Lead), Kris Nichols, Don Tanaka, Rebecca Phillips, Dave Archer, Scott Kronberg, and Marty Schmer.

Objectives

1. Determine the effects of improved cropping systems management to enhance precipitation use and/or soil quality.
2. Evaluate the ability of arbuscular mycorrhizal (AM) fungi to produce glomalin and impact soil aggregation.
3. Evaluate the effects of long-term grazing and dryland cropping management systems on greenhouse gas flux.

Approach

Research at NGPRL conducted within this project includes evaluations of agroecosystem effects on soil, which is a central resource for sustaining both plant and animal production. These evaluations span basic and applied science, address important agronomic and environmental issues, and contribute to improving agricultural sustainability. Specific approaches used in these evaluations include:

1. Develop dryland cropping systems utilizing no-till and minimum-till practices and evaluate their effects on precipitation-use efficiency and soil quality;
2. Assess the effects of crop diversity in on-farm, no-till management systems on soil physical, chemical, and biological attributes over time;
3. Quantify chemical and biological inputs affecting soil aggregation and stabilization;
4. Improve glomalin extraction efficiency over current methodology by decreasing extraction time and eliminating the use of high temperatures; and
5. Determine greenhouse gas intensity for prevalent grazing and cropping system practices through annual monitoring of carbon dioxide, methane, and nitrous oxide flux.

Anticipated products from this research include popular press articles, a web page, peer-reviewed publications, and an email list service. Collectively, these products will serve a broad range of clientele (e.g., agricultural producers, personnel from public and private sector organizations, and scientists), and will contribute to an overall outcome of increased understanding of agroecosystem effects on soil, with the intent of improving agricultural sustainability.

Major Accomplishments for Fiscal Year 2008

Inventory of Important Soil Archive Completed and Disseminated.
Archived soil samples are an important resource for quantifying changes in soil attributes over decadal time scales. An inventory of the NGPRL soil archive was conducted and information about the archive was disseminated in a leading soil science journal. Over 5000 samples are included in the archive, ranging in age from 4 to 90 yr. Samples were derived from both grazing and cropping studies, with the former being conducted near Mandan, and the latter as a part of an evaluation of soil carbon and nitrogen change at multiple locations throughout the Great Plains. Collaborative research opportunities using the NGPRL soil archive abound, and may include characterizations of soil organic matter fractions, micronutrients, and soil acidity.

Liebig, M.A., Wikenheiser, D.J., Nichols, K.A. 2008. Opportunities to utilize the USDA-ARS Northern Great Plains Research Laboratory soil sample archive. Soil Science Society of America Journal. 72:975-977.

Carbon Uptake by CRP Fields Documented Using Ground and Satellite Data.
Data indicating the net amount of carbon removed from the atmosphere for grass fields planted under the Conservation Reserve Program (CRP) are limited by availability of spatially explicit data over multiple growing seasons. Consequently, atmospheric carbon removal and potential carbon sequestration is not factored into CRP cost/benefit analyses or policy recommendations. We developed a method for determining the net exchange of ecosystem carbon using ground and satellite-base data and observed 1500 ND CRP fields over a ten- year contract. We observed 20,620 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.

Phillips, R.L., Beeri, O. 2008. Scaling-up knowledge of growing-season net ecosystem exchange for long-term assessment of North Dakota grasslands under the Conservation Reserve Program. Global Change Biology 14(5):1008-1017.

USDA-ARS northern Great Plains Research Laboratory CRIS (Current Research Information System) Project

RANGELAND AND LIVESTOCK RESOURCE MANAGEMENT

Scientists Supporting

Drs. Scott Kronberg (Lead), Mark Liebig, Jon Hanson, Dave Archer, Kris Nichols, Eric Scholljegerdes, John Hendrickson, and Rebecca Phillips

Objectives

1. Provide management guidelines to improve the conservation and enhancement of agroecosystem function and structure in grasslands of the NGP.
2. Improve the viability of cattle production on the NGP by providing management strategies that increase the efficiency of forage utilization.
3. Develop methods to alter the composition of beef so that it better meets the emerging market demand for healthier beef.

Approaches

An automated rainout shelter will be used to simulate drought conditions and test if early-season water stress and (or) defoliation following water stress will have greater impact on productivity of switchgrass or western wheatgrass or on mixtures of western wheatgrass and alfalfa.

The influence of soil attributes on growth characteristics of perennial grasses will be determined with greenhouse evaluations using soil collected under native vegetation and under severely weed invaded plant communities at four sites between Mandan, ND and Pierre, SD.

Field-based estimates of the greenhouse gases carbon dioxide and nitrous oxide will be used to determine if soil emissions of nitrous oxide offset carbon uptake by moderately grazed mixed-grass prairie.

Satellite-based estimates of plant canopy carbon:nitrogen ratio will be determined for five native rangeland pastures and these estimates will be used to determine if they can be used to estimate forage quality for pastures on the northern Great Plains.

Experiments with cattle will be conducted to determine if supplemental fat and ruminally undegradable protein will improve feed efficiency of grazing cattle, and if supplemental fat that is fed to forage-finished cattle can increase carcass quality and concentration of unsaturated fatty acids in beef.

Trials with cattle will also be conducted to determine if grazing higher quality forages with supplemental flaxseed and (or) forages containing condensed tannin will result in reduced methane emissions per unit of beef produced and greater economic returns.

Other trials with cattle will be conducted to determine if omega-3 fatty acid levels in beef can be raised substantially if fattening yearlings are fed flaxseed or flaxseed oil that is treated to protect the alpha-linolenic acid in it from hydrogenation by ruminal microbes.

Experiments with fistulated and normal cattle will be conducted to determine if restricting dietary intake of forage and supplemental unsaturated fat will not slow growth but will increase the level of unsaturated fatty acids in beef.

Anticipated Products of the Research

- Pasture-scale forage quality decision support tool.
- Greenhouse gas mitigation guidelines for grassland on the northern Great Plains.
- A fact sheet to provide producers with information about defoliation management during and after drought.
- A fact sheet for producers and management agencies describing guidelines to enhance soil attributes to assist in successful rangeland restoration.
- Computer-based guidelines for strategic energy supplementation protocols for cattle on the northern Great Plains.
- Web-based decision support tool to manage factors that influence methane emissions by beef cattle.
- Computer-based guidelines for managing cattle to increase omega-3 and other unsaturated fatty acids in beef.

Major Accomplishments for Fiscal Year 2008

Greenhouse Gas Emissions from Normal and Altered Cattle Urine in Mixed-Grass Prairie

Use of dietary amendments to reduce nitrogen (N) in excreta, such as condensed quebracho tannin, represent a possible strategy to decrease greenhouse gas (GHG) emissions from livestock. We quantified the effects of tannin-affected cattle urine and normal cattle urine on carbon dioxide, methane, and nitrous oxide flux over a six-week period in a mixed grass prairie. Though the tannin urine treatment possessed 34% less N than normal cattle urine, cumulative nitrous oxide emission between the treatments did not differ. Furthermore, methane uptake from the tannin urine treatment was 40% less than the normal urine treatment. Results from this study suggest the use of condensed quebracho tannin as a dietary amendment for livestock does not yield GHG mitigation benefits in the short-term.

Liebig, M.A., Kronberg, S.L., Gross, J.R. 2008. Effects of Normal and Altered Cattle Urine on Short-term Greenhouse Gas Flux from Mixed-Grass Prairie in the northern Great Plains. Agric. Ecosys. Environ. 125:57-64.

Condensed tannin did not protect alpha-linolenic acid from biohydrogenation by ruminal microbes

Enrichment of beef and lamb muscle with omega-3 fatty acids is one means to introduce these fatty acids into the human diet, but ruminal biohydrogenation eliminates much of these fatty acids before they can enter the blood stream and be available for uptake into muscle cells. Therefore, treatment of flaxseed, which contains the omega-3 fatty acid alpha-linolenic acid, with the condensed tannin quebracho tannin was evaluated as a means to protect alpha-linolenic acid from degradation by ruminal microbes. Unfortunately, this treatment did not appear to reduce biohydrogenation of alpha-linolenic acid by ruminal microbes because levels of omega-3 fatty acids were not increased in blood plasma when cattle were fed the tannin-treated flaxseed.

Kronberg, S.L., Scholljegerdes, E.J., Barcelo-Coblijn, G., Murphy, E.J. 2007. Flaxseed Treatments to Reduce Hydrogenation of alpha-Linolenic Acid by Rumen Microbes in Cattle. Lipids 42:1105-1111.

Fat supplementation and reproduction in beef cattle

Many beef cows either do not conceive or do not maintain pregnancy after they are artificially inseminated and this is an expensive problem for beef producers that use artificial insemination to improve the genetic composition of their herds. Therefore, the influence of short-term oilseed supplementation at the beginning of estrous synchronization on the fatty acid profile of blood in lactating beef cows grazing summer pasture was determined. Results from the study suggest that providing fat from either whole soybeans or flaxseed will increase the energy density of the diet and provide cattle with fatty acids key to reproduction during breeding and maternal recognition of pregnancy. In addition, there appears to be a lag phase in which dietary fatty acids become elevated in the blood, more so for flax-fed cattle than cattle fed soybeans. Therefore, producers wishing to use an oilseed to increase the energy density of the diet and provide certain key fatty acids in a relatively short period of time should choose soybeans.

Galbreath, C.W., Scholljegerdes, E.J., Lardy, G.P., Olde, K.G., Wilson, M.E., Schroeder, J.W., Vonnahme, K.A. 2008. Effect of feeding flax or linseed meal on progesterone clearance rate in ovariectomized ewes. Domestic Animal Endocrinology 35:164-169.

USDA-ARS northern Great Plains Research Laboratory CRIS (Current Research Information System) Project

INTEGRATED FORAGE, CROP, AND LIVESTOCK SYSTEMS FOR NORTHERN GREAT PLAINS

Scientists Supporting

Drs. John Hendrickson (Lead), Don Tanaka, Scott Kronberg, Joe Krupinsky, Mark Liebig, Rebecca Phillips, Jon Hanson, Dave Archer, Marty Schmer, Kris Nichols, and Eric Scholljegerdes

Objectives

The long-term goals of this project are to develop agricultural systems that (i) provide a safe, affordable, and nutritious food supply, (ii) help to meet growing energy needs, and (iii) provide environmental services for the Northern Great Plains while maintaining economic viability at the farm level and sustaining rural communities. Information gathered from this research will assist in developing dynamic-integrated agricultural systems that provide sustainable options for producers. Over the next five years, research will focus on the following specific objectives:

1) Determine the environmental and economic impacts of cover crop and cover crop mixtures in semiarid cropping systems.
2) Develop dynamic cropping systems to help meet bio-energy production needs and increase economic returns while enhancing natural resource quality.
3) Develop multiple enterprise systems that integrate crops and livestock to economically optimize the quality and quantity of agricultural products while maintaining or enhancing soil quality indicators.
4) Develop and identify management principles common to integrated agricultural systems across production regions that reduce risks, improve competitiveness, and promote environmental stewardship.
5) Understand the best ways new production technologies and management systems should be delivered so producers can more easily adopt them.

Approach

Research involving integrated agricultural systems is difficult because of the need to understand how different system components work together and quantify the benefits that occur from these interactions. The unique mix of scientific expertise, land resources and customer supports provides NGPRL an opportunity to make valuable contributes in this research area. The first three objectives of this project focus on specific components of integrated agricultural systems while objective four provides a conceptual basis for system development and objective five provides a way to measure the effectiveness of outreach. Approaches for the first three objectives will be multi-disciplinary, field based and applied and will include techniques and methods such as crop matrices, remote sensing, computer modeling, animal performance, soil evaluations and agronomic performance indicators. The last two objectives are more conceptual, use non-traditional techniques and require linkages at the national scale and will incorporate techniques such as panel discussions, web based evaluations and mail and phone surveys.

Anticipated Products of the Research

- Recommendations for including cover crops in annual cropping systems in the Northern Great Plains.
- Decision aid for selecting optimal crop sequences in Northern Great Plains semi-arid environment.
- Criteria for selection, management, and environmental impacts of bio-fuel cropping systems.
- Guidelines for incorporating annual crops as late-summer and fall forage.
- Identification of principles of integrated agricultural systems.
- Assessment of factors and barriers affecting the adoption and retention of research products.

Major Accomplishments for Fiscal year 2008

Biofuel Management Systems
The necessity of meeting more of our nation's energy needs from perennial grasses and other renewable sources requires the development of management systems that ensure sustainable production of sufficient quantities of biomass. Research at the Northern Great Plains Research Laboratory has evaluated the adaptability and yield of switchgrass cultivars at multiple locations in the northern Great Plains, the contribution of switchgrass to carbon sequestration and environmental parameters for germination and establishment of switchgrass and other warm-season grass species. Researchers demonstrated 'Sunburst' switchgrass had the highest and most sustainable yield across multiple field sites, increased soil organic carbon under established switchgrass stands compared to nearby cultivated fields and temperatures of 30C and pH of 6 were optimum for germination and establishment of switchgrass. This information is essential for perennial grasses to be incorporated into agricultural production systems that contribute to renewable energy.

Casler, M.D., Vogel, K.P., Taliaferro, C.M., Ehlke, N.J., Berdhal, J.D., Brummer, E.C., Kallenbach, R.I., West, C.P. 2007. Latitudinal and longitudinal adaptation of switchgrass populations. Crop Science. 47:2249-2260.

Sustainable Forage Management Systems
Intermediate wheatgrass is a high quality, high yielding perennial grass that lacks grazing persistence. Researchers at the Northern Great Plains Research Laboratory (NGPRL) utilized plant breeding techniques and grazing trials to evaluate new and existing intermediate wheatgrass germplasms. This research resulted in the release of 'Manifest' intermediate wheatgrass, a cultivar with exceptional yield and enhanced grazing persistence. When sufficient seed quantities are available, Manifest could have a potential economic impact of up to $10 million annually in the Great Plains by replacing

a portion of approximately 600,000 acres currently occupied by 'Reliant' and 'Manska' intermediate wheatgrasses (600,000 acres and increased yield of 0.3 tons per acre at estimated value of $60 per ton). In addition to work with intermediate wheatgrass, NGPRL has evaluated management scenarios for alfalfa. The development of yellow-flowered alfalfa, (*Medicago falcata)* provides new opportunities for management because of its grazing tolerance. A project evaluating defoliation of hay-type and grazing-type alfalfas indicated that the yellow-flowered alfalfa 'Yellowhead' provided good productivity even under dry conditions. The inclusion of alfalfa into grassland enhanced overall productivity without hurting grass yield.

Hendrickson, J.R., Liebig, M.A., Berdahl, J.D. 2008. Responses of Medicago sativa and M. falcata type alfalfas to different defoliation times and grass competition. Can. J. Plant Sci. 88:61-69.

Integrated Crop/Livestock Management Systems

Integrated crop and livestock systems have potential to enhance the economic and environmental sustainability of current agricultural systems but there is a lack of integrated systems research and publications. Truly integrated crop-livestock research requires a multi-disciplinary cohesive team and scientists must overcome differences of scale, experimental design compromises and statistical challenges. The Northern Great Plains Research Laboratory developed an integrated crop-livestock project that incorporated annual crops into winter feed for beef cows. This research indicated that the use of swathed annual crops reduced the winter feed costs for beef cows by $0.24 per head per day. In addition, trends in the fourth year of the experiment indicated that including livestock may enhance forage and grain production. This research demonstrated that integrated agricultural systems be economically viable as well as enhance agricultural sustainability in the northern Great Plains.

Tanaka, D.L., Karn, J.F., Scholljegerdes, E.J. 2008. Integrated Crop/Livestock Systems Research: Practical research considerations. Renewable Agriculture and Food Systems 23(1):80-86.

VALUE-ADDED ANIMAL PRODUCTION FOR THE NORTHERN GREAT PLAINS

Scientists Supporting

Drs. Chris Schauer and Jon Hanson

Objectives

The objective of this cooperative research agreement is for the University, through its Hettinger Research Extension Center, to cooperate with USDA-ARS in the development of sustainable value-added animal production systems for Northern Great Plains states.

Approach

Novel research addressing alternative feeding strategies for cattle and lambs will be conducted. Specifically, trials evaluating early-weaning strategies for May born calves, use of alternative and local feedstuffs in calf backgrounding and lamb finishing (dried distillers grains and corn gluten), and lamb finishing trials evaluating human health implications (Se-fortified meats) will be evaluated. Results from research trials will be integrated with a comprehensive educational program in an aggressive plan of technology transfer directed at individual producers. Furthermore, continual assessments of current activities will attempt to measure direct impact at the producer level and subsequent impact on rural communities.

Progress Report

- Evaluation of three different feeding management strategies on cull cows for 100-day feed period to add more white fat and improve quality grades prior to cow slaughter was completed in mid Feb. 2008.
    - The three feeding strategies evaluated include:

        1. High energy (60 Mcal NEg) corn based control diet.

        2. Local finishing diet using barley grain and barley silage (57 Mcal NEg).

        3. Self feeder finishing diet using a commercial modified intake system (Purina Impact product).

- Evaluating environmental and economic consequences of multiple-use management of agricultural lands in the northern Great Plains.

- Evaluated time of weaning on May-born calves raised under both natural and conventional production practices is ongoing.
    - Four treatments were investigated in this study:
        - Early wean-natural production.
        - Early wean-traditional production.
        - Normal wean-natural production
        - Normal wean-conventional production.
    - Currently, calves are being finished at NDSU Carrington Research and Extension Center.
- Evaluated feeding of varying levels of dried distillers' grains (DGS; 0, 20, 40 and 60% inclusion) in lamb finishing diets and its impact on lamb health, finishing performance and carcass characteristics.
    - Final weight, ADG, gain efficiency, mortality, hot carcass weight, leg score, conformation score, fat depth, body wall thickness, ribeye area, quality grade, yield grade and percent boneless closely trimmed retail cuts were not affected by treatment.
    - Intake increased in a linear manner as level of DGS inclusion increased.
    - DGS and supplemental thiamin can effectively replace up to 60% of a lamb-finishing ration with no negative effects on feedlot performance or carcass traits.

Publications

B. A. Stoltenow, G. P. Lardy, M. M. Stamm and R. J. Maddock. 2008. Impact of growing rate of gain on subsequent feedlot performance, carcass characteristics, and Warner-Bratzler shear force. J. of Anim. Sci. Vol. 86, e-Suppl. 3: 19. http://jas.fass.org/misc/abstr_proc.shtml.

C. S. Schauer, M. M. Stamm, P. B. Berg, D. M. Stecher, D. Pearson and D. Drolc. 2008. Feeding of 60% Dried Distillers Grains in Finishing Rations Results in Acceptable Lamb Performance and Carcass Quality. NDSU Sheep Research Rep. Hettinger Res. Ext. Center. NDSU Dept. of Anim. Sci. Rep. 49: 3-6.

M. M. Stamm, C. S. Schauer, V. L. Anderson, B. R. Ilse, D. M. Stecher, D. Drolc and D. Pearson. 2007. Influence of Weaning Date (Early or Normal) on Performance, Health, and Carcass Characteristics of May-born Angus Calves. NDSU Beef Feedlot Res. Rep. Carrington Res. Ext. Center. NDSU and ND Agricultural Expt. Sta. 30: 23-28.

COLLABORATIVE LIVESTOCK RESEARCH BETWEEN USDA-ARS AND NDSU HETTINGER RESEARCH EXTENSION CENTER

Scientists Supporting

Drs. Chris Schauer, Scott Kronberg, Eric Scholljegerdes, and Jon Hanson

Objectives

1. Determine if yearling cattle can be grown quickly and possibly fattened for slaughter on the northern Great Plains while obtaining most or all of their feed via grazing.
2. Determine if the cost and environmental impact of wintering cows on the northern Great Plains can be reduced by grazing perennial grasses instead of feeding hay.
3. Determine if the menace of leafy spurge can be reduced by combining livestock grazing and herbicide treatment.

North Dakota State University through its Hettinger Research Extension Center (HREC) will cooperate with the USDA-ARS Northern Great Plains Research Laboratory (NGPRL) on research to accomplish these three objectives.

Approach

Cooperative research will be conducted at the NGPRL to evaluate the hypothesis that yearling cattle can be grown quickly and possibly fattened for slaughter while meeting all or most of their nutritional needs while grazing.

Cooperative research will be conducted to evaluate the hypothesis that winter grazing of Altai and (or) Russian wildrye by cows in their second and third trimester of gestation will substantially reduce the economic and environmental costs of wintering cows on the northern Great Plains compared to wintering similar cows on hay.
Cooperative research will also evaluate methodologies for controlling leafy spurge that combine herbicide application and livestock grazing. Results from research trials will be integrated with comprehensive technology transfer programs directed at producers.

Progress Report

1. Results from the initial trial with yearling cattle indicate that they can be grown and fattened to USDA quality grades of select and low choice while grazing high quality perennial and annual forages with or without small amounts of supplementary grain and (or) oilseeds. These results may only apply to somewhat smaller-framed Angus cattle that weigh 1050 to 1200 lbs when slaughtered.

2. Results were obtained from the initial year of the trials associated with Objectives 2 and 3 of this project, but results from several more years are necessary before conclusions can be made.

SUSTAINABLE SYSTEMS FOR THE NORTHERN GREAT PLAINS

Scientists Supporting

Drs. John Hendrickson, Mark Liebig, Michael Hill, and Soizek Laguette

Objectives

1. Evaluate methodologies to quantify the environmental and economic benefits derived from implementing existing best management practices or new precision agriculture best management practices for minimizing offsite impacts and for increasing yields, including through a retrospective analysis of the added contribution of geospatial data, specifically remotely sensed data, to fields with documented historical cropping practices.

2. Evaluate the added contribution of multispectral and hyperspectral data from ground, airborne, and satellite sensors to grassland restoration studies. Use geospatial technologies to evalute the effectiveness of the various restoration treatments designed to change species composition and renew grassland productivity.

Approach

Results from research will be integrated with other available information and data to develop the capacity for farmers, ranchers, and other land managers to use remote sensing technology to develop site-specific best-management practices.

Progress Report

1. Switchgrass has become an important component in the development of agricultural systems that incorporate biofuels component in a cropping system.

2. Results from this work show that suitability of a region for switchgrass is dependent on agro-meteorological and soil conditions.

3. The addition of a variable winter minimum temperature in the decision tree brought additional precision to the classification. These results are consistent with the North Dakota climate and land-use patterns. A first map of the potential zones for switchgrass production in North Dakota has been developed. However the research needs to be deepened and refined at several levels.

4. In order to be more accurate, agro-meteorological data and derived products such as Growing Degree Day should be on a weekly time frame.

5. Soil data need to be refined and information such as soil structure and soil pH should be considered in order to get better information on soil water holding capacity.

6. A snow cover layer should be added to take into account the actual risk of winter injury and the potential decrease of survival percentage associated to it.

EVALUATION OF PERENNIAL HERBACEOUS BIOMASS CROPS IN NORTH DAKOTA

Scientists Supporting

Drs. Kris Nichols, Mark Liebig, and Mr. Arnie Kruse

Objectives

The objectives of this project are to establish 18 research/demonstration plots at six locations in North Dakota and to collect baseline soil quality data.

These plots will be used in a ten year project to obtain the following information for producers in North Dakota and the northern Great Plains:

1. The most appropriate herbaceous bioenergy crop.
2. The impact of annual and bi-annual harvests on biomass yield and maintenance of stands.
3. The economics of producing a dedicated bioenergy crop.
4. The soil carbon storage potential.
5. The impact of alfalfa on stand yield and maintenance (i.e. nitrogen fertilization), and chemical composition.

Approach

Soil samples will be collected using a deep core probe and divided into seven depths (0-5, 5-10, 10-20, 20-30, 30-60, 60-90, and 90-120 cm).

These samples will be processed for gravimetric water content and soil bulk density prior to air-drying for soil quality parameters or subsampling for two major pools of glomalin (citrate-extractable and recalcitrant) and water-stable aggregation (WSA).

Glomalin and WSA will be evaluated for the top three surface depths, while the other soil quality parameters will be measured on all seven depths.

Soil quality measurements include electrical conductivity, soil pH, total carbon and nitrogen, soil inorganic carbon, particulate organic matter, and extractable nitrate and phosphorus.

Soils data from the various treatments will be compared within and across location using PROC MIXED in SAS (SAS Institute, 1990).

Multivariate analyses will be used to identify inherent and management-related factors contributing to enhanced soil quality under bioenergy crops.

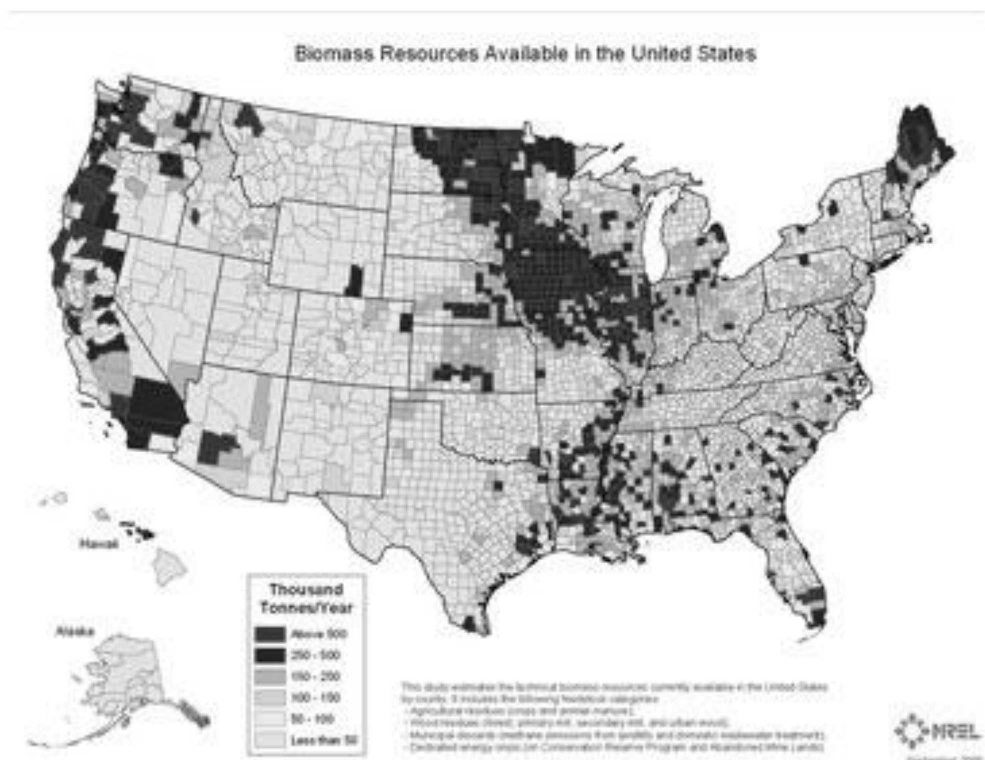
Progress Report

1. The carbon storage potential of perennial biofeedstocks is being evaluated at five locations throughout North Dakota over a period of ten years.

2. During the reporting period, laboratory analyses for water-stable aggregation and glomalin were completed on the baseline soil samples collected in May 2006.

3. Results were summarized by location and shared with collaborators.

4. These data sets will be used to assess changes in soil condition as well as calculate soil carbon accrual/loss rates following subsequent samplings in 2011 and 2016.



Toward a Sustainable Agriculture

Dr. Jon Hanson, Research Leader
Northern Great Plains Research Laboratory

Future trends in population growth, energy use, climate change, and globalization will challenge family farmers to develop innovative production systems that are highly productive and environmentally sound. Future farming systems must possess an inherent capacity to adapt to change to be sustainable.

Through a commitment of the U.S. agricultural community, this challenge can be met and family farmers can lead the way toward a sustainable future.

Agriculture Has Been Very Successful in Meeting the Needs of Most of the World's Population.

Today's agriculture feeds a population of six billion people using less than ½ acre of land per person. Despite such impressive achievements, there are concerns about the sustainability of modern agriculture. Intensive agriculture impacts the resource base and potentially reduces both its capacity and its sustainability. In the Great Plains, many cropping systems are characterized by a lack of diversity and declining soil organic carbon.

Sustainable Agricultural Systems

Agricultural systems need to be developed that are sustainable and adaptable to change, yet maintain their productivity. Most family farmers do not develop and use management systems that are designed to be unsustainable. Land managers have difficulty discerning between sustainable systems and those that are not.

Sustainable agriculture balances the need for essential agricultural commodities with the necessity of protecting the physical environment and public health, the foundation of agriculture. Future agricultural sustainability will be impacted by industrialization, global markets, energy supply, and water shortages.

Impact of Industrialization

Industrialization of agriculture leads to increasing farm consolidation and vertical integration in food, bioenergy, and industrial raw material production systems.

To see and understand more fully the intent of industrialized farming, we must examine its philosophies: (1) nature is a resource to be exploited and variation is to be suppressed; (2) natural resources are not valued except when a necessary expense in production is incurred; (3) progress is equivalent to the evolution of larger farms and depopulation of farm communities; (4) progress is measured primarily by increased material consumption; (5) efficiency is measured by looking at the bottom line; and (6) science is an unbiased enterprise driven by natural forces to produce social good.

Three Major Areas of Concern Regarding Industrialization of Agriculture

The first concern is ecological. In the industrial model, declining soil productivity, desertification, water pollution, increasing scarcity of water, increasing pest pressures, and rapid global climate change are viewed as negative impacts only if they have a direct cost to the production system. The second is the socio-economic concern. Issues include increased federal regulation, disparate family farmer incomes, disappearance of the mid-sized farm, and urban sprawl. Once again, without a direct cost to the production system, or an overriding social consequence, the industrial model does not view these changes in agricultural systems as losses or problems. The third is the human health concern. These issues include overuse of antibiotics in animal production, nitrate and pesticide contamination of water and food, and release of toxic residues into our food and fiber supply.

There is an alternative to the industrialization model for family farmers. Many farmers and ranchers are implementing management focused on keeping native grasses abundant and healthy. These managers see themselves as caretakers of the land, thus they value plants, wildlife, and even predators, but they are family farmers first. They tend to think of themselves, not as commodity-producing businessmen, but rather as whole-ecosystem stewards. Livestock are considered tools used to manage the enterprise.

Impact of Global Markets

Family farmers are competing in an increasingly global marketplace. Twenty-first century agriculture is likely to be characterized by: more global competition; expansion of industrialized agriculture; production of differentiated products; precision production; emergence of ecological agriculture; formation of food supply chains; increasing risk and more diversity. In agriculture of the future, successful family farmers will need to be better, faster, *and* cheaper to have a sustainable competitive advantage. This approach, however, only considers bottom-line economics as the measure for sustainability.

Expansion of trade and faster information flow through the internet are converging to create a new worldwide farm and food system. This new era is being fueled by at least five major issues: (1) finance, technology, and information are being democratized; (2) the internet has empowered global information dissemination and increased the speed of information dissemination; (3) the basic human desire for a better life has emerged at the root of globalization; (4) an increased role of world governments in developing policies that allow their agricultural sectors to become competitive in the global agricultural marketplace by becoming more efficient and offering higher quality service; and (5) opportunities have evolved through international trade to improve consumer health, provide consumer choices, and increase producer income.

Seven outcomes of globalization that will affect family farmers, include: (1) development of domestic policies that directly support international deals are in the best interest of corporate agribusiness; (2) disappearance of middle sized farms and loss of independent ownership; (3) unprecedented mergers, acquisitions, and concentration in all stages of agricultural production, marketing, and retailing; (4) more control of agriculture by fewer representatives; (5) increased agricultural industrialization leading to water, soil, and air pollution and overproduction leading to lower prices for independent producers; (6) a shift in land ownership and land availability, particularly away from minority-owned operations; and (7) the World Trade Organization placing more power and profits into the hands of transnational corporations.

Impact of Fossil-Fuel Energy Use

The use of fossil fuels in agriculture has greatly impacted agriculture. Escalating price of fuel has increased everything from transportation costs to fertilizer costs to feed costs. At the same time, high transportation costs have limited some attributes of industrialization, because high fuel costs mean that large firms can not simply ship either feed or product to areas of low labor costs.

Future family farmers will no longer focus solely on food and feed markets, but will produce for other outlets like energy and industrial uses. Use of a biofuel crop within an integrated system adds not only to farm diversity, but also contributes to the rural community. Selling starch (corn or dry peas) or lignocellulosic material (switchgrass or big bluestem) certainly gives the producer an added economic incentive.

In a base-line project conducted on marginal cropland, switchgrass was found to produce 540% more renewable energy than nonrenewable energy consumed. Managed correctly, average greenhouse gas emissions from cellulosic ethanol derived from switchgrass were 94% lower than estimated emissions from gasoline. Some 83% of the average U.S. household's carbon footprint for food consumption comes from production, while only 11% and 5% come from transportation and retailing, respectively.

Impact of Water Shortages

Humans use about 26% of terrestrial evapotranspiration and about 54% of available runoff. With increasing global population, water availability is decreasing throughout the world. Such water shortages are leading to vast areas being affected by desertification. Agriculture is the leading source of impairments in U.S. rivers and streams, because of fertilization, pesticide use, sedimentation, and animal activity (through manure impacts on N, P, and pathogen loads). Animal-based production enterprises need to manage for water conservation and healthy vegetation.

A Potential Solution

Full integration of livestock and cropping systems may help in slowing or reversing some of the detrimental environmental and sustainability issues associated with agriculture. Traditionally, family farms with livestock used animal manure in crop production and feed grains in animal production. Integration of livestock and cropping systems had benefits of enhancing nutrient cycling efficiency, adding value to grain crops, and providing a use for forages and crop residue. Crop producers with livestock traditionally raised a greater diversity of crops in rotation and livestock could convert low quality crop residues or failed crops into higher value protein. Despite these advantages, many farms in the Great Plains have not achieved integrated land use.

Use of forages and other crops in rotation can reduce energy-intensive inputs required by agriculture, enhance yield of subsequent crops, enhance and intensify nutrient cycling and improve soil quality. Use of legumes in rotation can add significant amounts of organic nitrogen to soil, which can be used by subsequent crops.

One often overlooked aspect of sustainability is the ability of family farmers to adapt to change. Farmers need to respond to rapid changes occurring in the agricultural environment by reducing risk, while retaining management flexibility. Holistic management and integrated agricultural systems are approaches, by which whole-farm strategies and technologies are organized, to help producers manage enterprises in a synergistic manner for greater profitability and natural resource stewardship. In the past, U.S. agriculture was focused solely on its ability to produce sufficient food and fiber to meet national and global demands. Agriculture has been largely successful in meeting these production demands.

What Does the Future Have in Store for U.S. Agriculture?

The driving factors for the near future in agriculture have been put in place. The U.S. Farm Bill has historically dictated the types of crops farmers produce and thereby drives the production practices employed. Despite changes in legislation over the past decade, the Farm Bill will probably maintain its major role to drive agricultural production. Crop insurance appears to stifle diversity, but it has been helpful to stabilize market signal demands for specific crops. Ultimately, this leads to competition between agricultural producers and other programs for federal funds. Increased competition for limited federal funds in combination with international trade issues are likely to result in changes to farm programs.

The majority of the current U.S. population is one or more generations removed from farming. This means the public has less direct connection to issues involved in agricultural production; but they still have a strong demand for perceived benefits from environmental stewardship. Consumers may not be well informed, but they are discerning. This will bring to the forefront such issues as product identity preservation, designer crops (i.e., biotechnological crops developed to meet specific criteria defined by the consumer), improved quality (especially in relation to health issues), and organic production (reduced use of chemical pesticides and fertilizers). These demands for environmental stewardship and food quality characteristics are likely to shape future agricultural policy and to be reflected in the marketplace.

Family farmers are looking for additional economic opportunities and are becoming more market astute. This will result in an increase in multiple farm enterprises within a single farm operation, development of other forms of income-generating operations (i.e., hunting, fishing, site-seeing, etc.), and flexibility to generate an alternative array of products. Changes in agriculture and public demand will benefit grazing and integrated crop livestock operations, in addition to other aspects of sustainable agriculture, by providing an environmentally sustainable agriculture that provides multiple income streams to the producer, while providing socially acceptable land management.

Cattle and Beef Production with Less Grain

Dr. Scott Kronberg, USDA-ARS Animal Scientist

High oil and grain prices are creating a challenging environment for cattle and beef production. This environment is likely to become more challenging in the future especially for cow-calf producers.

To increase sustainability of cow-calf producers in the northern Great Plains, Dr. Scott Kronberg, NGPRL Animal Scientist, says even more production costs must be driven out, or more value derived from production. With the frugal nature of cattlemen, little unproductive expense remains to be excised. For cattlemen to improve ranch profitability, they may need to raise calves to much closer to slaughter weight than they have in the past to realize profit normally gained by finishing feedlots.

The current thinking by many in the cattle industry is that there may be a significant cost advantage to grow cattle with more forage and less grain. Mainstream cattle producers interpret this to mean that the stocker sector will become more important and cattle will enter feedyards at heavier weights and spend less time on high-concentrate rations before slaughter. A much smaller segment of the industry, the grass-finished producers, interpret this to mean business as usual. However, there is a third way to grow and finish yearlings that requires much less concentrate feeding. Only small amounts of concentrate supplement diets primarily composed of high-quality forage. These diets can grow yearling steers at two to three pounds per day at a lower cost than high-concentrate rations, which typically grow yearlings at three to four pounds per day.

The more yearlings harvest their own feed via grazing, the lower the cost of gain may be. Cattleman increase ownership cost by holding cattle longer, but also reduce cost per pound of gain through less expensive feeds consumed.

How does one turn weaned calves into finished yearlings (i.e., from about 600 to 1200 or 1300 pounds and grading high select or choice) with high quality forage and only small amounts of concentrate? Select cattle that fatten easier and provide them with high-quality forage to graze during the growing season (May into September), high quality swaths of forage to graze during fall, and feed them high quality haylage or hay the rest of the year. Concentrates can be supplemented at 0.2 to 0.4% of the animal’s body weight without reducing forage digestion by rumen microbes and thus reducing nutrition derived by cattle from high quality forage.

Forage should be 60 to 80% digestible at all times, and with higher crude protein levels (10 to 16%) when the cattle are smaller and growing rapidly, but with lower crude protein levels (8 to 11%) when their growth has slowed considerably, but they still require fattening.

Forage quality levels can be met in spring and early summer by turning cattle on to pastures that are dominated by native or common introduced cool-season grasses and using good grazing management practices. Rotate cattle to a new pasture after they have grazed about 50% of the vegetation. Do not force cattle to eat older, lower quality vegetation that is typically closer to the soil.

In mid- to late-summer, cattle can consume high-quality forage from pastures after regrown from earlier grazing or mowing of cool-season grasses. High quality forage can also occur in pastures that have significant amounts of warm-season grasses such as big bluestem or switchgrass (eastern Dakotas) or blue grama (western Dakotas and eastern Wyoming and Montana), or grazing mixtures of alfalfa and grasses if bloat-prevention management is adequate.

If these strategies are not practical, annual crops may be utilized to grow yearlings at two to three pounds per day. Strip-grazing annual forages such as proso millet and sudangrass has been proven to be an economically viable option.

Strip grazing uses electric fence to limit cattle to only a day or two of forage at a time. They will stomp down some forage regardless of your grazing management. Most crop fields may benefit from the incorporation of this organic matter into the soil. Some may also be carried in the wind if not held tight in stubble.

Kronberg says that growing a legume such as hairy vetch along with an annual grass will improve future soil health and productivity, and enhance the quality of cattle diet.
Late summer and fall can be challenging to provide high quality forage grazing. For semi-arid areas in the northern Great Plains, a mix of warm- season annual grasses and a short-lived legume or two is unsurpassed. This mixture may be cut and windrowed in late September and used for strip grazing into late fall or early winter.

High quality hay or haylage can be made from many annual crops including corn. Cattlemen must carefully evaluate relative feed value and production expense. Corn silage may be excellent for feed production and quality, but cost per ton must be evaluated to optimize cost of production for each unique set of feed production opportunities and operating conditions.

At the Northern Great Plains Research Laboratory, yearling steers gained an additional 1/3 to 3/4 lbs. per day when forage diets were supplemented with concentrates. In 2007, Angus steers that grazed Proso millet in August and September, then grazed cool-season perennial grasses in late September and October, had average unsupplemented daily gains (ADG) of 1.83 lbs., 2.3 lbs. if they were supplemented with about 2 lbs. of ground flaxseed (0.2% of body weight) per day, and 2.39 lbs. (0.28% of body weight) if they were supplemented with a mixture of ground corn and soybean meal that had equivalent levels of crude protein and digestible energy as the flaxseed. There were not statistically significant differences in ADG between the two supplemented groups of steers, but the group of steers that were not supplemented gained significantly less.

Cattle that fatten easily can be finish to high select or choice with high quality forage that is grazed on pastures, fields of windrowed forage, and fed as silage or hay. Rates of gain derived from primarily high-quality forage diets can be improved with small amounts of supplemental concentrates.

Switchgrass May Mean Better Soil

Dr. Kris Nichols, USDA-ARS Soil Microbiologist

In a study at two locations, Dr. Kris Nichols, a microbiologist with the Northern Great Plains Research Laboratory, found that soils with native grasses such as switchgrass have higher levels of glomalin than soils planted to non-native grasses.


Dr. Marty Schmer harvesting Switchgrass

Glomalin is a sugar-protein compound that might assist in formation. The more glomalin in a given soil, the better and less erosion-prone that soil probably is.

In 2004, Nichols collected soil from under grass plots established between 1987 and 2002. The amount of glomalin in the soil increased as the degree of interdependence between plants and the arbuscular mycorrhizal fungi--which produce glomalin and live inside plant roots and the surrounding soil increased. That interdependence is greatest in warm-season native grasses such as switchgrass, blue grama, big bluestem and indiangrass.

Further evidence that soils underneath native grasses are higher in glomalin came from another study on rangeland areas at Mandan and near Platte, S.D.

In an earlier study, Nichols analyzed samples from undisturbed soils with native vegetation in Maryland, Georgia, and Colorado. According to her analysis, glomalin stored a large percentage of the carbon found in those soils and contributed greatly to soil fertility. On average, glomalin stored 15 percent of the soil carbon, with the highest amount, 30 percent, in a Colorado soil and the lowest amount, nine percent, in a Georgia soil. These results are similar to those from other soil samples taken around the world.

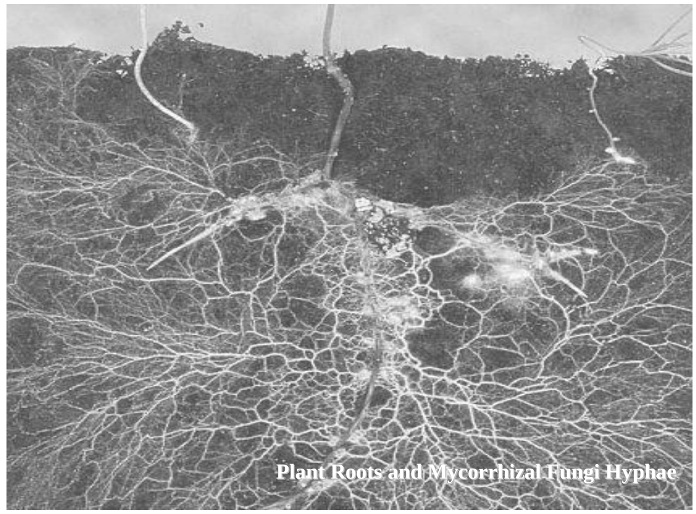
The increased glomalin and underground carbon storage observed with switchgrass adds to its value as a potential source of cellulosic ethanol.

Nichols uses glomalin measurements as a quick guide to evaluate how "soil friendly" farming or rangeland practices actually are.

Prior to joining the USDA-ARS staff at Mandan, Nichols worked with USDA-ARS soil scientist Sara Wright, who identified and named glomalin in 1996.

Glomalin Is Key to Locking Up Soil Carbon

Dr. Kris Nichols, USDA-ARS Soil Microbiologist



Plant Roots and Mycorrhizal Fungi Hyphae

A soil constituent known as glomalin provides a secure vault for the world's soil carbon. That's according to Dr. Kris Nichols, a microbiologist at the Northern Great Plains Research Laboratory.

Glomalin is a sticky substance secreted by the fungal hyphae that funnel nutrients and water to plant roots. It acts like little globs of chewing gum on strings or strands of plant roots and fungal hyphae. Into this sticky "string bag" fall the sand, silt, and clay particles that make up soil--along with plant debris and other carbon-containing organic matter. The sand, silt, and clay stick to the glomalin, starting aggregate formation, a major step in soil creation.

On the surface of soil aggregates, glomalin forms a lattice-like waxy coating to keep water from flowing rapidly into the aggregate and washing everything, including carbon, away. As the builder of the formation "bag" for soil, glomalin is vital globally to soil building, productivity and sustainablilty--as well as to carbon storage.

Nichols uses glomalin measurements to gauge which farming or rangeland practices work best for storing carbon. Since glomalin levels can reflect how much carbon each practice is storing, they could be used in conjunction with carbon credit trading programs.

In studies on cropland, Nichols has found that both tilling and leaving land idle--as is common in arid regions--lower glomalin levels by destroying living hyphal fungal networks. The networks need live roots and do better in undisturbed soil.

When glomalin binds with iron or other heavy metals, it can keep carbon from decomposing for up to 100 years. Even without heavy metals, glomalin stores carbon in the inner recesses of soil where only slow-acting microbes live. This carbon in organic matter is also saved--like a slow-release fertilizer--for later use by plants and hyphae.

CRP a Major Carbon Sequestration Benefit

Dr. Rebecca Phillips, USDA-ARS Plant Physiologist


Dr. Phillips and Bowen Ratio Energy Balance System

Organizations worldwide are asking how agricultural management practices, such as those specified under the Conservation Reserve Program (CRP), influence plant carbon uptake under variable climatic conditions. CRP contracts were written for millions of acres in North Dakota over the last two decades. CRP acres offer important environment benefits with respect to wildlife, but the environmental benefit associated with carbon uptake was previously unknown. Using data available from satellites and field stations, recent results indicate CRP acres in North Dakota represent a significant carbon sink.

Net carbon uptake for fields planted under the CRP would be expected to remove more carbon from the atmosphere, compared to annual crops, because they are not mechanically disturbed by tillage or chemically amended with fertilizers that release greenhouse gases, such as nitrous oxide.

To determine actual carbon uptake, Dr. Rebecca Phillips, Environmental Scientist at the USDA-ARS Northern Great Plains Research Laboratory, used field and satellite-based data to determine plant properties associated with carbon uptake on a year-by-year basis during a 10 year CRP contract (1997-2006).

Field data were collected with a Bowen Ratio Energy Balance System (see photo), which measures net carbon gains or losses every 20 minutes for a 40-acre field. Satellite optical data were collected monthly from the Landsat sensor between April and September.

Data representing wide variations in spatial and temporal variability were analyzed over 10 years using over 1450 CRP fields located in both Morton and McLean Counties. Carbon uptake observed during the 1997-2006 growing seasons vacillated with drought and deluge and ranged from -3000 to 6000 lb of carbon per acre per growing season. An average of 2000 lbs of carbon per acre per year was removed from the atmosphere over a 10-year period. Carbon uptake was greatest in 1999 and lowest in 2006.

Results indicate assessment of conservation practices on grassland carbon uptake during the growing season can be estimated at field and landscape scales under variable environmental conditions.

A video of this project can be viewed at: http://www.ars.usda.gov/Main/docs.htm?docid=16721. The audio of an interview with NPR is available at:http://www.earthsky.org/radioshows/52522/grasslands-soak-up-carbon-to-slow-climate-change. The full results of the study are available in the June 2008 edition of Global Change Biology, volume 14, pages 1008–1017.

The NGPRL Soil Sample Archive

Dr. Mark Liebig, USDA-ARS Soil Scientist

Sustaining highly productive and environmentally sound agricultural management systems will be a major challenge over the next several decades given projections for human population growth and global climate change. Because of these conditions, long-term agricultural experiments will play an important role in understanding how management systems affect soil attributes – and, in turn – how changes in soil attributes impact the broader environment.

NGPRL Soil Archive

Documenting management effects on soil attributes requires not only well-managed long-term experiments, but also carefully cataloged soil archives. Archived soil samples provide ‘time capsules’ for determining changes in soil attributes over time, and are particularly valuable as new analytical capabilities are developed.

In the 1940s, a soil archive was initiated at the Northern Great Plains Research Laboratory (NGPRL) to provide the opportunity for evaluate the effects of long-term grazing and cropping management practices on soil attributes over time. The NGPRL soil archive includes over 5000 samples ranging in age from 4 to 90 years. Most of the samples in the archive come from evaluations of the historical pasture treatments at NGPRL or from a multi-state cropping system evaluation conducted by Howard Haas in the early 1950s. The Haas samples included cropping treatments under various crop sequences and fertility regimes (e.g., manure, no manure), as well as native vegetation. These samples were used to by Haas to document the extent of soil carbon loss caused by converting native vegetation to dryland cropping throughout the U.S. Great Plains.

The sample archive is housed in a building south of the NGPRL main campus. The building was built in the 1940s to support regional soil studies by the USDA Soil Conservation Service (now NRCS).

SCS Building at NGPRL

There are numerous opportunities for research using the NGPRL soil archive, opportunities that include detailed characterizations of soil organic matter fractions, analyses of micronutrient content, and evaluations of soil acidity (just to mention a few examples). Overall, collaborative research projects using the NGPRL soil archive should provide a more in-depth understanding of long-term cropping and grazing effects on soil. This is particularly valuable for the region associated with the archive’s domain (semiarid Great Plains), as changes in soil properties resulting from management often take decades to be expressed.

Organic Price Premiums Make Organic Cropping Systems Profitable

Dr. Dave Archer, UDA-ARS Agricultural Economist

Reducing tillage and increasing crop diversity offer many environmental benefits. While organic farmers recognize the need to protect natural resources, management decisions are often driven by concern for economic survival.

An interdisciplinary research team led by Dr. Dave Archer, compared 16 different cropping system treatments including combinations of system type (organic, conventional), tillage (conventional, strip-tillage), rotation (corn-soybean, corn-soybean-wheat/alfalfa-alfalfa), and fertility (no fertilizer/manure, fertilizer/manure applied at recommended rates).

Reducing tillage intensity and increasing crop diversity reduced annual production costs by $10 to $47/acre within the conventional systems and by $6 to $43/acre within the organic systems.

Production costs were $3 to 21/acre higher for organic systems due to manure handling costs as well as higher fuel, labor, and machinery ownership costs.
Corn, soybean, and wheat yields were over 15% lower when using organic practices due to higher weed pressures.

There were significant reductions in short-term profitability of organic systems, but with organic price premiums, profits for several organic cropping system alternatives were competitive with conventional systems.

The full results of the study are available in the November-December 2007 issue of *Agronomy Journal*.

On-Farm Research Highlights Capacity of Switchgrass to Sequester Soil Carbon

Dr. Mark Liebig, USDA-ARS Soil Scientist

U.S. federal law requires renewable biofuels to meet certain greenhouse gas emission reductions from conventional gasoline using life-cycle assessments (LCAs). Currently, LCAs of switchgrass grown for bioenergy have been mixed, due in large part to the assigned net greenhouse gas emissions associated with switchgrass production. Net greenhouse gas emissions from switchgrass production are closely linked to carbon dioxide uptake and subsequent sequestration in soil, which is reflected by an increase in soil organic carbon (SOC). Unfortunately, nearly all measurements of SOC change under switchgrass have been based on small plot research. While these assessments are useful, it is important to document switchgrass-induced changes in SOC across field-scale, on-farm environments, where conditions are often more variable. To obtain this information, a study was conducted to evaluate changes in SOC in 10 switchgrass fields grown and managed for biomass energy over a five year period. Fields were located in Nebraska, South Dakota, and North Dakota, encompassing an area where previous modeling efforts have shown switchgrass production for biomass energy to be economically feasible. This study was done in conjunction with a large, more inclusive evaluation where net energy and economics of switchgrass production were determined.

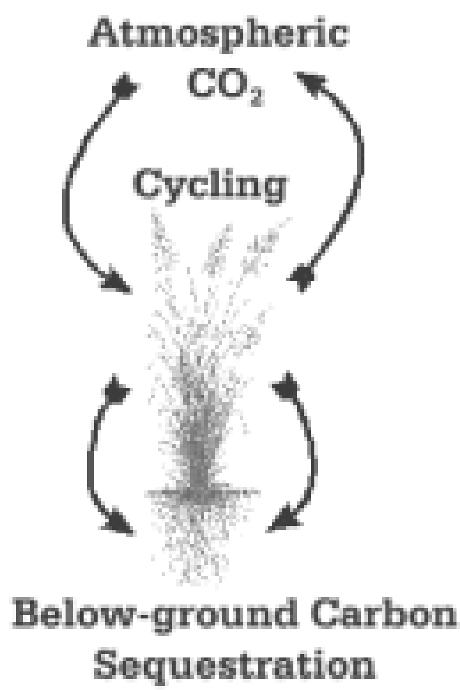


Figure 1. Switchgrass cycles and sequesters atmospheric CO_2

Over the five year study period, changes in SOC under switchgrass were highly variable, ranging from a decrease of 540 lbs C/ac/yr at a site near Ethan, SD to an increase of over 3800 lbs C/ac/yr at a site near Bristol, SD. Overall, however, changes in SOC increased across all sites at a rate of 980 lbs C/ac/yr within the 0-12 inch depth. In Nebraska, where four sites were sampled to a 48 inch soil depth, SOC increased at an average rate of 2590 lbs C/ac/yr.

Increases in SOC under switchgrass were likely caused by belowground carbon input from roots. Detailed surveys conducted by researchers at the University of Nebraska in the 1930s indicated switchgrass roots to extend over nine feet into the soil. Furthermore, the researchers observed switchgrass roots to regenerate by replacing dying roots with new, live roots. Such observations support the notion that significant carbon input to the soil is possible under switchgrass.

Accrual rates of SOC observed in this study contribute significantly to the potential of switchgrass to provide a favorable net greenhouse gas balance. As the suitability of bioenergy production systems in the USA are debated in the coming years, data generated in this study should prove useful for scientists and policy makers.

Drs. Mark Liebig and Marty Schmer contributed to this research project. Full results of the project are reported in Liebig, M.A., M.R. Schmer, K.P. Vogel, and R. Mitchell.2008. Soil carbon storage by switchgrass grown for bioenergy.Bioenergy Research. 1: 215-222.

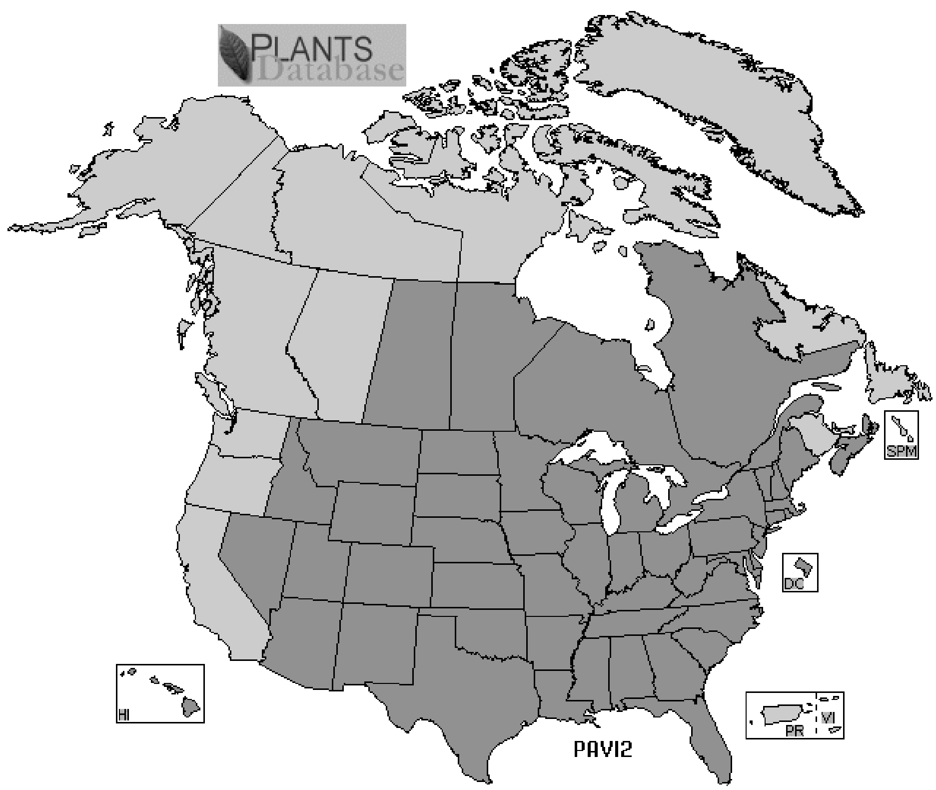


Figure 2. Switchgrass Adaptation Range (USDA-NRCS)

Farming Practices Influence Mineral Content of Grain and Legume Foods

Dr. Scott Kronberg, USDA-ARS Animal Scientist

Scientists at the Northern Great Plains Research Laboratory endeavored to determine if tillage and fertilization influenced mineral content of spring wheat and dry peas.

Mineral deficiencies are common throughout the world's population and often lead to serious health problems. Minerals in foods are ultimately derived from the soil on which they are produced.

Reducing tillage for soil conservation has been critical for increasing food quantity. New evidence from the USDA-ARS Mandan research lab establishes that no-till can also enhance food quality to improve nutrition for a growing human population.

The study found that conventional tillage systems reduced mineral uptake levels in wheat and dry pea compared to no-till or severely reduced soil disturbance systems.

No-till led to significantly higher levels of many important minerals in dry pea. Legumes, like dry pea, have greater mineral uptake with no-till due to their positive symbiotic relationship with mycorrhizal soil fungi. It was also found that increased nitrogen fertilization in dry pea raised manganese and zinc levels, but reduced magnesium levels.

Increased nitrogen fertilization also raised levels of magnesium in spring wheat, but lowered potassium levels.

The no-till production system significantly increased zinc levels in spring wheat. Recent human research has demonstrated that zinc has significant anti-inflammatory actions for the body. Even a mild zinc deficiency has severe negative impacts on immunological and other important bodily functions.

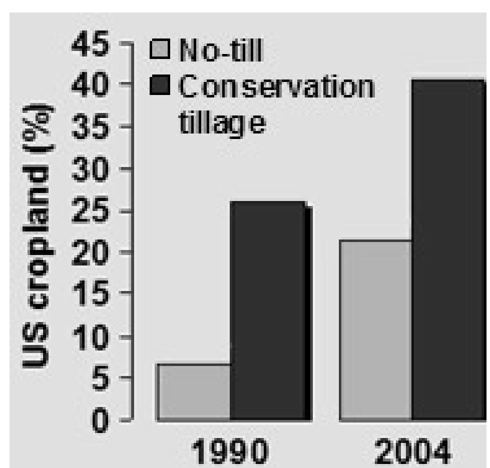
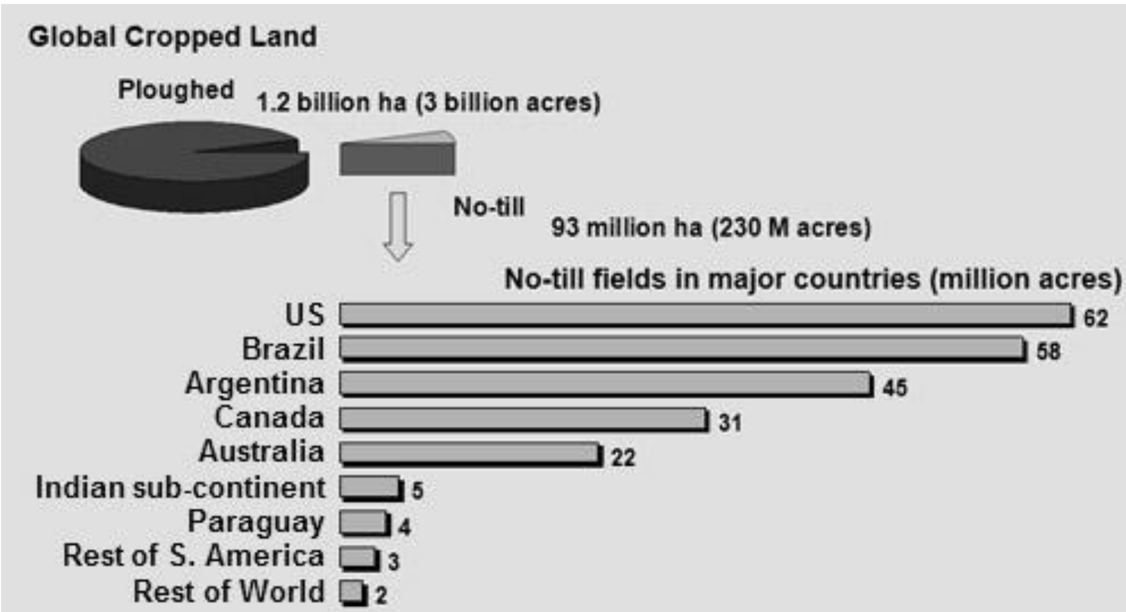


Figure 1. Increase in popularity of conservation tillage and no-till in the United States.

This study was initiated on land previously enrolled in the USDA Conservation Reserve Program (CRP). Non-removal of perennial vegetation at the onset of annual cropping resulted in higher levels of copper and iron in both spring wheat and dry pea, but lower levels of magnesium in spring wheat.

Improved, modern farming practices that significantly reduces soil tillage also reduces disturbance of the soil physical and biological processes. This supports increased uptake of minerals by plants and higher concentrations of minerals in plant and animal derived foods. This provides a win-win-win situation for soil conservation, food production, and human health.

Figure 2. Uptake of no-till around the world in 2004.



Tillage Economics for Irrigated Corn Production: Lessons from Northern Colorado

Dr. Dave Archer, USDA-ARS Agricultural Economist

While no-till is quite often used in Colorado dryland corn production, intensive moldboard plow tillage is still the norm for irrigated corn production. This results in serious wind and water erosion problems in the area.

Producers in the area are concerned about potential yield reductions with no-till and unsure if cost savings would offset any potential yield reductions.

To address these questions, economic analysis was conducted at the Northern Great Plains Research Laboratory using field research data collected by scientists at the ARS-Soil Plant Nutrient Research Unit in Ft. Collins from 2000-2005, comparing the production costs and profitability of conventional tillage (CT) to no-till (NT) irrigated continuous corn.

While corn yields were 16 bushels per acre lower under NT than for CT, net returns were $19 per acre higher with NT. This was due to reduction in operating costs of $23 per acre and reductions in machinery ownership costs of $35 per acre.

Economic optimum nitrogen rates were higher under NT than under CT, however fuel use was reduced by 75% and labor needs were reduce by 71-72%.

The results showed that, despite yield reductions, no-till could be an economically viable option for replacing conventional tillage in the central Great Plains.

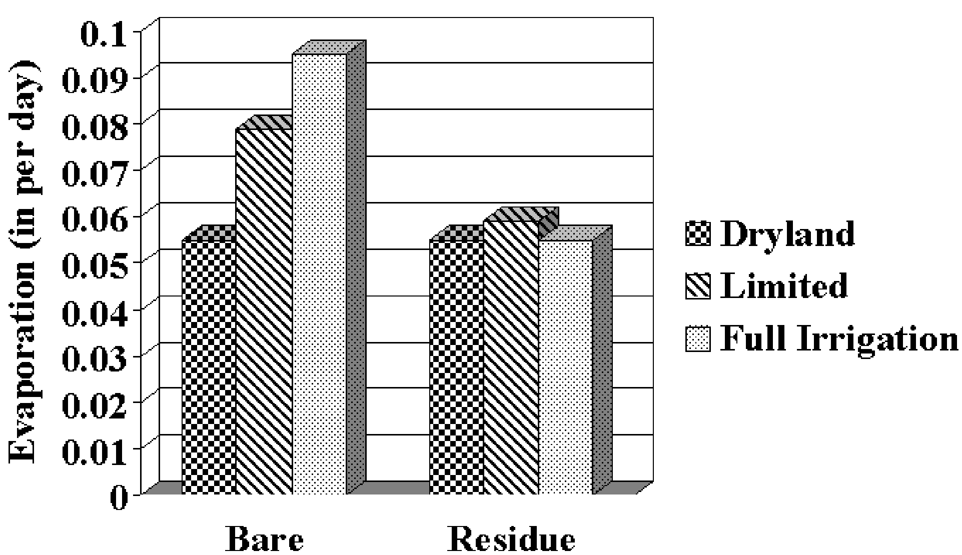


Figure 1. Using no-till on center pivot-irrigated fields can save even more soil moisture than no-till in dryland fields because the residue on the soil surface reduces evaporation from wet soil surfaces. *(From "Evaporation from soil influenced by crop shading, crop residue, and wetting regime" by R.W. Tood, N.L. Klocke, G.W. Hergert, and A.M. Parkhurst, in the Transactions of the American Society of Agricultural Engineers, Mar/Apr 1991.)*

	CT	NT
Expected Yield at optimum N rate (bu/ac)	189	173
Corn Price ($/bushel)	2.38	2.38
Operating Costs	——— $/ac ———	
Seed	62	62
Pesticides and P&K Fertilizer	62	76
Nitrogen Fertilizer*	55	75
Labor	20	6
Fuel	23	6
Irrigation	88	85
Repairs & Maintenance	32	11
Crop Insurance	24	24
Interest on Operating Capital	9	7
Total Operating Costs	375	352
Machinery Ownership Costs	100	65
Total Costs	475	417
Crop Revenue	451	411
Government Payments	61	61
Gross Returns	512	473
Net Returns to Land and Management	37	56
*Optimum Nitrogen rates (lb/ac):	138	188

Table 1. Average production costs, gross returns, and net returns at the economic optimum nitrogen fertilizer rates averaged over 2000-2005.

Designing Cropping Systems for Sustainable Bioenergy Production

Dr. Dave Archer, USDA-ARS Agricultural Economist

Biomass for bioenergy production can come from a variety of sources including grain, crop residues, dedicated energy crops, and agricultural processing residues. A challenge in developing sustainable biomass production systems is to produce these materials in a way that does not compromise our ability to meet current and future food, feed, and fiber demands, is economically viable, and protects our natural resource base and the environment.

Crop Residues – Lessons from Our Neighbors to the East

Research was conducted at the Northern Great Plains Research Laboratory (NGPRL) using field research data collected at the ARS-North Central Soil Conservation Research Laboratory (NCSCRL) in Morris, MN on effects of corn stover collection and alternative tillage systems on crop productivity. The field data were used to calibrate the EPIC simulation model, and the simulation model was used to evaluate the economic and environmental impacts of corn stover harvest across a range of soils.

In the short-term, profitable crop residue harvest is determined by: 1) the direct crop residue harvest and handling costs, 2) nutrient replacement costs, and 3) any short-term impacts on crop productivity. When harvesting corn stover by chopping, raking and baling the stalks, initial simulation results showed average breakeven prices ranged from \$25 to \$37 per ton at the edge of the field. Of this amount, \$22-28 per ton was needed to cover direct harvest and handling costs, and \$5-9 per ton was needed for nutrient replacement. For a corn-soybean rotation in a chisel-plow tillage system, corn stover harvest could have a positive or negative impact on short-term crop productivity. Impacts ranged from a *reduction* in crop productivity equivalent to \$2 per ton of stover removed to an *increase* in crop productivity equivalent to \$8 per ton of stover removed. Short-term impacts of stover harvest on crop productivity were likely due to effects on soil moisture and temperature conditions, with positive effects associated with quicker spring soil temperature warming and negative effects associated with reduced soil moisture available later in the season.

However, harvesting corn stover had a negative effect on soil organic carbon, led to higher erosion levels, and greater loss of phosphorous with sediment. These effects are important from an environmental standpoint since decreased soil organic carbon increases concentrations of greenhouse gases in the atmosphere, and increased erosion and phosphorous loss with sediment decreases water quality. These effects are also important for the farmer, since reductions in soil organic carbon, increases in erosion, and greater loss of soil phosphorous all tend to reduce soil productivity. This can contribute to lower crop yields, which can lead to further declines in soil productivity. The end result is a destructive cycle over time.

The challenge in managing corn stover harvest is to reduce or eliminate these negative effects. Simulation results showed that many of the effects could be offset by changing from a chisel plow tillage system to a strip tillage system. In a forthcoming paper in Agronomy Journal, scientists at the NGPRL and NCSCRL showed that switching from a chisel plow system to a strip tillage system would maintain profitability and would reduce economic risk. Switching to strip tillage has the added benefit of reducing the amount of energy used in crop production. However, reducing tillage is not the only option for making biomass production more sustainable. Figure 1 illustrates the historical declines in soil organic carbon that occurred with intensive tillage over time. Stover harvest has the potential to lead to further declines. However, practices such as no-till, use of cover crops, and diverse rotations could be used to offset further declines and perhaps even rebuild soil carbon levels.

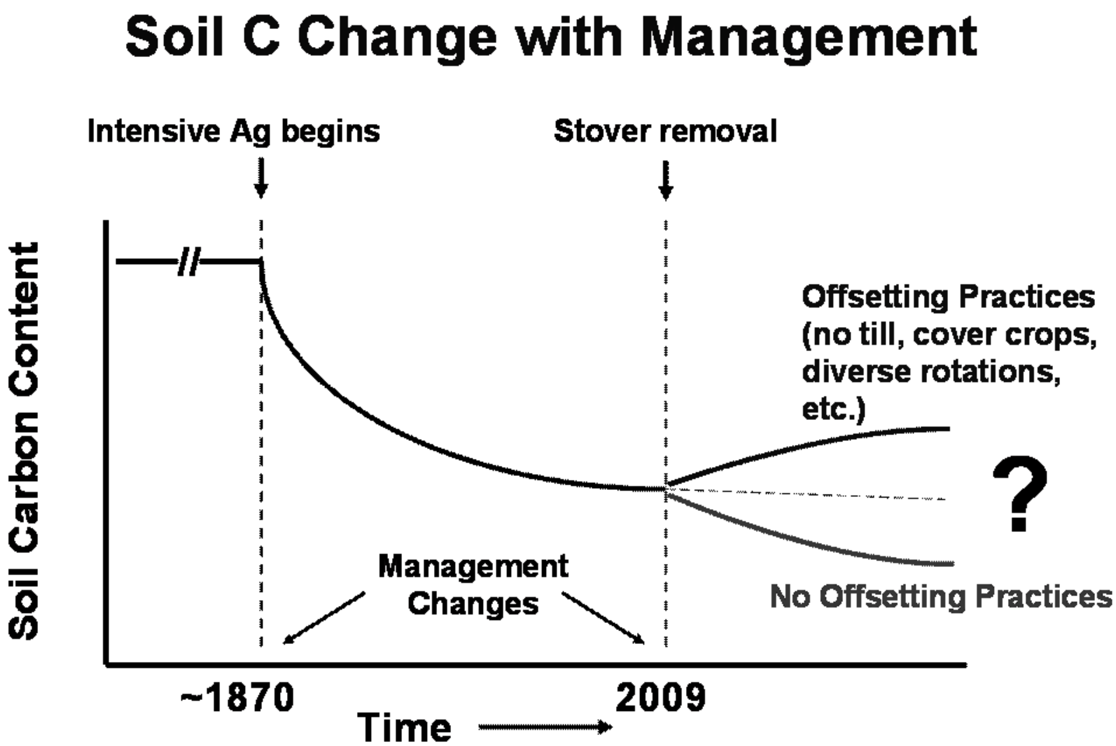


Figure 1. Example of soil organic carbon change with farming over time. Credit: Wally Wilhelm, USDA-ARS, Dec. 2005.

Application to northern Great Plains Conditions

Growing conditions in Minnesota are clearly different from the northern Great Plains, particularly annual precipitation which is about 8 inches higher in Morris than in central North Dakota. Consequently, we would expect the impacts of crop residue removal on soil moisture loss to be a much more important factor in northern Great Plains. Cropping practices also differ between the two regions, with greater crop diversity and greater acceptance of no-till and direct-seeding in the northern Great Plains than in Minnesota. The greater use of no-till in the northern Great Plains has allowed cropping intensity to increase and has helped rebuild soil carbon levels that had been depleted due to intensive tillage and fallow. Without further offsetting practices, harvest of crop residues could potentially reverse these gains. In addition, crop production in the northern Great Plains tends to be more variable than in Minnesota, yet bioenergy producers are going to require a reliable supply of biomass. This means it may be beneficial for at least a portion of agricultural production in the northern Great Plains to include crops that have flexible use that can be diverted to bioenergy if needed.

Sustainable production of biomass in the northern Great Plains will require practices which conserve water, build soil organic matter, and replace nutrients in an economically viable manner. Research is being conducted at the NGPRL on a range of agricultural production systems relevant to bioenergy production: annual crop systems with cover crops, incorporating perennial energy crops into annual crop rotations, dedicated perennial energy crop production, and annual cropping systems designed for multiple-use food, feed, and bioenergy production.

Switchgrass and Corn Stover

Evaluation of Perennial Herbaceous Biomass Energy Crops in North Dakota

Paul Nyren (NDSU), Ezra Aberle (NDSU), Gordon Bradbery (NDSU),
Eric Ericksmoen (NDSU), Mark Halverson (NDSU),
Kris Nichols (USDA-ARS) and Mark Liebig (USDA-ARS)

This 10-year study was initiated to:

- Evaluate the agronomic practices necessary to maximize the production of various grass and legume crops for biomass production.
- Determine the effect of perennial biomass energy crops on carbon sequestering and other soil physical properties.
- Provide an economic analysis of the production costs.

Introduction

A dedicated bioenergy crop study has been initiated by the North Dakota Natural Resources Trust, NDSU Agricultural Experiment Station, USDA-ARS Northern Great Plains Research Laboratory, ND Game and Fish Department, ND Department of Commerce, ND Farmers Union, Jamestown/Stutsman Development Corporation, Dakota West RC&D, Dakota Prairie RC&D and Natural Resources Conservation Service (NRCS). The project will determine the appropriate grass and legume species, harvest methods, and practices to maintain productive perennial biomass stands. The costs for producing a bioenergy crop and the impact of this crop production on soil organic matter and carbon storage will be evaluated.

At the turn of the century, with the exception of trains and water transportation, draft animals like horses and mules, fed by herbaceous biomass such as grasses and legumes, powered the transportation and agriculture industries of the U.S. Since the advent of the internal combustion engine, the source of our energy has changed, resulting in our dependence on oil, both domestic and foreign. Currently ethanol is produced from small grains, primarily corn and barley, and biodiesel is produced from soybeans. This results in grain resources moving away from feed and food production and into the energy sector. Some feel that because a perennial grass used for biomass production, i.e., switchgrass, has a lower value in the feed and food market, there is little or no competition for its final use. Additionally, because the areas in which it can be grown are much more diverse, a dedicated energy crop like switchgrass offers a wider geographical impact than corn or soybeans, and a perennial production system.

North Dakota has over seven million acres of highly erodible and saline crop land, with some counties in the western part of the state having as much as 90 percent of the crop land classified as highly erodible. Perennial energy crops would achieve more long-term sustainability on this land by reducing erosion, adding organic matter, reducing greenhouse gases, and sequestering carbon. These crops also provide more economic stability for the producer and the community. Several publications have indicated that

North Dakota would be a leading state in the production of biomass from herbaceous crops.

The objectives of this study are as follows:

- Determine the biomass yield and select chemical composition of perennial herbaceous crops at several locations throughout central and western North Dakota.
- Determine the optimum harvest dates for maximum biomass yield and maintenance of the stands.
- Compare annual and biennial harvests on total biomass yield and maintenance of the stands.
- Evaluate carbon sequestration and storage of the various perennial crops.
- Evaluate the economic feasibility of the various perennial herbaceous energy crops with competing crops in the surrounding area.

Methods

The species listed in Table 1 were seeded at all locations the week of May 15, 2006 starting in Hettinger and ending with Carrington. The plots were seeded with a plot drill designed and built at the USDA-ARS lab in Mandan by Mr. Louie Zachmeier. The drill was designed to seed small-seeded grasses and legumes and is equipped to seed 10 rows on 6-inch centers. Each plot measured 15 X 30 feet and required 3 passes with the drill.

Baseline soil samples, either deep core samples to 48 inches or surface samples to 4 inches, were collected at all sites in spring 2006 by Drs. Kris Nichols and Mark Liebig, USDA-ARS Northern Great Plains Research Lab.

Deep core samples were divided into seven depths (0-2, 2-4, 4-8, 8-12, 12-24, 24-36, and 36-48 inches) and processed for gravimetric water content, soil bulk density, electrical conductivity, soil pH, total carbon (C), nitrogen (N), soil inorganic carbon, particulate organic matter, and extractable nitrate and phosphorus. Soil processing of the deep core samples has been completed, and samples have been sent to a commercial laboratory for chemical evaluation.

The chemical and total C and N and inorganic C analyses will be completed by the end of 2006. Three aggregate size classes [two macroaggregate sizes (0.04-0.08 and 0.04-0.01 inches) and one microaggregate size (0.01-0.002 inches)] have been separated from surface core samples (which were divided into 0-2 and 2-4 inch depths).

Water stable aggregation has been conducted on about one quarter of the samples. All surface cores will be tested for water stable aggregation and glomalin concentration by February 2007.

Table 1. Species, seeding rates and harvest schedule for biomass plots at all locations in May 2006.		
Variety/species	Harvest schedule	Seeding rate in PLS/acre
Sunburst Switchgrass	Annual	10
Sunburst Switchgrass	Biennial	10
Trailblazer or Dakota Switchgrass*	Annual	10
Trailblazer or Dakota Switchgrass*	Biennial	10
Alkar Tall Wheatgrass	Annual	11
Alkar Tall Wheatgrass	Biennial	11
Haymaker Intermediate Wheatgrass	Annual	10
Haymaker Intermediate Wheatgrass	Biennial	10
CRP mix (Intermediate + Tall Wheatgrass)	Annual	5 + 6
CRP mix (Intermediate + Tall Wheatgrass)	Biennial	5 + 6
CRP mix (Intermediate + Tall + Alfalfa + Sweetclover)	Annual	4+4.5+1+.5
CRP mix (Intermediate + Tall + Alfalfa + Sweetclover)	Biennial	4+4.5+1+.5
Sunburst Switchgrass + Tall Wheatgrass	Annual	5 +5
Sunburst Switchgrass + Tall Wheatgrass	Biennial	5 +5
Sunburst Switchgrass + Sunnyview Big Bluestem	Annual	7+2.5
Sunburst Switchgrass + Sunnyview Big Bluestem	Biennial	7+2.5
Sunburst Switchgrass + Mustang Altai Wildrye	Annual	7+11
Sunburst Switchgrass + Mustang Altai Wildrye	Biennial	7+11
Magnar Basin Wildrye + Mustang Altai Wildrye	Annual	5+11
Magnar Basin Wildrye + Mustang Altai Wildrye	Biennial	5+11
*Trailblazer was seeded at Hettinger, Central Grasslands, and Carrington and Dakota at Williston and Minot.		

Results

While the summer of 2006 was dry in most of the locations, initial reports on the plots all seem encouraging. Table 2 shows the chemical and mowing treatments that were applied to the plots at each location. The plots were sprayed and mowed at least once at all locations except Hettinger, where they received only chemical applications.

Table 2. Weed control treatments applied to the plots at each location during the 2006 growing season.

Location/ date seeded	Treatment		
	Spray		Mow
Streeter	Date	Chemical/acre	Date
May 19	June 26	24 oz Bromoxynil	July 5
	September 13	64 oz 2,4-D +8 oz Banvel	August 15
			September 5
Hettinger	May 15	16 oz Roundup	
May 15	May 25	16 oz Roundup	
	June 15	16 oz Bromoxynil	
	June 27	0.3 oz Prosulfuron + 16 oz Bromoxynil	
	August 3	6 oz Fluroxypyr	
	September 19	16 oz 2,4-D	
Williston May 16	June 23 *Both irrigated and dryland*	32oz Buctril + 16 oz Starane	July 26
			September 6 *Irrigated plots only*
Carrington May 19	October 6	16 oz Banvel	July 7
			August 23
			September 22
Minot May 17	July 14	0.33 oz Harmony GT	July 21
			August 18

Hettinger Research Extension Center

Eric Ericksmoen reported that the trial was seeded into a dry seedbed. Germination and emergence commenced with late spring rainfall. The summer was hot and very dry. Weeds, especially kochia, were abundant and competed with developing switchgrass stands. Weed control was essential in establishing treatments; however, the alfalfa and sweetclover interseeded treatments were killed by the spray. These treatments will need to be reseeded next year. Although grass stands were not tall, there was enough to visually see rows going into dormancy this fall.

Williston Research Extension Center

Gordon Bradbury reported good stand establishment in the plots, both dryland and irrigated. Weeds were a problem and the plots (except those with alfalfa) were sprayed on June 23. The weeds continued to be a problem and during the last week of July both sites were mowed. The dryland site showed signs of drought stress after a long, hot, dry stretch in July and August. The irrigated plots were mowed a second time during the first week in September.

Carrington Research Extension Center

Ezra Aberle reported that the plots were mowed three times during the summer and went into the fall having pretty good stands for the most part.

North Central Research Extension Center, Minot

Mark Halverson reported that the stand established extremely well. The switchgrass and switchgrass-big bluestem plots were the most difficult to evaluate. The 1.78" rain in July, herbicide application, and mowing probably saved the stands. The plots were mowed twice and the grass-only plots were sprayed once. The alfalfa stands looked great early on and stand establishment is expected to be nearly 100%.

Central Grasslands Research Extension Center, Streeter

The plots at the Central Grasslands also experienced stress during the growing season due to the dry conditions and high temperatures. We did experience good rains in August, which surely helped the grass stands. By first frost, the rows of nearly all the cool-season plots could be seen. The plots were sprayed twice and mowed three times during the summer.

This study is expected to continue for 10 years. The stands will be evaluated next spring, with the first harvest expected to occur next September.

Developing Corn Management Strategies
for Drought Prone Regions of North Dakota

Drs. Joel Ransom (NDSU) Fargo and Don Tanaka, (USDA-ARS)

Corn production has expanded throughout North Dakota in recent years, with substantial acreage in western ND where drought frequently constrains yield. This expansion has been further consolidated by the presence of two large ethanol plants in that part of the state. Corn is one of the most water use efficient crops grown in ND. However, corn is sensitive to moisture stress during the period just before tasseling to the blister stage. Management practices such as rotation, plant special arrangement and plant population have been found to be helpful in increasing the stability of corn yield when moisture is limiting. Nevertheless, there is little basic information on how to manage corn in drought prone regions of ND and limited rigorous analysis of the risks of growing in western ND. The objectives of this research were to determine if plant spatial arrangement can impact the stability of corn production in moisture limiting environments and to determine if hybrids differ in their response to drought management practices.

Methodology

An experiment was established at the USDA-ARS Research Center in Mandan to determine the interaction of row spacing, plant density, and hybrid on the yield and yield stability of corn. The row spacing treatments were: 30" spacing all rows planted, 30" spacing - planting two rows and skipping one, and 30" spacing - planting one row and skipping one row. Eight hybrids with differing characteristics (stay green, fixed vs flex ears, prolificacy, maturity length, etc.) were planted under two plant populations in these different row spacings.

Results

This was the first year of this experiment. Table 1 summarizes the effect of corn hybrid averaged over the other treatments on yield, moisture and test weight.

Table 1. The effect of hybrid on yield, moisture and test weight of corn, Mandan, 2008

Hybrid	RM	% Moisture	TW	Yield (bu/a)
DK 29-97	79	13.9	57.2	64.1
DK 35-18	85	14.4	57.3	83.9
DK 43-27	93	16.1	55.1	89.7
PH 38-N87	93	15.9	54.2	88.9
PH 39-D85	87	15.5	55.5	78.8
LR 9584RB	84	16.3	57.0	84.4
LR 9792RB	84	18.1	55.8	89.2
BAXX RR	75	14.1	58.0	65.9
Mean		15.5	56.3	80.6
LSD 0.05		0.8	1.0	10.8

Hybrids did differ significantly with the later maturing hybrids generally being the most productive. Yields were relatively high for the region and moisture content at harvest was relatively low considering the cool growing season. The percent moisture was higher with longer relative maturity, and it was lower with shorter relative maturity hybrids. Test weight was higher with shorter maturity varieties and lower with longer maturity varieties. A relative maturity greater than 85 had a test weight below 56 lbs/bu. Hybrids did not interacted with population or row spacing.

Table 2 summarizes the effect of row spacing and plant population averaged over all hybrids. There was a significant row spacing and plant population main effect. Planting all rows resulted in the highest yield at both plant populations.

Table 2. Effect of row spacing and plant population on yield of corn, Mandan, 2008. Data were averaged over eight hybrids.

	Plant Population		
Spacing	**24,000 plants/acre**	**Variable, 12" between plants**	**Mean**
	-------------------------Bu/a----------------------------------		
30 in, all planted	87.6	93.2	90.4
Plant 2 skip 1	79.7	75.4	77.6
Plant 1 skip 1	78.9	68.9	73.9
Mean	82.1	79.2	

Though yield and the number of rows planted were correlated, the largest decrease in yield occurred when row spacing was increased from planting every row to planting two and skipping one (the plant 2 skip 1 and the plant 1 skip 1 treatments were similar). The effect of plant population, averaged over all other treatments was similar. However, reductions in yield were less when row spacing was increased if plant populations were maintained at 24,000 plants/a.

2008 HRSW Variety Trial - Continuously Cropped - No-till   Mandan

Eric Eriksmoen, NDSU Agronomist, Hettinger REC

Variety	Plant Height	Test Weight	Grain Protein	---- Grain Yield ---- 2006	2007	2008	Average Yield 2 yr	3 yr
	inches	lbs/bu	%	----------- Bushels per acre -----------				
Granger	41	56.3	14.5	30.4	58.8	64.2	61.5	51.1
Glenn	39	57.8	15.0	30.2	64.6	56.2	60.4	50.3
Steele-ND	37	54.6	14.8	29.6	58.2	59.5	58.8	49.1
Howard	36	55.2	14.6	30.4	59.3	57.6	58.4	49.1
Faller	35	54.3	14.4	20.5	60.4	58.5	59.4	46.5
Kelby	30	56.9	14.7		61.1	67.6	64.4	
Kuntz	32	56.4	14.0		60.1	67.7	63.9	
Choteau	32	54.3	15.0			60.5		
ND901CL	38	55.9	15.4			58.9		
Trial Mean	36	55.5	14.8	29.7	59.0	61.7	--	--
C.V. %	2.3	1.5	3.4	9.3	5.3	6.0	--	--
LSD .05	1	1.2	NS	4.7	5.3	5.4	--	--
LSD .01	2	1.7	NS	6.3	7.3	7.2	--	--

NS = no statistical difference between varieties.

Planting Date: April 22, 2008
Harvest Date: August 12, 2008
Seeding Rate: 1.1 million live seeds / acre (approx. 1.6 bu/A).
Previous Crop: 2005 & 2006 = hrww, 2007 = hrsw.

2008 Durum Variety Trial - Continuously Cropped - No-till Mandan

Eric Eriksmoen, NDSU Agronomist, Hettinger REC

Variety	Plant Height	Test Weight	Grain Protein	---- Grain Yield ---- 2006	2007	2008	Average Yield 2 yr	3 yr
	inches	lbs/bu	%	----------- Bushels per acre -----------				
Ben	42	55.3	15.5	28.6	61.6	55.1	58.4	48.4
Alkabo	39	55.5	14.7	28.1	56.1	60.2	58.2	48.1
Mountrail	40	54.1	15.7	27.3	59.6	56.9	58.2	47.9
Grenora	37	54.5	15.0	25.7	57.3	57.7	57.5	46.9
Divide	40	54.9	15.6	26.7	54.2	55.8	55.0	45.6
Lebsock	40	56.0	15.5	27.5	--	57.0		
Trial Mean	40	55.0	15.3	27.3	57.8	57.1	--	--
C.V. %	2.7	1.2	2.7	7.6	4.5	6.0	--	--
LSD .05	2	1.0	0.6	NS	4.9	NS	--	--
LSD .01	2	1.4	NS	NS	NS	NS	--	--

NS = no statistical difference between varieties.

Planting Date: April 22, 2008
Harvest Date: August 12, 2008
Seeding Rate: 1.25 million live seeds / acre (approx. 2.2 bu/A).
Previous Crop: 2005 & 2006 = hrww, 2007 = hrsw.

2008 Winter Wheat Variety Trial - Continuously Cropped - No-till
Mandan

Eric Eriksmoen, NDSU Agronomist, Hettinger REC
This Trial was funded by Ducks Unlimited, Bismarck

Variety	Winter Surv.	Plant Height	WSMV*	Test Weight	Grain Protein	---- Grain Yield ---- 2006	2007	2008	Average Yield 2 yr	3 yr
	%	inches	%	lbs/bu	%	----------- Bushels per acre -----------				
Millennium	99	32	12	53.9	12.8	36.9	84.2	55.5	69.8	58.9
Jagalene	96	29	2	55.4	12.7	42.0	60.1	56.7	58.4	52.9
CDC Buteo	99	32	4	56.2	12.6	38.3	70.7	49.2	60.0	52.7
Harding	99	31	3	52.5	12.2	36.5	69.1	52.3	60.7	52.6
Jerry	97	33	0	53.0	13.2	39.1	60.5	57.7	59.1	52.4
Wesley	91	25	20	51.3	13.7	41.1	73.1	38.0	55.6	50.7
Radiant	97	34	0	53.8	11.9	36.5	55.7	57.3	56.5	49.8
Alice**	81	26	10	52.1	12.4	43.5	61.6	42.1	51.8	49.1
CDC Falcon	98	27	9	53.3	11.7	37.4	54.1	52.6	53.4	48.0
Roughrider	98	37	0	52.1	13.2	37.2	66.0	38.6	52.3	47.3
Expedition	98	29	13	53.5	12.2	36.9	55.7	47.9	51.8	46.8
Yellowstone	91	31	2	52.9	12.6	34.5	50.6	53.6	52.1	46.2
Darrell	97	30	0	53.8	12.8		73.5	60.1	66.8	
Hawken	71	25	2	54.0	13.4		74.3	39.1	56.7	
NuDakota**	82	25	2	51.7	12.8		67.2	45.4	56.3	
Overland	98	30	0	54.3	12.1			58.9		
Accipiter	99	29	16	54.1	12.0			55.0		
Peregrine	98	37	20	53.4	12.4			52.3		
AP503CL2	70	27	2	54.0	12.7			44.1		
Lyman	94	30	18	52.2	12.8			43.5		
Norris	77	31	0	51.8	12.9			36.9		
Trial Mean	93	30	7	53.3	12.7	37.5	62.7	49.2	--	--
C.V. %	12.4	4.5	242	3.3	3.9	16.5	14.3	14.0	--	--
LSD .05	16	2	NS	2.5	0.7	NS	14.7	9.7	--	--
LSD .01	21	3	NS	3.3	0.9	NS	19.6	12.9	--	--

* % of plants infested with Wheat Streak Mosaic Virus
** Hard white winter wheat.
NS = No Statistical difference between varieties.

Planting Date: September 12, 2007 Harvest Date: August 12, 2008
Seeding Rate: 1 million live seeds / acre (approx. 1.4 bu/A).
Previous Crop: 2005 & 2006 = HRWW, 2007 = soybean.

2008 Oat Variety Trial - Continuously Cropped - No-till   Mandan

Eric Eriksmoen, NDSU Agronomist, Hettinger REC

Variety	Plant Height	Test Weight	------ Grain Yield ------ 2006	2007	2008	Average Yield 2 yr	3 yr
	inches	lbs/bu	------------- Bushels per acre -------------				
Souris	37	32.5	50.4	141.5	137.0	139.2	109.6
Killdeer	36	29.6	53.3	124.5	142.1	133.3	106.6
Maida	40	29.1	51.1	136.8	119.0	127.9	102.3
Beach	43	33.3	44.4	126.1	130.5	128.3	100.3
Jerry	41	32.0	54.8	111.5	127.2	119.4	97.8
Morton	43	32.4	47.0	119.9	124.6	122.2	97.2
Stark*	41	32.6		87.7	102.7	95.2	
Trial Mean	40	31.6	50.2	121.9	126.2	--	--
C.V. %	3.1	4.6	11.3	6.5	6.0	--	--
LSD .05	2	2.2	NS	13.9	11.3	--	--
LSD .01	3	3.0	NS	19.3	15.5	--	--

*Stark is a naked (hulless) type.

NS = no statistical difference between varieties.

Planting Date: April 22, 2008
Harvest Date: August 12, 2008
Seeding Rate: 750,000 live seeds / acre (approx. 1.7 bu/A).
Previous Crop: 2005 & 2006 = hrww, 2007 = hrsw.
Note: The 2006 trial sustained moderate heat and moisture stress.

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David Archer joined the NGPRL as an agricultural economist in January 2007. Before coming to Mandan, he was at the USDA-ARS laboratory in Morris, Minnesota for 7 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. Prior to joining ARS, Dave was a USDA-NRCS agricultural economist in Bismarck, North Dakota and in Spokane and Colfax, Washington. He received a Ph.D. in Agricultural Economics from Iowa State University in 1995 and a B.S. in Mathematics from Rocky Mountain College in 1988.

Dave is continuing his research on the economics of agricultural systems as part of an interdisciplinary team helping develop more sustainable integrated crop and livestock production systems. His specific research interests include risk management, simulation modeling, decision aid development, bioenergy economics, and decision making to achieve both economic and natural resource goals. Dave is a member of the Agricultural and Applied Economics Association, Western Agricultural Economics Association, Soil and Water Conservation Society, American Society of Agronomy, and Soil Science Society of America, and is an Associate Editor for Agronomy Journal. He has given numerous invited presentations at producer, industry, and professional meetings, and his work has often been featured in popular press articles.

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La Scala, N., A. Lopes, K. Spokas, D.W. Archer, and D.C. Reicosky. 2008. Short-term temporal changes of bare soil CO_2 fluxes after tillage described by first-order decay models. Eur. J. Soil Sci. (in press).

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Timothy C. Faller is Director NDSU Agroecosystems Research Group. Tim served as Director of the NDSU Research Extension Center at Hettinger for thirty eight years prior to retiring and from that job and becoming half time Assistant Director of the NDSU Experiment Station. His office is located at the USDA-ARS Northern Great Plains Research Laboratory at Mandan, North Dakota.

His responsibly includes fostering collaborative relationships between NDSU and the Laboratory. Special emphasis is given to bio-mass energy production and attracting new grant funded scientists to the location to research biomass production from field to fuel.

Tim views the opportunity presented by developing systems thinking and research efforts associated with enhancing the individual strengths of the USDA/ARS, Research Extension Centers statewide and the North Dakota State University Agricultural Experiment Station as being emence. Developing a vision that creates a feeling of a safe haven is critical as islands are joined by bridges to create a peninsula. Many times the element of change is the biggest hurdle to making progress.

Tim and his wife, Kathy, live north of Bismarck and they have three children, two of which reside in North Dakota and one in Wisconsin. Tim enjoys hunting, fishing, golfing, and old vehicles.

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Jason Gross returned to the Northern Great Plains Research Laboratory (NGPRL) in August 2002 after leaving in June 1997. He received his B.S. in Math/Science from the University of Mary, Bismarck, ND in 1993. During his hiatus from NGPRL, he worked on his M.S. in Environmental Science and Engineering at the Colorado School of Mines in Golden, Colorado. His thesis work monitored trichloroethene biodegradation by methanotrophic microbial communities in soil, and its long term effect on their populations. Jason also worked for the United States Environmental Protection Agency helping states and tribal governments acquiesce with the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). Following course work at the Colorado School of Mines, he worked for an environmental consulting firm in Denver providing soil and ground water remediation at military installations across the country. Currently, Jason is working with Mark Liebig to oversee a broad scale research program to determine the effects of land management practices on soil quality. His work includes field studies in cropping and rangeland agroecosystems, as well as laboratory and greenhouse evaluations.

Peer-Reviewed Journal Publications

Liebig, M.A., Gross, J.R., Kronberg, S.L., Hanson, J.D., Frank, A.B., Phillips, R.L. 2006. Soil response to long-term grazing in the northern Great Plains of North America. Agric. Ecosys. Environ. 115:270-276.

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Dr. Jon Hanson is the Research Leader and a Supervisory Rangeland Scientist of the Northern Great Plains Research Laboratory in Mandan, North Dakota. He received his Ph.D. in Range Science from Texas A&M University in 1979. Jon began his career with ARS at the High Plains Grassland Research Station in Cheyenne, Wyoming in 1979. In 1984, he was transferred to the range research group in Fort Collins, Colorado. A subsequent reorganization resulted in the formation of the Great Plains Systems Research Unit in 1986. As part of this unit, Jon began to work in both range and crop land systems. Jon's life-long goal is to contribute toward the development and implementation of sustainable and adaptive management systems for agriculture and natural resources by (1) synthesizing and enhancing knowledge of biological and physical processes, (2) developing, validating, and enhancing integrated models of agricultural and natural resource systems, and (3) developing methodologies for transferring technology to managers, action agencies, and scientists. His work has lead to the development and implementation of simulation models and decision support tools including SPUR, SPUR2, RZWQM, RZWQM98, GPFARM, and the Crop Sequence Calculator. He is a member of the Society for Range Management, the Agronomy Society of America, the Crop Science Society of America, and the Soil Science Society of America.

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John Hendrickson, a Rangeland Scientist, joined the staff at the USDA-ARS, Northern Great Plains Research Laboratory, Mandan in 1999. Prior to 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 dioxide sequestration in rangelands and using grazing to control noxious weeds. John received his bachelors in agriculture from the University of Nebraska in 1984. After a term in the Peace Corps, John received his masters in from the University of Nebraska in 1992. He received his Ph.D. from Texas A&M in Rangeland Ecology and Management in 1996. John was previously at the Mandan location as a post-doc. His long-term goals are to develop range and forage systems that are economically viable and promote long-term agricultural stability. John and his wife, Chris, live in Mandan and have three children.

Peer-Reviewed Journal Publications

Phillips, R.L., Beeri, O., Scholljegerdes, E., Bjergaard, D., and J. Hendrickson, 2009. Integration of geospatial and cattle nutrition information to estimate paddock grazing capacity in Northern US prairie. Agricultural Systems, *in press*.

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Holly Johnson, rangeland scientist, is a Category 3 scientist for the Northern Great Plains Research Laboratory (NGPRL) at Mandan, North Dakota. She has been on the staff since June 1999. She received her B.A. in Biology from Concordia College, Moorhead, MN, in 1996. After graduation, she worked for an environmental consulting firm in Minnetonka, MN which serviced businesses needing OSHA support, SARA, and Title II reporting. In December of 2000 she completed a M.S. degree in Range Science (Grassland Ecology) from North Dakota State University, Fargo, ND. Her thesis was on the biomass reallocation and growth characteristics of Northern Great Plains plant species. Her work includes field components in range and cropland systems, studies conducted in the station greenhouses and growth chambers, as well as some work in the laboratory. Currently, Holly works with Dr. Jon Hanson and is involved in projects researching switchgrass as a bioenergy fuel, selenium uptake by switchgrass, and mycorrhizal and water stress effects on switchgrass. Holly's long-term goal is to be actively involved in ecological-based research throughout the course of her career. She serves on the Northern Plains Area (NPA) Diversity Taskforce and as the NGPRL Greenhouse Committee Chair.

Peer-Reviewed Journal Publications

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Scott Kronberg started working at NGPRL in October of 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 7 years before coming to NGPRL. He has been conducting research on nutrition and feeding behavior of grazing livestock for about 25 years. He began this work while a graduate student and research assistant at Montana State University in the early 1980's and continued it as a graduate student and research assistant with Utah State University. Scott has also worked as a post-doctoral research associate at Montana State University and at the ARS's sheep research station near Dubois, Idaho. Scott plans to continue his research in ruminant nutrition and feeding behavior in respect to improving the nutritional value of red meat, reducing winter feeding costs for cows, and helping develop integrated crop and livestock production systems that are more economically and environmentally sustainable. Scott is a member of the American Society of Animal Science, the American Society of Agronomy, and the Ecological Society of America.

Peer-Reviewed Journal Publications

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Mark Liebig has worked at NGPRL since August 1999. Prior to coming to NGPRL, he 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 educational background includes a B.A. in Molecular, Cellular, and Developmental Biology from University of Colorado, and an M.S. and Ph.D. in Agronomy from University of Nebraska. Mark's research program at NGPRL is broad, encompassing soil quality and gas flux evaluations of crop, grazing, biofuel, and integrated management systems. Mark is an ARCPACS Certified Professional Soil Scientist and holds an adjunct appointment in the Department of Soil Science at North Dakota State University. He is also a member of the Chicago Climate Exchange Soil Carbon Technical Advisory Committee, and serves as an Associate Editor for *Renewable Agriculture and Food Systems*.

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Kris Nichols began her research career with the Agricultural Research Service (ARS) in 2000 in Beltsville, MD. She joined the Northern Great Plains Research Laboratory (NGPRL) in Mandan, ND in June, 2003 as a Soil Microbiologist. Nichols received Bachelor of Science degrees in Plant Biology and in Genetics and Cell Biology from the University of Minnesota in 1995, a Masters degree in Environmental Microbiology from West Virginia University in 1999, and a Ph.D. in Soil Science from the University of Maryland in 2003. Since 1993, Nichols has studied arbuscular mycorrhizal (AM) fungi – a plant-root symbiont. Her most recent work involves the investigation of glomalin – a glycoprotein produced by AM fungi. Glomalin contributes to nutrient cycling by protecting AM hyphae that are transporting nutrients from the soil to the plant and to soil structure and plant health by helping to form and stabilize soil aggregates. Nichols found glomalin to be a major component of soil organic matter (ca. 15-20%) in undisturbed soils and may be an agriculturally managed soil carbon sink. Kris has been examining the impacts of crop rotation, tillage practices, and livestock grazing management on soil aggregation, water relationships, and glomalin at NGPRL. Nichols had given numerous invited presentations to agriculture producers and educators throughout the U.S. and Canada. She has written several peer-reviewed journal articles and two book chapters. Numerous popular press articles have featured her work.

Peer-Reviewed Journal Publications

Nichols, K.A., and S. Samson-Liebig. An inexpensive and simple method to demonstrate water infiltration and holding capacity. J. Nat. Res. Life Sci. Ed. In review.

Nichols, K.A. and M. Toro. A new index for measuring whole soil aggregate stability. Soil Till. Res. In review.

Kronberg, S.K., D.L. Tanaka, G.F. Combs, Jr., M.A. Liebig, and K.A. Nichols. Farming Practices Influence Mineral Content of Grain and Legume Foods. J. Sci. Food Ag. In review.

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Book chapters

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Nichols, K.A. 2007. Hunting nutrients and trapping carbon. In: 11th Annual No-Till on the Plains Winter Workshop, Jan. 30-31. Salina, KS.

Nichols, K.A. 2006. Making Soil Biology Work for You. In: Andy Berntson (ed.) 28th Annual Zero Tillage & Winter Wheat Workshop. Feb 9-10. Manitoba-North Dakota Zero-Tillage Farmers Association. Bismarck, ND.

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Dr. Rebecca Phillips joined the NGPRL as a Plant Physiologist in June 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's School of Natural Resources 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. Her previous research projects include rangeland plant-animal interactions, soil microbial metabolism, trace gas exchange, and agricultural remote sensing. Dr. Phillips' research focuses on minimizing environmental impacts and designing strategies to promote sustainable use of natural resources. Phillips is affiliated with the American Geophysical Union, the Society of Wetland Scientists, and the Soil Science Society of America.

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Marty Schmer joined NGPRL in October 2008 as a research agronomist. Prior to coming to NGPRL, he was at the USDA-ARS Grain, Forage, and Bioenergy Research Unit in Lincoln, NE working on establishment and biofuel sustainability of switchgrass in the Northern Great Plains. Marty earned a Ph.D. in Agronomy, M.S. in Agronomy, and B.S. in Environmental Studies from the University of Nebraska. Marty's research interests at NGPRL are the development of sustainable cropping systems, integrating perennial systems in current annual cropping systems, and evaluating bioenergy-specific crops for the Northern Great Plains. Marty is a member of the American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, and Society for Range Management.

Peer-Reviewed Journal Publications

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Schmer, M.R., K.P. Vogel, R.B. Mitchell, L.E. Moser, K.M. Eskridge, R.K. Perrin. 2006. Establishment stand thresholds for switchgrass grown as a bioenergy crop. Crop Sci. 46:157-161.

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Eric Scholljegerdes started working at the Northern Great Plains Research Laboratory in January of 2005. Eric received his B. S. in Animal Science from the University of Missouri-Columbia in 1998. Upon completion of his bachelors, Eric moved to the University of Wyoming to complete his M.S. in 2001 and Ph.D. in 2005. Since 2005, Eric's research has focused on improving production efficiency in beef cattle through optimizing nutritional management. Specifically, he evaluated the impact of fat supplementation on site and extent of digestion in grazing beef cattle in an effort to improve feed efficiency. From this research, Eric has found that by feeding flaxseed, you can reduce forage intake but improve average daily gain and feed efficiency in grazing beef cattle. Through collaborative work with North Dakota State University, Dr. Scholljegerdes has demonstrated that short-term feeding of oilseeds during the breeding season can improve average daily gain in lactating beef cows but this improvement did not equate to an improvement in conception to AI. Eric is also evaluating the efficacy of an integrated crops and livestock system for fall forage production. Dr. Scholljegerdes has been working with other scientists at Mandan on a satellite-based grazing monitoring system to allow producers to develop grazing plans using satellite imagery. Scholljegerdes has given numerous talks to livestock producers and at regional and international scientific meetings. His research has been published in peer-reviewed journals, proceedings, and popular press. Dr. Scholljegerdes is a member of the American Society of Animal Science and the American Registry of Professional Animal Scientists. He also serves as an Associate Editor for the Journal of Animal Science.

Peer-Reviewed Journal Publications

Scholljegerdes, E. J., T. R. Weston, S. L. Lake, E. A. Van Kirk, G. E. Moss, and B. W. Hess. Effects of dietary high-linoleate safflower seeds on ovarian follicles and reproductive hormones in primiparous beef cows. J. Anim. Sci. (*Accepted with revision*)

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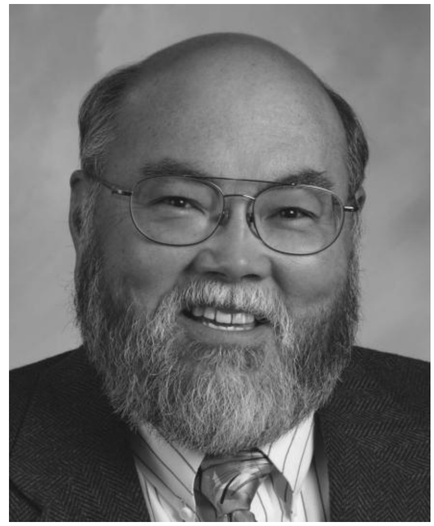

Donald Tanaka began conducting research with the Agricultural Research Service (ARS) at Sidney, MT in 1980. He has been a member of the research team at NGPRL since 1991. He has advanced degrees in agronomy with a concentration in soils and soil chemistry from the University of Nebraska. He has conducted soil and water conservation research in the northern Great Plains for 28 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. Dr. Tanaka is a member of the American Society of Agronomy, Soil Science Society of America, Soil and Water Conservation Society, and the American Association for the Advancement of Science. He has achieved recognition by being chosen Fellow of the American Society of Agronomy, receiving the Professional Award from the Dakota Chapter of Soil and Water Conservation, the U.S. Zero-Till Non-Farmer award from the Manitoba-North Dakota Zero-Tillage Farmers Association, and the Conservation Research Award from the Soil and Water Conservation Society. In addition to many peer-reviewed publications, he has given numerous scientific presentations at professional meetings, interviews with the media as well as popular press articles.

Peer-Reviewed Journal Publications

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Qingwu (Fred) Xue was employed by the NDSU BioEPIC Agroecosystems Research Group in October 2008 and office at the NGPRL. He earned a Ph.D. in agronomy from University of Nebraska, a M.S. in agriculture from West Texas A&M University, and a B.S. in biology from Shaanxi Teacher's University, China. Prior to coming to Mandan, Dr. Xue worked in Northwestern Agricultural Research Center, Montana State University at Kalispell, Montana. His research was focused on improving crop yield, grain quality and resources use efficiencies under both biotic and abiotic stress conditions in cereal cropping systems.

Fred plans to work with the NDSU Research Extension Centers throughout the state and USDA-ARS research team to study production issues in newly emerging biofuel crops in North Dakota. His research focus includes identifying appropriate biofuel crop species, developing management strategies, and better understanding the role of biofuel crops in an integrated cropping system.

Over the years, Xue has published many peer-reviewed journal articles and presented his research results at various cliental levels from Research Center Field Days and local agribusiness meetings to national and international conferences. He is a member of American Society of Agronomy, Western Society of Weed Science, and Western Society of Crop Science.

Peer-Reviewed Journal Publications

Xue, Q. and R. N. Stougaard. 2006. Effects of spring wheat seed size and reduced rates of tralkoxydim on wild oat control, wheat yield and economic returns. Weed Technol. 20: 472-477.

Guillen-Portal, F. R., R. N. Stougaard, Q. Xue, and K. M. Eskridge. 2006. Compensatory mechanisms associated with the effect of spring wheat seed size on wild oat competition. Crop Sci. 46:935-945.

Xue, Q., Z. Zhu, J. T. Musick, B. A. Stewart, and D. A. Dusek. 2006. Physiological mechanisms contributing to the increased water-use efficiency in winter wheat under deficit irrigation. J. Plant Physiol. 163: 154-164.

Stougaard, R. N. and Q. Xue. 2005. Quality versus quantity: spring wheat seed size and seeding rate effects on *Avena fatua* interference, economic returns and economic thresholds. Weed Res. 45: 351-360.

Stougaard, R. N. and Q. Xue. 2004. Spring wheat (*Triticum aestivum*) seed size and seeding rate effects on yield loss due to wild oat (*Avena fatua*) interference. Weed Sci. 52: 133-141.

Xue, Q., A. Weiss, T. J. Arkebauer, and P. S. Baenziger. 2004. Influence of soil water status and atmospheric vapor pressure deficit on leaf gas exchange in field-grown winter wheat. Environ. Exp. Bot. 51: 167-179.

Xue, Q., A. Weiss, and P. S. Baenziger. 2004. Predicting leaf appearance in field-grown winter wheat: evaluating linear and non-linear models. Ecological Modelling 175: 261-270.

Xue, Q., A. Weiss, and P. S. Baenziger. 2004. Predicting phenological development in winter wheat. Climate Res. 25: 243-252.

Xue, Q., Z. Zhu, J. T. Musick, B. A. Stewart, and D. A. Dusek. 2003. Root growth and water uptake in winter wheat under deficit irrigation. Plant and soil 257: 151-161.

Streck, N. A., A. Weiss, Q. Xue, and P. S. Baenziger. 2003. Improving predictions of developmental stages in winter wheat: a modified Wang and Engel model. Agric. For. Meteorol. 115: 139-150.

Streck, N. A., A. Weiss, Q. Xue, and P. S. Baenziger. 2003. Incorporating a chronology response into the prediction of leaf appearance rate in winter wheat. Ann. Bot. 92: 181-190.

Xue, Q. and R. N. Stougaard. 2002. Spring wheat seeding seed size and seeding rate affect wild oat demographics. Weed Sci. 50: 312-320.

Xue, Q., S. Madhavan, A. Weiss, T. J. Arkebauer, and P. S. Baenziger. 2002. Genotypic variation of gas exchange parameters and carbon isotope discrimination in winter wheat. J. Plant Physiol. 159: 891-898.

Proceedings

Stougaard, R. N. and Q. Xue. 2008. Wild oat response to imazamox rate in herbicide resistant spring wheat. Proc. West. Soc. Weed Sci., Anaheim, CA.

Stougaard, R. N. and Q. Xue. 2007. White cockle responses to auxinic herbicides. Proc. West. Soc. Weed Sci., Portland, OR.

Xue, Q. and R. N. Stougaard. 2006. Spring wheat seeding rate and seed size affect water-use efficiency under wild oat competition. Proc. 2nd International Symposium on Soil Erosion and Dryland Farming, Yangling, Shaanxi, China.

Xue, Q., R. N. Stougaard, J. A. Mickelson, Q. Khan, and F. R. Guillen-Portal. 2005. Spring wheat seed size and cultivar effects on yield and wild oat interference. Proc. West. Soc. Weed Sci., Vancouver, BC, Canada.

Stougaard, R. N. and Q. Xue. 2005. An economic analysis of spring wheat seed size and seeding rates effects on wild oat interference. Proc. West. Soc. Weed Sci., Vancouver, BC, Canada.

Stougaard, R. N., F. R. Guillen-Portal, and Q. Xue. 2003. Crop interference and crop response in spring wheat against wild oat. In: 2003 Annual Meeting Abstracts, ASA-CSSA-SSSA, Denver, CO.

Xue, Q. and R. N. Stougaard. 2003. Effects of spring wheat seed size and tralkoxydim rate on wild oat interference. Proc. West. Soc. Weed Sci., Kauai, HI.

Xue, Q. and R. N. Stougaard. 2001. Growth analysis of spring wheat with reference to seed size. In: 2001 Annual Meeting Abstracts, ASA-CSSA-SSSA, Charlotte, NC.

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