AREA 4 SCD Cooperative Research Farm

USDA Agricultural Research Service

2010 Research Results

February 15, 2011

Seven Seas Inn & Conference Center

Area 4 SCD Cooperative Research Farm & Northern Great Plains Research laboratory

PO Box 459 ⌗ 1701 10th Avenue SW ⌗ Mandan ND 58554-0459
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USDA Research Results
& Technology Conference

Seven Seas Inn & Conference Center

9 AM February 15, 2011

Welcome & Program Introduction

Marvin Halverson, Area 4 SCD Cooperative Research Farm Chairman
Dr. Matt Sanderson, Lab Director
Northern Great Plains Research Laboratory

The Conservation Effects Assessment Project (CEAP)

A New Component of NGPRL Research
Dr. Matt Sanderson

Break

Crop Residue for Bioenergy Production at Spiritwood, ND

Rich Garman, Great River Energy Engineer
Dr. Dave Archer, USDA-ARS Agricultural Economist

Area 4 SCD Cooperative Research Farm 2010 Research Results

Dr. Don Tanaka, USDA-ARS Soil Scientist
Dr. Mark Liebig, USDA-ARS Soil Scientist

Lunch

Introduction of Afternoon Q&A with USDA-ARS Scientists

Cal Thorson, USDA-ARS Technical Information Specialist

Research Review Synopsis

Open Discussions with Each Mandan Research Scientist

@ Individual posters

Wrap Up Discussion/Action Items

Dr. Matt Sanderson

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Message from the Lab Director

I am very pleased and excited to be serving as the Laboratory Director and Research Leader here at Mandan. I would like to tell you a bit about my background and also relay some thoughts on the future direction of research at the Northern Great Plains Research Laboratory (NGPRL).

I am originally from Willow City, ND and grew up on a cow-calf small-grain farm. My university degrees are from NDSU (B.S. and M.S.) and Iowa State University (Ph.D.). After Iowa State I spent a short time as a post doctoral researcher at the University of Missouri and then moved on to a faculty position at the Texas A&M University Agricultural Research and Extension Center in Stephenville, TX (about 60 miles southwest of Ft. Worth). At Texas A&M I did research on forage systems for dairies and also conducted some of the early research on switchgrass for bioenergy. After 8 years at Stephenville, I made a career change and joined the USDA-ARS as a forage agronomist at the Pasture Systems and Watershed Management Research Unit, also known as the 'Pasture Lab', at University Park, PA. The Pasture Lab is on the campus of Penn State University across the street from the university creamery where Ben and Jerry learned to make ice cream. At the Pasture Lab my research focused on forage and pasture management, native grasses for conservation and bioenergy, and grassland ecology.

The NGPRL has an international reputation for research on integrated agricultural systems and their interaction with the environment. This reputation and the high quality of the scientific staff are what drew me to this job. There are few research locations in the world that have such a unique combination of scientific expertise and facilities as we have here at Mandan.

Another distinguishing feature of the NGPRL is the ethos of cultivating partnerships. The co-location of Tim Faller and Dr. Igathi Cannayen of NDSU as partners at our laboratory (page 28) adds tremendous value to our research and outreach efforts. The involvement of our customer partners through the customer focus group and the Area 4 cooperative research farm (page 5) keep us firmly grounded and in tune with the agricultural community. Dr. John Hendrickson has worked with NDSU and several collaborators from across the Northern Great Plains to establish a new partnership with Sitting Bull College via a grant from the USDA Agricultural and Food Research Initiative (AFRI). Dr. Rebecca Phillips has formed a number of innovative collaborations with several institutions and agencies to conduct research on grassland and agricultural ecosystems. She is also the point person for the NGPRL in the NEON (National Ecological Observatory Network) continental-scale project sponsored by the National Science Foundation (page 60). These are only a few examples of the many partnerships at the NGPRL.

Research on integrated agricultural systems and environmental interactions is complex and long term. The research team at the NGPRL has made several important advancements in this area; however, in many ways they have just scratched the surface (or done shallow tillage). Much research remains to be done on integrating livestock into systems, developing alternatives for bioenergy cropping, and documenting the long-term effects on soil health, sustainability, and farm profitability. This will be an important direction for the NGPRL in the future. I hope to contribute some of my research expertise in perennial bioenergy crops to this future research direction.

Society is looking to agriculture to not only be the provider of food, feed, and fiber but to also be a contributor of other important ecosystem services. The NGPRL has been at the forefront on some of these issues and will continue to address them via innovative field- and landscape-scale research. I hope to contribute my grassland science expertise to address research problems in grassland and rangeland management as part of that effort. A new component of research at the NGPRL will be our involvement in the grazing lands Conservation Effects Assessment Project (CEAP) a multiagency effort (page 69) to quantify the environmental effects and ecosystem services of conservation practices implemented on the Nation's grazing lands.

This is an ambitious future that requires sustained support from a broad range of customers. It also requires sustained and adequate resources, both monetary and human. Scientific excellence, an ethos of collaboration and partnership, accountability, and service are core values at the NGPRL. We have a solid core of soil, plant, and animal science research expertise that is knit together with strong research capacity in agricultural economics and landscape scale biogeochemistry. This strong and closely knit core must be maintained during a challenging era of funding. I look forward to leading the NGPRL in meeting this challenge.

Please feel free to stop by, call, or email me to learn more about the NGPRL.

Dr. Matt A. Sanderson

History of the Area 4 Soil Conservation District Research Farm

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.

The Beginning

Since 1984, Area 4 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 4 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 4 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 4 SCD meeting on June 17, 1983. It was adopted November 13, 1983. Jerry Presser, Chairman of the Area 4 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 4 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 4 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 4 SCD Cooperative Research Farm 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 4 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 13,000 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 4 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 4 SCD Cooperative Research Farm experimental data, or modify it for soil, weather, and local conditions that may differ from the research location.

The Crop Sequence Calculator CD-ROM (CSC) 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 4 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 4 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 21st. Buses depart the campus at 3 PM to tour the Area 4 SCD Cooperative Research Farm.

Today, the Area 4 SCD Cooperative Research Farm will host the 27th 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 4 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 4 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 4 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,
President, North Dakota Association of Soil Conservation Districts

Area 4 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

McIntosh County SCD………………….Donavon Bender, Ventura, ND

Morton County SCD…………...………. Duane Olson, Mandan, ND

Oliver County SCD…………………….. Dale Berg, New Salem, ND

Sheridan County SCD………………….. Alvin Buckart, Kief, ND

South McLean County SCD…...………. Eugene Wirtz, Underwood, ND

Stutsman County SCD…………………. Donald Hofman, Medina, ND

West McLean County SCD……………. Ed Hauf, Max, ND

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

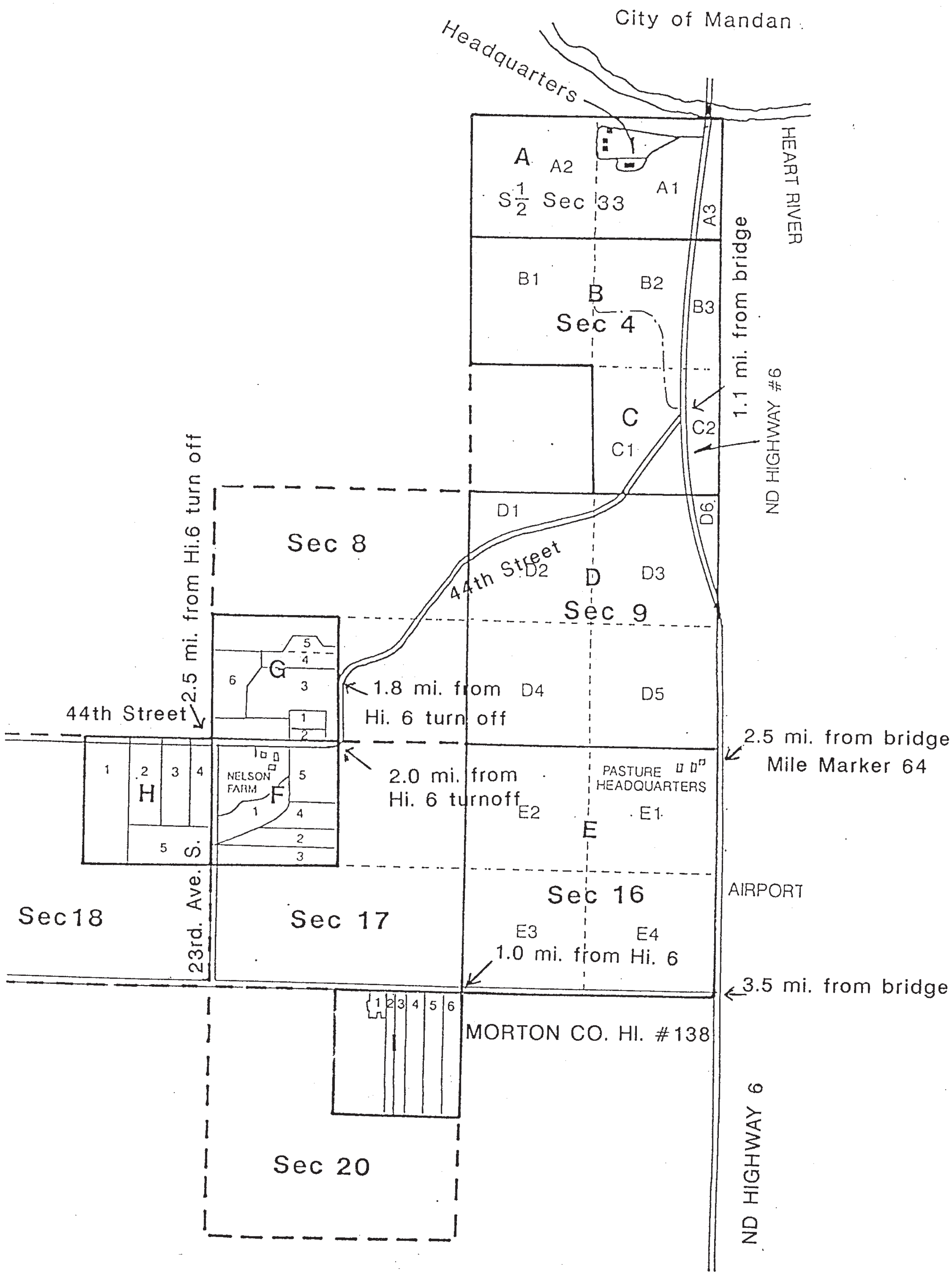
Blake Vandervorst………………………Ducks Unlimited

USDA-ARS LAND RESOURCES (FEDERAL & STATE) A, B, C, D, AND E

AREA 4 SCD COOPERATIVE RESEARCH FARM

LAND RESOURCES F, G, H, AND I

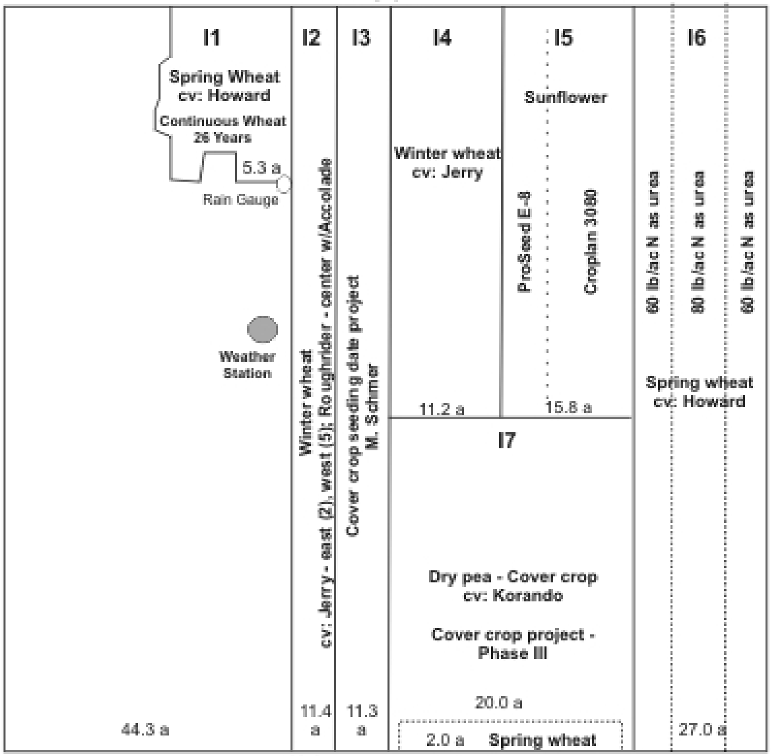
Figure 1



2010 Area IV Research Farm Crop Plan

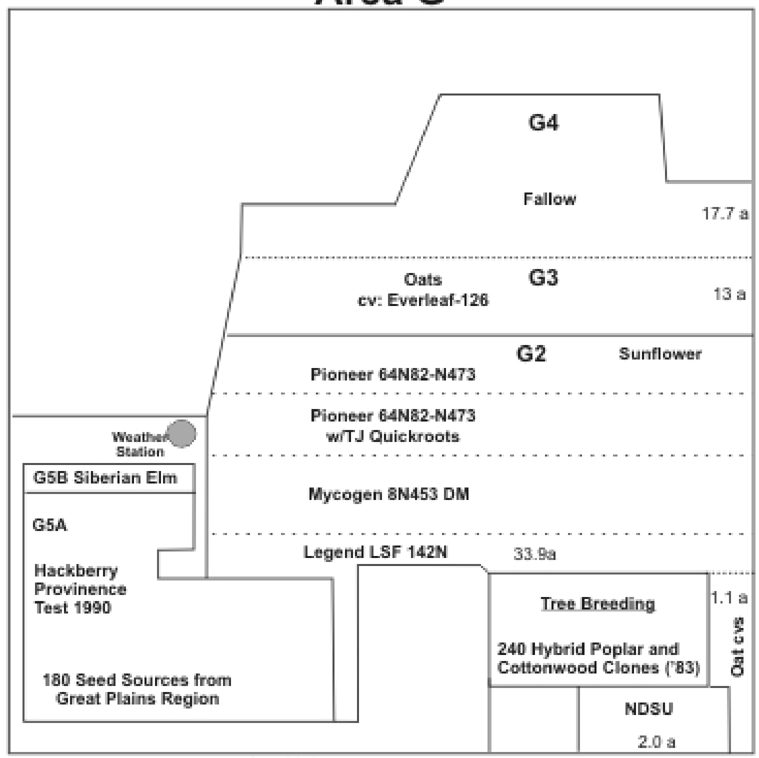
(06-26-10)

Area I



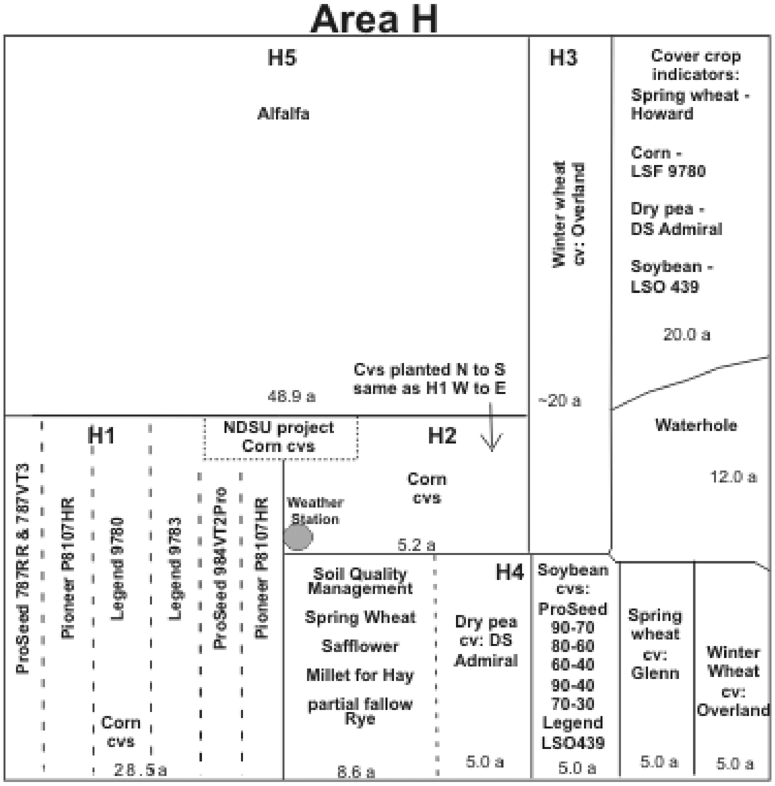
NE ¼ Section 20 T138N R81W

Area G



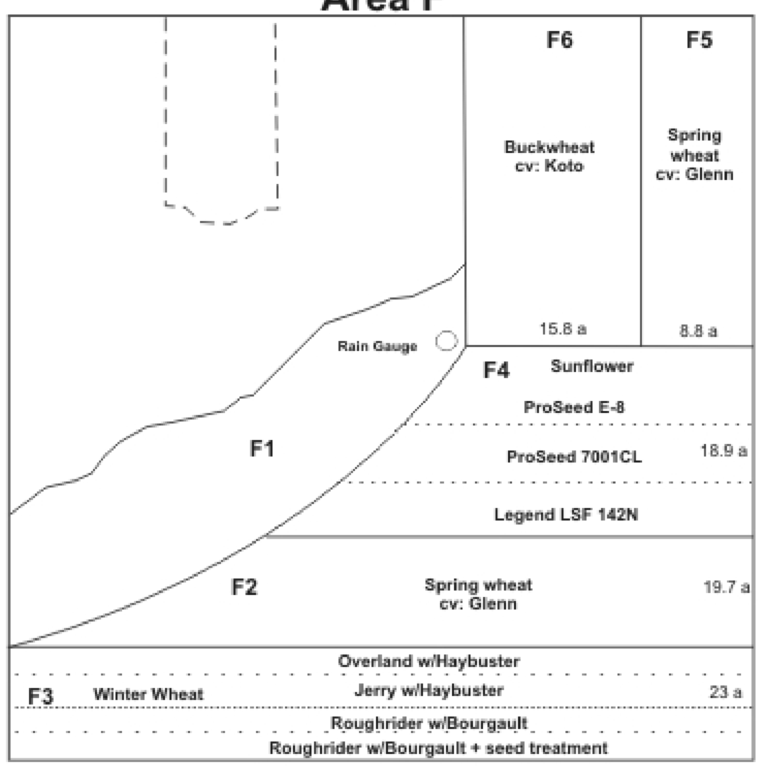
SW ¼ Section 8 T138N R81W

Area H



NE ¼ Section 18 T138N R81W

Area F



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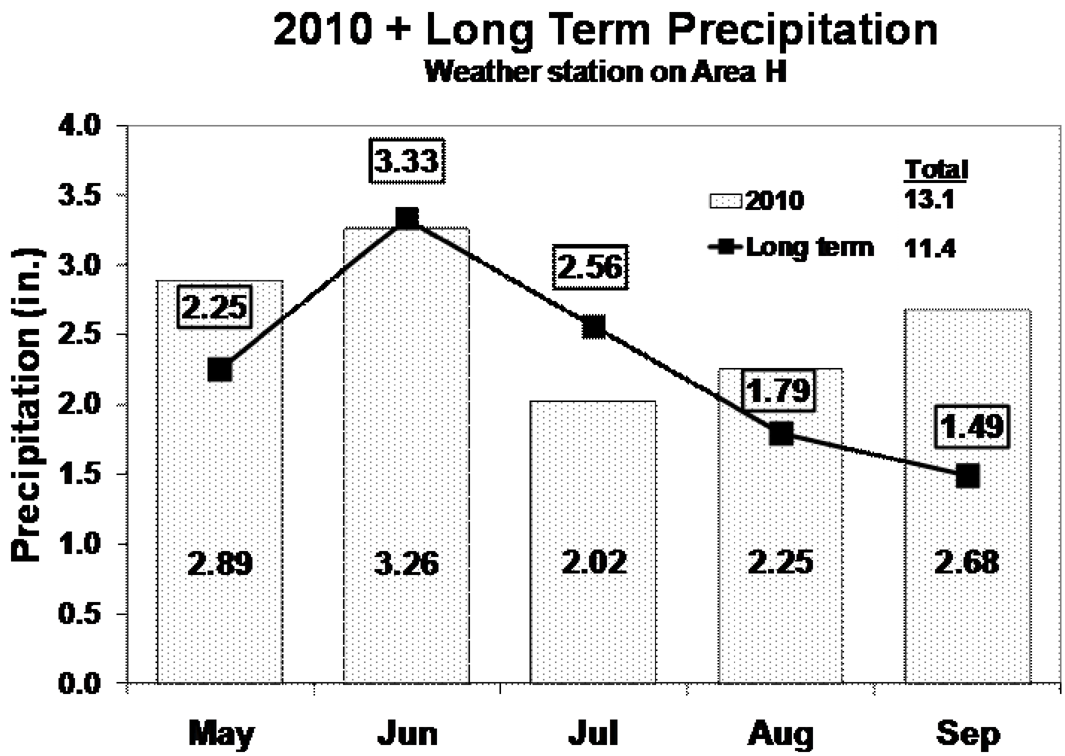
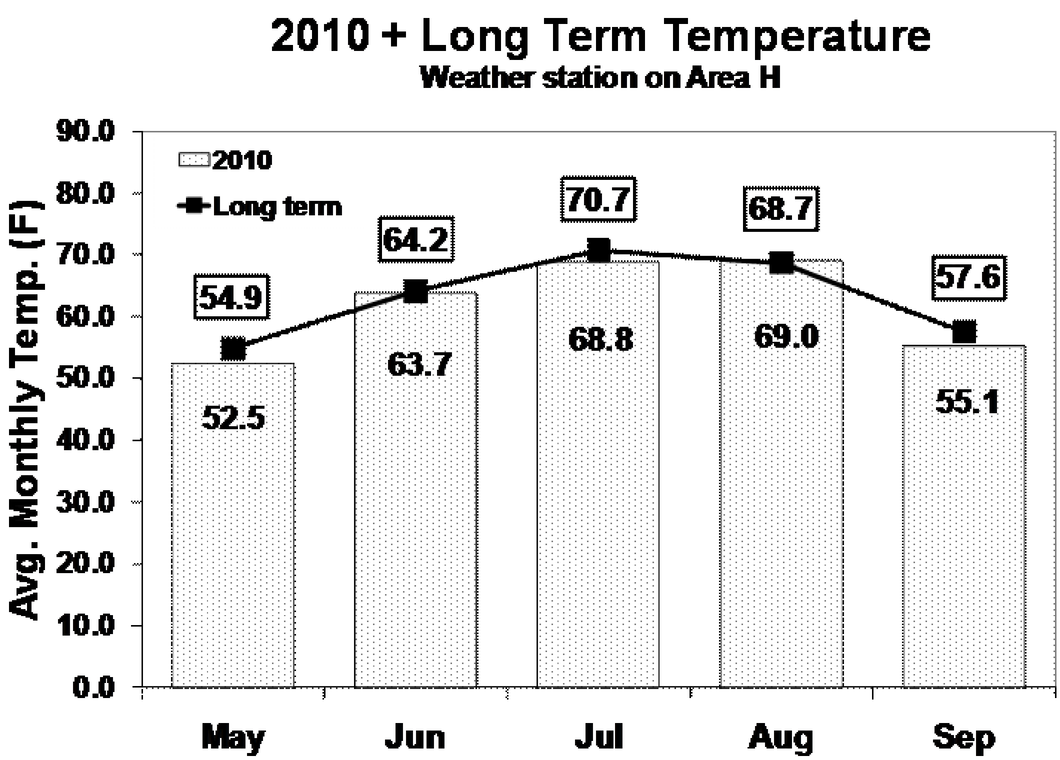

2010 + Long Term Precipitation
Weather station on Area H
Precipitation (in.)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Total
2010 13.1
Long term 11.4
3.33
2.25
2.56
1.79
1.49
2.89
3.26
2.02
2.25
2.68
May
Jun
Jul
Aug
Sep


2010 + Long Term Temperature
Weather station on Area H
Avg. Monthly Temp. (F)
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
2010
Long term
54.9
64.2
70.7
68.7
57.6
52.5
63.7
68.8
69.0
55.1
May
Jun
Jul
Aug
Sep

Area 4 SCD Cooperative Research Farm 2010 Management Practices

AREA-F FIELD OPERATIONS, NW ¼ Section 17 T138N R81W

FIELD F1 This conservation bench terrace area has been excluded from the total acreage leased by AREA 4 SCDs since 1987.

FIELD F2, GLENN SPRING WHEAT

Previous crop – Sunflower varieties

(Accolade donated by INTX Microbials)

04/17/10	Contractor sprayed field w/Glystar Plus @ 32 oz/ac + Sharpen @ 1 oz/ac + Helfire @ 1 qt/100 gal + MSO @ 1 gal/100 gal.
04/20/10	Contractor bulk spread urea @ 80 lb N/ac.
04/29/10	Field seeded with Sunflower drill @ 1.3 million seeds/ac + 70 lb/ac 11-52-0.
06/04/10	Contractor sprayed Wolverine @ 1.7 pt/ac + Headline @ 3 oz/ac (leaf diseases).
08/17/10	Field was harvested with JD 6620 and straight head (41.8 bu/ac).
09/15/10	Contractor sprayed Glystar Plus @ 32 oz/ac + dicamba @ 4 oz/ac + 2,4-D ester @ 12 oz/ac + Helfire @ 1 qt/100 gal.
09/25/10	Contractor sprayed Glystar Plus @ 32 oz/ac + Helfire @ 1 qt/100 gal.
10/5 & 6/10	Field seeded to Overland (north strip w/Accolade and 2 south strips with and without Accolade, N & S) and Jerry winter wheat (middle strip, w/Accolade). Overland seeded with Haybuster 8000 drill and Jerry with Bourgault drill @ 1.3 million seeds/ac + 70 lb/ac 11-52-0.

FIELD F3, OVERLAND, JERRY, & ROUGHRIDER WINTER WHEAT

Previous crop – Steele Spring Wheat

(Accolade donated by INTX Microbials)

09/24/09	Field seeded w/Haybuster 8000 drill (cv Overland & Jerry) & Bourgault drill (cv Roughrider) @ 1.3 million seeds/ac + 70 lb/ac 11-52-0.
04/20/10	Contractor bulk spread urea @ 80 lb N/ac.
05/22/10	Contractor sprayed field w/Wolverine @ 27 oz/ac + Propimax @ 2 oz/ac + ProGerm Micro 500 @ 48 oz/ac.
06/22/10	Contractor applied Presaro @ 7 oz/ac + Premiere 90 @ 3 oz/ac for scab control.
08/06/10	Field was harvested with JD 6620 and straight head (Overland, 58.6 bu/ac; Roughrider w/Accolade trt., 41.1 bu.ac, w/o Accolade trt., 37.5 bu/ac; Jerry, 36.3 bu/ac).
08/28/10	Contractor sprayed stubble for weed control w/Glystar Plus @ 32 oz/ac + surfactant.

FIELD F4, SUNFLOWER VARIETIES

Previous crop- Roughrider & Jerry Winter Wheat

Seed donated by ProSeed

04/20/10	Contractor bulk spread urea @ 80 lb N/ac.
05/23/10	Contractor sprayed Glystar Plus @ 32 oz/ac + Spartan @ 3.5 oz/ac + Aim @ 0.5 oz/ac + surfactant.
06/08/10	Field was seeded w/JD MaxEmerge II planter from north to south: ProSeed E-8, ProSeed 700 ICL and Legend LSF142N.

07/02/10	Contractor sprayed Assure II @ 7.2 oz/ac + surfactant + MSO for grass control.
08/19/10	Contractor sprayed Asana XL @ 9.6 oz/ac + Headline @ 6 oz/ac + surfactant for insects.
10/06/10	Contractor sprayed Gramoxone @ 32 oz/ac + surfactant (pre-harvest dessication).
10/22/10	Field was harvested with JD 6620 and all crop head.

FIELD F5, GLENN SPRING WHEAT

Previous crop – Koma Buckwheat

04/17/10	Contractor sprayed field w/Glystar Plus @ 32 oz/ac + Sharpen @ 1 oz/ac + Helfire @ 1 qt/100 gal + MSO @ 1 gal/100 gal.
04/20/10	Contractor bulk spread urea @ 80 lb N/ac.
04/29/10	Field seeded with Sunflower drill @ 1.3 million seeds/ac + 70 lb/ac 11-52-0.
06/08/10	Contractor sprayed Wolverine @ 1.7 pt/ac + Headline @ 3 oz/ac (leaf diseases).
08/16/10	Field was harvested with JD 6620 and straight head (50.9 bu/ac).
09/15/10	Contractor sprayed Glystar Plus @ 32 oz/ac + dicamba @ 4 oz/ac + 2,4-D ester @ 12 oz/ac + Helfire @ 1 qt/100 gal for post-harvest burndown.
10/07/10	Contractor sprayed Glystar Plus @ 32 oz/ac + dicamba @ 6.5 oz/ac + surfactant.

FIELD F6, KOTO BUCKWHEAT

Previous crop – Winter wheat varieties

04/20/10	Contractor bulk spread urea @ 60 lb N/ac.
06/04/10	Contractor sprayed Glystar Plus @ 32 oz/ac.
06/10/10	Field was seeded w/Sunflower drill at 56 lb/ac ob buckwheat + 70 lb/ac 11-52-0 with the seed.
07/02/10	Contractor sprayed Assure II @ 7.2 oz/ac + surfactant + MSO for grass control.
08/12/10	Field swathed w/20 ft. Versatile swather.
10/06/10	Field harvested w/6620 JD combine (2187 lb/ac, cleaned seed).
10/07/10	Contractor sprayed Glystar Plus @ 32 oz/ac + dicamba @ 6.5 oz/ac + surfactant for pre-seeding burndown.
10/7 & 8/10	Field seeded to Jerry (west side) and Overland (east side) winter wheat w/Bourgault and Haybuster 8000 drills, respectively at 1.3 million seeds/ac + 70 lb/ac 11-52-0.

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

FIELD G1, OAT VARIETIES

Previous crop – Howard Spring Wheat

06/01/10	Field sprayed w/Roundup WeatherMax @ 24 oz/ac + Sterling (dicamba) @ 4 oz/ac + AMS @ 5 gal./100gal.
06/04/10	Field seeded w/JD750 drill + 60 lb N/ac + 50 lb/ac 11-52-0.

See table on summary sheet (p. 20)

FIELD G2 SUNFLOWER VARIETIES

Previous crop – West side, Corn varieties; East side, Cover Crops Project

Seed donated by Pioneer, TJ Quickroots donated by TJ Technologies, Inc.

04/20/10 Contractor bulk spread urea @ 80 lb N/ac.

05/23/10 Contractor sprayed Glystar Plus @ 32 oz/ac + Spartan @ 3.5 oz/ac + Aim @ 0.5 oz/ac + surfactant.

06/07/10 Field was seeded w/JD MaxEmerge II planter from north to south: Pioneer 63N82-N473, Pioneer 63N82-N473 + TJ Quickroots, Mycogen 8N453 DM, and Legend LSF142N.

07/02/10 Contractor sprayed Assure II @ 7.2 oz/ac + surfactant + MSO for grass control on all but Pioneer cvs.

07/02/10 Miscommunication resulted in Beyond @ 4 oz/ac + surfactant + MSO being applied to Express tolerant sunflower (Pioneer 63N82-N473); plant damage resulted.

08/19/10 Contractor sprayed Asana XL @ 9.6 oz/ac + Headline @ 6 oz/ac + surfactant for insects.

11/12/10 Field harvested w/JD 6620 and all crop head (see table on summary sheet).

FIELD G3, EVERLEAF OATS (Foundation Seed, seed donated by Pulse USA)

Previous management- Fallow

04/17/10 Contractor sprayed field w/Glystar Plus @ 32 oz/ac + Sharpen @ 1 oz/ac + Helfire @ 1 qt/100 gal + MSO @ 1 gal/100 gal.

04/20/10 Contractor bulk spread urea @ 60 lb N/ac.

05/18/10 Field was cultivated w/Mulch Master to smooth drainage ways.

05/20/10 Field seeded w/Haybuster 107 drill @ 1 million seeds/ac + 60 lb/ac 11-52-0.

06/17/10 Contractor sprayed MCPA @ 1.2 pt/ac for weed control.

09/07/10 Field swathed w/20 ft. Versatile swather.

10/04/10 Field harvested w/JD 6620 combine and all crop head (90 bu/ac, estimate).

10/07/10 Contractor sprayed Glystar Plus @ 32 oz/ac + dicamba @ 6.5 oz/ac + surfactant.

FIELD G4, FALLOW

Previous management - Overland Winter Wheat

06/04/10 Contractor sprayed Glystar Plus @ 32 oz/ac + dicamba @ 4 oz/ac + surfactant.

07/15/10 Contractor sprayed Glystar Plus @ 32 oz/ac + Distinct @ 4 oz/ac + surfactant.

10/07/10 Contractor sprayed Glystar Plus @ 32 oz/ac + dicamba @ 6.5 oz/ac + surfactant.

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

FIELD H1, CORN VARIETIES

Previous crop – Sunflower varieties

TJ Micromix donated by TJ Technologies, Inc.

04/17/10 Contractor sprayed field w/Glystar Plus @ 32 oz/ac + Sharpen @ 1 oz/ac + Helfire @ 1 qt/100 gal + MSO @ 1 gal/100 gal.

04/20/10 Contractor bulk spread urea @ 80 lb N/ac.

06/01/10 Field seeded w/JD MaxEmerge II planter from west to east: ProSeed 787RR (3 rows) & 787VT3 (3 rows), Pioneer P8107HR, Legend 9780, Legend 9783, ProSeed 984VT2Pro, and Pioneer 8107HR (TJ Micromix added to seed).

06/04/10 Contractor sprayed Glystar Plus @ 32 oz/ac + dicamba @ 4 oz/ac + surfactant.

07/15/10 Contractor sprayed Glystar Plus @ 32 oz/ac + Distinct @ 4 oz/ac + surfactant.

10/29/10 Field harvested with JD 6620 combine and 6 row all crop header (see table on page 20).

FIELD H2, CORN VARIETIES

Previous crop – DS Admiral Peas

Seed donated by ProSeed, Pioneer, and Legend Seed.

04/17/10	Contractor sprayed field w/Glystar Plus @ 32 oz/ac + Sharpen @ 1 oz/ac + Helfire @ 1 qt/100 gal + MSO @ 1 gal/100 gal.
04/20/10	Contractor bulk spread urea @ 80 lb N/ac.
06/01/10	Field seeded w/JD MaxEmerge II planter from north to south: ProSeed 787RR (3 rows) & 787VT3 (3 rows), Pioneer P8107HR, Legend 9780, Legend 9783, ProSeed 984VT2Pro.
06/04/10	Contractor sprayed Glystar Plus @ 32 oz/ac + dicamba @ 4 oz/ac + surfactant.
07/15/10	Contractor sprayed Glystar Plus @ 32 oz/ac + Distinct @ 4 oz/ac + surfactant.
10/29/10	Field was harvested with JD 6620 and 6 row header.

FIELD H3 WEST, OVERLAND WINTER WHEAT

Previous crop – Tradition Barley

Accolade donated by INTX Microbial, LLC.

09/23/09	Field seeded w/Haybuster 8000 drill @ 1.3 million seeds/ac + 70 lb/ac 11-52-0.
04/20/10	Contractor bulk spread urea @ 80 lb N/ac.
05/22/10	Contractor sprayed field w/Wolverine @ 27 oz/ac + Propimax @ 2 oz/ac + ProGerm Micro 500 @ 48 oz/ac.
06/22/10	Contractor applied Presaro @ 7 oz/ac + Premiere 90 @ 3 oz/ac for scab control.
08/05/10	Field was harvested with JD 6620 and straight head (54.7 bu/ac).
09/15/10	Contractor sprayed Glystar Plus @ 32 oz/ac + dicamba @ 4 oz/ac + 2,4-D ester @ 12 oz/ac + Helfire @ 1 qt/100 gal.
09/25/10	Contractor sprayed Glystar Plus @ 32 oz/ac + Helfire @ 1 qt/100 gal.
09/30/10	Seeded Jerry winter wheat w/Bourgault drill @ 1.3 million viable seeds/ac + 70 lb/ac 11-52-0 (seed treated w/Accolade).

FIELD H3 EAST, COVER CROP PROJECT PHASE II (cont.)

Previous crop – DS Admiral Peas

04/17/10	Contractor sprayed field w/Glystar Plus @ 32 oz/ac + Sharpen @ 1 oz/ac + Helfire @ 1 qt/100 gal + MSO @ 1 gal/100 gal.

FIELD H3 SOUTH ("waterhole"), Flooded

Previous crop – Roughrider Winter Wheat

FIELD H4, SOIL QUALITY MANAGEMENT

See 'Management Strategies for Soil Quality' on page 21

Management practices.

Crop	Date	Activity	Data
Peas	04/29/10	Planting	cv: DS Admiral
Spring wheat	05/21/10	Planting	cv: Howard
Soybeans	06/03/10	Planting	cv: Legend 0439RR
Corn	06/01/10	Planting	cv: Legend 9780RB
Corn & soybeans	06/02/10	Spraying	Roundup (16 oz/ac), Aim (0.5 oz/ac), AMS
Peas	06/15/10	Spraying	Rezult (52 oz/ac), MSO (20 oz/ac)
Spring wheat	06/23/10	Spraying	Tacoma (8 oz/ac), Bison (16 oz/ac), Headline (3 oz/ac).
Soybeans	07/08/10	Spraying	Roundup (16 oz/ac), Status (2.5 oz/ac)
Corn	07/09/10	Spraying	Roundup (16 oz/ac), Status (2.5 oz/ac)
		Plot combine (estimated yield):	
Peas	08/09/10	Harvest	12.6 bu/ac (overall avg.)
Spring wheat	09/14/10	Harvest	40.1 bu/ac (overall avg.)
Soybeans	11/08/10	Harvest	34.3 bu/ac (overall avg.)
Corn	11/05/10	Harvest	101 bu/ac (overall avg.)

FIELD H4, DS ADMIRAL DRY PEAS

Previous crop – Roughrider Winter Wheat

04/17/10 Contractor sprayed field w/Glystar Plus @ 32 oz/ac + Sharpen @ 1 oz/ac + Helfire @ 1 qt/100 gal + MSO @ 1 gal/100 gal.

05/04/10 Field seeded w/JD750 drill @ 350,000 seeds/ac + 50 lb/ac 11-52-0.

06/08/10 Field sprayed w/Rezult @ 52 oz/ac + Headline @ 8 oz/ac + MSO @ 20 oz/ac + MegaGrow @ 2 oz/ac.

08/18/10 Field harvested w/JD4420 combine and flex header (15 bu/ac).

09/25/10 Contractor sprayed Glystar Plus @ 32 oz/ac + surfactant.

FIELD H4, SOYBEAN VARIETIES

Previous crop – NDSU Corn Variety Experiment

Seed donated by ProSeed and Legend Seed.

04/17/10 Contractor sprayed field w/Glystar Plus @ 32 oz/ac + Sharpen @ 1 oz/ac + Helfire @ 1 qt/100 gal + MSO @ 1 gal/100 gal.

06/23/10 Field seeded w/JD MaxEmerge II planter @ 180,000 seeds/ac (all varieties).

07/07/10 Field sprayed w/Assure II @ 6 oz/ac + MSO @ 1.5 pt/ac.

07/29/10 Contractor sprayed Glystar Plus @ 32 oz/ac + surfactant.

11/10/10 Field harvested w/JD4420 combine and all-crop header (cv. avg. 8.3 bu/ac).

FIELD H4, GLENN SPRING WHEAT

Previous crop- Soybean Varieties

Accolade donated by INTX Microbial, LLC.

04/17/10 Contractor sprayed field w/Glystar Plus @ 32 oz/ac + Sharpen @ 1 oz/ac + Helfire @ 1 qt/100 gal + MSO @ 1 gal/100 gal.

04/20/10 Contractor bulk spread urea @ 80 lb N/ac.

05/03/10 Field seeded with Sunflower drill @ 1.3 million seeds/ac + 70 lb/ac 11-52-0.

06/08/10 Contractor sprayed Wolverine @ 1.7 pt/ac + Headline @ 3 oz/ac for weed control.

08/18/10 Field was harvested with JD 6620 and straight head (46.7 bu/ac).

09/15/10 Contractor sprayed Glystar Plus @ 32 oz/ac + dicamba @ 4 oz/ac + 2,4-D ester @ 12 oz/ac + Helfire @ 1 qt/100 gal.

09/25/10 Contractor sprayed Glystar Plus @ 32 oz/ac + Helfire @ 1 qt/100 gal.

09/30/10 Seeded Overland winter wheat w/Haybuster 8000 drill @ 1.3 million viable seeds/ac + 70 lb/ac 11-52-0 (seed treated w/Accolade).

FIELD H4 EAST, OVERLAND WINTER WHEAT

Previous crop- Glenn Spring Wheat

09/23/09 Field seeded w/Haybuster 8000 drill @ 1.3 million seeds/ac + 70 lb/ac 11-52-0.

04/20/10 Contractor bulk spread urea @ 80 lb N/ac.

05/22/10 Contractor sprayed field w/Wolverine @ 27 oz/ac + Propimax @ 2 oz/ac + ProGerm Micro 500 @ 48 oz/ac.

06/22/10 Contractor applied Presaro @ 7 oz/ac + Premiere 90 @ 3 oz/ac for scab control.

08/05/10 Field was harvested with JD 6620 and straight head (54.8 bu/ac).

09/15/10 Contractor sprayed Glystar Plus @ 32 oz/ac + dicamba @ 4 oz/ac + 2,4-D ester @ 12 oz/ac + Helfire @ 1 qt/100 gal.

09/25/10 Contractor sprayed Glystar Plus @ 32 oz/ac + Helfire @ 1 qt/100 gal.

FIELD H5, ALFALFA (cont.)

Previous crop- Alfalfa, establishment year

05/30/09 Field seeded w/ JD750 drill.

04/16/10 Contractor sprayed field w/Raptor @ 4 oz/ac + Ammonium sulfate @ 1 qt/ac + MSO @ 1 gal/100 gal.

04/20/10 Contactor bulk spread 11-52-0 @ 100 lb material/ac.

06/12/10 Field harvested by contractors for hay (2.4 ton/ac, 15% moisture).

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

FIELD I1, HOWARD SPRING WHEAT (CONTINUOUS SPRING WHEAT 26 YRS).

Previous crop – Howard Spring wheat

04/17/10 Contractor sprayed field w/Glystar Plus @ 32 oz/ac + Sharpen @ 1 oz/ac + Helfire @ 1 qt/100 gal + MSO @ 1 gal/100 gal.

04/20/10 Contractor bulk spread urea @ 80 lb N/ac.

05/18/10 Field seeded with Sunflower drill @ 1.3 million seeds/ac + 70 lb/ac 11-52-0.

06/04/10 Contractor sprayed Wolverine @ 1.7 pt/ac + Headline @ 3 oz/ac (leaf diseases).

08/20/10 Field was harvested with JD 6620 and straight head (46.1 bu/ac).

09/15/10 Contractor sprayed Glystar Plus @ 32 oz/ac + dicamba @ 4 oz/ac + 2,4-D ester @ 12 oz/ac + Helfire @ 1 qt/100 gal.

09/25/10 Contractor sprayed Glystar Plus @ 32 oz/ac + Helfire @ 1 qt/100 gal.

FIELD I2, JERRY & ROUGHRIDER WINTER WHEAT

Previous crop – Pennant Mustard

09/24/09 Field seeded w/Bourgault drill @ 1.3 million seeds/ac + 70 lb/ac 11-52-0.

04/20/10 Contractor bulk spread urea @ 80 lb N/ac.

05/22/10 Contractor sprayed field w/Wolverine @ 27 oz/ac + Propimax @ 2 oz/ac + ProGerm Micro 500 @ 48 oz/ac.

06/22/10 Contractor applied Presaro @ 7 oz/ac + Premiere 90 @ 3 oz/ac for scab control.

08/13/10 Field was harvested with JD 6620 and straight head.

09/15/10 Contractor sprayed Glystar Plus @ 32 oz/ac + dicamba @ 4 oz/ac + 2,4-D ester @ 12 oz/ac + Helfire @ 1 qt/100 gal.

09/25/10 Contractor sprayed Glystar Plus @ 32 oz/ac + Helfire @ 1 qt/100 gal.

FIELD I3, HOWARD SPRING WHEAT (NORTH HALF)

Previous crop – Steele Spring Wheat

04/17/10 Contractor sprayed field w/Glystar Plus @ 32 oz/ac + Sharpen @ 1 oz/ac + Helfire @ 1 qt/100 gal + MSO @ 1 gal/100 gal.

05/19/10 Field seeded with Sunflower drill @ 1.3 million seeds/ac + 130 lb/ac of 50-50 blend Environmentally Safe Nitrogen (ESN, polycoated urea, 20 lb N/ac) + 11-52-0.

06/04/10 Contractor sprayed Wolverine @ 1.7 pt/ac + Headline @ 3 oz/ac (leaf diseases).

08/20/10 Field was harvested with JD 6620 and straight head (33.1 bu/ac).

FIELD I3, COVER CROP SEEDING DATE PROJECT (SOUTH HALF)

Previous crop – Steele Spring Wheat

FIELD I4, JERRY WINTER WHEAT

Previous crop – Tradition Barley

09/23/09 Field seeded w/Bourgault drill @ 1.3 million seeds/ac + 70 lb/ac 11-52-0.

04/20/10 Contractor bulk spread urea @ 80 lb N/ac.

05/22/10 Contractor sprayed field w/Wolverine @ 27 oz/ac + Propimax @ 2 oz/ac + ProGerm Micro 500 @ 48 oz/ac (west half w/Micro 500, east half w/o Micro 500).

06/22/10 Contractor applied Presaro @ 7 oz/ac + Premiere 90 @ 3 oz/ac for scab control.

08/12/10 Field was harvested with JD 6620 and straight head (w/Micro 500, 45.3 bu/ac; w/o Micro 500, 47.9 bu/ac).

09/15/10 Contractor sprayed Glystar Plus @ 32 oz/ac + dicamba @ 4 oz/ac + 2,4-D ester @ 12 oz/ac + Helfire @ 1 qt/100 gal.

FIELD I5, PROSEED E-8 & CROPLAN 3080 SUNFLOWER

Previous crop – Jerry Winter Wheat

04/20/10 Contractor bulk spread urea @ 80 lb N/ac.

05/23/10 Contractor sprayed Glystar Plus @ 32 oz/ac + Spartan @ 3.5 oz/ac + Aim @ 0.5 oz/ac + surfactant.

06/08/10 Field was seeded w/JD MaxEmergeII planter @ 24,000 seeds/ac: ProSeed E-8 (west side) and Croplan 3080 (east side).

07/02/10 Contractor sprayed Assure II @ 7.2 oz/ac + surfactant + MSO for grass control.

08/19/10	Contractor sprayed Asana XL @ 9.6 oz/ac + Headline @ 6 oz/ac + surfactant for insects.
10/06/10	Contractor sprayed Gramoxone @ 32 oz/ac + surfactant (pre-harvest dessication).
10/18/10	Field was harvested with JD 6620 combine and all crop head (E-8, 1600 lb/ac; 3080, 2679 lb/ac).

FIELD I6, HOWARD SPRING WHEAT – N FERTILIZER TREATMENTS

Previous crop – Sunflowers, Proseed 2001 CL & E-85

Field divided into 3 management strips - west, middle and east (~ 9 ac apiece).

04/17/10	Contractor sprayed field w/Glystar Plus @ 32 oz/ac + Sharpen @ 1 oz/ac + Helfire @ 1 qt/100 gal + MSO @ 1 gal/100 gal.
04/20/10	Contractor bulk spread urea in west and east strips @ 60 lb N/ac & middle strip @ 80 lb N/ac.
05/18/10	Field seeded with Sunflower drill @ 1.3 million seeds/ac + 70 lb/ac 11-52-0 (applied 20 lb N/ac as ESN, slow- release N, in west strip).
06/04/10	Contractor sprayed Wolverine @ 1.7 pt/ac + Headline @ 3 oz/ac (leaf diseases).
06/05/10	Contractor applied 20 lb N/ac as liquid (27-0-0-1, east strip).
08/20/10	Field was harvested with JD 6620 and straight head (see table in summary page).
09/15/10	Contractor sprayed Glystar Plus @ 32 oz/ac + dicamba @ 4 oz/ac + 2,4-D ester @ 12 oz/ac + Helfire @ 1 qt/100 gal.
09/25/10	Contractor sprayed Glystar Plus @ 32 oz/ac + Helfire @ 1 qt/100 gal.
10/1 & 4/10	Field seeded Jerry winter wheat w/Bourgault drill @ 1.3 million seeds/ac

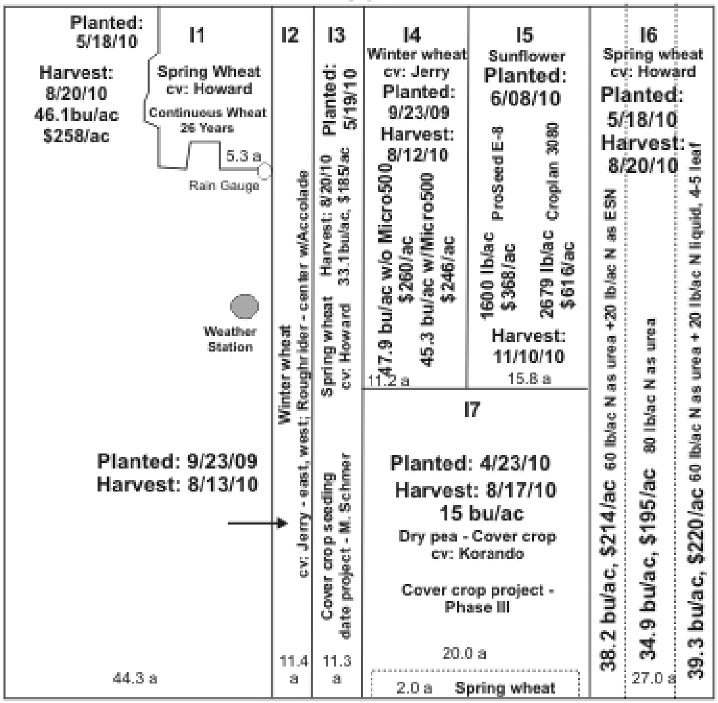
FIELD I7, KORANDO DRY PEA (Certified Seed), COVER CROP PROJECT (Phase III)

Previous crop – Howard Spring Wheat

04/17/10	Contractor sprayed field w/Glystar Plus @ 32 oz/ac + Sharpen @ 1 oz/ac + Helfire @ 1 qt/100 gal + MSO @ 1 gal/100 gal.
04/23/10	Field was seeded w/JD750 drill @ 350,000 seeds/ac.
06/08/10	Field sprayed w/Rezult @ 52 oz/ac + Headline @ 8 oz/ac + MSO @ 20 oz/ac + MegaGrow @ 2 oz/ac.
08/16-17/10	Field was harvested w/JD4420 and flex head (10 bu/ac).
08/20/10	Contractor sprayed field w/Glystar Plus @ 32 oz/ac + Helfire @ 1 qt/100 gal.
08/25/10	Seeded 12 treatments of Cover Crop Project.
08/26/10	Seeded remaining 6 treatments of Cover Crop Project.

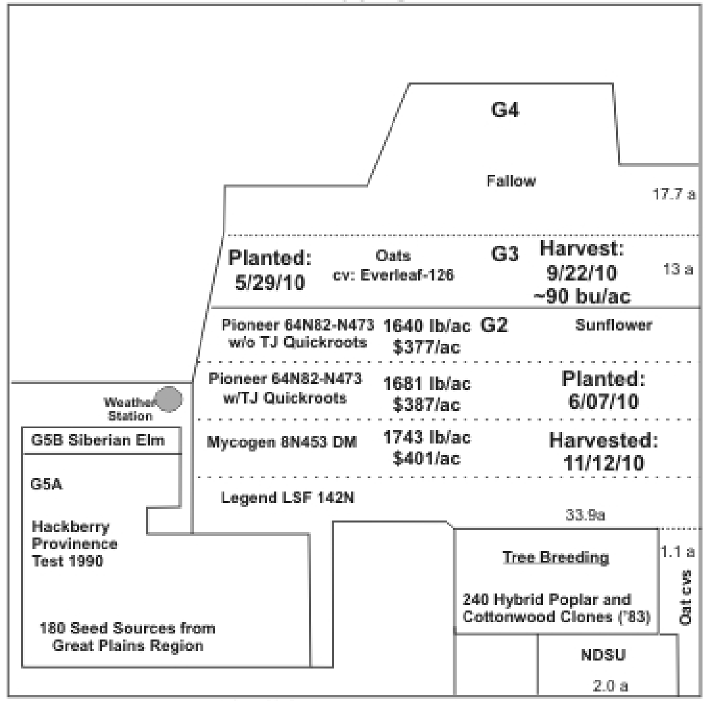
2010 Area IV Research Farm
Crop Summary

Area I



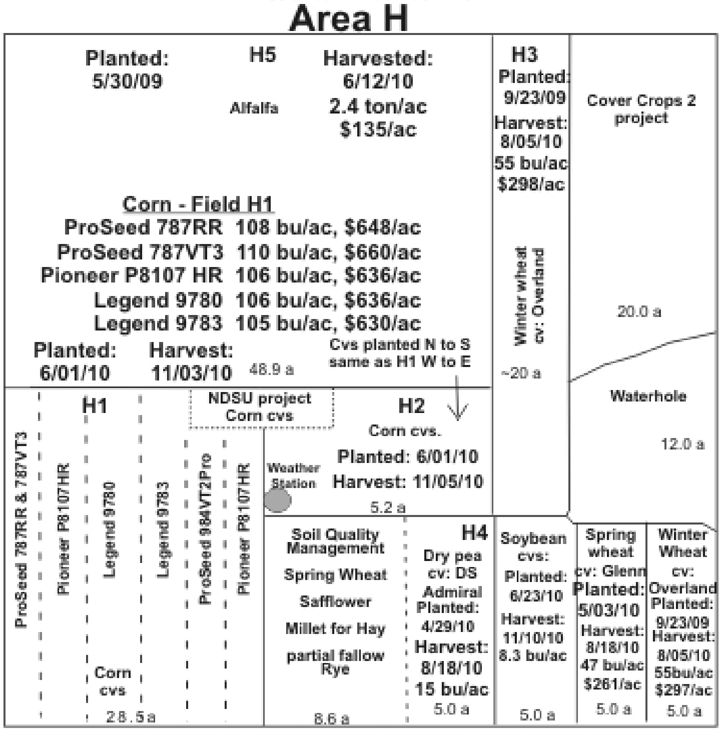
NE ¼ Section 20 T138N R81W

Area G



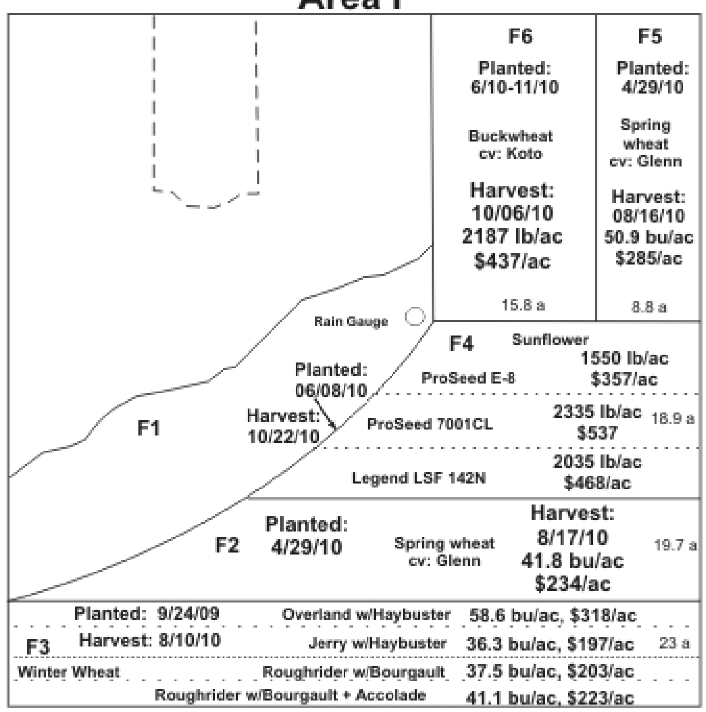
SW ¼ Section 8 T138N R81W

Area H



NE ¼ Section 18 T138N R81W

Area F



NW ¼ Section 17 T138N R81W

2010 Area IV Research Farm - Supplemental Data Sheet

Winter Wheat - 2010 Crop

Field	Variety	Yield	Protein	$/bu
		(bu/ac)	(%)	
F3	Overland	58.6	11.4	5.42
F3	Jerry	36.3	12.6	5.42
F3	Roughrider w/Accolade	41.1	13.6	5.42
F3	Roughrider w/o Accolade	37.5	13.3	5.42
I4	Jerry east	45.3	11.7	5.42
I4	Jerry west	47.9	10.8	5.42

List of Crops grow	
1. Alfalfa	7. Saffl
2. Barley	8. Soyb
3. Buckwheat	9. Sprir
4. Corn	10. Sun
5. Oats	11. Wir
6. Peas	

Spring Wheat - 2010 Crop

Field	Variety	Yield	Moisture	Test wt.	Protein	$/bu
		(bu/ac)	(%)	(lb/bu)	(%)	average
F2	Glenn	41.8	13.1	62.2	11.8	5.59
F5	Glenn	50.9	14.6	61.3	13.3	5.59
H4 west	Glenn	46.7	13.3	60.9	13.8	5.59
I1	Howard	46.1	16.8	54.9	13.0	5.59
I3	Howard	33.1	14.3	56.5	12.5	5.59
I6	Howard, east	39.3	11.5	59.3	12.8	5.59
I6	Howard, middle	34.9	12.0	59.0	11.8	5.59
I6	Howard, west	38.2	11.4	59.5	12.4	5.59

Sunflower varieties

Field	Company	Variety/Treatment	Yield	Moisture	Test wt.	$/hw
			(bu/ac)	(%)	(lb/bu)	averag
F4	ProSeed	E-8	1550	12.1	24.1	23.0C
I5	ProSeed	E-8	1600	11.8	27.4	23.0C
F4	ProSeed	7001CL	2335	9.8	28.0	23.0C
G2	Pioneer	64N82-N473 w/TJ Quickroots	1681	13.7	31.1	23.0C
G2	Pioneer	64N82-N473 w/o TJ Quickroots	1640	13.1	30.4	23.0C
G2	Mycogen	8N453 DM	1743	14.4	30.6	23.0C
I5	Croplan	3080	2679	14.5	26.0	23.0C

Corn varieties (Field H1)

Company	Variety	Yield	Moisture	Test wt.	$/bu
		(bu/ac)	(%)	(lb/bu)	estimated
ProSeed	787 RR	108	20.1	50.6	6.00
ProSeed	787 RR VT3	110	20.6	50.1	6.00
ProSeed	984 VT2	103	19.1	50.6	6.00
Pioneer	P8107 HR	106	18.4	51.3	6.00
Legend	9780	106	17.6	50.5	6.00
Legend	9783	105	17.3	50.9	6.00

Oat forage varieties (Field G-1)

Variety	Oat biomass production	Protein
	(lb/ac)	(%)
Souris	7307	11.2
Everleaf 126	7182	10.5
Kona	7009	13.4
Shooting Star	6188	12.8
Viking	6143	11.3

2010 Growing Degree Units - from NDAWN

Month	Wheat base	Avg/ Normal	Corn base	Avg/ Norm
May	638	717	252	285
June	966	984	433	445
July	1158	1182	583	624
August	1178	1144	596	586
Sept.	-------	-------	262	315
Total	**3940**	**4027**	**2126**	**2255**

Management Strategies for Soil Quality

Drs. Donald Tanaka and Mark Liebig

(Roundup Weather Max donated by Monsanto)

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	05/18/10	Parshall	1.3 million	60 lb N/ac recrop; 30 lb N/ac fallow + 10 lb P/ac.	JD750	8/25/10 rep 1 9/13/10 reps 2 & 3
Safflower	05/18/10	Montola 2003	300,000	60 lb N/ac + 10 lb P/ac	JD750	9/28/10
Rye	11/10/09	Dacold	1.3 million	50 lb/ac 11-52-0	Haybuster 8000	7/6/10 sampled 7/7/10 sprayed 7/12/10 tilled
Millet (hay)	06/11/10	Manta – Siberian red	4 million	60 lb N/ac + 10 lb P/ac as 11-52-0	JD750	8/17/10 sampled 8/30/10 swathed

Residue from previous crops was uniformly distributed at harvest. All spring wheat and safflower no-till plots were sprayed April 21, 2010 with Roundup Weather Max (16 oz./a) + Aim (0.5 oz/a). Rye plots were sprayed May 3, with Bison (8 oz/a). Minimum-till plots were tilled with an undercutter about 3 inches deep prior to seeding. Millet plots were sprayed June 7 with Roundup Weather Max (20 oz/ac). Spring wheat was sprayed June 21 with Tacoma (8 oz/a) + Bison (16 oz/a) + Headline (3 oz/a). Safflower was sprayed July 6 with GT Harmony (1/12 oz/a) and July 7 with Assure II (6 oz/a) and crop oil and with Quadris (6.2 oz/a) for fungal disease on August 11. 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. Post-harvest spray was applied on all plots September 30 using Roundup Weather Max (24 oz/a) + 2, 4-D LV6 (20 oz/a) + surfactant.

Summary:

1. Growing season precipitation (May through August) for 2010 was 105% of the long-term average (9.9 inches). The wet May delayed seeding by at least 2 weeks.
2. Average monthly air temperatures (May through August) were cooler for all months except August. May was 2.4°F cooler than the long-term average (54.9).
3. Spring wheat seed yield for the treatments (Figure 1) responded to the cool wet spring with the SW-F having the lowest yield and the 3-year rotations having the highest yield (SW-S-F and SW-S-R average spring wheat seed yield was 29% greater than SW-F seed yield).
4. Adding crop diversity to rotations by including rye and safflower improved spring wheat and safflower seed yield (Figures 1 and 2).

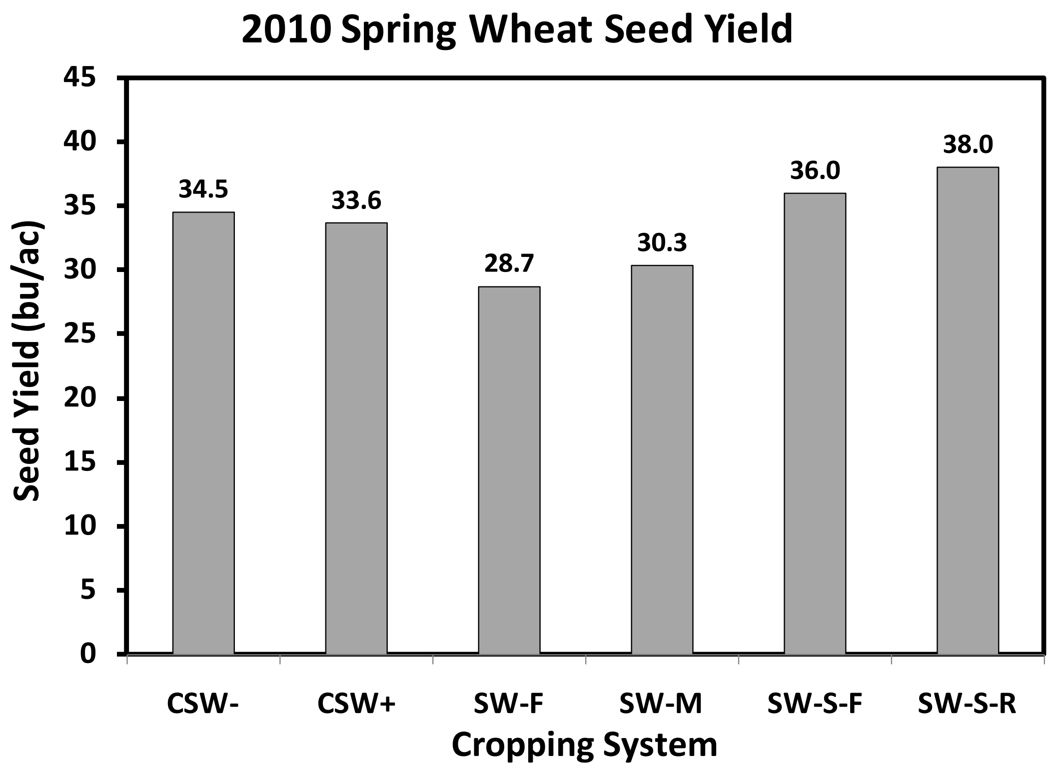


Figure 1. Spring wheat seed yield as influenced by cropping system. Yields are the average of minimum and no-till.

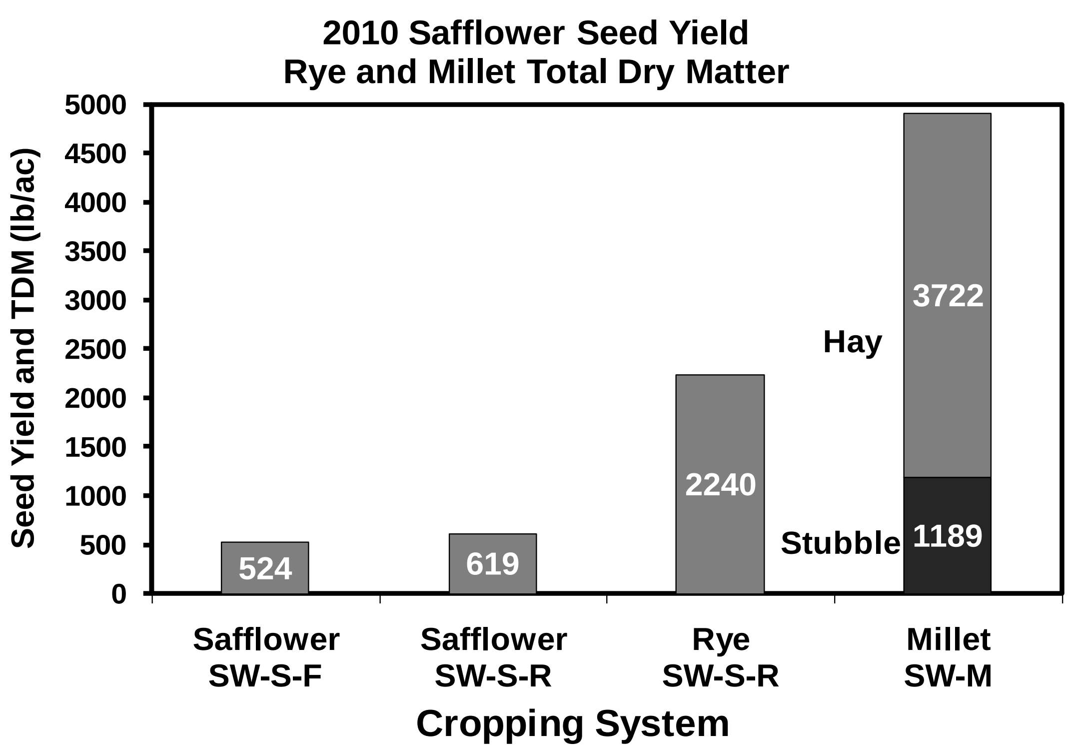


Figure 2. Safflower seed yield as influenced by cropping system. Total dry matter production for rye used as partial fallow (cover crop) and Siberian millet used for hay. Yields are the average of minimum and no-till.

Integrated Crop/Livestock Systems - 2010 Summary

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

(Roundup Weather Max donated by Monsanto; Oats donated by Pulse USA)

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 May 20 where corn was previously grown. Oat strips were sprayed prior to planting (May 17) with Roundup @ 16 oz/ac + dicamba @ 2 oz/ac + Aim @ 0.5 oz/ac + AMS. Oats was swathed with a 20’ swather on August 6 and swath grazed from Oct. 6 to Nov. 9. Corn was seeded on May 27 where sorghum x sudan was previously grown. Sprayed corn with Roundup Weather Max @ 20 oz/ac + Sterling @ 8 oz/ac + AMS @ 5 gal/100 gal on June 14 and on July 13 with Roundup Weather Max @ 20 oz/ac + Status @ 2.5 oz/ac. Corn was harvested on November 9 with an all-crop head and residue left in a windrow. Corn residue was grazed starting Nov. 10. Sorghum x sudan was seeded on June 8 & 9 after applying Roundup Weather Max @ 20 oz/ac (June 7). Sorghum x sudan was swathed with a 12’ swather on October 5 and swath grazed starting Dec. 2. Grazing ended Dec. 14. Cows and calves grazed oats with only cows grazing corn residue and sorghum x sudan.

Table 1. Crop parameters for 2010.

Crop	Cultivar or type	Planting	Planting rate	Fertilizer	Drill	Swathed / Harvest
Oats	Everleaf 126	5/20/10	1.0 million viable seeds/ac	30 lb N/ac (urea) 50 lb/ac (11-52-0)	JD750	08/06/10
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//8-9/10	285,000 viable seeds/ac	30 lb N/ac (urea) 50 lb /ac 11-52-0	JD750	10/05/10
Sweet clover/ Red clover	YB / common		8-10 lb/ac total			
Corn	Legend LR9783 RB	5/27/10	25,380 seeds/ac skip-row	60 lb N/ac (urea) seed treated w/Jump Start	JD Max Emerge II	11/09/10

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

Crop Consumer	Days of Grazing	ADG (lbs/day)	% Crude Protein
Oats*	34	-1.2	13.6
Corn Residue	21	-1.7	4.1
Sorghum-Sudan	22	1.6	8.5
Grazing then Hay Control	77	-0.36,-2.2, -1.7**	7.5, 8.1***

**Calves were present while grazing oats. Stocking rate was 8 head on 12.6 acres for windrowed annual crops and 8 head on 15 acres of typical pasture, then 40 lbs/day of chopped prairie grass hay.*

***Changes in body weights of control cows given for each type of annual crop consumed.*

****Crude protein level of grass and hay.*

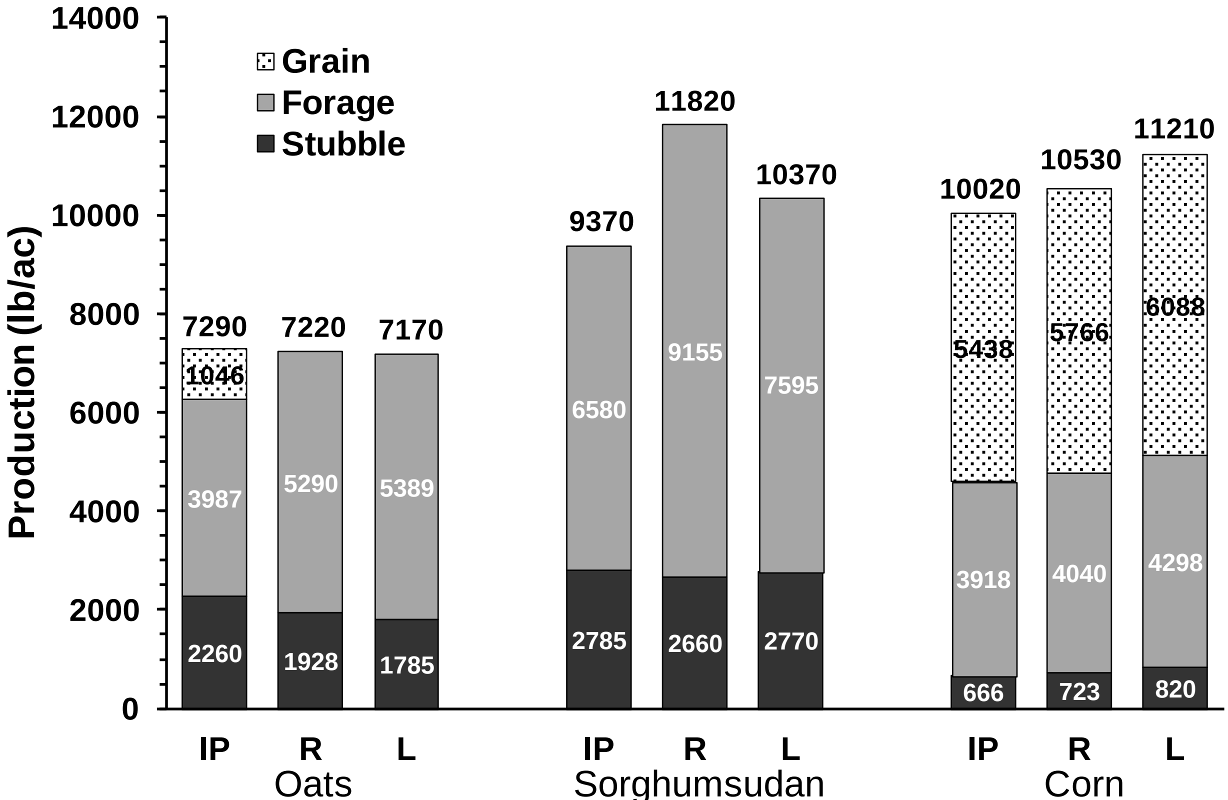


Figure 1. Grain and biomass production of three cropping systems in 2010. IP = grain harvested residue left in place. R = grain harvested residue removed. L = residue or forage swath grazed by livestock.

Summary:

1. Corn GDU's were below average for all months except August. Total GDU's from May through September were 94% of the long-term average.

2. Growing season precipitation was 105% of long-term (9.9) and coupled with above average temperatures in August resulted in one of the best forage yields for sorgum x sudan for the past 4 years.

3. Cows plus calves grazed oats first then corn residue after harvest and sorghum x sudan last. Because of large quantities of snow in sorgum x sudan (>15 inches) cows were removed in late December.

NDSU Hetinger Research Extension Center Studies on the Area 4 SCD Cooperative Research Farm

2010 Field Pea Variety Trial - Continuously Cropped - No-till at Mandan

Variety	Brand	1000 Seed wt.	Test Weight	Seed Yield
		grams	lbs/bu	bu/A
Yellow Cotyledon Types				
CDC Golden	Alt. Seed Str.	200	60.9	57.3
Agassiz	Meridian Seeds	229	60.1	53.9
DS Admiral	Pulse USA	195	60.9	53.2
Green Cotyledon Types				
Cruiser	Pulse USA	158	60.9	48.7
Majoret	Pulse USA	190	60.8	46.9
CDC Striker	Alt. Seed Str.	202	61.0	44.9
Arogorn	Progene	174	59.8	42.9
Malachite	Pulse USA		60.6	42.0
Trial Mean			59.7	42.9
C.V. %			0.9	8.3
LSD .05			0.9	5.8
LSD .01			1.2	7.7

Planting Date: April 22
Harvest Date: August 16
Seeding Rate: 330,000 live seeds / acre.
Previous Crop: HRSW

2010 HRSW Variety Trial - Continuously Cropped - No-till at Mandan

Variety	Plant Height	Test Weight	Grain Protein	---- Grain Yield ---- 2008	2009	2010	Average Yield 2 yr	3 yr
	inches	lbs/bu	%	----------- Bushels per acre -----------				
Mott	37	57.9	14.2	59.1	67.0	71.1	69.0	65.7
Barlow	36	58.0	14.7	66.2	63.2	64.3	63.8	64.6
Faller	35	55.3	14.1	58.5	69.2	61.4	65.3	63.0
Steele-ND	35	57.7	15.1	59.5	54.6	64.6	59.6	59.6
Howard	34	57.1	14.2	57.6	57.3	58.4	57.8	57.8
Glenn	35	59.6	15.1	56.2	54.1	60.4	57.2	56.9
Brennan	30	56.8	13.9		65.6	66.2	65.9	
Briggs	35	57.9	14.6		64.4	66.6	65.5	
RB07	31	55.7	14.5			62.9		
Trial Mean	34	56.5	14.3	61.7	61.9	64.1	--	--
C.V. %	3.0	1.1	3.3	6.0	5.0	4.4	--	--
LSD .05	1	0.9	0.7	5.4	4.5	4.0	--	--
LSD .01	2	1.2	0.9	7.2	6.0	5.4	--	--

Planting Date: April 22
Harvest Date: August 16
Seeding Rate: 1.1 million live seeds / acre (approx. 1.6 bu/A).
Previous Crop: 2007& 2008 = hrsw, 2009 = field pea.

2010 Winter Wheat Variety Trial - Continuously Cropped - No-till at Mandan

Variety	Winter Survival	Plant Height	Test Weight	Grain Protein	---- Grain Yield ---- 2008	2009	2010	Average Yield 2 yr	3 yr
	%	inches	lbs/bu	%	----------- Bushels per acre -----------				
Overland	99	29	57.0	10.0	58.9	84.4	51.4	67.9	64.9
Jagalene	97	27	56.4	10.8	56.7	86.7	44.5	65.6	62.6
Darrell	97	30	56.7	10.0	60.1	77.1	48.9	63.0	62.0
Millennium	98	30	57.7	10.6	55.5	77.7	51.1	64.4	61.4
Peregrine	97	35	57.6	9.6	52.3	86.0	44.5	65.2	60.9
Radiant	93	31	54.3	10.3	57.3	85.7	38.4	62.0	60.5
Jerry	92	30	55.3	11.1	57.7	76.3	47.0	61.6	60.3
Accipiter	98	28	57.6	10.2	55.0	80.8	44.4	62.6	60.1
Lyman	98	30	57.3	10.8	43.5	87.5	47.3	67.4	59.4
Yellowstone	97	29	52.6	11.5	53.6	75.7	47.5	61.6	58.9
Falcon	98	26	56.4	10.2	52.6	78.7	40.7	59.7	57.3
Wesley	99	27	54.1	12.4	38.0	81.7	50.1	65.9	56.6
Hawken	96	26	55.3	12.7	39.1	83.2	45.9	64.6	56.1
Decade	98	29	56.0	11.6		92.2	49.6	70.9	
Boomer	95	30	54.4	11.4		81.8	48.3	65.0	
Art	97	26	56.0	11.4		80.4	44.7	62.6	
Mace	95	25	52.4	11.0		76.5	40.5	58.5	
Striker	95	26	55.8	11.3		74.0	41.4	57.7	
Carter	96	25	55.2	11.6			40.0		
Trial Mean	96	28	55.4	11.0	49.2	81.3	45.1	--	--
C.V. %	4.6	5.3	1.6	7.8	14.0	7.1	15.4	--	--
LSD .05	NS	2	1.3	1.2	9.7	8.1	9.8	--	--
LSD .01	NS	3	1.7	1.6	12.9	10.8	12.9	--	--

Planting Date: October 8, 2009 Harvest Date: August 18, 2010
Seeding Rate: 1 million live seeds / acre (approx. 1.4 bu/A).
Previous Crop: 2007 = soybean, 2008 & 2009 = hrsw.
Note: The 2010 trial sustained significant nitrogen deficiency causing relatively poor protein content and yields.

2010 Barley Variety Trial, Continuously Cropped, No-till at Mandan

Variety	Plant Height	Test Weight	% Plump	Grain Protein	---- Grain Yield ---- 2009	2010	2 yr
	inches	lbs/bu	>6/64	%	--------- bu/A ---------		
2 Row Types							
Pinnacle	34	45.9	90	11.6	79.4	89.4	84.4
Rawson	34	45.1	90	11.9	73.3	86.5	79.9
Conlon	33	46.4	92	12.8	72.2	79.5	75.8
6 Row Types							
Tradition	31	45.6	92	12.2	90.1	91.4	90.8
Stellar-ND	33	44.7	93	12.4	88.0	87.9	88.0
Celebration	31	44.8	91	13.0	83.7	90.1	86.9
Trial Mean	33	45.4	91	12.3	81.1	87.5	--
C.V. %	4.6	1.1	1.9	2.6	3.9	2.7	--
LSD .05	2	0.8	NS	0.5	4.8	3.5	--
LSD .01	NS	1.0	NS	0.7	6.6	4.9	--

NS = no statistical difference between varieties.

Planting Date: April 22
Harvest Date: August 16
Seeding Rate: 750,000 live seeds / acre (approx.. 1.4 bu/A).
Previous Crop: 2008 & 2009 = hrsw.

2010 Oat Variety Trial - Continuously Cropped - No-till Mandan

Variety	Plant Height	Test Weight	------ Grain Yield ------ 2008	2009	2010	Average Yield 2 yr	3 yr
	inches	lbs/bu	------------- Bushels per acre -------------				
Killdeer	39	35.1	142.1	166.7	142.2	154.4	150.3
Souris	39	36.0	137.0	159.0	139.7	149.4	145.2
Maida	45	36.5	119.0	153.8	146.5	150.2	139.8
Morton	46	36.3	124.6	154.1	133.2	143.6	137.3
Jerry	42	37.4	127.2	127.5	118.2	122.8	124.3
Rockford	45	38.4		172.4	142.7	157.6	
Trial Mean	43	36.6	126.2	157.8	137.1	--	--
C.V. %	2.8	1.2	6.0	4.1	3.1	--	--
LSD .05	2	0.7	11.3	9.6	6.4	--	--
LSD .01	3	0.9	15.5	13.2	8.8	--	--

Planting Date: April 22
Harvest Date: August 16
Seeding Rate: 750,000 live seeds / acre (approx. 1.7 bu/A).
Previous Crop: 2007, 2008 & 2009 = hrsw.

2010 Durum Variety Trial - Continuously Cropped - No-till at Mandan

Variety	Plant Height	Test Weight	Grain Protein	---- Grain Yield ---- 2008	2009	2010	Average Yield 2 yr	3 yr
	inches	lbs/bu	%	----------- Bushels per acre -----------				
Grenora	37	55.5	13.5	57.7	68.1	71.7	69.9	65.8
Alkabo	37	57.3	13.1	60.2	70.2	67.1	68.6	65.8
Divide	38	57.2	14.3	55.8	69.6	69.2	69.4	64.9
Mountrail	39	56.0	13.4	56.9	63.0	70.0	66.5	63.3
Tioga	40	56.6	13.8		66.8	65.6	66.2	
Trial Mean	39	56.8	13.7	57.1	67.1	68.8	--	--
C.V. %	2.0	0.8	2.8	6.0	4.2	4.1	--	--
LSD .05	1	0.7	0.6	NS	4.3	NS	--	--
LSD .01	2	0.9	0.8	NS	5.9	NS	--	--

Planting Date: April 22
Harvest Date: August 16
Seeding Rate: 1.25 million live seeds / acre (approx. 2.2 bu/A).
Previous Crop: 2007& 2008 = hrsw, 2009 = field pea.

NDSU and USDA-ARS Partner to Establish Biomass Testing Laboratory

Dr. Igathi Cannayan

Cole Gustafson and Igathi Cannayen of the NDSU Department of Agricultural and Biosystems Engineering, received $450,000 from the North Dakota Renewable Energy Council and USDA-ARS to establish the first dedicated biomass testing laboratory in the state.

The lab will be designed specifically to test the dimensional, thermal and physical properties of biomass. It will be located at the Northern Great Plains Research Laboratory.

NDSU and NGPRL have established 10-year research trials using more than 50 different varieties of biomass at multiple locations around the state. Igathi initially will evaluate production from these trials for both energy content and densification for shipping. Engineers are striving to develop new biomass harvesting, processing and transportation machines. Information on the physical properties of biomass will help the industry design optimal equipment.

Biomass product characteristics will be important in developing new market standards and grades, which in turn will facilitate commercialization.

Information on biomass densification will aid in planning with respect to infrastructure and roads that may be needed to support the industry. The development of the lab requires time to calibrate and validate test equipment. Time is needed to conduct these steps in advance of industry demand. Additional funding is being sought to develop biomass market standards, assist agricultural producers in forming a biomass supply network, and develop a hands-on mobile biomass processing display to educate potential biomass suppliers on differing harvesting and processing methods.

The new biomass testing lab will contain four primary machines: (1) a universal testing machine to measure the force needed to compress, shear or cut biomass, (2) a machine to monitor the mass and temperature of biomass as it is heated in a controlled inert environment (these data are useful in determining the burning point of biomass and temperatures needed for operations, such as pelleting,) (3) a bomb calorimeter to measure the energy content of various biomass samples, and (4) an environmental control chamber to allow biomass storage studies in a controlled environment that has a constant temperature and humidity. The lab is expected to take two years to develop before it becomes fully operational. The lab will be able to evaluate biomass samples submitted by the industry, researchers and producers.

A goal of the project is to develop a database of biomass characteristics obtained from samples coming to the lab from across the state. Information from the database will be utilized to recruit additional processors to the region.

Soil Resource Evaluation of Management Systems to Enhance Agroecosystem Sustainability

Scientists

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

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 the Northern Great Plains Research Laboratory 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 peer-reviewed publications, popular press articles, a web page, and a 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 2010

Grazing Management Affects Greenhouse Gas Emissions. Grazing lands represent one of the largest land resources in the world, yet their role as net sinks or sources of greenhouse gases (GHGs) is essentially unknown. A team of scientists at the USDA-ARS Northern Great Plains Research Laboratory in Mandan, ND, estimated net global warming potential (GWP) for three grazing management systems located in central North Dakota. The team measured soil organic carbon change and nitrous oxide and methane flux in the three grazing treatments, and combined their findings with estimates for methane emission from cattle (via enteric fermentation) and carbon dioxide emissions associated with producing and applying nitrogen fertilizer. Summing across factors, net GWP was negative for native vegetation pastures, implying net removal of GHGs from the atmosphere. This finding underscored the value of grazed, mixed-grass prairie as a viable agroecosystem to serve as a net GHG sink in the northern Great Plains.

Greenhouse Gas Emissions from Fallow In Dryland Cropping Systems. Among the management options available to agricultural producers in the northern Great Plains, the use of fallow has persisted despite documented drawbacks of reduced precipitation-use efficiency and impaired soil quality compared to annually cropped land. Given the prevalence of this critical non-cropping phase, a study was undertaken by ARS scientists in Mandan, North Dakota, to contrast green- and chemical-fallow phases in no-till cropping systems for their effects on soil organic carbon and greenhouse gas flux. Soil samples collected prior to initiation of gas flux measurements indicated no difference in organic carbon between cropping systems in the surface four inches of soil. Furthermore, cumulative fluxes of carbon dioxide, methane, and nitrous oxide did not differ between the two fallow phases, suggesting there was no net greenhouse gas benefit from incorporating a green manure cover crop during the fallow phase.

Agronomic Rates of Urea Addition Affect Gas Emissions. Granular urea is the most common form of synthetic nitrogen (N) used to fertilize crops in the Northern Great Plains, and may affect soil gas emissions from arable cropland and prairie hay land ecosystems. ARS scientists in Mandan, North Dakota conducted a study to determine if agronomic rates of urea applied to cropland and prairie soils would increase nitrous oxide emissions and reduce methane uptake. In these soils, at approximately 20 to 120 pounds per acre of N, urea did not increase nitrous oxide emission or reduce methane uptake. However, soils from both ecosystems showed a significant response in carbon dioxide production to urea addition. Results suggest the role of fertilization on greenhouse gas emissions in for crops in semi-arid climates may be less than expected.

Scientific Publications

Liebig, M.A., Tanaka, D.L., Gross, J.R. 2010. *Fallow Effects on Soil Carbon and Greenhouse Gas Flux in Central North Dakota*. Soil Science Society of America Journal. 74(2): 358-365.

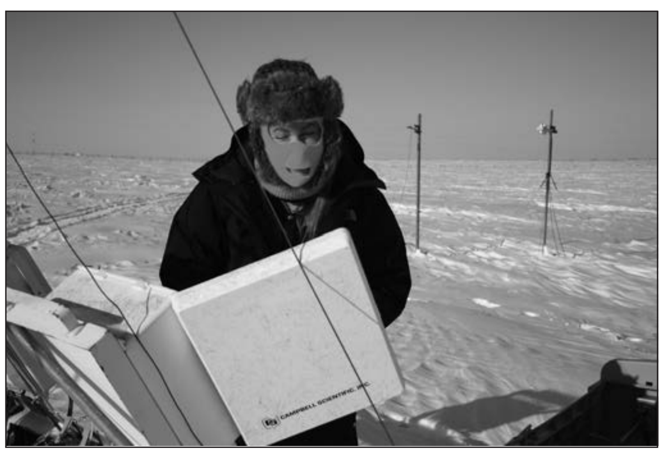
Liebig, M.A., Gross, J.R., Kronberg, S.L., Phillips, B.L., Hanson, J.D. 2010. *Grazing Management Contributions to Net Global Warming Potential: A Long-Term Evaluation in the Northern Great Plains*. J. Environ. Qual. 39(3):799-809.

Phillips, B.L., Podrebarac, F.A. 2009. *Net Fluxes of C02, but not N20 or CH4, are Affected Following Agronomic-Scale Additions of Urea to Prairie and Arable Soils*. Soil Biology and Biochemistry 41:2011-2013.

Tanaka, D.L., Lyon, D.J., Miller, P.R., Merrill, S.D., Mcconkey, B.G. 2010. *Soil and Water Conservation Advances in the Northern Great Plains*. p. 81-102.

T.M. Zobeck and W.F. Schillinger (eds.) S*oil and Water Conservation Advances in the United States*. SSSA Spec. Publ. 60. SSSA, Madison, WI.

Stott, D.E., Andrews, S.S., Liebig, M.A., Wienhold, B.J., Karlen, D.L. 2009. *Evaluation of E-Glucosidase Activity as a Soil Quality Indicator for the Soil Management Assessment Framework (SMAF)*. Soil Science Society of America Journal.



Dr. Rebecca Phillips monitoring instruments in -20°F Temperatures

Rangeland and Livestock Resource Management

Scientists

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

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.

Approach

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.

Finally, 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.

Major Accomplishments for 2010

Shrubs in northern grasslands increase carbon and nitrogen in soil. Overgrazing and fire suppression have contributed to an increased abundance of shrubs within grasslands throughout the world. Increases in shrubs have come at the expense of grasses, and little is known about how this shift in vegetation dominance will affect grassland ecosystems. ARS scientists in Mandan, North Dakota conducted a study to determine the influence of shrub expansion on soil carbon and nitrogen in a northern mixed-grass prairie grassland near Mandan, North Dakota. They found that carbon and nitrogen was greater under established shrubs as compared to grassland in the surface six inches of soil. Accumulation of soil carbon and nitrogen under shrubs in northern grasslands may contribute to `islands of fertility', which can have long-term impacts on ecosystem functions.

Ingestion of condensed tannin in water to reduce methane emissions of ruminant livestock. It has been shown that intake of some types of condensed tannins by sheep, cattle, and goats can reduce their emissions of methane by as much as 30%. However, many commonly grazed or fed forages do not contain condensed tannins and livestock grazing high quality forage will often not consume solid supplements that could contain condensed tannin. However, since grazing livestock usually drink it may be possible to supplement their diets with condensed tannin if they will drink water containing small amounts of condensed tannin. ARS scientists at Mandan, North Dakota evaluated this approach and concluded that ruminant livestock will ingest small amounts of condensed tannin via their drinking water. Therefore, this approach may be a practical way to put methane reducing condensed tannin into grazing livestock.

Effect of supplemental ground flaxseed to beef cattle grazing summer range. Supplementing energy sources such as grain is problematic because growth response differs with the type of energy supplement, but feed use efficiency has been improved by supplementing vegetable oil or oilseeds such as soybean or corn oil or whole soybeans. ARS scientists at Mandan, North Dakota supplemented grazing cattle with ground flaxseed (another type of oilseed) and found that daily weigh gain and feed use efficiency was improved by supplementing flaxseed. These results suggest that supplementing cattle during summer grazing with flaxseed could be beneficial to producers who wish to increase livestock growth rates.

Scientific Publications

Springsteen, A., Loya, W., Liebig, M.A., Hendrickson, J.R. 2010. *Soil carbon and nitrogen across a chronosequence of woody plant expansion in North Dakota.* Plant and Soil 328: 369-379.

Kronberg, S.L. 2010. *Sheep Intake of Water Containing Quebracho or Black Wattle Tannin.* Rangeland Ecological Management 63:258-262.

Scholljegerdes, E.J., Kronberg, S.L. 2010. *Effects of Supplemental Ground Flaxseed Fed to Beef Cattle Grazing Summer Native Range on the Northern Great Plains.* Journal of Animal Science 88:2108-2121.

Northern Great Plains Research Laboratory cow herd

Integrated Agricultural Systems for the Northern Great Plains

Scientists

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

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

Multiple methodologies will be used depending on the specific objectives because of the complexity of this integrated agricultural systems research project.

Objective 1 will use a modified crop matrix where different cover crops are seeded into a common residue to evaluate the above- and below-ground impact of cover crops on subsequent crops.

Objective 2 will use small plot techniques, crop rotation, economic analysis, and modeling techniques to develop economically feasible management strategies for biofuels and an Eddy Covariance System to measure $C0^2$ flux as a surrogate for environmental impact of biomass crops.

Integration of crops and livestock, objective 3, will compare the performance of livestock when grazing annual crops in the fall to livestock performance when grazing perennial grasses in the fall.

In the first 3 objectives, common data collected will include soil properties, biomass accumulation and soil water use.

Data on the impact of bio-char will be collected in objective 2.

L:ivestock production data will be collected in Objective 3.

Economic analysis will be conducted as appropriate.

The approaches for objectives 4 and 5 are not field based.

Objective 4 will continue an existing roundtable that brings national and international leaders together to share ideas, concepts, and philosophies of integrated systems.

Objective 5 will use a non-ARS collaborator to conduct surveys and coordinate with USDA-ARS to develop metrics that enhance the adoption of integrated agricultural technology by producers.

Major Accomplishments for 2010

Irrigated cropping system management for economic returns and greenhouse gas reductions. Cropping system management could potentially be used to reduce greenhouse gas emissions from agriculture. However, farmers are understandably unlikely to adopt management practices that are not profitable. Scientists at the USDA-ARS Northern Great Plains Research Laboratory and the USDA-ARS Soil Plant Nutrient Research Unit in Mandan, North Dakota analyzed the relationship between economic returns and greenhouse gas emissions for contrasting tillage, crop rotation, and nitrogen fertilizer management systems on irrigated cropland in Northeastern Colorado. Results showed that avoiding over application of nitrogen fertilizer and switching from conventional tillage to no-till could increase profitability and reduce net

Prairie Harvest Germplasm Hackberry (Celtis occidental's) is being released as a selected class germplasm for use in windbreak plantings, riparian area plantings, wildlife plantings, ornamental/recreational plantings, and other conservation uses. It is a northern source seed propagated release expected to exhibit genetic diversity to broaden its area of adaptation to various site conditions and climatic extremes. There are no dependably winterhardy northern source releases commercially available that are adapted for conservation use in this region. Hackberry is promoted as an alternative choice tree species to add diversity in conservation plantings and reduce the high numbers of green ash (Fraxinus pennsylvanica) currently being planted. Green ash is being threatened by the emerald ash borer (Agrilus planipennis).

NGPRL staff developed an outreach tool called the Cover Crop Chart. Patterned after the periodic table of elements, the chart includes information on 46 crop species that may planted individually or in cocktail mixtures. Information on growth cycle, relative water use, plant architecture, forage quality, pollination characteristics, and nutrient cycling are included crop species. The chart is downloadable from the ARS Products Services webpage in Portable Document Format (pdf).

Scientific Publications

Archer, D.W., Halvorson, A.D. 2010. *Greenhouse Gas Mitigation Economics for Irrigated Cropping Systems in Northeastern Colorado.* Soil Sci. Soc. Am. J.74 (2) :446-452 .

Phillips, B.L. 2009. *Denitrification at Sub-Zero Temperatures in Arable Soils: A Review.* IN: Sustainable Agriculture. Eric Lichtfouse, Mireille Navarrete, Philippe Debaeke, Veronique Souchere, Caroline Alberola (Eds). Sustainable Agriculture published by Springer Netherlands. p. 51-59. DOI 10.1007/978-90¬481-2666-8. ISBN 978-90-2665-1.

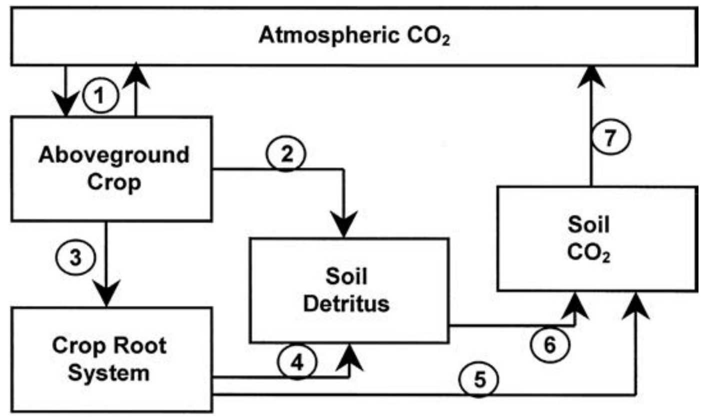
Johnson, J.M., Archer, D.W., Barbour, N.W. 2010. *Greenhouse Gas Emission from Contrasting Management Scenarios in the Northern Corn Belt.* Soil Science Society of America Journal. 74(2):396-406.

Evaluating cover crop at the Area 4 SCD Cooperative Research Farm

Fallow Effects on Soil Carbon and Greenhouse Gas Flux in Central North Dakota

Liebig, M.A., Tanaka, D.L., Gross, J.R. 2010. Fallow Effects on Soil Carbon and Greenhouse Gas Flux in Central North Dakota. Soil Science Society of America Journal. 74(2):358-365.

Among the management options available to agricultural producers in the northern Great Plains, the use of fallow has persisted despite documented drawbacks of reduced precipitation-use efficiency and impaired soil quality compared to annually cropped land. In fact, fallow periods are common throughout the region due to absence of consistent precipitation, and may occupy up to 35% of cropland area in any given year. Given the prevalence of this critical non-cropping phase, a study was undertaken to contrast fallow phases in two no-tillage cropping systems in central North Dakota for their effects on soil organic carbon and greenhouse gas flux. One cropping system possessed a traditional 19 month fallow period (spring wheat “ fallow), while the other incorporated a rye cover crop during the non-cropping period [spring wheat “ safflower “ fallow (Rye)]. Soil samples collected prior to initiation of gas flux measurements indicated no difference in organic carbon between cropping systems in the surface four inches of soil. Furthermore, cumulative fluxes of carbon dioxide, methane, and nitrous oxide did not differ between the two cropping systems, suggesting there was no net greenhouse benefit from incorporating a rye cover crop during the fallow phase. Future investigations may seek to evaluate the effects of other cover crops (or cover crop mixtures) on soil organic carbon and emission of nitrous oxide, two variables that largely dictate the greenhouse gas balance of dryland cropping systems.



Carbon Cycle

Effective Methods in Educating Extension Agents and Farmers on Conservation Farming Technology

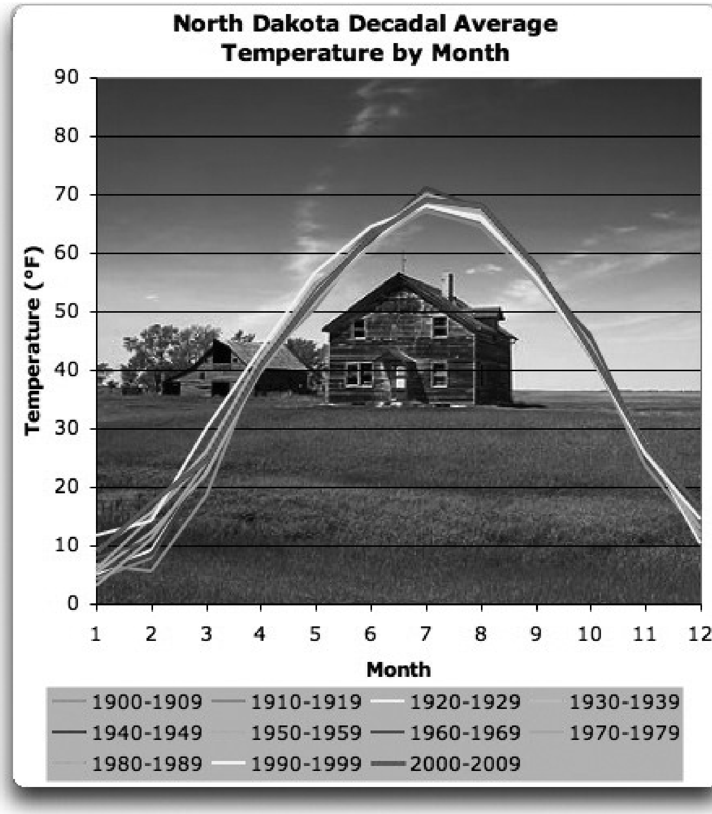
Jayaratne, K.U., Schomberg, H.H., Raper, R.L., Balkcom, K.S., Archer, D.W., Kaphammer, B.J. 2010. Effetcive methods in educating extension agents and farmers on conservation farming technology [abstract]. North American Colleges and Teachers of Agriculture.


Dr. Mark Liebig Leading a School Tour

Adoption of new technologies requires transfer of information from developers to end users. Efficiency of the transfer process influences the rate of adoption and ultimate impact of the technology. Various channels are used to transfer technology from researchers to farmers. Two commonly used ones are direct (face to face) and indirect (through Extension Agents or publications). Conservation farming systems technology provides environmental and economic benefits over time that may not be readily apparent in the short term. Since benefits are not readily observable, it has been challenging to convince farmers to adopt this technology. We explored how agricultural scientists face this educational challenge by determining scientists perceptions about effective methods to educate farmers and Extension agents on conservation farming technology. Scientists from 18 states in the USDA Agricultural Research Service (ARS) Agricultural Systems National Program answered questions in a descriptive survey. We received 90 usable responses comprising a 67% response rate. Research publications, field demonstrations and one-on-one meetings were the methods ARS scientists most commonly used in educating Extension agents and farmers. USDA-ARS scientists perceived that direct contact through one-on-one meetings, field demonstrations, training workshops and group discussions were the most effective educational methods in teaching farmers and Extension agents. Even though, ARS scientists commonly used research journals as the main outlet in communicating research results, research publications were identified as the least effective method in educating farmers. In addition, ARS scientists perceived that videos and web postings were less effective methods in educating farmers compared to direct communication.

Denitrification at Sub-Zero Temperatures in Arable Soils: A Review

Rebecca Phillips. Sustainable Agriculture published by Springer Netherlands. p. 51-59. DOI 10.1007/978-90-481-2666-8. ISBN 978-90-2665-1.



Nitrogen in agricultural fertilizers is denitrified by soil bacteria when oxygen is limited, which effectively removes plant available nitrogen from the soil to the atmosphere. Reported denitrification rates range from 0 to 213#/acre/year and depending upon environmental conditions and management, may reduce the amount of nitrogen available for crop growth by 27%. Denitrification in soils also results in emissions of nitrous oxide (N^2O), which is a recognized pollutant that contributes to stratospheric ozone destruction and radiative forcing in the troposphere. Practitioners of sustainable agronomy aim to improve plant nitrogen-use efficiency and reduce emissions of the greenhouse gases by synchronizing nitrogenapplication and plant nutritional requirements. However, it is difficult to predict denitrification rates during and after the growing season based on current knowledge. High rates are consistently reported in irrigated cropping systems following heavy applications of nitrogen fertilizer, but few studies report denitrification during the dormant season. Denitrification in winter may represent a significant sink for nitrogen fertilizer in cropping systems, but further research at sub-zero soil temperatures is needed. Here, the three factors required for microbial denitrification: limited O^2 availability, electron donors and electron acceptors, are reviewed based on soil research performed both above and below freezing. Gaps in the knowledge of denitrification rates in cropping systems, particularly when soils are frozen, are identified. Sustainable management of nitrogen in cropping systems such as greater nitrogen use efficiency and lower greenhouse gas emissions could be advanced by greater understanding of denitrification in winter.

Precipitation Regulates the Response of Net Ecosystem CO^2 Exchange to Environmental Variation on U.S. Rangelands

Polley, H.W., Emmerich, W., Bradford, J.A., Sims, P.L., Johnson, D.A., Saliendra, N.Z., Svejcar, T., Angell, R., Frank, A.B., Phillips, R.L., Snyder, K.A., Morgan, J.A., Sanabria, J., Mielnick, P.C., Dugas, W.A. 2010. Rangeland Ecology and Management. 63:176-186.

The concentration of carbon dioxide (CO^2) gas in air is increasing with possible consequences for Earth's climate. Growing plants remove carbon dioxide from air, whereas respiration by plants and animals adds carbon dioxide to air. The balance between these carbon dioxidefluxes depends partly on variability in precipitation and other climatic variables. We measured carbon dioxide exchange and climatic variables like temperature and precipitation on eight native rangeland ecosystems in the western USA to determine how fluctuations in climate affected carbon dioxide uptake and release. Rangelands studied included Great Plains grasslands, desert shrubland, desert grasslands, and sagebrush steppe. Variability in the carbon dioxide balance at each site resulted mostly from year-to-year differences in how fluxes responded to changes in light and water availability. This source of variability in carbon dioxide exchange was more important on typically dry than wetter rangelands. In any given year, therefore, the carbon dioxide balance of these ecosystems, and especially of dry rangelands, may differ because of differences in the response of carbon dioxidefluxes to a given shift in climatic variables.

Switchgrass

Mitchell, R.B, Vogel, K.P., Schmer, M.R., and Pennington, D. Switchgrass for biofuel production. Sustainable Ag Energy Community of Practice, eXtension. (http://extension.org/pages/Switchgrass_for_Biofuel_Production). 2010. (Extension Circular)

Switchgrass (Panicum virgatum) is a native warm-season grass that is a leading biomass crop in the US. More than seventy years of experience with switchgrass as a hay and forage crop suggests switchgrass will be productive and sustainable on rain-fed marginal land east of the 100th Meridian. Long-term plot trials and farm-scale studies in the Great Plains and plot trials in the Great Plains, Midwest, South, and Southeast indicate switchgrass is productive, protective of the environment, and profitable for the farmer. Weed control is essential during establishment, but with good management is typically not required again. Although stands can be maintained indefinitely, stands are expected to last at least 10 years, after which time the stand will be renovated and new, higher-yielding material will be seeded on the site. Fertility requirements are well understood in most regions, with about 12 to 14 pounds of N per acre required for each ton of expected yield if the crop is allowed to completely senesce before the annual harvest. Historically, breeding and genetics research has been conducted at a limited number of locations by USDA and university scientists, but the potential bioenergy market has promoted testing by public and private entities throughout the US. Switchgrass is well-suited to marginal cropland and is an energetically and economically feasible and sustainable biomass energy crop with currently-available technology.

Switchgrass Affects on Soil Property Changes in the Great Plains

Schmer, M.R., Liebig, M.A., Vogel, K.P., Mitchell, R. 2010. Switchgrass affects on soil property changes in the Great Plains. Abstract #56-8. ASA-CSSA-SSSA Annual Meeting Abstracts (CDROM), 1-3 Nov. 2010, Long Beach, CA.

The capacity of perennial grasses to affect change in soil properties is well documented but soil property information on switchgrass (Panicum virgatum L.) managed for bioenergy is limited. Potential improvements in near-surface soil function are important should switchgrass be included as a perennial phase within existing cropping systems. An on-farm study (10 fields) located in North Dakota, South Dakota, and Nebraska was sampled using transects across fields prior to switchgrass establishment and after five years to determine changes in soil bulk density, pH, soil phosphorous, and equivalent mass soil organic carbon. Changes in soil bulk density were largely constrained to near-surface depths where plant biomass inputs and management influences are greatest. Soil bulk density increased at the Nebraska locations, while most South Dakota and North Dakota locations showed declines in soil bulk density. Soil pH change was significant at five of the 10 locations at near surface depths, but absolute changes were modest. Available phosphorous declined at all sites where it was measured (North Dakota and South Dakota locations), with decreases most prevalent at the 2 inch depth. When summed across the surface one foot depth, annual decreases in available phosphorous averaged 1.3 pounds phosphorous per acre per year. Averaged across locations, equivalent mass soil organic carbon increased by 0.22 tons of carbon per acre per year and 1.1 tons of carbon per acre per year for the 1115 ton per acre and 4460 ton per acre soil masses, respectively. Results from this study underscore the contribution of switchgrass to affect changes in soil properties over time, though considerable variation in soil properties exists within and across locations. Further long-term evaluations of soil property changes under perennial bioenergy systems are needed at multiple ecoregions and spatial scales.

Response of Soil Carbon and Nitrogen to Transplanted Alfalfa in North Dakota Rangeland

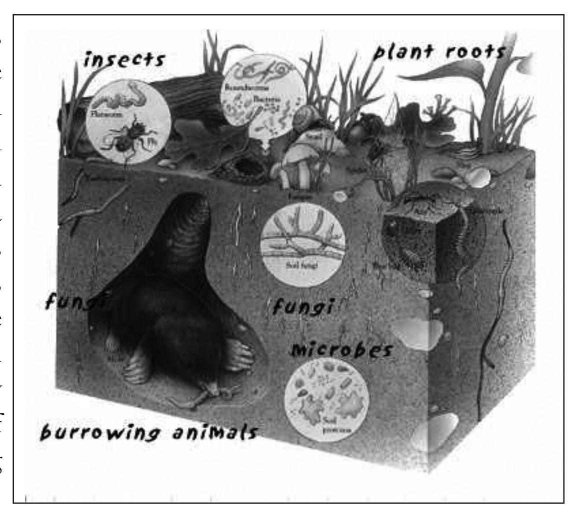
Liebig, M.A., Hendrickson, J.R., Berdahl, J.D. 2010. Response of Soil Carbon and Nitrogen to Transplanted Alfalfa in North Dakota Rangeland. Can. J. Soil Sci. 90(3):523-526.

Management interventions are needed to concurrently increase forage production and quality on native rangelands while improving the soil resource. Incorporation of alfalfa into rangelands represents one such intervention, though information regarding the influence of alfalfa on key indicators of soil quality in rangelands is limited. A study was undertaken to assess the effects of alfalfa interseeded into native rangeland on soil organic carbon (SOC) and total nitrogen (TN) for a mixed-grass rangeland site near Mandan, North Dakota, USA. Status of SOC and TN to a depth of approximately 16 inches was determined over a four year period for three interseeded alfalfa cultivars (one hay-type alfalfa and two grazing-type alfalfas) as well as rangeland not seeded to alfalfa. Soil organic C and TN at the beginning of the study did not differ among treatments. Four years later, two interseeded alfalfa cultivars (Vernal and Anik) possessed greater SOC and TN than the non-alfalfa control, but only within the surface four inches of soil. Stocks of SOC and TN within an equivalent mass of surface soil increased significantly between 2001 and 2005 under the interseeded alfalfa treatments. Though results from this study are short-term, interseeding grazing- or hay-type alfalfas into rangelands of the northern Great Plains appears to be a viable management intervention for increasing soil C and N stocks.

Soil Aggregation as Mechanism for Understanding the Roles of Soil Biota in the Sustainable Usage of Natural Resources

Dr. Kris Nichols

Global food insecurity and rapidly diminishing water, soil, and energy resources resulting from increases in population numbers and wealth are putting pressure on agroecosystems to efficiently produce the most nutrient dense food while maintaining or enhancing natural resources. To address these needs, the roles of soil biota in sustainable food, feed, and fiber production systems need to be better understood by doing more than identifying the organisms involved or correlating these organisms with a particularly soil parameter. Soil aggregation is a widely-impacting soil parameter involved in several soil processes including erosion control, water movement, nutrient cycling, and plant growth and health. However, two different processes, aggregate formation and aggregate stabilization, are involved in aggregation with often contrary biological, chemical, and physical mechanisms whose relationships are derived primarily from corollary evidence. Polysaccharides which help to 'glue' aggregates together are not water stable biomolecules and/or are readily decomposed unless present in biofilms while hydrophobic biomolecules add surface stability to aggregates but the repelling forces between these molecules would inhibit structural formation. Arbuscular mycorrhizal fungi are thought to play key roles in both these processes with fungal hyphae creating the lattice structure upon which aggregates are formed and mycorrhizal biomolecules, such as glomalin, stabilizing aggregates. The data suggesting the relationship between glomalin and aggregate stability has been corollary, where stability was measured on a sub-sample of aggregates while glomalin was extracted from another sub-sample. To directly relate glomalin to aggregate stability, a sub-sample of aggregates will be subjected to repeated wet-dry cycles to identify different levels of stability followed by sequential extraction of polysaccharides and glomalin from each group of unstable and stable aggregates. This data will then be used to begin forming a model for aggregate formation and stability linked to biological activity.



Variability in Light-Use Efficiency for Gross Primary Productivity on Great Plains Grasslands

Dr. Rebecca Phillips

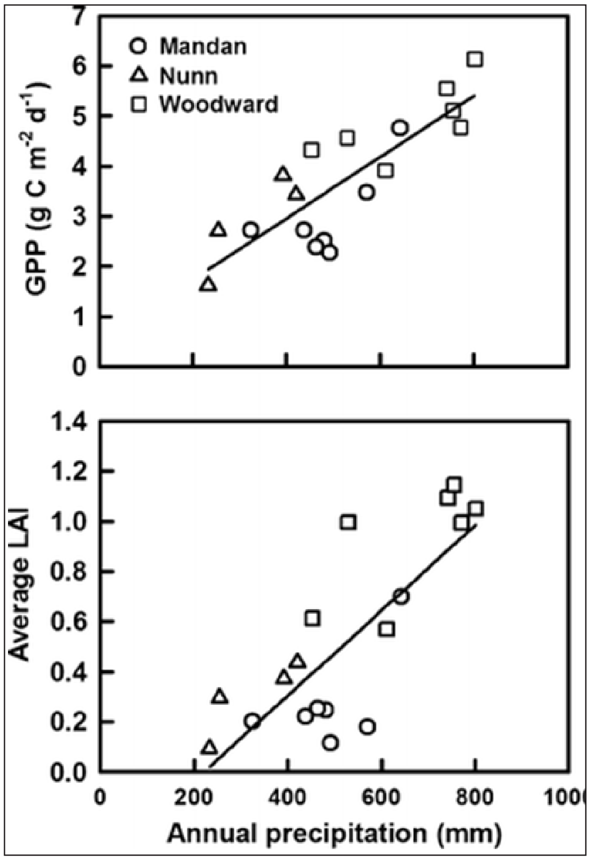


Figure 1 Relationships between growing season means of GPP per day (upper panel) or the average value of LAI per season (lower panel) and annual precipitation (ppt). Data from all years and grasslands combined (n = 18) were fit with linear functions (GPP = 0.518 + 0.006 × ppt, r 2 = 0.68, P < 0.0001; LAI = −0.376 + 0.002 × ppt, r 2 = 0.63, P < 0.0001).

The amount of carbon that plants capture via the process of photosynthesis (gross primary productivity; GPP) determines plant productivity and affects the amount of carbon that is stored in terrestrial ecosystems. Gross primary productivity often is estimated at regional and global scales by multiplying the amount of light absorbed by the plant canopy by a value of light use efficiency, C uptake per unit of absorbed light. Light use efficiency usually is assumed either to be constant or to change predictably as temperature and other environmental conditions change. An implicit assumption of this approach is that environmental effects on light use efficiency do not differ from year-to-year or among ecosystems. We used measurements of carbon uptake and release from 3three native grasslands in the central Great Plains to determine whether environmental effects on light use efficiency varied among years and grasslands. Light use efficiency was measured as the slope of the linear relationship between GPP and the amount of light that plants absorbed. Light use efficiency declined as the amount of absorbed light increased and varied among grasslands and among years on each of the grasslands. Light use efficiency was greater during years when the mean air temperature was high than low. Our results indicate that we must account for site-to-site variation in plant and environmental variables in order to accurately predict GPP.

Recent Trends in Soil Science and Agronomy Research in the Northern Great Plains of North America

Malhi, S.S., Gan, Y., Schoenau, J.J., Lemke, R.L., Liebig, M.A. 2010. Recent trends in soil science and agronomy research in the northern Great Plains of North America. Research Signpost, Trivandrum, Kerala, India. Complete Book. 427 pp.

The book "Recent Trends in Soil Science and Agronomy Research in the Northern Great Plains of North America" summarizes published research in soil science and agronomy from various field experiments conducted in the soil-climatic/agro-ecological regions of the Northern Great Plains of North America. Collectively, the book represents an up-to-date compilation of scientific information related to the sustainable management of dryland cropping systems in this important agricultural area. Fifteen chapters, written by Canadian and U.S. scientists, review a myriad of topics focused on developing a better understanding of dryland cropping systems and their management. Specific topics reviewed in the book include the impact of soil, crop and fertilizer/nutrient management practices, land use, landscape, organic amendments, and other parameters in dryland cropping systems on crop production, economics, plant diseases, grain and forage quality, nutrient accumulation and distribution in soil, soil properties, microbial diversity, greenhouse gas emissions, and water-, nutrient- and energy-use efficiency. Information in the book may be most useful to researchers and practitioners in the Prairie Provinces of Canada, adjoining northern U.S. states, and other parts of the world possessing similar soil-climatic attributes as the Northern Great Plains.

Bovine Adipose Triglyceride Lipase is not Altered and Adipocyte Fatty Acid Binding Protein is Increased by Dietary Flaxseed

Deiuliis, J., Shin, J., Murphy, E., Kronberg, S.L., Eastridge, M.L., Suh, Y., Yoon, J., Lee, K. 2010. Bovine adipose triglyceride lipase is not altered and adipocyte fatty acid binding protein is increased by dietary flaxseed. Lipids 45:963-973. DOI: 10.1007/s11745-010-3476-2

In this paper, we report the full length coding sequence of bovine ATGL cDNA are reported and analyze its expression in bovine tissues. Similar to human, mouse, and pig ATGL sequences, bovine ATGL has a highly conserved patatin domain that is necessary for lipolytic function in mice and humans. This suggests that ATGL is functionally intact as a triglyceride lipase enzyme in cattle. Tissue distribution of ATGL gene expression was highest in fat and muscle (skeletal and cardiac) tissue, while protein expression was solely detectible in the adipose tissue. The effect of 109 days of flaxseed supplementation on ATGL and adipocyte fatty acid binding protein (FABP4 or A-FABP, E-FABP or FABP5) expression was examined in Angus steers. Supplemented steers had greater triacylglycerol content in the muscle compared with unsupplemented steers. Additionally, supplementation increased A-FABP expression and decreased stearoyl-CoA desaturase 1 (SCD-1) expression in muscle, while total ATGL expression was unaffected. In summary, supplementation of cattle rations with flaxseed increased muscle triacylglycerol concentrations; attributed in part to increased expression of key enzymes involved in lipid trafficking (A-FABP) and metabolism (SCD-1).

Land Allocation in Agricultural Systems: Use of a Simple Model to Examine Impacts of External Drivers

Hendrickson, J.R., Hanson, J.D., Archer, D.W., Sassenrath, G.F., Halloran, J.M. 2009. Land Allocation in Agricultural Systems: Use of a Simple Model to Examine Impacts of External Drivers. Meeting Proceedings.

One of the most basic and expensive resources in the agricultural enterprise is land. Optimally allocating this valuable resource among different enterprises can be difficult and has substantial impacts on profitability and sustainability of the production system. Land allocation is based on environmental, economic and production benefits and producers" preference, risk tolerance and potential income. Producers must consider also future changes in societal values. We developed a model that uses producer derived and easily accessed information to determine land allocation among different enterprises. The model was parameterized using four agricultural enterprises common to the northern Great Plains of the USA. Initial data were derived from cropping experiments at the Northern Great Plains Research Laboratory in Mandan, North Dakota and North Dakota enterprise profitability and price data. Indices were developed for environmental quality, economic stability, production stability, and producer preference. Producer tolerance to risk and net return for each enterprise were also included. Examination of agricultural production in North Dakota suggested net return was the primary driver behind land allocation decisions. This indicates society must use economic drivers if land allocation patterns are to be impacted. Future iterations of the model will include information from different regional production systems by working with the Integrated Agricultural Systems Working Group.

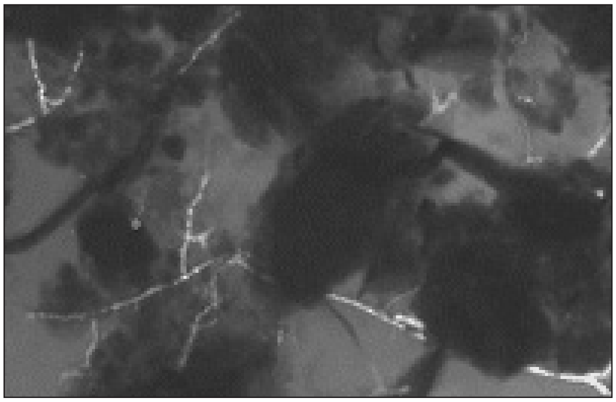
Barley Production in North America

Schillinger, W.F., Mckenzie, R.H., Tanaka, D.L. 2011. Barley Production in North America. Book Chapter. pages 241-251.

Most of the barley produced in North America comes from Canada (provinces of Alberta, Saskatchewan, and Manitoba) and northern-tier U.S. states (North Dakota, Montana, Idaho, Washington, and Minnesota). Over the past ten years, barley was produced on 9.7 million acres per year in Canada and 4.3 million acres per year in the U.S. Since the peak in the mid-1980's, barley acreage in the U.S. has declined five-fold due to conversion of land to perennial grass and shrubs, difficulty making malt-grade quality in rainfed areas, and low commodity price. No-till along with dynamic cropping systems provides a sustainable approach to barley production. A diversity of crops in cropping systems, particularly legumes and other broadleaf crops, greatly improves barley yields. The future of barley production in North America is promising given current global status of cereal grains. Advances in cultural practices along with better crop genetics for cold-hardy cultivars could result in greater use of winter barley for food, feed, and fuel.

Soil Microbial Community Function, Structure, and Glomalin in Response to Tall Fescue Endophyte Infection

Buyer, J.S., Zuberer, D.A., Nichols, K.A., Franzluebbers, A.J. 2010. Soil microbial community function, structure, and glomalin in response to tall fescue endophyte infection. Plant and Soil Journal. DOI: 10.1007/S11104-010-059Z-Y.



Tall fescue plants are naturally infected with a fungus that offers host-plant resistance to environmental and biological stresses, but through its production of toxic chemical compounds causes a variety of health disorders in grazing animals. One of the beneficial ecological consequences of fungus infection is the accumulation of soil organic matter, either through enhanced plant production and/or through reduced soil microbial activity. Scientists at the USDA-Agricultural Research Service in Beltsville MD, Mandan ND, and Watkinsville GA, along with a scientist from Texas A&M University, quantified the changes in soil microbial community structure and function throughout a year of tall fescue growth. Some microbial functions were inhibited by endophyte infection of tall fescue, but effects were subtle. A soil with low microbial biomass was more negatively affected by endophyte infection of tall fescue than a soil with higher microbial biomass, suggesting that a threshold level of challenge may have occurred. The subtle, short-term changes in soil microbial community structure and function in response to endophyte infection support previous observations of long-term changes in soil organic carbon and nitrogen storage in field studies. These results will have implications for producers managing soil quality on the 14 Mha of tall fescue in the eastern USA, for scientists in understanding the mechanisms of plant-soil-microbial interactions, and for policy makers in promoting conservation practices for sequestering soil organic carbon.

Camelina: A Potential Winter Crop for the Northern Corn Belt

Gesch, R.W., Archer, D.W. 2009. Camelina: A Potential Winter Crop for the Northern Corn Belt [abstract][CD-ROM]. ASA-CSSA-SSSA Annual Meeting Abstracts. ASA-CSSA-SSSA Annual Meeting. Nov. 1-5, 2009, Pittsburgh, PA.

Camelina may offer a low-input oilseed alternative for biodiesel and other vegetable oil applications. Little is known about its agronomic potential or the winter survivability of winter cultivars in the northern Corn Belt. The potential of following winter camelina with a spring crop was also examined. Spring plant stands did not differ between cultivars, but were greater in no-till soil and when seeded in early October. Severe early-season water logging led to a 27 to 32% loss of stand at harvest. Averaged across tillage and planting dates, yield was greater for Joelle (545 lbs/acre) than BSX-WG1 (347 lbs/acre). Yield did not differ with tillage, but was slightly higher when seeded in early- to mid-October. BSX began flowering about 3 to 4 days earlier than Joelle. Plants reached 50% flowering as early as May 22 and were harvested between June 26 and July 15. Time between 50% flowering and harvest ranged from 34 to 45 days. Early-maturing soybean, sunflower, and Siberian foxtail millet were planted following the earliest camelina harvests and yielded 70, 76, and 100%, respectively, of their full-season counterparts. Winter camelina appears to have good survivability for the northern Corn Belt and can be harvested early enough to allow potential for double cropping a food and biofuel crop in a single growing season.

Camelina plants merging through the snow. December 2007. Lethbridge, AB

Rotational Effects of Cuphea on Corn, Spring Wheat, and Soybean

Gesch, R.W., Archer, D.W., Forcella, F. 2010. Rotational Effects of Cuphea on Corn, Spring Wheat, and Soybean. Agronomy Journal. 102(1):145-153.


Harvesting Cuphea at Morris, MN

Most farmers in the northern Corn Belt grow just corn and soybean and a little bit of wheat. Sometimes they rotate these crops every other year, but sometimes they grow one crop, such as corn, year after year in the same field. This has resulted in certain insect, disease, and weed pests becoming well adapted to surviving in fields where only a couple of crops are rotated, or one crop is grown year after year. In turn, the farmer must use a great deal of pesticides and fertilizer to maintain high crop yields. One way to reduce this problem is to add more types of crops to a crop rotation. Cuphea is a new oilseed crop that we are developing for commercial production in the northern Corn Belt, but we don"t know how it might affect corn, soybean, and wheat when it is added to rotation with these crops. Therefore, we conducted a 4-year long field experiment in Morris, Minnesota, to test the effects of cuphea when rotated one year to the next with these crops. We found that seed yields of corn, soybean, and wheat were not negatively affected when they were grown the next year after cuphea. Also, these crops did not negatively or positively affect cuphea yields when they were grown the year before. Cuphea production the previous year did, however, result in better wheat plant stand establishment the next year. Furthermore, the wheat grain harvested had an 8% higher protein content when it was grown after cuphea than when it was grown after corn or soybean. The cost of growing cuphea was higher than that for growing soybean and wheat, but it was less than that for growing corn. We found that for cuphea to be profitable for a farmer, he or she would need to get paid about $1830 per ton of harvested seed. We also found that corn and soybean were more profitable when they were grown the next year after cuphea than when they were each grown year after year. Our results prove that cuphea can be successfully rotated with corn, soybean, or wheat. We recommend that it be rotated the year after growing soybean and the year before growing corn or wheat. Besides other crop scientists, our finding will be beneficial for seed companies contracting with farmers to grow cuphea, and for university extension and crop consultants helping farmers to manage cuphea production in their fields.

Evaluating a Hybrid Soil Temperature Model in a Corn-Soybean Agroecosystem and a Tallgrass Prairie in the Great Plains

Feng, S., Salvagiotti, F., Schmer, M.R., Wingeyer, A., Weiss, A. 2010. Evaluating a hybrid soil temperature model in a corn-soybean agroecosystem and a tallgrass prairie in the Great Plains. Great Plains Research 20 (Fall 2010):249-60.

Soil temperature is an important factor that regulates chemical, physical and biological processes within soils. Approaches to simulate soil temperature, with different degrees of complexity, are implemented in different crop and land surface models. The objective of this research was to compare a relatively simple hybrid soil temperature model that was developed for a forest region and apply it to a no-tillage corn and soybean rotation cropping system and a native grassland. The hybrid model did a reasonable job in predicting soil temperature at various soil depths in both the cropping system and grassland system. Hybrid model advantages are the model's relative simplicity using easily available data, ability to be incorporated into a larger model where soil temperatures are required, and to evaluate surface litter impacts on soil temperatures. Given the applied nature of this hybrid model, it would be well suited to simulate soil temperatures in the first 50 cm (20 inches) of soil over a vegetated surface for processes related to soil respiration, soil organic matter decomposition and soil-borne pests.

Efficient Methods of Estimating Switchgrass Biomass Supplies

Schmer, M.R., Mitchell, R., Vogel, K.P., Schacht, W.H., Marx, D.B. 2010. Efficient Methods of Estimating Switchgrass Biomass Supplies. BioEnergy Research. 3(3):243-250.

Switchgrass is being developed as a biofuel feedstock for the United States. Efficient and accurate methods to estimate switchgrass biomass feedstock supply within a production area will be required by biorefineries. Our main objective was to determine the effectiveness of indirect methods for estimating biomass yields and composition of switchgrass fields. Indirect measurements were conducted in plot research and on fields across the Great Plains. A modified Robel pole was used to determine visual obstruction, elongated leaf height, and canopy height measurements. Prediction models from the study showed that elongated leaf height, visual obstruction, and canopy height measurements accounted for >91%, >90%, and >82% of the variation in switchgrass biomass, respectively. Visual obstruction was the best method for estimating yield on switchgrass fields with low to variable stand densities while elongated leaf height measurements would be recommended on switchgrass fields with high, uniform stand densities. Twenty to thirty elongated leaf height measurements in a field could predict switchgrass biomass yield within 10% with 95% confidence. These procedures can be used by biorefineries in estimation of feedstock supply in a production area and by government agencies in estimating national bioenergy supplies from switchgrass.

A USDA student biological aide is seen taking plant height measurements to estimate switchgrass yields near Munich, ND. Simple plant height measurements were found to be one way to estimate switchgrass yield with minimal time and labor costs.

Drivers Impacting the Adoption of Sustainable Agricultural Management Practices and Production Systems of the Northeast and Southeast U.S.

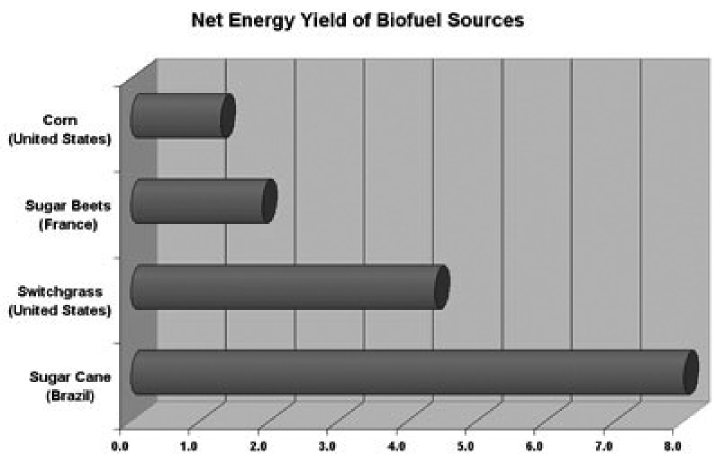
Sassenrath, G.F., Halloran, J.M., Raper, R.L., Vadas, P.A., Hendrickson, J.R., Archer, D.W., Hanson, J.D. 2010. Drivers Impacting the Adoption of Sustainable Agricultural Management Practices and Production Systems of the Northeast and Southeast U.S. Journal of Sustainable Agriculture. 34:680-702.

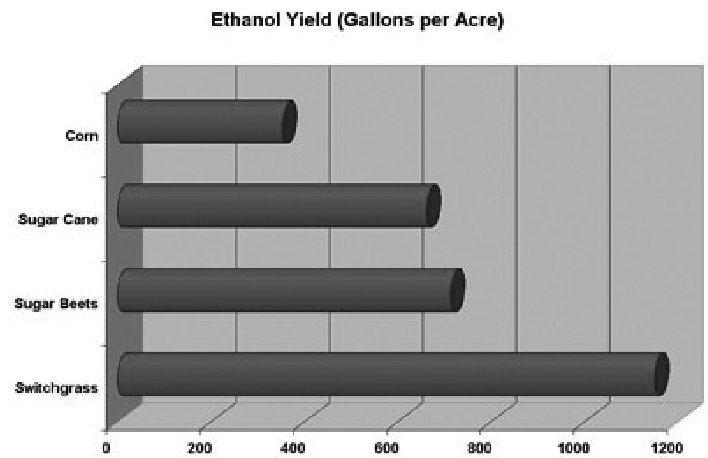
Agriculture is the primary mechanism for synthesis of products necessary to support life and society. As such, the health of a country"s and the world's agricultural systems is critical for the continued success and support of society. However, recent economic and environmental conditions have exposed weaknesses in current agricultural systems. Changes in the global economy have led to rapid increases in input costs of fuel and fertilizers. The initial gains in commodity prices and net farm income following the expansion of bio-fuel production quickly evaporated due to escalating input costs. Other resource constraints facing US agriculture are increased competition for water and land, and depletion of soil. Food production will always be paramount, but in an era of diminishing or degraded resources, the importance of transitioning agricultural production towards sustainability is of increasing importance. In this paper, we present the drivers and characteristics of the Northeastern production systems. We discuss the social/political, economic, environmental and technological factors that influence the production systems, and then explore interactions between the drivers and the unique characteristics of the production systems. We compare these to Southeastern agricultural systems, examine variances between the two regions, and potential causes of that variation. While the two regions have the same drivers impacting agriculture, the interactions between drivers and how they influence decision-makers do vary substantially to create unique regional characteristics of the production systems. Through an examination of the production systems, drivers and unique characteristics of the systems, we gain insight into the basis for producers' decision making and the underlying principles of production. By identifying the responsiveness of current production systems to forces that are shaping agricultural production, we can determine successful strategies that can be used to address the future challenges to agriculture. This information can be used by producers, scientists and policy makers to direct agricultural production and agricultural research.

Long-term persistence of synthetic populations of a lowland switchgrass ecotype and the cultivar Cave-in-Rock

Sanderson, M.A. 2010. Long-term persistence of synthetic populations of a lowland switchgrass ecotype and the cultivar Cave-in-Rock. Forage and Grazinglands.

Switchgrass, a warm-season perennial grass native to much of North America, has received extraordinary attention as a candidate cellulosic bioenergy crop. Long-term data on the persistence and yield of alternative varieties and ecotypes of switchgrass are limited for the northeastern USA. An existing field-plot study provided an opportunity to evaluate the long-term persistence (20 years) of a standard switchgrass variety (Cave-in-Rock) compared with germplasm (six synthetic switchgrass populations) used in the development of recently released varieties (`BoMaster" and `Performer") specifically developed for biomass energy production. The field-plot experiment was established in 1989 and continued through 2009. After 20 years of management there were no significant differences among switchgrass entries for plant height, tiller density, or biomass yield. The results from this long-term evaluation of the yield and persistence of these switchgrass populations indicate that southerly adapted lowland cultivars could provide diversity in cultivar choices for switchgrass bioenergy production in the northeastern USA.





From "Switchgrass is a Better Biofuel Source Than Corn", Mongabay.com, 2008

Stability of Production and Plant Species Diversity in Managed Grasslands

Sanderson, M.A. 2010. Stability of production and plant species diversity in managed grasslands. Basic and Applied Ecology. 11(3):216-224.

Complex mixtures of many forage grasses and legumes in pastures have been viewed as being more stable in terms of forage yield with time and more efficient in the use of environmental resources than monocultures or simple mixtures. A retrospective analysis was conducted of three studies in which 181 mixtures of forages were compared for several years. The objective was to determine the relationship between the number of species sown in mixtures and the resulting herbage yield along with an examination of whether increasing mixture complexity contributed to yield stability with time. The analysis of forage yield variability in 181 mixtures of temperate grasses and legumes revealed that monocultures and two-species mixtures had lower yield stability year to year than more complex mixtures. Within forage mixtures, however, there was no consistent relationship between forage yield or yield stability and measures of plant species diversity or mixture complexity. Results of this research revealed that forage species identity and composition of forage mixtures may be more important determinants of herbage yield than simply the number of species included in a mixture.

Crop Sequence Influences on Sustainable Spring Wheat Production in the Northern Great Plains

Tanaka, D.L., Liebig, M.A., Krupinsky, J.M., Merrill, S.D. 2010. Crop sequence influences on sustainable spring wheat production in the northern Great Plains. Sustainability. 2(12), 3695-3709.

Since World War II, American agriculture has been extremely successful and has met the demand of an industrialized food system. This success has come from highly specialized, standardized, and simplified cropping systems which lack crop diversity. Objectives of our research were to determine the benefits and/or drawbacks of previous crop sequences on spring wheat seed yield, seed N concentration, and seed precipitation-use efficiency. Spring wheat production risks were mitigated when second year crop residue was dry pea. During below-average precipitation years like 2004, dry pea as the second year residue crop increased spring wheat seed yield by 30% when compared to spring wheat residue as the second year crop residue. Hence, crop sequence played a pivotal role to synergize agroecological parameters and improve production efficiencies. Diversifying the cropping system with crops other than spring wheat, synergized the following spring wheat crop and enhanced sunlight capture, nutrient uptake, and precipitation use. To be sustainable in the future, cropping systems need to move beyond fossil fuel derived yield increases and rely more on renewable systems that are resilient.

Fertilizer Application Timing Influences Greenhouse Gas Fluxes Over a Growing Season

Phillips, B.L., Tanaka, D.L., Archer, D.W., Hanson, J.D. 2009. Fertilizer Application Timing Influences Greenhouse Gas Fluxes Over a Growing Season. Meeting Abstract.

Microbial production and consumption of greenhouse gases (GHG) is influenced by temperature and nutrients, especially during the first few weeks after agricultural fertilization. The effect of fertilization on GHG fluxes should be sensitive to environmental conditions during and shortly after application, yet data indicating how application timing affects both GHG fluxes and crop yields during a growing season are lacking. We designed a replicated (n=5) field experiment to test for the short-term effect of fertilizer application timing on fluxes of methane (CH4), carbon dioxide (CO2), and nitrous oxide (N2O) over a growing season in the northern Great Plains. Each 0.30-ha plot was planted to maize (Zea mays L.) and treated similarly with the exception of fertilizer timing: five plots were fertilized with urea in early-spring (1 April) and five plots were fertilized with urea in late-spring (13 May). We hypothesized time-integrated fluxes over a growing season would be greater for the Late-Spring treatment, resulting in greater net GHG flux, as compared to the Early-Spring treatment. Data collected on 59 dates and integrated over a 5-month time course indicated CO2 fluxes were greater ($P<0.0001$) and CH4 fluxes were lower ($P<0.05$) for soils fertilized in Late-Spring. Net GHG flux was also significantly affected by treatment, with 0.84 ±0.11 kg CO2 equivalents m-2 for Early-Spring and 1.04 ±0.13 kg CO2 equivalents m-2 for Late-Spring. Nitrous oxide fluxes, however, were similar for both treatments. Results indicate fertilizer application timing influences net GHG emissions in dryland cropping systems and additional research is needed.

Relationship of Bite Mass of Cattle to Sward Structure of Four Temperate Grasses in Short-Term Foraging Sessions

Soder, K.J., Sanderson, M.A., Gregorini, P., Orr, R.J., Rubano, M.D., Rook, A.J. 2009. Relationship of bite mass of cattle to sward structure of four temperate grasses in short-term foraging sessions. Grass and Forage Science. 64(4):421-431.

The amount of pasture forage harvested per bite (bite mass) is a fundamental element of ingestive behavior of grazing cattle. A study was designed to compare the sward structure and forage species effects of four cool-season grasses found in northeastern USA pastures on bite mass of grazing cattle. Four grasses were each sown separately in plastic boxes to create micro-swards that were offered to Holstein cows in short-term foraging tests in two consecutive years. Forage species did not affect bite mass and therefore had little influence on the decision-making process of bite placement in this study. However, bite mass did differ between years, primarily due to differences in sward structure between the years. Therefore, generic sward features (independent of forage species) such as sward height, bulk density and herbage mass had greater influence on bite mass between years than did forage species. In practice, sward height is frequently used as an empirical tool to evaluate intake potential of herbage. Current grazing management studies may need to evaluate factors other than sward height, such as green leaf availability, bulk density, and herbage mass that influence bite features of grazing cattle.

Management Strategies and Practices for Increasing Storage of Organic Carbon and Nitrogen in Soil in Cropping Systems in the Northern Great Plains of North America

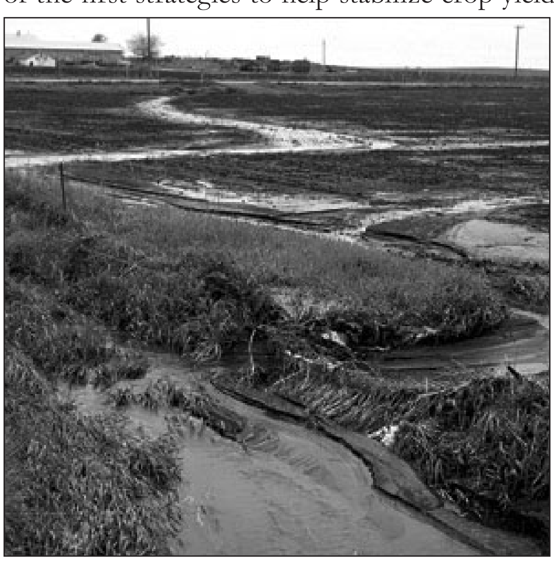
Malhi, S.S., Lemke, R., Liebig, M.A., Mcconkey, B., Schoenau, J.J., Cihacek, L.J., Campbell, C. 2010. Book Chapter. P. 325-384. IN: S.S. Malhi et al. (Eds.) Research Signpost, Kerala, India.

Soils in the Northern Great Plains of North America have lost a substantial amount of their original organic carbon (C) and nitrogen (N) reserves in the last 100 or more years, mainly due to tilled summer fallow. Currently, many soils represent a potential sink for atmospheric carbon dioxide. A thorough review of literature found storage of organic C and N can be increased in cultivated soils by implementing proper soil (elimination of tillage and minimizing summer fallow frequency), crop residue (returning residue), nutrient management (balanced fertilization, and combined use of organic amendments and mineral fertilizers) and land use (conversion of marginal cultivated lands to perennial grassland) practices that prevent loss of C from soil and/or increase C input. Furthermore, it would appear C and N storage in soil provides the accompanying benefits of more sustainable crop production (due to an improvement in soil quality and nutrient supplying power), and reducing the potential for greenhouse gas emissions.

Soil and Water Conservation Advances in the Northern Great Plains

Tanaka, D.L., Lyon, D.J., Miller, P.R., Merrill, S.D., Mcconkey, B.G. 2010. Soil and Water Conservation Advances in the Northern Great Plains. p. 81-102. In: T.M. Zobeck and W.F. Schillinger (eds.) Soil and Water Conservation Advances in the United States. SSSA Spec. Publ. 60. SSSA, Madison, WI.

"Great American Desert" is what many maps often call the Great Plains of North America. This is where dryland agriculture practices for North America have their roots. The purpose of this part of the book was to determine the advances in soil and water conservation technology over the past century and how these practice have evolved to present day agricultural systems that use precipitation more efficiently in the northern Great Plains. The northern Great Plains includes Alberta, Saskatchewan, and Manitoba in Canada, as well as Nebraska, Wyoming, South Dakota, North Dakota, and Montana in the United States. The interaction of parent material-native vegetation-climate resulted in soils in the Mollisol order. Many of the early settlers to this region came in the late 1890's and early 1900's from eastern areas that had greater precipitation and longer growing seasons. Settlers brought their tillage tools, cropping systems, and seeds during a period of time that was considered a wet cycle (1895-1910). When weather conditions turned dry, their eastern cultural practices were not resilient and prone to crop failure. One of the first strategies to help stabilize crop yields and reduce the risk of crop failure during drought periods was crop-fallow. Summer fallow, the practice of leaving land idle and controlling weeds with tillage, started in the late 1920's or early 1930's with five million acres and reached a peak in the late 1960's with forty-one million acres. Soil erosion was a serious problem on summer fallow lands; therefore, better soil and water conservation practices have been developed and currently we have only fourteen million arces of summer fallow. The reductions in summer fallow can be attributed to conservation tillage (no-till and minimum- or reduced-tillage) and changes in cropping systems. Present day dynamic cropping systems for soil and water conservation rely on responsiveness to environmental factors. The Crop Sequence Calculator was designed to improve response time for research, extension, consultants, and producers. In the future, cropping systems will not only need to take advantage of crop sequencing but will also promote synergism by using cover crops, interspecies seeding, relay crops, and possibly livestock. These systems will have enhanced soil attributes that make them more resilient.



Nutrient Removal as a Function of Corn Stover Cutting Height and Cob Harvest

Johnson, J.M., Wilhelm, W.W., Karlen, D.L., Archer, D.W., Wienhold, B.J., Lightle, D.T., Laird, D.A., Baker, J.M., Ochsner, T.E., Novak, J.M., Halvorson, A.D., Arriaga, F.J., Barbour, N.W. 2010. Nutrient removal as a function of corn stover cutting height and cob harvest. BioEnergy Research. 3:342-352.

Corn stover, leaves, stems and cobs that remain after the grain is harvested have the potential to be used as a feedstock for bioenergy production. More plant nutrients are removed from a field when stover is harvested compared to harvesting only grain. Therefore, harvesting stover may change fertilizer requirements for corn production. Some elements such as chloride and potassium, found in corn stover, can cause problems when processing corn stover for bioenergy. We reported the nutrient concentrations in stover at various heights above the ground. We calculated the amount of each element that would be removed from the field depending on cutting height or if only cobs were harvested. We found that corn cobs have more carbon and less of other elements compared to stover (without the cobs) above and below the grain-containing ear. We estimated that the fertilizer cost to replace nitrogen, phosphorus and potassium removed when harvesting cobs only would be about half as much as the fertilizer cost to replace nutrients if all of the stover (including the cobs) were harvested above the ear. In general, harvesting cobs plus stover from the ear upward at grain harvest provided a higher quality feedstock with less total nutrient removal than harvesting the whole plant. Impact: This information is beneficial to people in the bioenergy industry who are interested in feedstock quality of corn stover to be used for fermentation or thermochemical energy conversion. It is also useful for producers, agronomists, and crop consultants trying to balance soil fertility when nutrients are removed with harvested stover. The information will also help to ensure the sustainability of the fledging biofuel industry in the United States and elsewhere.

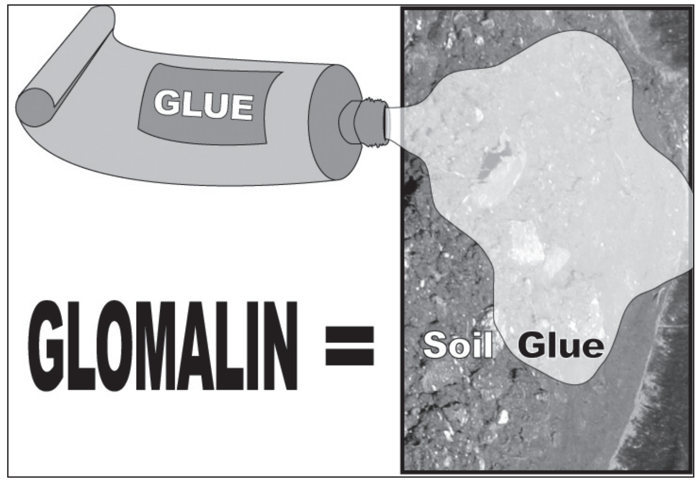
Vertical Distribution of Corn Stover Dry Mass Grown at Several U.S. Locations

Wilhelm, W.W., Johnson, J.M., Lightle, D., Barbour, N.W., Karlen, D.L., Laird, D.A., Baker, J.M., Ochsner, T.E., Novak, J.M., Halvorson, A.D., Archer, D.W., Arriaga, F.J. 2011. Vertical distribution of corn stover dry mass grown at several U.S. locations. BioEnergy Research. 4(1):11-21.

Corn stover is the plant material (leaves, stems and cobs) remaining after the grain is harvested. Stover is a non-food material that can be used to make liquid fuels like ethanol or as a substitute for coal and natural gas. It is important to keep some stover in the field to reduce runoff, minimize soil erosion and replenish soil organic matter. Prototype combines can harvest corn grain and corn stover or harvest corn grain and corn cobs in one pass across the field. The amount of stover that is harvested is controlled by the vertical height of the combine's cutter blades as it moves through the field. Cutting the plant close to the ground harvests most of the stover and returns very little to the field compared to cutting just below the ears of corn. The height of ears and plant height varies depending on where the crop is grown, the weather and the variety planted. Plant height, dry grain, stover and cob yield data from eight locations (Ames, IA; Auburn, AL; Florence, SC; Fort Collins, CO; Lincoln, NE; Mandan, ND; Morris, MN; and St. Paul, MN) were collected from across the United States to: 1) determine the height distribution of stover biomass; 2) determine the percentage of stover that is corn cob; and 3) develop a general relationship between plant harvest height and stover remaining in the field. This information, though still limited, will significantly improve the capacity of RUSLE2, WEPS and other models to predict erosion risks associated with harvesting corn stover. It will also help ensure the sustainability and feasibility of the fledging biofuels industry in the United States and elsewhere.

Glomalin and Extraradical Mycelium in Tropical Agroecosystems

Dr. Kris Nichols



Given growing interest in environmentally-friendly techniques to improve agriculture, such as the use of cover crops and application of arbuscular mycorrhizal (AM) inoculants to soil, a study of Venezuelan agriculture was conducted to better understand management effects on soil quality and AM fungi in tropical agroecosystems. Results of this study suggest conservation management techniques, such as cover crop usage and biological fertilization with AM fungi, promote the stabilization of soil aggregates. Additionally, AM mycelium and glomalin increased under these treatments compared to more traditional treatments. Many studies have shown a corollary relationship between these mycorrhizal parameters and soil aggregation. This study also highlighted the role of glomalin as an indicator of AM fungal presence in agricultural systems, thus showing that alterations in symbiosis and/or propagules may result from modifications in agricultural practices. Long-term studies are needed to better understand biological effects from AM fungi on soil physical properties. These studies should include analysis of additional soil types under contrasting management practices in order to refine conclusions regarding the ecological importance of AM fungi in Venezuelan agricultural soils. Although results obtained in this study provided useful information on soil biophysical properties in tropical agroecosystems, no conclusive statements could be made regarding differences among treatments. Complexity associated with the measured parameters and tropical agroecosystems suggests future evaluations on soil biophysical properties would benefit from investigations of less complex agroecosystems.

Effect of Soil Depth and Topographic Position on Plant Productivity and Community Development on 28-Year Old Reclaimed Mine Lands

Submitted to Journal of Soil and Water Conservation, Wick, A., Merrill, S., Toy, T. Liebig, M .

Determination of adequate topsoil replacement depths following surface mining has been an ongoing issue in reclamation research. Several short-term studies were initiated using soil wedge designs in the 1970's and 1980's to make recommendations to mining companies for soil replacement depths; however, assessment of these recommendations for long-term sustainability has become an important topic within the last decade. This study was undertaken in 2003 to understand plant-soil dynamics after 28 years of vegetation establishment on various replaced soil depths. The ultimate goal was to determine if original recommendations should be altered to address long-term sustainability. Results obtained in this study were compared directly to previous results from a 1979 study conducted at this location. Plots originally seeded to aggressive cool season species showed lower diversity after 28 years than plots seeded to less aggressive species such as alfalfa or Russian wildrye. There was also a weaker dependence of plant productivity on soil depth/topographic position and a slight shift to higher production values on deeper soil depths across all subsoil types in 2003 compared to 1979. This is attributed to the following: (a) changes to plant communities from the originally seeded monocultures utilizing surface soil water early in the growing season to more diverse communities which require soil water later in the season and deeper in the profile, and (b) depth of soil development increased with returned subsoil depth, supporting the shift of increased plant productivity with soil depth in 2003. In summary, replaced soil depths should be determined based on soil stabilization and initial establishment of diverse, sustainable plant communities to reduce invasion of undesirable plant species.

Reclamation in Jenkins Township, Luzerne County, PA

Effects of Grazing Pressure on Efficiency of Grazing on North American Great Plains Rangelands

Smart, A.J., Derner, J.D., Hendrickson, J.R., Dunn, B.H., Mousel, E.M., Johnson, P.S., Gates, R.N., Sedivec, K.K., Harmoney, K.R., Volesky, J.D. Effects of Grazing Pressure on Efficiency of Grazing on North American Great Plains Rangelands. Rangeland Ecology and Management 63:397-406.

Many individual grazing studies have been conducted evaluating livestock and vegetation responses to stocking rate treatments in the North American Great Plains. Comparisons across these studies are limited by lack of consistency in the terms light, moderate and heavy grazing at individual sites. Here, we calculated forage allowances for the different studies and stocking rate treatments to facilitate across site comparisons for six long-term studies in Wyoming, South Dakota, Kansas, Colorado, North Dakota, and Oklaoma. We determined that harvest efficiency of the livestock grazing was 42% heavy, 26% moderate, and 16% for light stocking rates. Forage allowance was not linear with either grazing or harvest efficiency resulting in increased efficiencies at low forage allowances and decreased efficiencies at high forage allowances. Using forage allowance to "standardize" stocking rates across rangeland ecosystems should facilitate increased communications among scientists, management agencies, land managers and the public regarding this primary rangeland management practice for production and conservation goals on these lands.

Spatial and Temporal Effects on Switchgrass Stands and Yield in the Great Plains

Schmer, M.R., Mitchell, R., Vogel, K.P., Schacht, W.H., Marx, D.A. 2010. Spatial and Temporal Effects on Switchgrass Stands and Yield in the Great Plains. BioEnergy Research. 3:159-171.

Switchgrass (Panicum virgatum L.) is being developed into a bioenergy crop for use in temperate regions of the USA. Information on spatial and temporial variation for stands and biomass yield among and within fields in large agroecoregions is not available. Spatial and temporal variation information is needed to model feedstock availability for future biorefineries. In this study, the spatial and temporal variation for biomass yield and stands was determined among and within ten fields located in North Dakota, South Dakota, and Nebraska. Switchgrass fields were managed for bioenergy from 2000 to 2004 for the Nebraska locations and 2001 to 2005 for the South Dakota and North Dakota locations. A global positioning system (GPS) receiver was used to repeatedly measure within field quadrat sites for switchgrass stands using frequency grid measurements in June for five growing seasons. Sixteen quadrat yield samples were taken post-killing frost in the establishment year and in August in subsequent years at each location. Topographic within field effects on switchgrass stand frequency and biomass yields were largely insignificant. Stands tended to increase from establishment year to year 3 and then begin to plateau. Weather factors, which were the principal source of temporal variation, were more important in switchgrass yield variation than on switchgrass stand frequencies. Temporal standard deviations for yield were higher on quadrat sites with higher than average field means while temporal standard deviations were smaller in quadrat sites that had lower than average field means at six locations. In the Northern Great Plains agroecoregion, there is greater temporal and spatial variation for switchgrass biomass yields among fields than within fields. Results indicate that modeling feedstock availability for a biorefinery can be based on field scale yields.

Dr. Matt Sanderson

Sheep Ingestion of Water Containing Quebracho or Black Wattle Tannin

Kronberg, S.L. 2010. Sheep Intake of Water Containing Quebracho or Black Wattle Tannin. Rangeland Ecol. Manage. 63:258-262.

Ingestion of small amounts of condensed tannin by ruminants can produce valuable outcomes such as improved nitrogen use, reduced bloating and methane output, and internal parasite reduction. Many grasses and forbs have little if any condensed tannin in them. Not all livestock will consistently consume solid supplements while grazing especially when grazing high quality forage, but they all usually drink water each day. Also, not all condensed tannins have similar effects on ruminants. Therefore, eight lambs with the same initial weight were individually penned, fed alfalfa pellets twice daily, and had free-choice access to two liquids. Liquid intake was measured daily. After an adjustment period to pens, feeding, and watering conditions and water with condensed tannin in it, three sequential week-long trials were conducted. In Trial 1, lambs chose between normal water and a quebracho tannin-water mixture of moderate concentration (ca. 1% dry matter intake). In Trial 2, lambs chose between normal water and a quebracho tannin-water mixture of lower concentration, and in Trial 3 lambs chose between a quebracho tannin-water mixture and a wattle tannin-water mixture with both of the same concentration. In Trials 1 and 2, they had inconsistent intakes of tannin water and normal water from day to day and neither preferred nor avoided tannin solutions when they had normal water to drink. They also had inconsistent intakes of the two tannin solutions (quebracho and black wattle) offered simultaneously, and generally showed no preference for either tannin solution when offered only the two tannin solutions to drink. Results support other observations that sheep and cattle will voluntarily consume water with small amounts of condensed tannin in it, and provide no evidence that sheep prefer consuming small amounts of quebracho versus black wattle tannin in water.

Plant Community and Target Species Affect Responses to Restoration Strategies

Hendrickson, J.R., Lund, C.B. 2010. Plant community and target species affect responses to restoration strategies. Rangeland Ecology and Management.

Increases in Kentucky bluegrass and smooth brome on northern Great Plains rangelands have impacted seasonal forage distribution, lowered plant diversity and increased carbon and nitrogen losses from the ecosystem. We evaluated five different restoration strategies for reducing the amounts of these invasive perennial grasses in rangelands. We found that fire and herbicide caused the greatest reduction in Kentucky bluegrass but mowing and raking reduced smooth brome the most. Community composition and time following treatment application impacted the results. Our results suggest that a single restoration strategy is not applicable for both these invasive species and successful strategies will need to incorporate both the invasive species and the community in their planning.

Grazing Management Contributions to Net Global Warming Potential: A Long-Term Evaluation in the Northern Great Plains

Liebig, M.A., Gross, J.R., Kronberg, S.L., Phillips, B.L., Hanson, J.D. 2010. Grazing Management Contributions to Net Global Warming Potential: A Long-Term Evaluation in the Northern Great Plains. Journal of Environmental Quality 39(3):799-809.

Contributions of grassland ecosystems to net global warming potential (GWP) are largely unknown. Furthermore, no long-term evaluation of net GWP for grassland ecosystems in the northern Great Plains (NGP) of North America have been reported. Given this need, we sought to determine net GWP for three long-term grazing management systems (two native vegetation pastures and one seeded forage pasture) located in the NGP, a region possessing a semi-arid continental climate and abundant grassland resources. Five factors were assessed in each pasture for their contribution to net GWP: 1) CO2 emissions from N fertilizer production and application, 2) CH4 emissions from cattle, 3) change in soil carbon, 4) soil-atmosphere CH4 flux, and 5) soil-atmosphere N2O flux. Overall, the contribution of factors on net GWP decreased in relative impact in the order of, 1) change in soil carbon, 2) soil-atmosphere N2O flux, 3) CH4 emission from cattle, 4) CO2 emission associated with N fertilizer production, and 5) soil-atmosphere CH4 flux. Summing across factors, net GWP was negative for both native vegetation pastures, implying net CO2 uptake. This finding underscores the value of grazed, mixed-grass prairie as a viable agroecosystem to serve as a net CO2 sink in the NGP. Conversely, net GWP for the seeded forage was positive, implying net CO2 emission to the atmosphere. When GWP data were expressed per unit of animal production, the native vegetation pasture with a lower stocking rate was found to be most effective at achieving net reductions in greenhouse gas emissions among the three pastures.

Virginia Wildrye Persistence and Performance in Riparian Areas

Sanderson, M.A., Van Der Grinten, M., Stout, R.C. 2010. Virginia wildrye persistence and performance in riparian areas. Crop Science Journal 50(4):1546-1551.

Programs such as Conservation Reserve Enhancement Program (CREP) have created a need for more information on the suitability of locally adapted native grasses for the northeastern USA. Because of the nature of riparian areas, native plants used in CREP plantings must be able to withstand seasonally wet soils. We could not find any research information on the use of Virginia wildrye in conservation plantings, especially in wet soils, in the northeastern USA. In this research, we evaluated Virginia wildrye in three states on sites that would qualify for inclusion in the CREP program. Our results demonstrated that Virginia wildrye tolerated wet soils at all sites and seasonal flooding at some sites during three years. These data confirm its classification as a facultative wetland plant with medium tolerance to anaerobic conditions. Wildrye had moderate survival at bottom slope positions along a stream or ephemeral waterway; however, it was most vigorous and persistent at the top and mid slope positions. Populations from specific wildrye accessions could be used to develop broadly adapted plant material specifically selected for conservation uses in the Northeastern USA.

Change in Soil Phosphorus as Influenced by Crop Sequence, Tillage, and Nitrogen Fertilization

Liebig, M.A., Halvorson, A.D. 2010. Change in Soil Phosphorus as Influenced by Crop Sequence, Tillage, and N Fertilization. p. 205-210. IN: A.J. Schlegel and H.D. Bond (Eds.) Great Plains Soil Fertility Conference Proceedings Vol. 13. Denver, CO. March 2-3, 2010. Kansas State University

Crop sequence, tillage, and N fertilization can influence soil properties, including the availability of nutrients necessary for plant growth. Within the portfolio of essential plant nutrients, phosphorus is particularly important for crop production in the northern Great Plains as soils in the region are inherently low in plant-available P. Recent increases in P fertilizer costs have placed a premium on identifying management practices that efficiently use plant-available soil P. To help address this need, a study was conducted to determine the effects of crop sequence, tillage, and N fertilization on plant-available soil P within a long-term cropping systems experiment near Mandan, ND. Results from the study found soil P to be greater under crop-fallow as compared to continuous cropping, and lower under treatments receiving moderate-to-high levels of N fertilizer relative to treatments receiving no or low levels of N fertilizer. Increased grain removal with continuous cropping and moderate-to-high levels of N fertilizer likely enhanced depletion of soil P. Outcomes from this study underscore the importance of tailoring soil fertility recommendations for dryland cropping systems based on the frequency of fallow and use of N fertilizer.

Effects of Supplemental Ground Flaxseed Fed to Beef Cattle Grazing Summer Native Range on the Northern Great Plains

Scholljegerdes, E.J., Kronberg, S.L. 2010. Effects of Supplemental Ground Flaxseed Fed to Beef Cattle Grazing Summer Native Range on the Northern Great Plains. Journal of Animal Science. 88:2108-2121.

Supplementing cattle during the summer grazing period can be desirable for livestock producers wishing to increase livestock growth performance. Use of fats in supplements for grazing animals has improved feed efficiency with various fat sources, such as soybean oil, corn oil, or whole soybeans. Two experiments were conducted simultaneously to evaluate the effects of supplemental ground flaxseed on site and extent of digestion and growth performance in beef cattle grazing summer native range. Six Angus heifers fitted with ruminal and duodenal cannulas were used in Experiment one and eighteen Angus cross steers were used in Experiment two. Cattle from both experiments were allotted to one of three individually fed treatments: grazing only with no supplement; grazing plus a cracked corn-soybean meal supplement fed at 0.32% of body weight once daily; or grazing plus a ground flaxseed supplement fed at 0.18% of body weight once daily. Feeding flaxseed at 0.18% of body weight to grazing cattle can be as effective as feeding a conventional corn-soybean meal based supplement in improving the energy density of the diet without negatively impacting forage intake or diet digestibility. In addition, supplemental flaxseed will provide an improvement in feed efficiency when forage quality is higher than will corn. In addition, the supply of linolenic acid, an omega-3 fatty acid, to the small intestine will ultimately provide tissues with more of this essential fatty acid. Therefore, ground flaxseed, appears to be a viable option for use as an energy supplement to steers grazing native range by improving growth performance without reducing forage utilization.

Glomalin Production and Accumulation in Soilless Pot Cultures

Nichols, K.A. 2010. Glomalin production and accumulation in soilless pot cultures. Canadian Journal of Soil Science 90:567-570. doi:10.4141/CJSS09041

Arbuscular mycorrhizal fungi form a symbiotic relationship with about 90% of all vascular plants. In this relationship, the fungus receives carbon from the plant in exchange for nutrients and water that the fungus picks up from the soil. Glomalin is a recalcitrant glycoprotein produced by Arbuscular mycorrhizalfungi and has been measured in concentrations ranging from 2 to 15 mg glomalin g-1 soil. A soilless pot culture system with a sand and crushed coal potting medium and a root chamber separated from a hyphal chamber by a seamless 38-µm nylon mesh bag was used to measure total glomalin accumulation after each of three consecutive 14-week culturing periods. Corn seedlings inoculated with one of two species of Arbuscular mycorrhizal fungi were planted in the root chamber. Glomalin was measured in different sections of pots: 1) on Arbuscular mycorrhizal colonized roots and hyphae in the root chamber, (2) on Arbuscular mycorrhizal fungal hyphae and associated debris in the hyphal chamber, and (3) on sand:coal potting media in the hyphal chamber. Results showed that glomalin levels in the hyphal chamber did not increased with consecutive culturing. However, plant growth, hyphal weight and glomalin accumulation were affected by irradiance with greater production under high light conditions. Immunofluorescence assays, using an antibody specific against glomalin, showed glomalin on hyphae of Arbuscular mycorrhizal fungi and on a square of horticultural mesh covering the drain holes at the bottom of the pot. It was concluded that because of the large amount of glomalin on this mesh, the high flow-through watering system, and the large pore space and low surface charge of the sand:coal media much of the freshly-produced glomalin was lost through the bottom of the pot.

Short- and Long-Term Economic Analysis of Forage Mixtures and Grazing Strategies

Deak, A., Hall, M.H., Sanderson, M.A., Rotz, C.A. 2010. Short- and Long-Term Economic Analysis of Forage Mixtures and Grazing Strategies. Agronomy Journal. 102:1201-1209.

Using forage mixtures in pasture management can result in improved forage yields and yield stability. Because mixtures are more difficult to manage than pure stands, farmers will only adopt them if there is a greater net profit. We used a whole-farm simulation model to evaluate the economics of altering forage mixtures and grazing strategies on a typical dairy farm of Pennsylvania. Specifically, we assessed the effect of grazing management based on canopy height or plant morphology and the effect of using pure grass stands and mixtures of two, three, five or seven grasses and legumes. Results showed that grazing management and pasture mixture affected overall farm net return. Grazing management based on canopy height rather than plant morphology criteria increased pasture production and net economic returns. The use of nitrogen fertilizer in pure stands of grass increased forage production both in the short- and long-term analysis but only increased net returns in the long run. Increasing mixture complexity increased net return both in the short- and long-term analyses. Furthermore, forage mixtures had smaller production risk. Consequently complex forage mixtures are a useful alternative for dairy pastures to manage forage production risks in dry years and thereby increase and stabilize annual net returns.

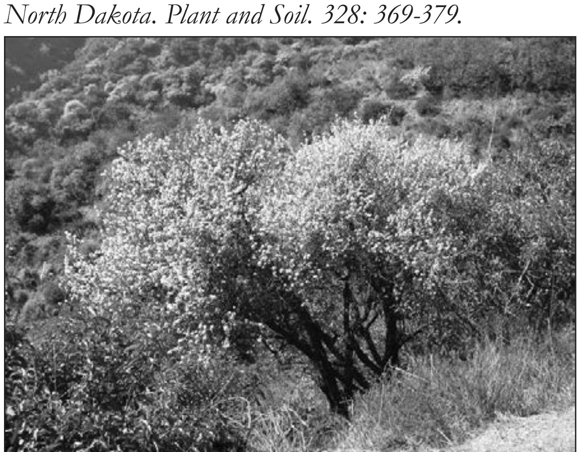
Nutritive Value and Herbage Accumulation Rates of Pasture Sown to Grass, Legume, and Chicory

Sanderson, M.A. 2010. Nutritive Value and Herbage Accumulation Rates of Pasture Sown to Grass, Legume, and Chicory Mixtures. Agronomy Journal. 102(2):728-733.

Plant species composition of pastures greatly influences herbage nutritive value. Our previous research showed that using diverse forage mixtures could increase forage yield and reduce weed invasions in pastures. A concern by farmers, however, is that large changes in the botanical composition of pastures may cause unstable and lower herbage nutritive value. In this grazing experiment, we tested the hypothesis that pastures planted to complex mixtures of forage species would be less stable in nutritive value than a simple grass-legume mixture. We studied four mixtures ranging from two to nine species. Our results showed that the number of forage species in the mixture did not control herbage nutritive value. Rather, functional group proportions (i.e., grasses, legumes, and chicory) controlled the nutritive value of mixed-species swards. Legume proportion controlled crude protein concentrations in the herbage, whereas the grass component controlled fiber concentrations. Thus, our research did not support the hypothesis that complex mixtures are inherently unstable in nutritive value.

Soil Carbon and Nitrogen Across a Chronosequence of Woody Plant Expansion in North Dakota

Springsteen, A., Loya, W., Liebig, M.A., Hendrickson, J.R. 2010. Soil carbon and nitrogen across a chronosequence of woody plant expansion in North Dakota. Plant and Soil. 328: 369-379.



Overgrazing and fire suppression have contributed to an increased abundance of shrubs within grasslands throughout the world. Increases in shrubs have come at the expense of grasses, and little is known about how this shift in vegetation dominance will affect the structure and function of grassland ecosystems. A study was undertaken to understand the influence of shrub expansion on soil carbon, nitrogen, and roots in a northern mixed-grass prairie grassland near Mandan, North Dakota. Total carbon and nitrogen was found to be greater under established shrubs as compared to grassland in the surface 6 inches of soil. Soil carbon and nitrogen under shrubs was estimated to be accumulating at a rate of 96 pounds of carbon and 11 pounds of nitrogen per acre per year respectively. Results of this study suggest shrub expansion is altering semiarid northern grasslands similarly to arid grasslands in the southwestern U.S.

Grazed Native Pasture Traps Greenhouse Gases

Dr. Mark Liebig

Grazing lands represent one of the largest land resources in the world, yet their role as net sinks or sources of greenhouse gases is essentially unknown. While previous work has emphasized contributions of grazing management to affect change in soil organic carbon, there is a lack of information regarding management impacts on the flux of two potent greenhouse gasses, nitrous oxide and methane.

A team of scientists at the USDA-ARS Northern Great Plains Research Laboratory estimated net global warming potential for three grazing management systems located in central North Dakota. The grazing management systems represented two native vegetation pastures (est. 1916) differing in stocking rate, and a seeded crested wheatgrass pasture (est. 1932) receiving supplemental nitrogen. The team measured soil organic carbon change and nitrous oxide and methane flux in the three grazing treatments, and combined their findings with estimates for methane emission from cattle (via enteric fermentation) and carbon dioxide emissions associated with producing and applying nitrogen fertilizer. Collectively, the data allowed net global warming potential to be estimated for each grazing treatment. Results from the study were published in the May-June issue of Journal of Environmental Quality.

Summing across factors, net global warming potential was negative for both native vegetation pastures, implying net removal of greenhouse gases from the atmosphere. This finding underscored the value of grazed, mixed-grass prairie as a viable agroecosystem to serve as a net greenhouse gas sink in the northern Great Plains. Conversely, net global warming potential for the seeded forage was positive, implying net greenhouse gas emission to the atmosphere. When global warming potential data were expressed per unit of animal production, the native vegetation pasture with a lower stocking rate was found to be most effective at achieving net reductions in greenhouse gas emissions among the three grazing treatments.

Mark Liebig, lead scientist on the project, stated "It's important to keep in mind the greenhouse gas balance we measured for the grazing treatments falls short of encompassing the full life-cycle of a steer. While our results suggest grazed native vegetation in the northern Great Plains is a net greenhouse gas sink, we need to acknowledge there is additional greenhouse gas emissions associated with cattle production outside of what we measured or estimated."

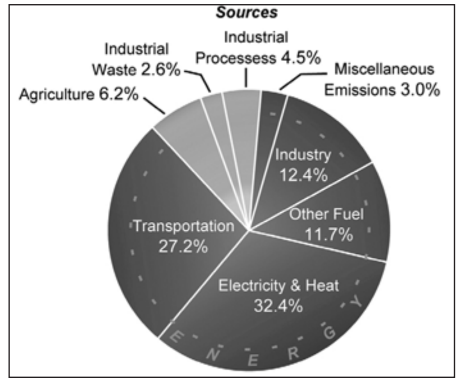
The study was conducted as part of a USDA-ARS cross-location research effort called GRACEnet (Greenhouse Gas Reduction through Agricultural Carbon Enhancement Network), which seeks to provide information on global warming potential of current agricultural practices, and to develop new management practices to reduce net greenhouse gas emissions from soil.

Liebig, M.A., J.R. Gross S.L. Kronberg, R.L. Phillips, and J.D. Hanson. 2010. Grazing management contributions to net global warming potential: A long-term evaluation in the northern Great Plains. Journal of Environmental Quality 39(3):799-809.

	Moderately grazed	**Heavily grazed**	**Crested wheatgrass**
Variable	- - - - - - - - - - - - - - - - - **lb $CO_{2equiv.}$ ac^{-1} yr^{-1}** - - - - - - - - - - - - - - - - -		
N fertilizer	0 b	0 b	228 a
Ent. Ferment.	157	432	503
SOC change	-1264	-1354	-1517
CH_4 uptake	-56	-55	-54
N_2O emission	464 b	426 b	1192 a
NET GWP	**-699 b**	**-551 b**	**354 a**

Managing Nitrogen ertilizer for Economic Returns and Greenhouse Gas Reductions in Irrigated Cropping Systems

Dr. Dave Archer



Tillage and nitrogen fertilizer management decisions can influence greenhouse gas emissions from farming activities. While nitrogen fertilizer is important for increasing crop productivity, which can help maintain soil organic carbon levels, nitrogen application can increase nitrous oxide emissions from cropland. Additionally, nitrogen fertilizer use leads to indirect greenhouse gas emissions due to manufacturing and transportation of fertilizer to the farm. Tillage practices also influence greenhouse gas emissions, with greater tillage intensity generally associated with higher greenhouse gas emissions due to lower soil organic carbon storage and higher fuel use. There can be important interactions between nitrogen fertilizer and tillage management decisions. For irrigated corn, higher nitrogen may be needed to minimize reductions in corn yield associated with no-till (NT) corn production. Tillage and nitrogen fertilizer decisions at the farm level are driven largely by economics. While management can lead to reductions in greenhouse gas emissions, producers are understandably unlikely to adopt management practices that are not profitable. This paper looks at the economic feasibility of reducing net greenhouse gas emissions using results from an irrigated cropping systems field study conducted near Fort Collins, Colorado. Cropping systems included conventional plow tillage continuous corn (CT-CC), no-till continuous corn (NT-CC), and no-till corn-soybean or dry bean (NT-CB).

The economic consequences of achieving greenhouse gas emission reductions were analyzed by combining enterprise budget data, constructed using the field study data, with net global warming potential calculated as carbon dioxide equivalents with one unit methane = 23 units carbon dioxide and one unit nitrous oxide = 296 units of carbon dioxide. Net global warming potential was calculated as the sum of carbon dioxide equivalents from irrigation, farm operations, nitrogen fertilizer production, soil nitrous oxide emissions, and soil methane emissions minus the annual increase in soil organic carbon (See Archer et al., 2008, and Archer and Halvorson, 2010, for details on economic analysis and net global warming potential methodology).

Average emissions of greenhouse gas from production activities (irrigation, farm operations, nbitrogen fertilizer production). At the highest nitrogen fertilizer rates, emissions associated with nitrogen fertilizer manufacture and transportation account for about half of the emissions from production activities. Excluding nitrogen fertilizer emissions, average greenhouse gas emissions from production activities for the NT systems were 178 to 182 pounds of carbon dioxide-equivalent per acre lower under NT than under CT, primarily due to lower diesel fuel use.

Net global warming potential emissions were calculated by adding emissions associated with production activities to soil greenhouse gas emissions. Combining net returns with net global warming potential shows some opportunities for managing greenhouse gasemissions while increasing profitability. Excessive application of nitrogen fertilizer reduces profitability while increasing net global warming potential. For a producer growing CT-CC, the economic optimum nitrogen fertilizer rate in this study was 130 pounds of nitrogen/acre. A producer applying 200 pounds of nitrogen/acre would increase greenhouse gas emissions by 460 pounds of carbon dioxide-equivalent/acre while reducing profitability by $16/acre compared to the economic optimum for the CT system. Reducing nitrogen fertilizer rates within a tillage/rotation system below the economic optimum could further reduce net global warming potential , but these reductions would come at a cost to the producer. However, switching from CT to either of the two NT systems offers opportunities to increase profitability while further decreasing net global warming potential. Comparing systems at the economic optimum nitrogen rates for this study, switching from CT-CC to NT-CC increases net returns by $19/acre and reduces global warming potential by 1,310 pounds of carbon dioxide-equivalent/acre, while switching from CT-CC to NT-CB increases net returns by $92/acre and reduces global warming potential by 830 pounds of carbon dioxide-equivalent/acre.

While greenhouse gas emissions tend to increase with increasing nitrogen fertilizer application rates, nitrogen fertilizer is necessary to maintain crop productivity and economic viability. For irrigated corn production in northeastern Colorado, our results indicate that greenhouse gas emissions can be reduced and profitability improved by avoiding over-application of nitrogen fertilizer. Further reductions in greenhouse gas emissions and increases in profitability could be realized by switching from CT to NT production systems.

References

Archer, D.W., A.D. Halvorson, and C.A. Reule. 2008. Economics of irrigated continuous corn under conventional-till and no-till in Northern Colorado. Agron. J. 100:1166-1172.

Archer, D.W. and A.D. Halvorson. 2010. Greenhouse gas mitigation economics for irrigated cropping systems in Northeastern Colorado. Soil Sci. Soc. Am. J. 74:446-452.

This article excerpted from: Archer, D.W. and A.D. Halvorson. 2010. Managing nitrogen fertilizer for economic returns and greenhouse gas reductions in irrigated cropping systems. Better Crops 94:4-5.

Northern Great Plains Research Laboratory Bioenergy Research Summary

The mission of the Northern Great Plains Research Laboratory (NGPRL) is to develop environmentally sound practices and add value to agricultural systems in the Great Plains in terms of food, feed, and biomass by conducting team-focused, systems-oriented research and technology transfer. Research on bioenergy-related topics has been conducted at NGPRL since 1999, with an emphasis on understanding production potential and natural resource impacts of switchgrass. Here are some of the major cellulosic biofeedstock developments contributed to by NGPRL scientists:

Cellulosic Raw Material Biofeedstock Development

Temperature and pH Effects on Germination

Summary: Optimum conditions for germination were evaluated for eight switchgrass cultivars. Results indicated germination of switchgrass occurred most successfully in substrates with a pH of 6 and at a temperature of 77°F. Optimum stand establishment in the field should be realized in soils that are warm with a pH range of 5 to 8.

Citation: Hanson, J.D., and H.A. Johnson. 2005. Germination of switchgrass under various temperature and pH regimes. Seed Tech. 27(2):203-210.

Cultivar Evaluation

Summary: Biomass yield and phenology of eight diverse switchgrass cultivars were measured over three years at three field sites in western North Dakota. Biomass yields of Sunburst, the cultivar with the highest and most stable yield, fluctuated widely in response to available soil water (3.2 to 12.5 Mg ha-1). Consequently, producers may have difficulty providing a consistent supply of switchgrass biomass in regions subject to periodic droughts.

Citation: Berdahl, J.D., A.B. Frank, J.M. Krupinsky, P.M. Carr, J.D. Hanson, and H.A. Johnson. 2005. Biomass yield, phenology, and survival of diverse switchgrass cultivars and experimental strains in western North Dakota. Agron. J. 97:549-555.

Summary: Switchgrass can fill a forage gap during summer when hot dry weather reduces production of cool-season forages. In this study, we used feeding trials with sheep to determine the forage quality of Trailblazer, Shawnee, Cave-in-Rock, and Pathfinder switchgrass hays. In most instances, the stage of plant maturity at hay harvest accounted for more of the variation in nutritive value and digestibility among switchgrass hays and harvest dates than cultivar identity. Switchgrass cultivars selected for improved dry matter digestion in the laboratory did not have greater dry matter or fiber digestion compared with standard cultivars when fed to sheep. Differences among cultivars in nutritive value and digestion mostly were due to differences in plant maturity.

Citation: Sanderson, M.A., and J.C. Burns. 2010. Digestibility and intake of hays from upland switchgrass cultivars. Crop Science 50:2641-2648

Crop Stand Establishment

Summary: For Switchgrass to become a primary biomass energy source stock, farmers need to learn how to produce it. Field scale trials in the Northern Great Plains states of North Dakota, Nebraska, and South Dakota, were used to determine minimal plant populations for switchgrass when grown as a biomass energy crop. Results from the three-state evaluation area indicate that an establishment year stand survivability of 40% or greater can be considered stand threshold for successful establishment.

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

Disease Identification

Summary: Potential diseases capable of affecting switchgrass production were evaluated in a multi-location collaborative research effort. Biopolaris oryzae, a common fungal pathogen on rice, was identified as the causal agent of a leaf-spot disease on switchgrass. This pathogen has the potential to reduce yields of switchgrass under intensive plantings, particularly if susceptible cultivars are seeded over a large area.

Citation: Krupinsky, J.M., J.D. Berdahl, C.L. Schoch, and A.Y. Rossman. 2004. Leaf spot on switchgrass (Panicum virgatum), symptoms of a new disease caused by Bipolaris oryzae. Can. J. Plant Path. 26:371-378.

Long-Term Herbaceous Biomass Study Collaboration

Description: NGPRL scientists are cooperating with North Dakota State University and five NDSU Research Extension Centers located in diverse growing regions of North Dakota on an extensive ten-year evaluation of perennial herbaceous biomass crops. The potential of warm- and cool-season grasses and mixes, including mixes with alfalfa and clover are being assessed. Two harvesting treatments (annual, biennial) are also being evaluated. Treatment effects on soil carbon sequestration and soil quality improvements will be measured on a five-year frequency.

Status: Baseline soil samples were collected to quantify levels of carbon storage and biological life prior to seeding in 2006 with soil sampling scheduled again in 2011.

Economics and Life Cycle Analyses

What Does It Cost Farmers to Grow Switchgrass in the Great Plains States?

Summary: Switchgrass was managed as a biomass energy crop in field trials on marginal cropland on ten farms in three Great Plains states (North Dakota, Nebraska, and South Dakota) for five years to determine net energy based on inputs and yields. Costs for individual farms, ranged from $29 to $110 per ton of biomass. The potential for reducing establishment costs and increasing yields suggests that substantial quantities of switchgrass would be produced in just a few years with prices as low as $36-$40 per ton at the farm gate. At a conversion rate of 80 gallons of ethanol per ton, the biomass feedstock cost at the farm gate would be about $0.50 per gallon.

Potential for Biofuel Production from CRP Lands

Summary: Concerns about finding sufficient land for biofuel production has experts eyeing marginal croplands that have been placed in the Conservation Reserve Program (CRP). An extensive study by ARS scientists of grassland sites across major Northeastern ecoregions determined the effects plant species composition, diversity, above ground biomass, and chemical composition had on potential biofuel yield. This study showed that CRP lands with a high proportion of native warm-season prairie grasses have the potential to produce more than 600 gallons of ethanol per acre, while still maintaining the ecological benefits of grasslands.

Citation: Adler, P.R., M.A. Sanderson, P.J. Weimer, and K.P. Vogel. 2009. Plant species composition and biofuel yields of conservation grasslands. Ecol. Appl. 19:2202-2209). Life Cycle Analysis of switchgrass Production

Summary: Switchgrass was managed as a biomass energy crop in field trials on marginal cropland on ten farms in three Great Plains states for five years to determine net energy based on inputs and yields. Switchgrass produced 540% more renewable energy than nonrenewable energy consumed. Greenhouse gas emissions from switchgrass were 94% and 76% lower than gasoline or corn ethanol, respectively. Switchgrass managed for high yield had equal or greater net energy than low input perennial polycultures and can produce 350% more liquid fuel per hectare. Improved switchgrass genetics and agronomics will enhance net values and increase total energy yields per acre.

Citation: Schmer, M.R., Vogel, K.P., Mitchell, R., Perrin, R.K. 2008. Net Energy of Cellulosic Ethanol from Switchgrass. Proceedings of the National Academy of Sciences. 105: 464-469

Switchgrass Still Productive After 20 Years of Management.

Summary: Switchgrass, a native warm-season perennial grass, has received extraordinary attention as a candidate cellulosic bioenergy crop. Despite being native, there is little information on its long-term (>10 years) persistence and performance. USDA-ARS scientists measured the biomass yields and plant density of experimental switchgrass germplasm and the standard cultivar Cave-in-Rock after 20 years of management. Biomass yields of all switchgrasses were stable and stand density was relative high after 20 years demonstrating the long-term sustainability of switchgrass as a bioenergy crop. These are the first long-term data on the experimental germplasm (since released as the cultivars BoMaster and Peformer by ARS in Raleigh, NC) and indicate that southerly adapted lowland cultivars can provide diversity in cultivar choices for switchgrass bioenergy production in the northeastern U.S. BoMaster and Performer are now marketed by Ernst Conservation Seeds in Meadville, Pennsylvania. (Sanderson, M.A. 2010. Long-term persistence of synthetic populations of a lowland switchgrass ecotype and the cultivar Cave-in-Rock.

Citation: Online. Forage and Grazing Lands. doi:10.1094/FG-2010-0426-02-RS. www.plantmanagementnetwork.org.) Soil Quality and Carbon Sequestration

A Matter of Balance: Conservation and Renewable Energy

Summary: Soils have a tremendous capacity to sequester carbon, if managed wisely, offering agriculture an exceptional opportunity to remove carbon dioxide, a greenhouse gas, from the atmosphere. Use of agricultural biomass for energy can also be part of our energy solution. Research is being conducted to determine how much, when and where biomass can be removed without soil and/or environmental degradation. A balanced, sustainable approach is critical.

Citation: Johnson, Jane M-F., Don Reicosky, Ray Allmaras, Dave Archer, and Wally Wilhelm. 2006. A matter of balance: Conservation and renewable energy. J. Soil and Water Conserv. 61(4):125A-129A.

On-Farm Research Shows Soil Carbon Accrual Over Time Under Switchgrass

Summary: Life-cycle assessments of bioenergy crops such as switchgrass requires data on soil organic carbon change and harvested carbon yields to accurately estimate net greenhouse gas emissions. Nearly all information to date has been based on either modeled assumptions or small plot research, which do not take into account spatial variability within or across sites for an agro-ecoregion. Change in soil organic carbon and harvested carbon yield for switchgrass fields was measured on ten farms in the central and northern Great Plains over a five year period. Soil carbon accrual under switchgrass across the ten farms averaged 1.1 Mg C ha-1 yr-1 for the 0 to 30 cm depth.

Citation: Liebig, M.A., Schmer, M.R., Vogel, K.P., Mitchell, R. 2008. Soil Carbon Storage by Switchgrass Grown for Bioenergy. BioEnergy Research. 1:215-222.

Switchgrass Biomass and Carbon Dynamics

Summary: Two switchgrass cultivars were evaluated for carbon sequestration and partitioning among plant components. Root biomass was found to account for over 80% of total biomass, and crown tissue contained approximately 50% of total biomass carbon. Soil organic carbon was found to increase at a rate of 1.01 kg C m-2 yr-1 over the 0 to 0.9 m depth. Sitchgrass plantings in the northern Great Plains have potential for storing a significant quantity of soil carbon.

Citation: Frank, A.B., J.D. Berdahl, J.D. Hanson, M.A. Liebig, and H.A. Johnson. 2004. Biomass and carbon partitioning in switchgrass. Crop Sci. 44(4):1391-1396.

Switchgrass Stores Carbon Deep in the Soil Profile

Summary: Soil carbon stocks were evaluated under established switchgrass stands and nearby cultivated cropland throughout the northern Great Plains and northern Cornbelt. Soil organic carbon was greater in switchgrass stands than cultivated cropland at soil depths of 0 to 2", 12' to 24", 24" to 36", and especially so at the deeper soil depths where treatment differences were 3.5 and 1.9 tons/acre for the 12' to 24", 24" to 36" depths, respectively. Switchgrass appears to be effective at storing soil organic carbon not just near the soil surface, but also at depths below one foot where carbon is less susceptible to loss.

Citation: Liebig, M.A., H.A. Johnson, J.D. Hanson, and A.B. Frank. 2005. Soil carbon under switchgrass stands and cultivated cropland. Biom. Bioe. 28(4):347-354.

Mycorrhizal Fungi Evaluations

Description: Above- and below-ground biomass and carbon:nitrogen ratios, tiller number, Haun score, and interactions with mycorrhizal fungi (i.e., glomalin production) are being evaluated for switchgrass under ambient (365 ppm) and elevated (730 ppm) carbon dioxide levels. The experiment was conducted in a controlled environment growth chamber using the Sunburst switchgrass cultivar. Each pot contained one of three mixes of mycorrhizal inoculum: 1. a mixture of regionally adapted mycorrhizal fungi (native inoculum), 2. a mixture of commercially produced fungi from Mycorrhizal Applications, Inc. in Oregon (commercial inoculum), or 3. a combination of both the native and commercial inoculums.

Status: Preliminary results indicate the interactions between carbon dioxide level and mycorrhizal inoculum is not significant. The higher carbon dioxide level (730 ppm) did result in a significantly higher above- and below-ground biomass and carbon:nitrogen ratios. The commercial inoculum provided highest above and below ground biomass while the native and native commercial inoculums were not significantly different from each other. Based on these results, new experiments were designed to assess the impact of these inoculum sources on switchgrass under drought and defoliation stress conditions.

The Northern Great Plains Research Laboratory (NGPRL) is located in west central North Dakota near the confluence of the Missouri and Heart Rivers. Climate is characterized as semiarid/subhumid, with mean average precipitation of 16 inches and a mean average temperature of 41°F. Research sites at NGPRL are characterized by a gently rolling topography. Soils are predominantly Temvik-Wilton silt loams (Typic and Pachic Haplustolls).

Outreach Tool For Cover Crops

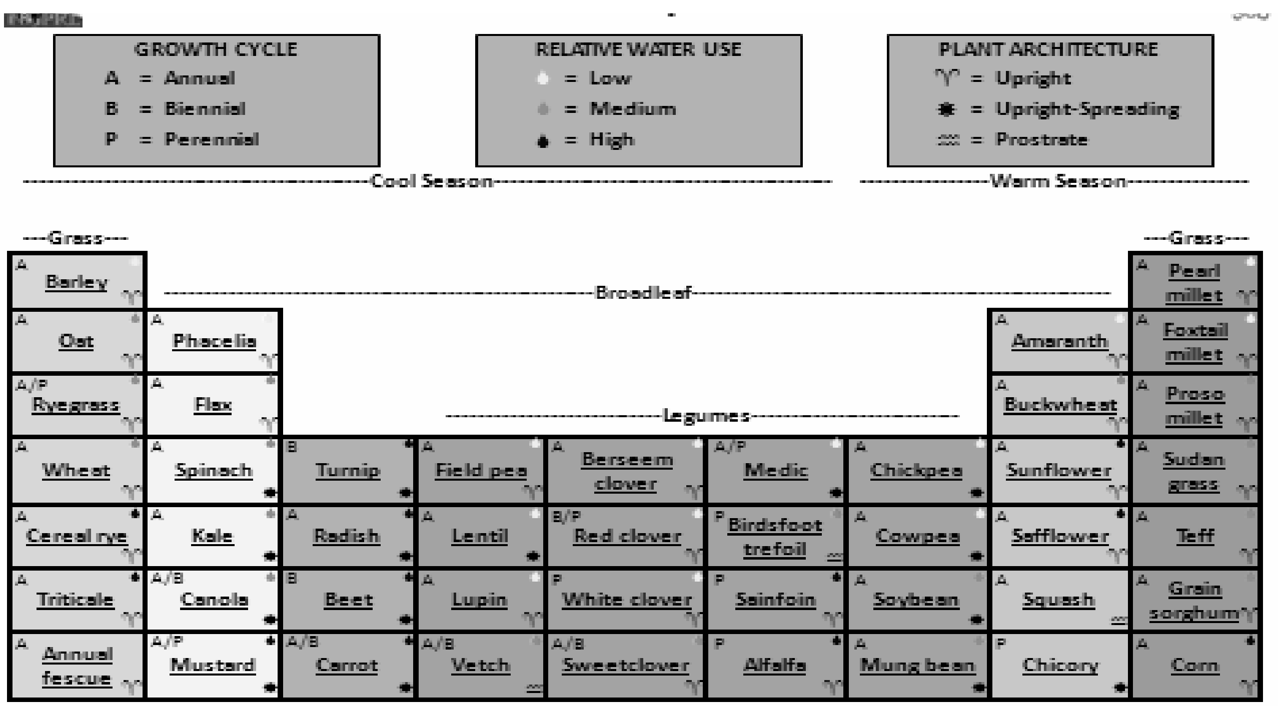
Dr. Mark Liebig

Interest in cover crops by farmers and ranchers throughout the Northern Great Plains has increased the need for information on the suitability of a diverse portfolio of crops for different production and management resource goals. To help address this need, NGPRL staff developed an outreach tool called the Cover Crop Chart (Figure 1). Patterned after the periodic table of elements, the chart includes information on 46 crop species that may be planted individually or in cocktail mixtures. Specifics on growth cycle, relative water use, plant architecture, forage quality, pollination characteristics, and nutrient cycling are included for most crop species.

Information in the chart was gathered from multiple sources throughout the U.S. and Canada, such as the Midwest Cover Crops Council, USDA-SARE, USDA-NRCS PLANTS Database, and the 3rd edition of Managing Cover Crops Profitably. Accordingly, information in the chart was not based on research conducted at NGPRL. However, input from local NRCS personnel and producers from the Area IV Soil Conservation Districts was instrumental in deciding which crops and related information to include in the chart.

The chart was developed in Portable Document Format (pdf), requiring only Adobe Reader© for use on a personal computer. Using a simple 'point and click' format, users can select individual crop species by clicking on the crop name, which will direct them to additional information about the selected crop. Icons within each crop page return the user to the crop selection screen, thereby easily allowing comparisons of different crops.

The chart can be downloaded for free through the NGPRL website at www.mandan.ars.usda.gov.



National Ecological Observatory Network

Dr. Rebecca Phillips

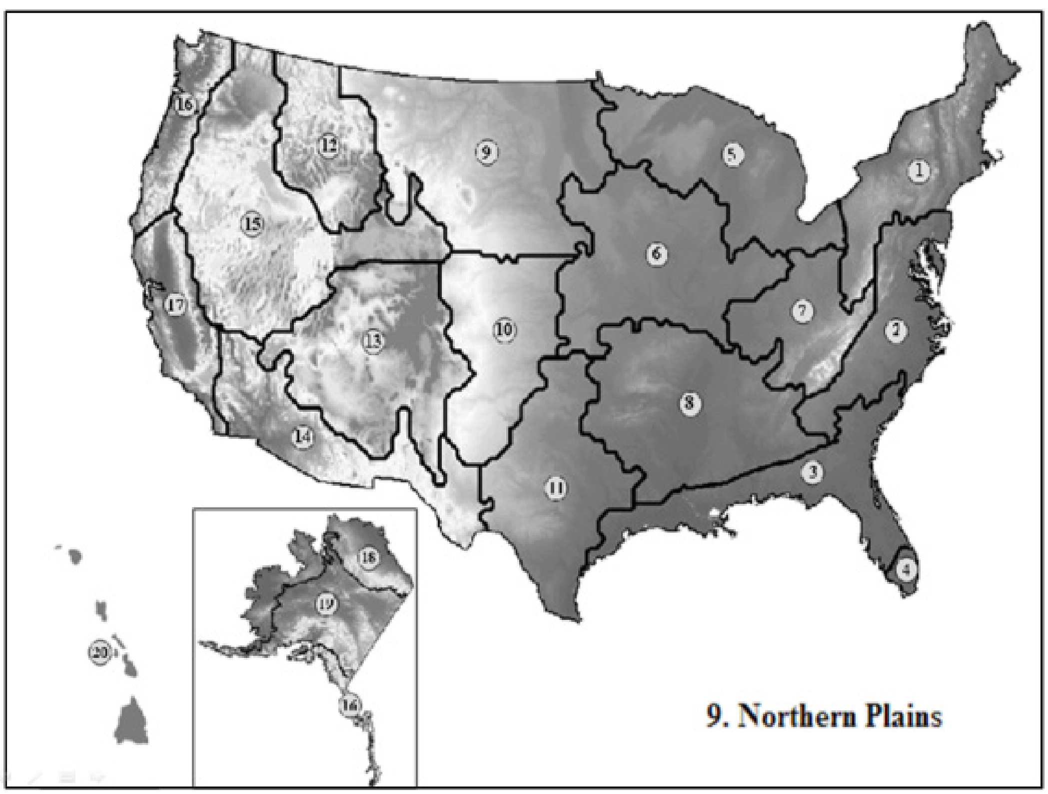
The ARS-USDA Northern Great Plains Research Laboratory in Mandan was selected as a National Ecological Observatory Network (NEON) site to represent agricultural ecosystems site in the Northern Plains. There are 106 NEON sites across the United States chosen to represent 20 eco-climatic domains, including regional variations in vegetation, landforms, climate, and ecosystem performance.

NEON will be the first observatory network of its kind designed to detect and enable forecasting of ecological change at continental scales over multiple decades. This is an exciting opportunity for education and worldwide research collaborations here in Mandan.

The National Ecological Observatory Network (NEON) will collect data across the United States on the impacts of climate change, land use change and invasive species on natural resources and biodiversity. It is a project of the U.S. National Science Foundation, with many other U.S. agencies and NGOs cooperating.

Data will be collected from strategically locations within each domain and synthesized into information products that can be used to describe changes in the nation's ecosystem through space and time. These data and information products will be readily available to scientists, educators, students, decision makers, and the public, enabling a wide audience (including members of underserved communities) to use NEON tools to understand and address ecological questions and issues. The NEON infrastructure is a means of enabling transformational science and promoting broad ecological literacy.

NEON's goal is to contribute to global understanding and decisions in a changing environment using scientific information about continental-scale ecology obtained through integrated observations and experiments. NEON's national observatory network will collect ecological and climatic observations across the continental United States, including Alaska, Hawaii and Puerto Rico. NEON is currently in the planning and development stages, and expects to enter the construction phase in late 2010, when sites will be built and data will begin to come in. Constructing the entire NEON network will take approximately five years, so NEON expects to be in full operation by 2016.



Switchgrass for Biofuel Production

Mature stand of switchgrass in its third year of production at Michigan State University. Photo courtesy of Dennis Pennington.

Switchgrass is a native warm-season grass that is a leading biomass crop in the United States. More than 70 years of experience with switchgrass as a hay and forage crop suggest switchgrass will be productive and sustainable on rain-fed marginal land east of the 100th meridian. Long-term plot trials and farm-scale studies in the Great Plains and plot trials in the Great Plains, Midwest, South, and Southeast indicate switchgrass is productive, protective of the environment, and profitable for the farmer. Weed control is essential during establishment but with good management is typically not required again. Although stands can be maintained indefinitely, stands are expected to last at least 10 years, after which time the stand will be renovated, and new, higher-yielding material will be seeded on the site. Fertility requirements are well understood in most regions, with about 12 to 14 pounds of N per acre required for each ton of expected yield if the crop is allowed to completely senesce before the annual harvest. Historically, breeding and genetics research has been conducted at a limited number of locations by USDA and university scientists, but the potential bioenergy market has promoted testing by public and private entities throughout the United States. Switchgrass is well suited to marginal cropland and is an energetically and economically feasible and sustainable biomass energy crop with currently available technology.

Introduction

Grassland scientists have conducted research on switchgrass for more than 70 years, with initial research focusing on livestock and conservation. In 1936, L. C. Newell, an agronomist with the Bureau of Plant Industry, USDA, in Lincoln, Nebraska, began working with switchgrass and other grasses to potentially re-vegetate large areas of the central Great Plains and Midwest that had been devastated by the drought of the 1930s. The first switchgrass cultivar from this program was Nebraska 28 which was jointly released by USDA and the University of Nebraska in 1949. Since that time, establishment and management practices have been developed and refined, genetic resources have been evaluated, seed production has been improved, and a wealth of information has been made available to producers.

Most of the general public first heard about switchgrass on January 31, 2006, when President George W. Bush in his State of the Union Address said, "We must also change how we power our automobiles. We will increase our research in better batteries for hybrid and electric cars, and in pollution-free cars that run on hydrogen. We'll also fund additional research in cutting-edge methods of producing ethanol, not just from corn, but from wood chips and stalks, or switchgrass. Our goal is to make this new kind of ethanol practical and competitive within six years." Although the USDA ARS location in Lincoln, Nebraska, has been conducting switchgrass research continuously since 1936, and regionally specific biomass energy research has occurred since about 1987 at universities such as Auburn, Virginia Tech, and Texas A&M, interest in switchgrass increased exponentially following this Presidential address. Recently, significant attention has been given to switchgrass as a model perennial grass for bioenergy production to reduce our dependence on foreign oil, boost our rural economies, reduce fossil fuel emissions, reduce erosion on marginal cropland, and enhance wildlife habitat.

Current Potential for Use as a Biofuel

Switchgrass has excellent potential as a bioenergy feedstock for cellulosic ethanol production, direct combustion for heat and electrical generation, gasification, and pyrolysis. The U.S. Department of Energy (DOE) Bioenergy Feedstock Development Program selected switchgrass as the herbaceous model species for biomass energy. Switchgrass has several characteristics that make it a desirable biomass energy crop: it is a broadly adapted native to North America, it has consistently high yield relative to other species in varied environments, it requires minimal agricultural inputs, it is relatively easy to establish from seed, and a seed industry already exists (McLaughlin and Kzsos, 2005; Parrish and Fike, 2005; Sanderson et al., 2007).

Biology and Adaptation

Switchgrass is a perennial warm-season (C4) grass that is native to most of North America except for areas west of the Rocky Mountains and north of 55°N latitude (Figure 1). Switchgrass grows 3 to 10 feet tall, typically as a bunchgrass, but the short rhizomes can form a sod over time. Switchgrass has high yield potential on marginal cropland and will be productive in most rain-fed production systems east of the 100th meridian (Vogel, 2004). Productive switchgrass stands can be grown west of the 100th meridian with irrigation (Biofuels Cropping Systems Research and Extension, Washington State University). Switchgrass is adapted to a wide range of habitats and climates and has few major insect or disease pests. Root depth of established switchgrass may reach 10 feet, but most of the root mass is in the top 12 inches of the soil profile. In addition to potential bioenergy production, switchgrass uses include pasture and hay production, soil and water conservation, carbon sequestration, and wildlife habitat.

Switchgrass has distinct lowland and upland ecotypes. Upland ecotypes occur in upland areas that are not subject to flooding, whereas lowland ecotypes are found on floodplains and other areas that receive run-on water (Vogel, 2004). Generally, lowland plants have a later heading date and are taller with larger and thicker stems. Upland ecotypes are either octaploids or tetraploids, whereas lowland ecotypes are tetraploids (Vogel, 2004). Lowland and upland tetraploids have been crossed to produce true F1 hybrids that have a 30 to 50% yield increase over the parental lines (Vogel and Mitchell, 2008). These hybrids are promising sources for high-yielding bioenergy cultivars.

Figure 1. Switchgrass is adapted to much of North America. Photo courtesy of USDA NRCS.

Production and Agronomic Information

Establishing Stands

Successful stand establishment during the seeding year is mandatory for economically viable switchgrass bioenergy production systems (Perrin et al., 2008). Weed competition is the major reason for switchgrass stand failure. Acceptable switchgrass production can be delayed by one or more years by weed competition and poor stand establishment (Schmer et al., 2006). Vogel and Masters (2001) reported a stand frequency of 50% or greater (two or more switchgrass plants per square foot) indicated a successful stand, whereas stand frequency from 25 to 50% was marginal to adequate, and stands with less than 25% frequency indicated a partial stand. In a study conducted on 12 farms in Nebraska, South Dakota, and North Dakota, switchgrass fields with a stand frequency of 40% or greater provided a successful stand (Schmer et al., 2006).

Switchgrass is readily established when quality seed of an adapted cultivar is used with the proper planting date, seeding rate, seeding method, and weed control. In the central Great Plains, switchgrass can be planted two or three weeks before to two or three weeks after the recommended planting dates for corn, typically from late April to early June. Switchgrass should be seeded at 30 pure live seed (PLS) per square foot (5 PLS pounds per acre) based on the quality of the seedlot. Excellent results are obtained by planting after a soybean crop using a properly calibrated no-till drill with depth bands that plant seeds 0.25 inch to 0.5 inch deep followed by press wheels (Figure 2). Row spacing for switchgrass is typically 7.5 to 10 inches. If switchgrass is planted after crops that leave heavy residue such as corn or sorghum (Sorghum bicolor), it may be necessary to graze the residue, shred or bale the stalks, or use tillage to reduce the residue. If tillage is required, the seedbed needs to be packed to firm the soil. The packed soil needs to be firm enough so that walking across the field leaves only a faint footprint. Applying 8 oz of quinclorac plus 1 quart of atrazine per acre immediately after planting has provided effective grassy and broadleaf weed control for establishment. The most cost-effective method to control broadleaf weeds in switchgrass fields during the establishment year is to apply 2,4-D at 1 to 2 quarts/acre^{-1} after switchgrass seedlings have about four leaves. After the establishment year, a successfully established switchgrass stand requires limited herbicide applications.

Figure 2. Soybean stubble provides an excellent seedbed for no-till seeding switchgrass. During the establishment year, all harvests must occur after a killing frost to avoid damaging stands. In the establishment year, good weed management and rainfall will provide about half of the fully established yield potential of the site and cultivar. Photo courtesy of Rob Mitchell.

Nitrogen fertilizer is not recommended during the planting year since

Figure 3. Seeding into corn or sorghum stubble may require plowing, disking, and packing to develop a firm seedbed. Pack the tilled soil until walking across the field leaves only a faint footprint to ensure good seed-to-soil contact and prevent soil in-filling of the packer wheel depression. Photo courtesy of Rob Mitchell.

nitrogen will encourage weed growth, increase competition for establishing seedlings, increase establishment cost, and increase economic risk associated with establishment if stands should fail (Mitchell et al., 2008). Soil tests are recommended prior to planting. Since switchgrass is deep rooted, soil samples should be taken from each 1-foot increment to a depth of 5 feet. In most agricultural fields, adequate levels of phosphorus (P) and potassium (K) will be in the soil profile. If warranted by soil tests, phosphorous and potassium can be applied before seeding to encourage root growth and promote rapid establishment. Recommended phosphorus levels for the western corn belt are in Table 1. Switchgrass can tolerate moderately acidic soils, but optimum seed germination occurs when soil pH is between 6 and 8 (Hanson and Johnson, 2005). With good weed management and favorable precipitation, a crop equal to about half of potential production can be harvested after frost at the end of the planting year, with 75 to 100% of full production achieved the year after planting.

Established Stands

	Soil Test Levels		
P Index Value	Bray & Kurtz #1	Olsen P (Na HCO_3)	P Rate
	---------- ppm ----------		lb P_2O_5/Acre
Very low	0-5	0-3	40
Low	6-15	4-7	20
Medium	16-25	8-14	10
High	25+	15+	0

Table 1. Phosphorus (P) recommendations for the western corn belt based on two common soil test levels (Anderson and Shapiro, 1990).

Although switchgrass can survive on low fertility soils, it does respond to fertilizer, especially nitrogen. The amount of nitrogen required by switchgrass is a function of the yield potential of the site, productivity of the cultivar, and other management practices being used (Vogel et al., 2002). Consequently, the optimum nitrogen rate for switchgrass managed for biomass will vary, but a few references indicative of the responses to nitrogen in different regions of the United States are included (Table 2). Additionally, biomass will decline over years if inadequate nitrogen is applied, and yield will be sustainable only with proper nitrogen application (Muir et al., 2001). In Nebraska and Iowa, Cave-in-Rock yield increased as nitrogen rate increased from 0 to 270 pounds of nitrogen acre^{-1}, but soil nitrogen increased when more than 100 pounds of nitrogen acre^{-1} were applied (Vogel et al., 2002). They reported biomass was optimized by applying 100 pounds of nitrogen acre^{-1}, with about the same amount of nitrogen being applied as was being removed by the crop. A general nitrogen fertilizer recommendation for the Great Plains and Midwest region is to apply 20 pounds of nitrogen acre^{-1} yr^{-1} for each ton of anticipated biomass if harvesting during the growing season, with nitrogen rate reduced to 12 to 14 pounds of nitrogen acre-1 yr^{-1} for each ton of anticipated biomass if harvesting after a killing frost. The nitrogen rate can be reduced when the harvest is after a killing frost because switchgrass cycles some nitrogen back to roots during autumn. If soil tests indicate a new switchgrass field has high residual nitrogen levels, nitrogen rates can be significantly reduced during the initial production years using the above information as a guideline. Apply

State(s)	Parameters Evaluated	Reference
AL	N rate and row spacing effect on C partitioning	Ma et al., 2001
IA	Yield and quality parameters for 20 strains	Lemus et al., 2002
IA, NE	Harvest date and N rate effects	Vogel et al., 2002
NC, KY, TN, VA, WV	Long-term yield under different management regimes	Fike et al., 2006a Fike et al., 2006b
SD	Harvest date and N rate effects on biomass, persistence, species composition, and soil organic carbon of switchgrass-	Mulkey et al., 2006 Lee et al., 2007
	dominated CRP	
TX	Yield and stand responses to N and P as affected by row spacing	Muir et al., 2001

Table 2. Switchgrass publications addressing nitrogen fertilizer application for different regions of the United States listed by state, the major parameters evaluated in the study, and references for each study.

nitrogen at switchgrass green-up to minimize cool-season weed competition.

Spraying herbicides to control broadleaf weeds typically is needed only once or twice every ten years in an established, well-managed switchgrass stands. When needed, the most effective and economical approach is with broadcast applications of 2,4-D at 1 to 2 quarts/acre^{-1}. Spray broadleaf weeds as early in the growing season as possible to reduce the impact of weed interference on switchgrass yield. In some cases, cool-season grasses may invade switchgrass stands and reduce yield. Harvesting after switchgrass senescence in autumn but while cool-season grasses are growing, then applying glyphosate at 1 to 2 quarts/ per acre^{-1}, is an effective method to reduce cool-season grasses. However, make certain switchgrass is dormant when glyphosate is applied, or stands could be damaged. Spring applications of atrazine at 2 quarts/acre^{-1} can be used to control cool-season grasses in established switchgrass stands.

Figure 4. Rotary head mowers (disc mowers) effectively harvested this 6-ton per acre switchgrass field at anthesis. Additionally, after a killing frost, the multidirectional arrangement of the switchgrass in the windrow was easier to bale than the linearly arranged windrow left by the sickle-bar head. Photo credit Rob Mitchell.

Harvest and Storage

Maximizing yield currently is the primary objective when harvesting biomass feedstocks. In the Great Plains and Midwest, maximum first-cut yields are attained by harvesting switchgrass when panicles are fully emerged to the post-anthesis stage (~1 August). Sufficient regrowth may occur about one year out of four to warrant a second harvest after a killing frost. Do not harvest switchgrass within six weeks of the first killing frost or shorter than a 4-inch stubble height to ensure translocation of storage carbohydrates to maintain stand productivity and persistence. Dormant season harvests after a killing frost will not damage switchgrass stands but will reduce the amount of snow captured during winter. In general, a single harvest during the growing season maximizes switchgrass biomass recovery, but harvesting after a killing frost will ensure stand productivity and persistence, especially when drought conditions occur, and reduce N fertilizer requirements. Delaying harvest until spring will reduce moisture and ash contents, but yield loss can be as high as 40% compared with a fall harvest (Adler et al., 2006). With proper management, productive stands can be maintained indefinitely and certainly for more than 10 years. Harvesting switchgrass in summer at or after flowering when drought conditions exist is not recommended.

Switchgrass can be harvested and baled with commercially available haying equipment. Self-propelled harvesters equipped with a rotary head (disc mowers) have most effectively harvested high-yielding (>6-ton per acre) switchgrass fields. Additionally, after a killing frost, the multidirectional arrangement of the switchgrass in the windrow was easier to bale than the linearly arranged windrow left by a sickle-bar head. Round bales tend to have less storage losses than large square bales (>800 lb) when stored outside, but square bales tend to be easier to handle and load a truck for transport without road width restrictions. After harvest, poor switchgrass storage conditions can result in storage losses of 25% in a single year. In addition to storage losses in weight, there can be significant reductions in biomass quality, and the biomass may not be in acceptable condition for a biorefinery. Switchgrass grown for use in a biorefinery may have to be stored for a full year or longer since biorefineries will operate 365 days a year. Some type of covered storage will be necessary to protect the producer's investment.

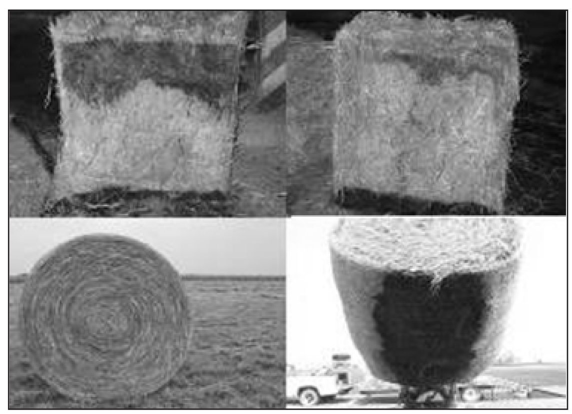


Figure 5. Proper storage of switchgrass bales is imperative to maintain total harvested dry matter and prevent spoilage. Large square bales can spoil from the top and bottom and can lose more than 25% of total dry matter in six months when stored outside in the open (top left), but covering the large square bales with hay tarps (top right) reduces dry matter loss to about 7% in six months. Wrapping big round bales with at least three wraps of net-wrap maintains the structure of the bale and reduces the surface area of the bale that contacts the ground. Covering big round bales stored outside can reduce dry matter loss to less than 3% in six months. Photo courtesy of Rob Mitchell.

Potential Yield

Switchgrass yield is strongly influenced by precipitation, fertility, soil, location, genetics, and other factors. Most plot and field-scale switchgrass research has been conducted on forage-type cultivars selected for other livestock-based characteristics in addition to yield. Consequently, the forage-type cultivars in the Great Plains and Midwest are entirely represented by upland ecotypes which are inherently lower yielding than lowland ecotypes. Thus, yield data comparing forage-type upland cultivars like Cave-In-Rock, Shawnee, Summer, and Trailblazer do not capture the full yield potential of switchgrass and are not fair comparisons. For example in Nebraska, high-yielding F1 hybrids of Kanlow and Summer produced 9.4 tons acre^{-1} year^{-1}, which was 68% greater than Summer and 50% greater than Shawnee (Vogel and Mitchell, 2008). New biomass-type switchgrass cultivars will be available in the near future for the Great Plains and Midwest. Knowing the origin of a switchgrass cultivar is important since switchgrass is photoperiod sensitive. Planting a switchgrass cultivar too far north of the cultivar origin area (>300 miles) can result in winter stand loss. Planting a switchgrass cultivar south of its origin area results in less biomass because the shorter photoperiod causes plants to flower too early.

Production Challenges

There are major challenges to using switchgrass for cellulosic ethanol (Mitchell et al., 2008). An ethanol plant requires a reliable and consistent feedstock supply. A 50-million-gallon per year plant will require 625,000 U.S. tons of feedstock per year assuming 80 gallons of ethanol can be produced from one ton of feedstock. Although cellulosic ethanol plants likely will use multiple feedstocks, this example assumes switchgrass will be the only feedstock. Operating every day of the year, the plant will require 1,712 dry matter tons of feedstock per day, or 342 acres of switchgrass yielding 5 DM tons per acre. If a loaded semi can deliver 30 round bales each containing 0.6 dry matter tons (18 U.S. tons), the ethanol plant will use 95 semi loads of feedstock per day, requiring a semi to be unloaded every 15 minutes 24 hours per day, 7 days per week.

There must be an available land base in the local agricultural landscape to produce feedstock. The biomass and ethanol yield of the feedstock will determine the land area required for feedstock production. Assuming 25 miles is the maximum economically feasible distance feedstock can be transported, all of the feedstock must be grown within a 25-mile radius of the bio-refinery, an area containing about 1.26 million acres. Assuming a 50-million-gallon per year cellulosic ethanol plant requires 625,000 tons of feedstock per year, if feedstock yield is 1.75 dry matter tons/acre, 28% of the land would need to grow the feedstock, and this is not feasible in most agricultural areas. At 5 dry matter tons/acre, a commonly-achieved yield with available forage cultivars, only 10% of the land would be needed for feedstock production and is feasible in most agricultural areas. However, at 10 dry matter tons/acre, only 5% of the land base would be needed for feedstock production and would minimally alter the agricultural landscape. Dry matter yield will exceed 10 tons/acre in many areas of the South and Southeast, so less than 5% of the land base would be needed for feedstock production. This example reinforces the importance of high dry matter yield to the agricultural feasibility of cellulosic ethanol, not to mention the inability of the producer to profit by growing low-yielding energy crops. A majority of the switchgrass likely will be grown on marginal lands that have suboptimal characteristics (i.e., slope, soil depth, etc.) for producing food and feed, or on lands currently enrolled in conservation programs.

Table 3. Reported dry matter (DM) yield, acres required to grow 625,000 tons of dry matter per year, and the percent of the land base required to provide feedstock for a 50-million-gallon cellulosic ethanol plant for different herbaceous perennial feedstocks in the Great Plains and Midwest.

Feedstock	Yield, DM tons/acre	Acres needed to grow 625,000 DM tons/year	Percent of land in 25-mile radius
LIHD prairie[1]	1.75	357,000	28
Managed native prairie[2]	2.5	250,000	20
Shawnee switchgrass[3]	5	125,000	10
Bioenergy switchgrass[4]	7.4	84,460	6.6
Hybrid switchgrass[5]	9.4	66,489	5.3

1Low-input, high-diversity human-made prairies (Tilman et al., 2006).
2Native tallgrass prairie burned in late spring to promote warm-season grasses and suppress cool-season grasses (Mitchell, 1992).
3Shawnee is an upland forage-type switchgrass cultivar released in 1995.
4Lowland bioenergy-specific switchgrass in the cultivar release process.
5F1 hybrid of Summer and Kanlow switchgrass that will likely reach field-scale production in less than 10 years (Vogel and Mitchell, 2008).

Growing switchgrass must be profitable for the producer, it must fit into existing farming operations, it must be easy to store and deliver to the ethanol plant, and extension efforts must be provided to inform producers on the agronomics and best management practices for specific regions, all of which have been addressed for switchgrass. Switchgrass fits well into the production systems of most farmers. Harvesting switchgrass after frost is a time when most farmers have completed corn and soybean harvests and handling switchgrass as a hay crop is not foreign to most producers. The economic opportunities of switchgrass for small, difficult-to-farm, or poorly-productive fields will be attractive to many producers.

There are potential difficulties with large-scale switchgrass monocultures, but most are speculation at this point. Concerns arise for potential disease and insect pests, and the escape of switchgrass as an invasive species with the production of millions of switchgrass acres, especially since little research has been conducted on these topics. Most pathogen issues cannot be fully realized until large areas are planted to switchgrass. However, the broad genetic diversity available to switchgrass breeders, the initial pathogen screening conducted during cultivar development, and the fact that switchgrass has been a native component of central U.S. grasslands for centuries will likely limit the negative pest issues. Switchgrass has been used widely throughout the Great Plains and Midwest for pasture and conservation purposes for decades, and no invasive problems have developed or been identified.

Production Cost

Results of a recent economic study based on the five-year average of 10 farms in Nebraska, South Dakota, and North Dakota indicated producers can grow switchgrass at a farm gate cost of $60/ton (Perrin et al., 2008). However, producers with experience growing switchgrass had five-year average costs of $43/ton, and one producer grew switchgrass for $38/ton. These costs include all expenses plus land costs and labor at $10/hour. Each big round bale (Photo 4) represents 50 gallons of ethanol assuming 80 gallons per ton of switchgrass, with a farm gate cost of $0.75/gallon at $60/ton. This research from nearly 50 production environments indicates that growing switchgrass for cellulosic ethanol is economically feasible in the central and northern Great Plains. It should be noted that fuel and land prices have increased since this study, so the cost increases for those inputs need to be considered when determining switchgrass production costs.

Environmental and Sustainability Issues

Sustainable biomass energy crops must be productive, protective of soil and water resources, and profitable for the producer. Numerous studies have reported that switchgrass will protect soil, water, and air quality; provide fully sustainable production systems; sequester C; create wildlife habitat; increase landscape and biological diversity; return marginal farmland to production; and increase farm revenues (McLaughlin and Walsh, 1998; McLaughlin et al., 2002). Switchgrass root density in the surface 6 inches is two-fold greater than alfalfa, more than three-fold greater than corn, and more than an order of magnitude greater than soybean (Johnson et al., 2007). In a five-year field study conducted on 10 farms in Nebraska, South Dakota, and North Dakota, Liebig et al. (2008) reported that switchgrass stored large quantities of C, with four farms in Nebraska storing an average of 2,590 pounds of soil organic C (SOC) acre-1 year-1 when measured to a depth of 4 feet. However, they noted that SOC increases varied across sites, and the variation in SOC change reiterated the importance of long-term environmental monitoring sites in major agro-ecoregions.

Energy produced from renewable carbon sources is held to a different standard than energy produced from fossil fuels, in that renewable fuels must have highly positive energy values and low greenhouse gas emissions. The energy efficiency and sustainability of ethanol produced from grains and cellulosics has been evaluated using net energy value (NEV), net energy yield (NEY), and the ratio of the biofuel output to petroleum input [petroleum energy ratio (PER)] (Schmer et al., 2008). An energy model using estimated agricultural inputs and simulated yields predicted switchgrass could produce greater than 700% more output than input energy (Farrell et al., 2006). These modeled results were validated with actual inputs from multi-farm, field-scale research to predict energy output. Switchgrass fields on 10 farms in Nebraska, South Dakota, and North Dakota produced 540% more renewable energy (NEV) than nonrenewable energy consumed over a five-year period (Schmer et al., 2008). The estimated on-farm NEY was 93% greater than human-made prairies and 652% greater than low-input switchgrass grown in small plots in Minnesota (Tilman et al., 2006). The 10 farms and five production years had a PER of 13.1 and produced 93% more ethanol per acre than human-made prairies and 471% more ethanol per acre than low-input switchgrass in Minnesota (Schmer et al., 2008). Average greenhouse gas (GHG) emissions from switchgrass-based ethanol were 94% lower than estimated GHG emissions for gasoline (Schmer et al., 2008). Switchgrass for bioenergy is an energetically positive and environmentally sustainable production system for the Great Plains.

Implementing switchgrass-based bioenergy production systems will require converting marginal land from annual row crops to switchgrass and could exceed 10% in some regions depending on the yield potential of the switchgrass strains (Table 3). In a five-year study in Nebraska, the potential ethanol yield of switchgrass averaged 372 gallons acre-1 and was equal to or greater than that for no-till corn (grain + stover) on a dry-land site with marginal soils (Varvel et al., 2008). Removing 50% of the corn stover each year reduced subsequent corn grain yield, stover yield, and total biomass. Growing switchgrass on marginal sites likely will enhance ecosystem services more rapidly and significantly than on more productive sites.

Feasibility

Perennial herbaceous energy crops provide several challenges. A stable and consistent feedstock supply must be available year-round to the ethanol or power plant. For the producer, perennial herbaceous energy crops must be profitable, they must fit into existing farming operations, they must be easy to store and deliver to the plant, and extension efforts must be provided to inform producers on the agronomics and best management practices for growing perennial herbaceous energy crops. However, perennial herbaceous energy crops have potential for improvement, and they present a unique opportunity for cultural change on the agricultural landscape. There are numerous environmental benefits to perennial herbaceous cropping systems that can improve agricultural land use practices such as stabilizing soils and reducing soil erosion, improved water quality, increased and improved wildlife habitat, and storing C to mitigate greenhouse gas emissions. There is large potential for achieving all of these benefits, provided agronomic, genomic, and operational aspects of perennial herbaceous cropping systems are fully developed and accepted by farmers. Herbaceous perennial energy crops may be used in conjunction with agriculture residues (corn stover and wheat straw), which likely would be harvested in autumn, and perennial grasses could be harvested in very early spring while they are dry, similar to when prairies are typically burned. This may help reduce the need for feedstock storage by providing feedstock at different times during the year.

Growing seed to meet potential demand for bioenergy will not be an issue. Switchgrass has many desirable seed characteristics and can produce viable seed during the seeding year, especially under irrigation. Established seed production fields can produce 500 to 1,000 pounds of seed per acre with irrigation, and the seed is easily threshed, cleaned, and planted with commercial planting equipment. Seed production systems are well established (Cornelius, 1950), and a commercial industry for switchgrass seed has existed for over 50 years.

Summary

Contrary to popular belief, switchgrass is not a new or novel crop but has more than 70 years of research and farming experience. Currently available plant materials and production practices can reliably produce five tons per acre in the central Great Plains and Midwest and 10 tons per acre in much of the Southeast. New cultivars and management practices will significantly increase yields similar to the yield increases achieved in corn in the last 30 years. The availability of adequate acres of agricultural land and the profit potential provided to farmers for growing switchgrass in a region will determine the success of growing switchgrass for biomass energy. Production practices and plant materials are available to achieve sustainable and profitable biomass production, for both farmers and bio-refineries, to help meet the energy requirements of the nation and reduce our dependence on foreign oil.

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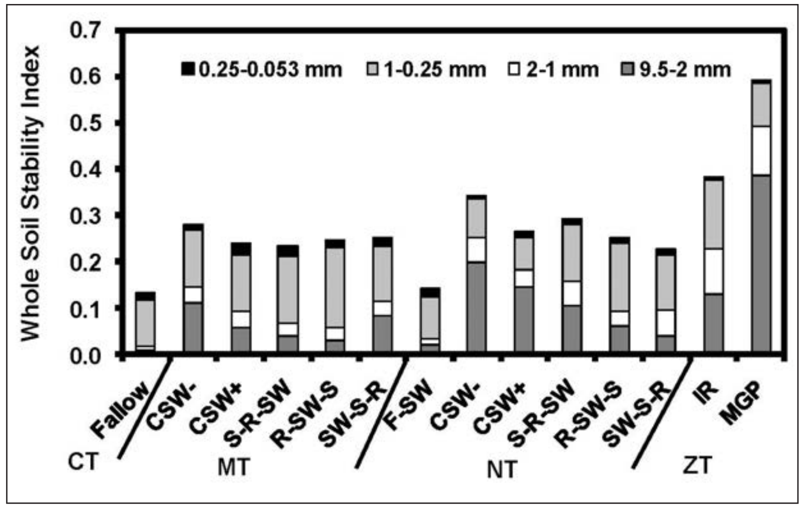
Soil Biology Improves Soil Aggregation and Soil Quality

Dr. Kris Nichols

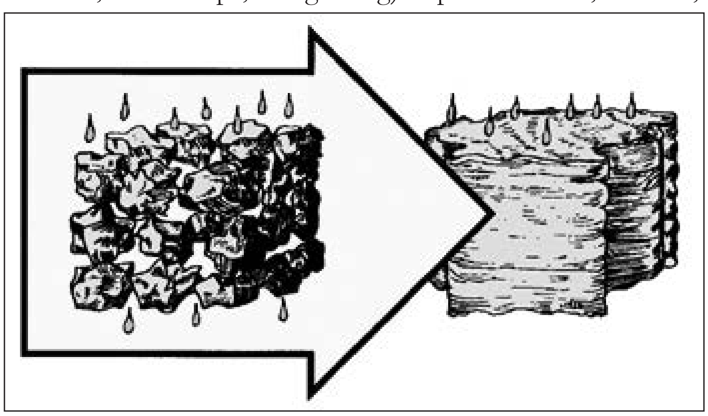


Although soil directly or indirectly supports all life on Earth, it is a 'big black box' of poorly understood biological, chemical and physical interactions.

Soil quality and soil health are defined by how well a soil functions. These functions include resistance to erosion, water infiltration, water retention, gas exchange, biological activity, and nutrient cycling which impact plant growth and health. Soil aggregates, or small pellets of soil ranging in size from 0.002 to 0.4 inches, provide pore space, or empty space between aggregates, for water and air movement, root penetration, and earthworm and insect movement. As pore space decreases, the soil becomes more dense or compacted.

Ideally, soil should be about 50% pore space; 50% sand, silt, and clay minerals; and 5% organic matter. Aggregates themselves provide a habitat for soil organisms and help soil resist erosion by combining fine soil particles into larger pellets which take more energy, i.e. stronger wind or rain, to move.

Research at the Northern Great Plains Research Laboratory is exploring how aboveground management (tillage intensity, crop rotation, cover crops, and grazing) impacts the size, amount, and stability of the soil aggregates.



Research at the lab has led to a recently published index, called a "Whole Soil Stability Index" (WSSI). The index is used to quantify aggregate formation and aggregate stabilization separately to identify management practices which may result in aggregate formation, but not in the stabilization of these aggregates.

The WSSI was developed to rank aggregates based on size. There will be more pore space between large (0.01 to 0.4 inches) aggregates (macroaggregates) than small (<0.01 inches) aggregates (microaggregates).

Research was conducted on soils collected from the Area 4 SCD Cooperative Research Farm by Dr. Kris Nichols and Dr. Marcia Toro, a visiting scientist from Venezuela. Soils which were not disturbed by tillage and had continuous plant cover such as a moderately-grazed pasture or an ungrazed grassland had a higher WSSI than cropland sites. The WSSI values were statistically lower for a no-till spring wheat-fallow site and a conventionally tilled continuous fallow site. Even without soil disturbance from tillage, the lack of a growing plant in the fallow systems impacted soil aggregation, particularly aggregate stability.

Further research is currently examining stable and unstable aggregates to identify what, if any, biological molecules are involved in aggregate formation and aggregate stabilization and how this may differ depending on the size of the aggregate.

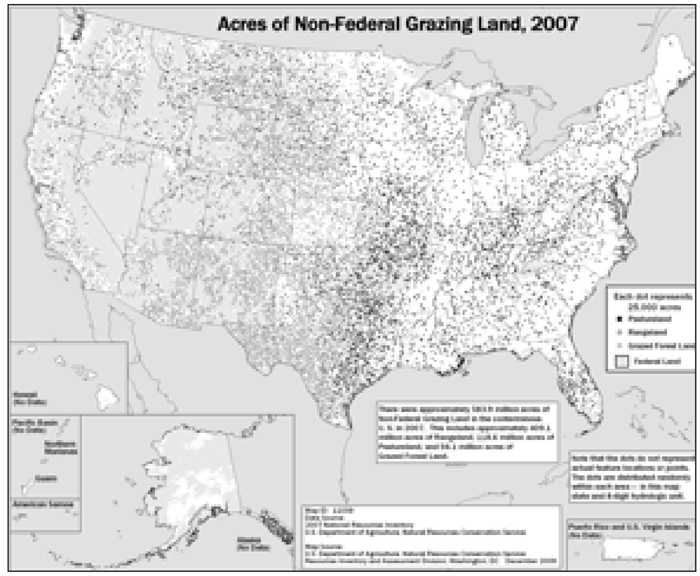
In most cases, microaggregates are held together by chemical and physical processes, while macroaggregates are stabilized by molecules formed by soil organisms. Approximately 70% of the carbon dioxide fixed by a plant through photosynthesis remains in or near the roots. This feeds soil organisms and becomes part of the bodies of the organisms and the molecules they produce. Therefore, the limiting nutrient in soil aggregation and soil health is carbon.

The value of free services provided by soil organisms including nitrogen fixation and improving the availability of phosphorus, sulfur, and micronutrients is estimated on a global scale at over $1.5 trillion per year. The value of soil itself which in part stems from soil aggregation is estimated at well over $20 trillion. Soil is a foundation for building, water purification system, and source of nutrients and raw materials, such as clays and sands, and the cost savings in air and water pollution from erosive forces. To obtain maximum economic benefits, soil biological activity can be stimulated to improve soil aggregate formation and stabilization.

Grazing Land Resources, Conservation Practices, and Ecosystem Services: The Conservation Effects Assessment Project (CEAP)

Dr. Matt A. Sanderson

The Conservation Effects Assessment Project (CEAP) is a multiagency effort focused on science and the environmental outcomes of conservation practices on private lands. The purpose of CEAP is to help policy makers and program managers implement existing and design new conservation programs to more effectively and efficiently meet the goals of land managers.



The principal components of CEAP include (1) a national assessment of conservation practices, (2) studies of conservation practices up to the watershed level, and (3) detailed bibliographies and syntheses of scientific literature regarding environmental outcomes of specific conservation practices. Assessments were conducted within three main agro-ecological resource areas: croplands, wetlands, and grazing lands including effects on wildlife in each. These assessments contribute to determining the effectiveness of current programs and the process of building the science base for conservation, which includes research, monitoring and data collection, and modeling.

The CEAP grazing lands assessment, begun in 2006, was partitioned into rangelands, located primarily in the west, and pasture/hayland, located primarily in the east. First, a bibliography of relevant scientific literature was compiled. That was followed by commissioning a synthesis of the scientific literature regarding conservation practices with funding by the USDA-Natural Resources Conservation Service (USDA-NRCS) through the USDA-ARS and the American Forage and Grassland Council. A similar synthesis document was completed for rangelands in collaboration with the Society for Range Management. These literature syntheses will be available in book form in mid to late 2011.

The grazing land CEAP literature synthesis books are the result of a three-year effort by pasture, rangeland, forage, soil, animal, and watershed scientists from across the U.S. who thoroughly searched, compiled, interpreted, and synthesized the scientific literature regarding environmental outcomes from conservation practices on grazing lands. A major purpose of CEAP is to expose scientists to needs of practitioners and to expectations of policy makers who must account for intended environmental outcomes from each conservation practice. The overarching goal of these books is to communicate the depth and comprehensiveness of the science that supports each conservation practice on grazing lands in the USA. The conclusions and recommendations developed by the science teams also will serve to guide new research to enhance the science of conservation practices on grazing lands.

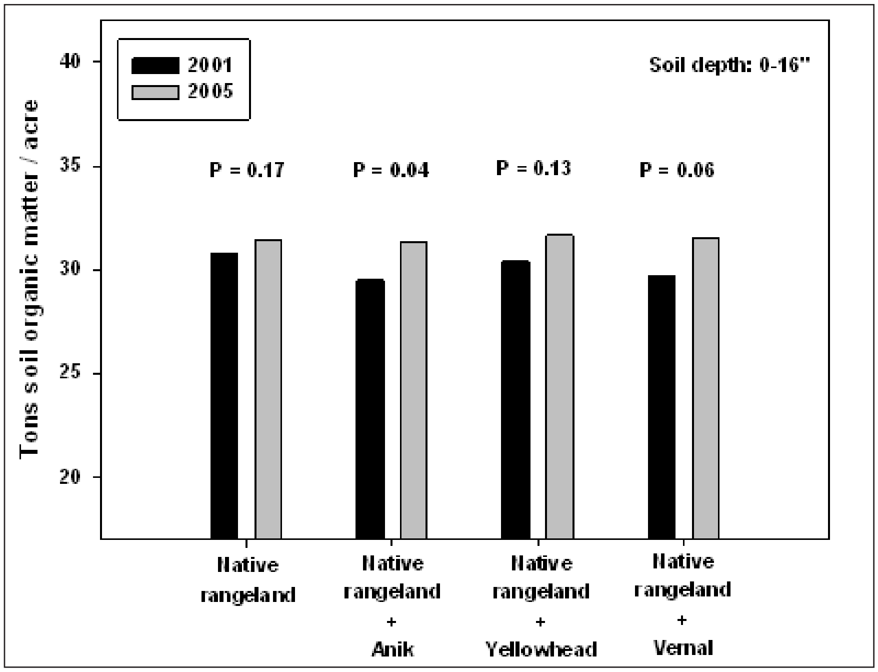
Another major goal of CEAP is to develop the science base for managing agricultural landscapes for environmental quality. For example, some grazing lands CEAP research is focused on developing better models for predicting water runoff, erosion, and nutrient transport from grazing lands. USDA-ARS scientists in Nevada and Idaho are developing a rangeland hydrology and erosion model (RHEM), which has been tested in the far western states but has not been applied to grazing lands in the Northern Great Plains or on pasturelands farther east. Grazing land CEAP-related research conducted at other ARS locations in the U.S. includes comparing the effects of different grazing systems on vegetation and soil health and the value of plant diversity in sustaining productive pastureland.

Scientists at the NGPRL will be participating in the grazing land CEAP effort via collaborative research projects within ARS and with universities and other public agencies. For example, I am currently a technical advisor to the NRCS on their pilot project for the pastureland National Resource Inventory (NRI). Both the pastureland and rangeland NRI efforts will provide nationwide data on the status of the nation's grazing lands, which can be used in monitoring and other scientific projects. The grazing land CEAP effort will be an exciting new component of research at the NGPRL.

Incorporating Alfalfa in Grassland Increases Soil Organic Matter

Dr. Mark Liebig

Incorporating alfalfa into grassland has been found to improve the quantity and quality of forage for livestock production. Belowground, alfalfa has been found to increase soil nitrogen as well as improve soil aggregate stability in extended cropping systems or permanent pasture. Information regarding soil property changes under alfalfa incorporated into semiarid rangeland, however, is scarce. In 2001, John Hendrickson (NGPRL Rangeland Scientist) initiated a study to investigate defoliation timing effects on alfalfa interseeded into rangeland. The study provided an ideal opportunity to concurrently evaluate potential changes in soil properties under the alfalfa and rangeland treatments.



Soil organic matter to a depth of approximately 16 inches was determined over a four year period for three interseeded alfalfa cultivars [one hay-type alfalfa (Vernal) and two grazing-type alfalfas (Anik and Yellowhead)], as well as rangeland not seeded to alfalfa. The study site was located at the NGPRL southern research station on a Temvik silt loam soil.

Soil organic matter at the beginning of the study did not differ among treatments. Four years later, soil under interseeded Vernal and Anik alfalfa possessed greater soil organic matter content than the non-alfalfa control (6.1% and 6.2% soil organic matter, respectively, vs. 5.9% soil organic matter), but only in the surface four inches of soil. Between 2001 and 2005, total soil organic matter stocks increased significantly under native rangeland interseeded with Anik and Vernal, but not under interseeded Yellowhead or the unseeded control.

Increased soil organic matter under the interseeded alfalfa treatments may be explained by increased biomass productivity relative to native rangeland without alfalfa. Hendrickson et al. (2008) found significantly greater total biomass yield from the interseeded alfalfa treatments compared to the native rangeland without alfalfa in two of three years. Though root biomass and rhizodeposits were not measured in this study, an increase in lateral roots in near-surface soil depths from alfalfa would be expected to increase soil organic matter inputs to the soil. Furthermore, fibrous root density from alfalfa is often greatest in the surface four inches of soil.

Previous research by USDA-ARS scientists at Cheyenne, WY found rangeland interseeded with yellow-flowered alfalfa to increase soil carbon relative to rangeland without alfalfa on a ranch in northwestern South Dakota. Results from this study extend the findings from South Dakota in that both grazing-type (Anik) and hay-type (Vernal) alfalfas were found to increase soil organic matter when interseeded in native rangeland.

Soil organic matter is a fundamental building block for creating a healthy soil. This study highlighted a management intervention that concurrently increases forage production while improving the health of grassland soils in the northern Great Plains.

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Helping Growers Balance Economics and Environmental Benefits

Dr. Dave Archer

Growing crops using sustainable farming practices requires care and awareness of the shifting pluses and minuses in both systems and the area between. While environmental benefits accrue from reducing tillage and increasing crop diversity, the economic factors may encourage the continued use of intensive tillage and specialized crop production, especially when weather is uncooperative.

A study published in Agronomy Journal, titled "Crop Productivity and Economics During the Transition to Alternative Cropping Systems," examined crop yields, input costs, and economic returns during the transition to a range of cropping system alternatives in the Northern Corn Belt region. These systems included organic vs. conventional, conventional vs. strip tillage, rotation between corn-soybean vs. corn-soybean-wheat/alfalfa-alfalfa, and fertility regimens such as no fertilizer/manure vs. fertilizer/manure applied at recommended rates. This study was completed for publication in late 2006, and as we all know, prices have increased in an uneven fashion since that time. Understanding how the recent run-up of prices and costs will shift this paradigm will require additional number crunching.

Farmers on the way to organic

Organic crop production depends on crop rotations to maintain productivity. Organic production may be both environmentally sound and economically viable and has his¬torically represented a small portion of the total cropland in Minnesota where the study was done. In recent years, it has more than doubled from 56,275 acres in 1997 to 115,470 acres in 2003, according to USDA's 2006 figures. Organic production systems are at least partially driven by the potential for increasing farm profitability due to the price premiums offered for certified organic crops. A drawback to organic systems is their reliance on tillage for weed control. Farmers in the Northern Corn Belt have been slow to adopt less intensive tillage systems during the last decade, but recently the use of no-till or reduced till has increased as energy costs have risen. One result is reduced erosion and loss of soil organic matter.

As producers learn how to manage new systems during the transition period, biological changes and management adjustments may increase input costs or depress yields, inhibiting adoption of these systems in the short term. A few studies have examined short-term effects on crop yields and input costs during the transition period to organic systems. This study examined the transition effects over a wider range of alternative production systems.

Crop diversity has declined in the Northern Corn Belt region. Corn and soybean production in Minnesota increased steadily since the early 1900s, reaching 73% of the harvested area in 2005, with resulting reductions in hay and small grains. This study was designed to investigate the agronomic, environmental, and economic performance of a wide range of cropping systems. The original hypothesis was that systems that reduce tillage, increase crop diversity, and reduce use of purchased inputs can improve overall sustainability by increasing economic returns, reducing greenhouse gas emissions, and enhancing soil quality, while maintaining adequate weed control, soil fertility, and crop productivity. The objective of the study was to determine the effects of adopting alternative production systems on input costs, crop yields, and economic returns during the transition period, a short-term focus.

Study conditions

A long-term cropping systems field study was established in 2002 at the Swan Lake Research Farm located near Morris, MN. Annual precipitation in this region averages 25.8 inches, and average monthly temperatures range from below 8.4°F in January to 71.6°F in July. Average growing degree days at the site during the corn growing season is 2,199. Five soil series were identified within the experimental site; these are soil types that are normal for Minnesota farmland.

Seeding rates were comparable between systems. 'Wrangler' alfalfa was grown all years, 'Alsen' wheat was grown in 2002-2004, and 'Oklee' wheat was grown in 2005. Corn and soybean varieties changed from year to year as newer varieties became available. Soybean relative maturi¬ty groups ranged from 0.7 to 1.3 in the conventional system and 0.9 to 1.1 in the organic system. Corn relative maturity ratings ranged from 93 to 94 days in the conventional system and 94 to 95 in the organic system. In the conventional system, glyphosate-resistant soybean varieties were used each year; a Bt (Bacillus thuringiensis) corn variety was grown in 2002, and corn varieties with both glyphosate-resistance and Bt traits were planted in 2003-2005.

In the organic system, non-genetically modified, non-treated seeds were used for all crops, with clear-hilum soybean varieties planted each year. Certified organic seed was used for the organic treatments in 2004-2005. Both system treatments were planted at the same time, with the exception of alfalfa, which was planted simultaneously with the wheat in the conventional treatments or with a broadcast spreader just before the second harrow operation after wheat emergence in the organic treatments. A rye cover crop was seeded into corn in the organic treatments using a broadcast spreader before the second inter-row cultivation operation to meet nominally the minimum rotation requirements for organic certification. Fertilizer or manure was applied according to best practices.

Yield samples for corn, soybean, and wheat grain were measured from a central strip within each plot, using identical size plots and methods. The organic and conventional prices used in the analysis are shown in Table 1. To isolate production-related effects from market effects, average prices for the period 1995 to 2003 were used in calculating crop revenues. Market year average prices for Minnesota were used for conventional crops, and organic prices for the upper Midwest were used for organic crops. The effect of government loan deficiency payments was included in the values shown in Table 1, using 2005 commodity loan rates for Stevens County, MN. Loan deficiency payments for 1995 to 2003 were calculated as the difference between the loan rate and the market year average price for each year. If the loan rate was less than the market year average price, the loan deficiency payment was zero. The average loan deficiency payment for the period 1995 to 2003 was added to both the conventional and organic average crop prices. Despite demand for organic dairy products, a market for organic alfalfa has not yet been established, and an organic price premium was not available for alfalfa.

A variety of production cost factors were noted (Table 2). Some included machinery ownership costs, changes in fuel costs, herbicide costs, and in some cases, increased crop drying costs, even though planting dates were the same for strip tillage and conventional tillage treatments. There were a variety of offsets, such as primary tillage costs, offset by increased use of secondary tillage and mowing for weed control. Seed, fertilizer, and chemical costs were somewhat lower for the organic treatments than for their conventional counterparts; however, this cost reduction was offset by the cost of manure handling and loading and added diesel fuel and labor costs for field operations, resulting in higher overall operating costs for the organic treatments.

Table 1. Conventional and organic crop prices including government loan deficiency payments.S

Crop	Conventional price	Organic price
	$/ton	
Corn	95.05	177.52
Soybean	232.12	575.65
Spring wheat	143.81	245.89
Alfalfa hay	93.18	93.18

Source: Conventional prices from USDA-NASS (2006) and organic prices from Streff and Dobbs (2004) adjusted for county loan rates from USDA-FSA (2004, 2005).

Yields

Corn yields during the four-year transition period were affected by system, fertility, tillage, and five interactions: system by fertility, fertility by rotation, system by tillage, tillage by rotation, and system by tillage by rotation. Average corn yield over the four-year transition period was slightly higher for the treatment of conventional system, conventional tillage, corn-soy rotation, and fertilizer added at recommended rates than for other treatments but not significantly higher than yields obtained under four other conventional system treatments. This system represents the most common cropping system in the region. Average corn yield for this treatment was significantly greater than yields obtained under any of the organic treatments, with the best organic treatments showing a 34% reduction in average corn yield in comparison.

This yield reduction was greater than that reported by researchers for a comparable study in southwestern Min¬nesota and contrary to the findings of another study that showed no yield reduction for organic vs. conventional corn production during the transition years in Iowa. The low nutrient content and/or availability of the applied manure may have contributed to the yield reduction in the organic treatments relative to those in the conventional treatments of this study and the organic treatments of the other Minnesota study.

Soybean yields were affected by system, fertility, tillage, system by rotation interaction, and system by tillage interaction but were not significantly different among the following treatments: conventional; organic, conventionally tilled, corn-soy rotation with added manure; or the organic, conventionally tilled, corn-soy-wheat/alfalfa-alfalfa rotation with added manure.

Bean leaf beetles were observed in 2002, approaching threshold levels for insecticide applications, but no insecticide was used. Soybean aphid (Aphis glycines Matsumura) populations exceeded threshold levels in 2003 and 2005 and were sprayed in the conventional treatments only. This may have lead to relative reductions in soybean yield of organic treatments in those years.

Wheat yields were affected by system, fertility, and tillage. Average wheat yield for the treatment of conventional system, conventional till, corn-soy-wheat/alfalfa-alfalfa rotation with recommended levels of fertilizer was higher than the wheat yields obtained under any other system except the conventional strip tillage system using recommended levels of fertilizer.

Alfalfa yields were affected by system, fertility, and system by fertility interaction. In the conventional system, average alfalfa yield for the system with added fertilizer treatments was somewhat higher than for the no-fertilizer treatments.

Significant yield trend by treatment interactions were observed for each of the crops during the four-year transition period. For corn, the trend was affected by systems with a significant downward trend in organic corn yields. Soybean yield trend was affected by a system by rotation interaction, with a significant upward trend in conventional treatment soybean yields grown in a corn-soybean-wheat/alfalfa-alfalfa rotation. The conventional treatments provided significantly higher yields than organic treatments in soybean, so even though average soybean yields for conventional treatments were not significantly different from the top two organic treatments, they were diverging over the transition period. Wheat yield trend was affected by a system by tillage interaction. None of the systems rated by tillage trends were significantly different from zero; however, the organic strip-tilled yield trend was significantly lower than the trends for the other system by tillage interactions. Similarly, for alfalfa, trends were affected by fertility, with the alfalfa yield trend for no fertilizer treatments significantly lower than the trend for added fertilizer treatments.

Table 2. Average production costs for treatments averaged over years 2002 to 2005.

	Conventional								Organic							
	Conventional tillage				Strip tillage				Conventional tillage				Strip tillage			
	C-S		C-S-W/A-A		C-S		C-S-W/A-A		C-S		C-S-W/A-A		C-S		C-S-W/A-A	
Operating costs	YF	NF	YF	NF	YF	NF	YF	NF	YF	NF	YF	NF	YF	NF	YF	NF
	$/acre															
Drying	109	82	69	54	119	91	67	54	84	64	57	49	89	67	49	47
Diesel	62	62	64	64	49	49	52	52	86	84	79	77	89	84	79	77
Labor	35	32	54	54	32	30	52	49	69	67	72	72	74	72	84	82
Seed, fert., chem.	469	309	338	237	479	333	358	262	296	296	203	203	296	296	198	207
Manure haul & load	—	—	—	—	—	—	—	—	143	—	101	—	143	—	101	—
Other operating‡	94	89	96	91	84	77	84	79	119	109	106	101	119	109	109	104
Total operating cost	768	573	622	499	763	578	613	499	795	620	618	501	810	630	620	519
Machinery ownership	452	447	499	492	400	393	445	437	479	469	516	509	425	417	571	563
Total cost	1,223	1,020	1,121	993	1,163	971	1,057	936	1,275	1,089	1,134	1,010	1,235	1,045	1,195	1,082

[1]C-S, corn-soybean rotation; C-S-W/A-A, corn-soybean-wheat/alfalfa-alfalfa rotation; YF, fertilizer or manure applied at recommended rates; NF, no added fertilizer or manure.

[2]Includes machinery repairs and maintenance, insurance, and interest on operating capital.

Total weed seed production in 2002 was relatively low, with no difference between conventional and organic treatments. However, as years progressed, total weed seed production increased considerably in the organic plots. No obvious effects occurred due to fertility management. The higher weed pressures that emerged in organic treatments compared with the conventional treatments likely contributed to the observed reductions in corn and wheat yields and also to the significant diverging yield trends that occurred for organic vs. conventional corn and soybean yields.

Net present values

Net present value analysis was chosen for this project because it incorporates both the timing and magnitude of net returns. This may be important in transitioning to new systems where returns may be changing over time, and particularly for organic systems where net returns may dramatically increase after certification. While this approach is suitable for analyzing the short-term performance of these systems, it is important to recognize that the ultimate economic viability of these systems also depends on long-term performance and that uncertainty about future returns can also act as an economic barrier to adoption. Net present values for the complete rotations without organic price premiums were affected by system, tillage, rotation, and tillage by system interaction. Without organic price premiums, the best conventional treatment, conventionally tilled in a corn-soy rotation with fertilizer applied, had a net present value more than $280/acre higher than any of the organic treatments. Although net present values ranged from $136/acre to $319/acre among the conventional treatments, no significant differences due to tillage, rotation, or fertility were detected.

Organic premiums change the picture

When organic price premiums were included for the organic treatments in 2004 and 2005, the net present values for 2002 to 2005 were affected by tillage, fertility, rotation, and tillage by system, and rotation by system interactions. The best organic treatment (organic, corn-soy rotation, conventional tillage, and manure addition) produced net present values that were comparable to or exceeding those from any of the conventional treatments.

Particularly with organic systems, where substantial price premiums may be received beginning in the third year of transition from conventional systems, the entry point into the system can have a significant effect on net present values. For this analysis, entry point refers to the crop grown in the first year of the study, which was the first transition year. Looking at the fertilizer-added treatments only, net present values for each rotation entry point were affected by system, tillage, rotation, entry point, and interactions of tillage by system, rotation by system, entry point by tillage, entry point by rotation, entry point by tillage by system, and entry point by rotation by system. The organic, conventionally tilled corn-soy treatment, starting with soybean in 2002, provided the highest net present value over the four-year transition period at $507/acre, which was $217/acre higher than for that treatment with a corn entry point. Note that these results are somewhat sensitive to the length of time over which the comparisons are made, and over a longer time period, these differences should diminish. However, these short-term differences may be critical in determining economic survival during the transition years.

Treatments that included alfalfa in the rotation with the alfalfa entry point generally provided the lowest net pres¬ent value, since no alfalfa was harvested in 2002, providing no income for that year. This entry point was not expected to be one that most producers would consider. However, in the organic treatments, the alfalfa entry point was comparable to both the corn and soybean entry points, likely due to the benefit of alfalfa in providing nitrogen for the succeeding corn crop in organic systems. The extremely poor performance of the alfalfa entry point in the strip tillage organic treatments may be caused by the detrimental effect that volunteer alfalfa had on succeeding crops under limited tillage, thus making this option agronomically and economically unfavorable.

Sensitive points regarding organic conversion

This study showed that, with typical organic price premiums, net present values for several organic cropping system alternatives during transition from a conventional system were competitive with conventional systems. However, without organic price premiums, there were significant reductions in short-term profitability for the organic systems that could act as a barrier to their adoption if organic price premiums were to decline. Although organic systems required less expenditures on purchased inputs, they required more fuel and labor and higher investments in machinery ownership, which resulted in higher total production costs compared with conventional production systems. Organic production costs were sensitive to manure costs and could substantially increase or decrease depending on the cost of obtaining and handling manure. Organic systems had low¬er corn yields and generally lower wheat and alfalfa yields compared with the highest-yielding conventional systems; however, soybean yields for the highest-yielding organic systems were not significantly different from the highest yielding conventional systems. This study also illustrated the importance of timing transition decisions to the appropriate entry point when short-term profitability is critical.

Within conventional systems, no significant differences in net present values were detected for tillage and rotation alternatives, suggesting no economic barriers to adoption of greater crop diversity and less tillage in the short term. Within organic systems, net present values were reduced for the combination of reduced tillage and increased crop diversity compared with other combinations, and this was directly related to reductions in crop yields for this treatment. With the exception of this treatment, production costs were generally lower for systems with reduced tillage and for systems that increased crop diversity. Within conventional systems, no significant difference in corn and soybean yields were detected for tillage and rotation alternatives, and the cost savings associated with these treatments did not lead to significant differences in profitability. Although crop yields were expected to be lower without the use of fertilizer or manure inputs, significant reductions generally were detected only for wheat and alfalfa over the four-year period, and this, combined with cost savings realized from fertilizer and manure inputs, resulted in no significant difference in profitability for the two fertility treatments during the transition from conventional high input production.

An important determining factor for long-term economic viability is long-term productivity. In particular, weeds werincreasing rapidly in organic compared with conventional systems over four years, which almost certainly impacted crop yields. The diverging trends in corn and soybean yields, with conventional systems showing higher yield trends compared with organic systems, raises concern about the long-term viability of the organic systems; however, this can only be determined by additional years of study.

This article was adapted from "Crop Productivity and Economics during the Transition to Alternative Cropping Systems,' by D.W. Archer, A.A. Jaradat, J.M-F Johnson, S.L. Weyers, R. W. Gesch, F. Forcella, and H. K. Kludze. Agron. J. 99:1538-1547.

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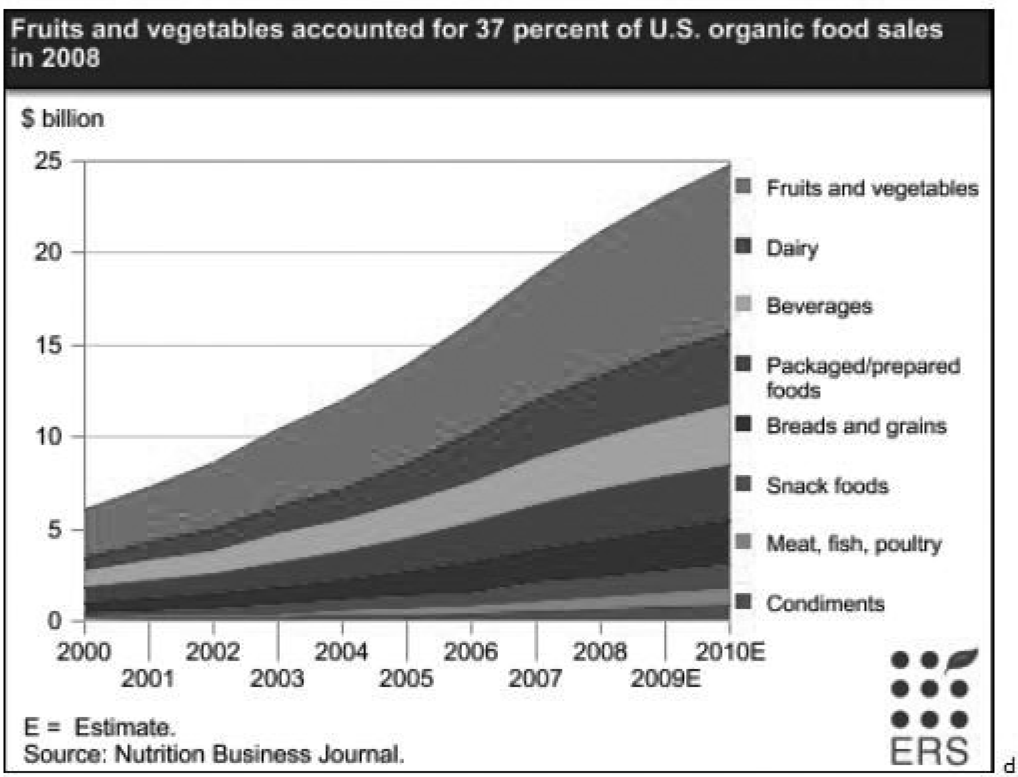

Smaller-Framed Cows May Help Contain Input Costs

Technician Clay Erickson with USDA Cows

Grazing as long as possible in the winter and having a smaller-framed cow herd that eats less are some of the ways that may help keep input costs low and ranches profitable, says Dr. Scott Kronberg, an ARS research range scientist with an animal focus.

"A lot of us think it will cost more to feed cattle in the future," Kronberg said as he explained that oil has a trickledown effect and other prices tend to be tied in with oil. As oil prices rise, other costs such as fertilizer and fuel to run farm equipment, also rises.

When it comes to a choice between driving their cars or paying high prices for beef, consumers are more likely to buy cheaper cuts of beef and continue to drive, Kronberg said. For some, beef may even be a luxury if it is unaffordable.

So for producers to stay profitable in the future, they have to be able to break even and continue to have an efficient operation when cattle prices are low.

"Then they can be really profitable when prices are high," he said.

Kronberg was one of several speakers on the crop tour at the USDA-ARS Northern Great Plains Research Laboratory's annual Friends and Neighbors Day in Mandan.

There are a lot of ways to cut the cost of livestock production and still be productive, Kronberg said.

"We're looking at grazing more and feeding less. If I could graze all year I would," he said.

Kronberg said even in heavy snow, cows will eat the grass sticking up through the snow. They grew altai wildrye, which grows very tall, and allowed the cow herd to graze well into January. If the snow is just too high, they can supplement when needed.

He said he is just building a smaller-framed cow herd to base his research on, and wants cows to be smaller and thicker, in the 1,100 pound range producing calves who are 500 to 600 pounds by the end of October.

"It might seem a little different to raise smaller cows. It is probably not what your neighbors are doing. But these smaller-framed cows may be more efficient and live a long time," Kronberg said. In addition, he wants cows that will produce a "nice calf" for 20 years.

At the ARS ranch, they calve in May instead of March. The reason is so the calves will not become bigger cows who could end up in their last trimester in the winter and need a higher-quality feed for good nutrition.

"A lot of producers really don't know how much their cows weigh because they don't weigh them," he said. Instead, an average of the cattle is usually obtained when cattle are weighed in groups.

He challenged the crowd to guess the weight of three Angus cows who gathered in front of an electric fence with their spring calves.

"There really isn't a cow here who is one I'm looking for yet," he said.

Cow number one was the largest of the three and weighed 1,483.

"She is a pretty common size for cattle in many regions up here," Kronberg said. Last year, the cow weaned a heifer calf that was 472 pounds on April 20. This year, her calf was 76 pounds at birth.

Cow number two was 1,280 pounds and weaned a bull calf that was 520 pounds in October. This year, she gave birth to a 86-pound calf on May 12.

Cow number three weighed 1,005. The calf size was not given.

While Kronberg does not know for sure that smaller framed cows will eat less and still be efficient, his research is focusing on that.

"If you have a cow that has to be culled in year eight because of no calf, that is not efficient to your cattle production because it costs a lot to bring her into the herd," he said.

Range scientists in Miles City, Mont., have devised a new method of determining exactly how much forage grazing calves are consuming. It does not involve inserting a canella into the cow.

"We can't look at production efficiencies until we know what goes into the feeding expenses everyday," he said.

Winter feeding is usually the most expensive feed for producers if cattle are kept in a feedlot or in the yard. In addition, if cows are in their third trimester, feeding a lot of hay is expensive. Smaller cows that calve in late spring or summer would not run into that problem.

"If we can graze well into the winter, the costs go way down," he said.

by Sue Roesler, Farm & Ranch Guide

Switchgrass Shines as an Energy Crop

The prospect of producing bioenergy from marginal land got a big leg up when researchers recently released results of a five-year, on-farm study of switchgrass grown to produce ethanol.

"The research suggests that growing switchgrass for ethanol can be a highly sustainable system," says Marty Schmer, agronomist, Northern Great Plains Research Laboratory, USDA Agricultural Research Service, Mandan, North Dakota.

"Given the levels of soil carbon sequestration we found, coupled with the high net energy balance and low emissions of greenhouse gases, switchgrass is a great energy crop for marginal cropland," he says.

While research models showed that switchgrass, when managed for maximum production, can compete with corn in volume of ethanol produced per acre, it excelled in net energy output.

"For every unit of nonrenewable energy required to grow switchgrass, we got 6.4 units of energy back," says Schmer. "With corn grain, for every unit of nonrenewable energy put into producing the crop, there are 1.2 to 1.8 units of energy that come out."

Differences in the processing of the ethanol account for a large part of this difference in net energy outputs.

Energy efficiency aside, switchgrass shines, too, because of the soil organic carbon the crop sequesters.

"We measured some significant carbon accrual rates in on-farm settings across three states," says Mark Liebig, soil scientist at the Northern Great Plains Research Laboratory.

"This work impacts the carbon accrual rates researchers are using in models designed to calculate carbon offsets of various bioenergy feedstock crops," he says. "Previous models evaluating switchgrass production for biomass energy have used carbon offset rates of fourfold to elevenfold lower than the carbon sequestration rates we found in this study."

Scientists' accurate calculation of carbon offsets is important because this information is used to draft formulas for life-cycle assessments (LCAs) of bio-energy production systems. The results of these assessments will ultimately determine which bioenergy production systems will gain political support.

"Federal law will require renewable biofuels to meet certain greenhouse gas emission reductions from conventional gasoline," says Liebig. "Accrual rates of soil organic carbon observed in this study contribute significantly to the potential of switchgrass to provide a favorable net greenhouse gas balance."

The five-year USDA-ARS study encompassed 10 on-farm fields in Nebraska, South Dakota, and North Dakota. The fields averaged 17 acres in size and were located in areas of marginal land that would have qualified for the CRP.

Because the study was evaluating switchgrass as a bioenergy crop, fields received annual applications of nitrogen to maximize production.

"Applications of nitrogen varied in amount and type across sites based on soil-moisture conditions and expectations of biomass yield," says Liebig. "On average, fields received just under 70 pounds of nitrogen per year."

The switchgrass was harvested by baling. Depending upon site and moisture conditions, yield volume ranged from 2.5 to 5 tons of switchgrass per acre.

"We used pasture cultivars of switchgrass," says Schmer. "As cultivars bred for the purpose of producing a bioenergy crop become available, yields will increase."

Average cost of production, based on farmers' actual costs, averaged $50 per acre. Increases in soil organic carbon over the course of the study were significant.

"Within the top 12 inches of soil, soil organic matter increased across all sites at a rate of 980 pounds per acre per year," says Liebig. "In Nebraska, where four sites were sampled to a depth of 48 inches, soil organic carbon increased at an average rate of 2,590 pounds per acre per year."

But the changes in soil organic matter were variable among sites, ranging from a decrease of 540 pounds per acre per year to an increase of more than 3,800 pounds per acre per year.

The variability in amounts of soil organic carbon switchgrass sequesters in the soil suggests geographical pockets not best suited to switchgrass production.

Switchgrass can't be considered a silver bullet for bioenergy production in all climates and in all soil types," says Liebig. "Even though the geographical domain for switchgrass covers nearly the entire continent of North America, that doesn't mean it's the best biofeedstock option across that entire area. There needs to be regional research looking at other options."

In general, higher levels of soil organic carbon correlated with higher switchgrass biomass in above-ground plant material as well as in roots. Since fields were fertilized with N for maximum yield, this correlation explains, in part, the reason the study showed overall higher levels of soil organic carbon sequestered by switchgrass than have previous studies. Other studies of switchgrass have centered on small-plot research using low-input production methods.

"Increases in soil organic carbon under the switchgrass were likely caused by below-ground carbon input from roots," says Liebig. "Research has documented that switchgrass roots extending more than 9 feet into the soil. Because of their extensive root system, perennial grasses are effective at sequestering soil carbon and, in doing so, move the soil closer to its condition before being broken out for agriculture," he says. "When we look at the portfolio of biofeedstock options, the perennial crops are going to excel at contributing carbon to the soil."

by Raylene Nickel, Successful Farming magazine

Alfalfa fabulous in removing carbon dioxide from atmosphere

In 50 acres of lush alfalfa fields, scientists at the USDA-ARS Northern Great Plains Research Laboratory (NGPRL) south of Mandan, N.D., are studying how much carbon dioxide is being taken out of the atmosphere.

Rebecca Phillips and Interns at Friends & Neighbors Day

There is increased interest in sequestering carbon dioxide to reduce global warming while at the same time maintaining active production agriculture, according to Rebecca Phillips, plant physiologist at NGPRL.

Phillips said scientists are studying ways changes in management such as putting on fertilizer at the right time, using no-till methods, planting the type of plants that take up more carbon dioxide such as alfalfa, adding organic matter, and improving nitrogen management can lessen carbon dioxide emissions in production agriculture.

By the end of July 2010, the Rangelander variety alfalfa was tall and blooming purple flowers. Producers toured the fields to see the ongoing research project that had begun last year.

In 2009, they no-till planted the perennial alfalfa without fertilizer and let it stand.

"We then let it go to seed, and found between July and November, the alfalfa had removed 1,400 pounds of carbon per acre from the atmosphere," Phillips said. "Of course, this year it removed a great deal more."

As a frame of reference, she used a nearby native prairie range of mostly cool season grasses.

"The native prairie is picking up carbon dioxide as well, but not as vigorously as the alfalfa," she said.

In 2010, scientists measured carbon dioxide and water vapor fluxes at the canopy over the entire alfalfa field at regular intervals since it was planted June 1.

"We're using this sophisticated weather system to measure water vapor and carbon dioxide 20 times per second," Phillips said, adding they use the covariance between the vertical wind and temperature, carbon dioxide and water to calculate the exchange of energy and matter continuously every half-hour.

"We end up having a positive net uptake of carbon dioxide by these plants," Phillips said.

In addition to finding out the carbon dioxide measurements at the canopy level, the interns working with her were checking carbon dioxide uptake at the leaf level.

"They are looking at how well alfalfa photosynthesizes at a given level of light and under certain conditions and especially at differences in the canopy," she said.

In measuring the differences in the canopy, interns measured how the leaves respond to different levels of light at the bottom layer of the plant versus the middle layer and top level.

As expected, there was a significant decrease from the top layers of the plant to the bottom in terms of photosynthesis.

Alfalfa grows in several different vegetative stages, budding stages and reproductive stages, and they studied the photosynthesis levels at each stage.

The interns reported they didn't find significant differences in the photosynthesis levels at the various stages.

Last year, scientists conducted similar photosynthesis research on bromegrass in a pasture at the center, Phillips said.

"What we found is alfalfa is photosynthesizing on a per square meter basis close to twice as quickly as bromegrass," she said. "Its photosynthesis mechanism is such that it is taking carbon dioxide and photosynthesizing faster than the bromegrass."

Why is photosynthesis important?

Phillips said photosynthesis is important because carbon dioxide is a greenhouse gas, and plants use carbon dioxide to photosynthesize.

"Without it, they would not have a carbon source. Since plants use or take up carbon dioxide to grow, controls on photosynthesis are important," she said.

Corn is also a fast photosynthesizer, Phillips said. But alfalfa is very close to being as fast of a photosynthesizer as corn, she said.

Phillips said alfalfa is definitely a "carbon dioxide uptake powerhouse."

"Alfalfa is doing a fabulous job of removing carbon dioxide (from the atmosphere)," she said, adding there is a little bit more water use by the alfalfa, but it isn't three times more.

Basically, in the alfalfa field, they are demonstrating the environmental effects in terms of carbon dioxide being removed from the atmosphere, as well as production and production costs.

"We hope to determine the accumulation of carbon on an annual basis, taking into account carbon harvested and carbon transfer to soils," Phillips said. "We are also including other important greenhouse gases."

Some of the carbon dioxide is going into biomass and some of it is going below the ground which helps the soil quality, Phillips said.

Dave Archer, agricultural economist at NGPRL, is putting to-gether the economic benefits of planting a perennial like alfalfa in cropping systems. The economics in 2009 was somewhat expensive because they wanted to make sure they could establish a good stand of alfalfa and it was not cut.

In 2010, they received a return on their initial investment. Phillips said they expect to see continued income from the alfalfa cuttings in the next five years which is the limit of the research project. Input costs were kept low, but the field was sprayed for weeds this spring (but not in 2009) and phosphorus was added, she said.

In addition, they found it was a good hay with good feed value. They calculated the feed value as $56 per ton, with a 3.2 ton per acre yield for its first cutting ($179 per acre total income). Protein level at the first cutting was around 25 percent.

"The reason we used a perennial forb is we thought it removed more carbon dioxide from the air than an annual crop, and we thought it had use as a possible viable cellulosic feedstock as well as being a hay for producers," she said.

In addition, they knew alfalfa grew well in the Northern Plains states.

"This should be a win-win situation with the economic positives of planting alfalfa as well as its positive environmental impacts," Phillips said.

While she was unsure of the viability of alfalfa as a cellulosic feedstock, she said scientists at Iowa State are working on advanced biofuel processing options, including nitrogen capture, for alfalfa.

by Sue Roesler, Farm & Ranch Guide

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David Archer joined the NGPRL as an agricultural economist in January 2007. He has 11 years research experience with ARS, both in Mandan and in Morris, MN, conducting research on the economics of agricultural systems evaluating the economic feasibility of alternative systems, and identifying barriers to adoption of more sustainable practices. Before joining ARS, Dave was an 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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Igathinathane (Igathi) Cannayen is Assistant Professor of Department of Agricultural and Biosystems Engineering, NDSU with appointment responsibilites of 60% research and 40% extension as Biomass Process Engineer. He joined the department in October 2009. Igathi maintains offices at the NGPRL, USDA-ARS, Mandan and at the National Energy Center of Excellence (NECE) on the campus of Bismarck State College. Much of his research work will be done at NGPRL where he will work collaboratively with the USDA-ARS research scientists and he belongs to the NDSU Agroecosystems Research Group. At the NECE, he will work with faculty and students in their energy related programs.

Igathi received his Ph.D. in Agricultural and Food Engineering in 1997 and M.Tech. in Post Harvest Engineering in 1991 from the Indian Institute of Technology, Kharagpur, India, and a B.E. in Agricultural Engineering in 1989 from the Tamil Nadu Agricultural University, Coimbatore, India. Prior to joining here, he was Assistant Professor in Agricultural Engineering with Andhra Pradesh Agricultural University, India. Recently, he was a Postdoctoral Research Associate with Mississippi State University, University of British Columbia, and the University of Tennessee with emphasis on biomass feedstock process engineering. He conducted research on integrated size reduction and separation of biomass, on field moisture relations of biomass, aboveground biomass quantification, thermal processing of biomass, image processing for size and size distribution of particulate biomass and airborne dust, and physical, hygroscopic, and mechanical properties of plant stalks and biomass pellets. Igathi's research and extension focus addresses the engineering related issues of the harvest, collection, storage, transport, and preprocessing of biomass feedstocks.

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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 responsibilities include 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 immense. 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.

John Hendrickson

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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 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.

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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 plant species from the Great Plains. Her current work includes field components in range and cropland systems, studies conducted in the station greenhouses and growth chambers, as well as work in the laboratory. At this time, Holly works with Dr. Mark Liebig, a soil scientist at NGPRL, and is involved in projects researching switchgrass, cover crops, and soil quality. Her long-term goal is to be actively involved in ecological-based research throughout the course of her career at the Agriculture Research Service. She serves on the Northern Plains Area (NPA) Diversity Taskforce and as the NGPRL Greenhouse Committee Chair.

Scott Kronberg

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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 continues 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.

Mark Liebig

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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 Soil Science Society of America Journal and Renewable Agriculture and Food Systems.

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Kris Nichols

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Kris Nichols has been a Soil Microbiologist with the USDA, Agricultural Research Service (ARS) Northern Great Plains Research Laboratory (NGPRL) in Mandan, ND for over seven years. She was raised on a primarily corn-soybean conventional farm in southwestern Minnesota. Kris 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 Enivronmental Microbiology from West Virginia University in 1999, and a Ph.D. in Soil Science from the University of Maryland in 2003. Since 1993, she has studied arbuscular mycorrhizal (AM) fungi – a plant-root symbiont. Her most recent work involves the investigation of glomalin – a substance produced by AM fungi. Glomalin contributes to nutrient cycling by protecting AM hyphae transporting nutrients from the soil to the plant and to soil structure and plant health by helping to form and stabilize soil aggregates. Kris has been examining the impacts of management such as crop rotation, tillage practices, organic production, cover crops, and livestock grazing on soil aggregation, water relationships, and glomalin at NGPRL.

Moffatt Kang'iri Ngugi

Ecologist

Moffatt K. Ngugi joined the NGPRL as an Ecologist in 2010 and departed laer in the year. He is a geospatial ecologist with training in range management, physical land resources and ecology. He undertook graduate studies at University of Ghent and Colorado State University and has research experience overseas in Kenya and Belgium. Recent endeavors include postdoctoral research at University of California Davis using GIS/remote sensing to constrain biogeochemical modeling of greenhouse gases and working as a terrestrial carbon science consultant. Ngugi is interested in a greater understanding of emerging ecological concerns regarding soils, plants and animals across multiple scales over time and space. He is affiliated with the Ecological Society of America, American Association for the Advancement of Science, Soil Science Society of America, American Geophysical Union, Society of Range Management, Earth Systems Scholars Network, International Geospatial Society (Global Spatial Data Infrastructure Association) and International Resources Group (IRG).

Rebecca Phillips

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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.

Matt Sanderson

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Matt Sanderson joined the NGPRL as Laboratory Director and Research Leader in November 2010. Matt received his A.A., B.S. and M.S. from North Dakota State University, and earned his Ph.D. degree in Crop Production and Physiology from Iowa State University in 1987. He worked at the Texas A&M University Agricultural Research and Extension Center at Stephenville, TX for eight years before joining ARS as a Research Agronomist at the Pasture Systems and Watershed Management Research Unit in University Park, PA in 1996. Dr. Sanderson's research has focused on providing science-based information for managing diverse forage and grazing lands to support the traditional functions of forage, food, and fiber production and to address emerging ecosystem services such as carbon sequestration, greenhouse gas mitigation, and bioenergy production. He has served as an adjunct faculty member at Texas Tech University and Penn State University. Sandereson is a Fellow of the American Society of Agronomy and the Crop Science Society of America.

Marty Schmer

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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, production, 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.

Eric Scholljegerdes

Animal Nutritionist

Eric Scholljegerdes worked at the Northern Great Plains Research Laboratory from 2005 to 2010. 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. Concluding five years of research at Mandan, Dr. Scholljegerdes assumed the Range Ruminant Nutritionist position with the Department of Animal and Range Sciences at New Mexico State University this year. Eric's research at Mandan 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 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 also evaluated the efficacy of an integrated crops and livestock system for fall forage production. Dr. Scholljegerdes worked with other scientists at Mandan on a satellite-based grazing monitoring system to allow producers to develop grazing plans using satellite imagery. Scholljegerdes provided 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.

Donald Tanaka

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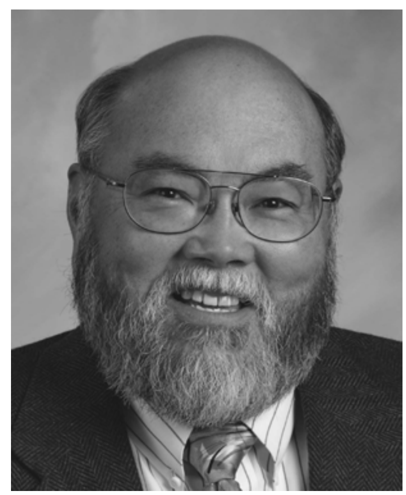

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Donald Tanaka began conducting research with the Agricultural Research Service (ARS) at Sidney, MT in 1980. He has been a member of the research team at NGPRL since 1991. He has advanced degrees in agronomy with a concentration in soils and soil chemistry from the University of Nebraska. He has conducted soil and water conservation research in the northern Great Plains for 30 years. Dr. Tanaka has pioneered no-till crop sequence research to take advantage of soil/crop ecology interactions, and in doing so, contributed to 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 Society, the U.S. Zero-Till Non-Farmer award from the Manitoba-North Dakota Zero-Tillage Farmers Association, and the Conservation Research Award from the International Soil and Water Conservation Society. In addition to many significant peer-reviewed publications, he has given numerous scientific presentations at professional meetings, interviews with the media, as well as popular press articles.

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Staff of the USDA-ARS Northern Great Plains Reserch Laboratory, 2009

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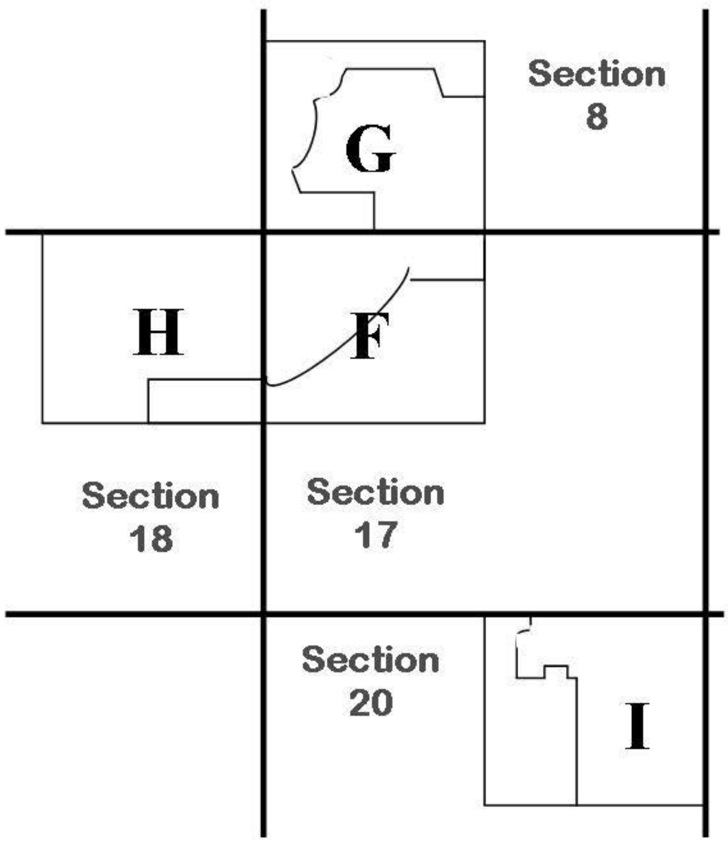

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