

Northern Great Plains Research Laboratory



NORTHERN GREAT PLAINS

INTEGRATOR

For environmentally and economically sound agro ecosystems for the northern Great Plains.

February 2006



An Integrated Approach to Crop/Livestock Systems

During the last quarter of the twentieth century farmers gradually became more specialized. Grain and livestock production systems have gradually been separated. There is mounting evidence that this approach is neither profitable for producers nor good for the environment. Including cattle in a crop production system adds value and facilitates marketing grain and/or crop residue through cattle and deposition of manure and urine directly on the land turns a potential problem into an asset. Integrating annual crop production and livestock grazing produces higher levels of both soil nitrogen and water-stable soil aggregates.

Integrated crop and livestock system research was initiated at the Northern Great Plains Research Laboratory in 1999 to determine potentially beneficial synergies to both enterprises. The system emphasizes crop rotations, conservation tillage, cover crops, integrated pest management, and grazing and forage management.

Forage and grain production for swath grazing

Objectives of this research were to determine the influences of winter grazing beef cows on no-till forage and grain production, water-use efficiency, and protein and phosphorous production for an oat/pea-triticale/sweet clover-corn three-year cropping system.

Cropping system treatments were: 1) straw and corn chopped and left in place [IP], 2) straw and corn baled and removed without livestock [R] and 3) straw and corn swath grazed by livestock [L].

All crops were seeded with a no-till drill. Nitrogen rates less than those used in traditional crop production were applied, in the attempt to take advantage of the legumes in the cropping system.

Water-use efficiency for above-ground total dry matter followed trends similar to total dry matter production. Corn responded to additional residue more favorably than oat/pea or triticale crops. Precipitation in July along with the additional residue for the IP treatment suppressed evaporation of soil water in August and improved TDM per unit of water.

The treatments were not significantly different for oat/pea and triticale after the addition of residue managers to move about 50% of the surface residue away from the seed opener for better seed to soil contact. Neither grain, straw, nor total above-ground dry matter production was significantly different among treatments for oat/pea or triticale crops.

Averaged over all years, corn was about 1.5 times more efficient in using water for dry matter production when compared to oat/pea or triticale. Generally, protein and phosphorous production per acre

were highest for corn and lowest for triticale.

About half of the nitrogen used for protein production was derived from sources other than applied commercial fertilizer.

Wintering beef cows on swathed crops

The most expensive aspect of a beef cow operation is wintering dry pregnant cows. Using annual crops or crop residues for onsite winter swath grazing may allow producers to reduce feeding costs, while animal activity and deposition of wastes directly on the land may be beneficial to soils and subsequent crop production.

Beef cow nutrient requirements are lowest in the middle trimester when the current year calf is weaned and the fetus for next years' calf is still small. This is the time when cows should be able to maintain their weight and body condition on properly supplemented crop residue.

The winter livestock research began in the winter of 1999-2000 with 20 Hereford cows/treatment. Treatments were: 1) rotationally grazed swaths of oat/pea and triticale crop residue and swathed drilled corn (RGSC), 2) swathed western wheatgrass (SWWG), and 3) cows fed in a drylot (control). Swath grazing had no adverse affects on mid-aged beef cow performance. There were no significant differences among calf data from cows on the three winter treatments for any of the three years.

Swath grazing is a viable alternative to drylot feeding and results in lower feed costs. Cows wintered on RGSW for an average of 49¢/cow/day, which was 24¢/cow/day less than cows wintered in a drylot on large bales of hay. Direct costs of wintering cows on SWWG were 9¢ less than drylot feeding. Cost savings for swath grazing can also include reduced labor costs, less wear on machinery required to bale, transport and feed hay and minimal manure handling costs. Corn produced forage at 2.24 cows/acre for 100 days with a production cost of \$121.50/acre.

If snow or ice becomes a problem, mechanical treatment may be necessary to temporarily assist cows in gaining access to the swathed materials. Cattle can graze swaths through as much as 20 inches of snow.

An important aspect of swath grazing is to limit animal access to swaths. An electric fence was used to limit cow access to swaths. We moved the fence on a daily basis to reduce feed waste and provide cows with fresh feed on a regular basis.

Properly supplemented cows swath grazed on a system of oat/pea and triticale crop residue and swathed corn, or grazed on swathed western wheatgrass had weight changes, condition scores and reproductive performances comparable to cows fed baled hay in a drylot.

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Table 1. Feed offered, feed refused, and feed costs for the rotationally grazed crops, swathed crops and baled hay treatments averaged over 3 years.

Feedstuff	Dry Matter offered/day	Estimated waste	Days on a feed	Feed cost/cow	Feed cost/cow/day
	#	%		\$	¢
Swathed corn	84.48	48.3	53.4	30.44	32
Crop residue	97.46	59.6	41.3	3.36	4
Supplement	2.86	0	95.0	12.35	13
RGSC total			95.0	46.15	49
RGSC average	92.62	51.8			
SWWG	43.12	7	85.0	56.62	60
Supplement	.99	0	95.0	4.37	5
SWWG total	44		95.0	60.99	65
Baled hay in drylot	35.64	12.3	95.0	69.35	73

RGSC=rotationally grazed swathed crops; SWWG=swathed western wheatgrass.

Visit to Macaulay Land Use Research Institute

Drs. Jon Hanson and John Hendrickson visited the Macaulay Land Use Research Institute from January 11 to January 18, 2006 to explore the potential for future scientific collaboration. The Macaulay Institute is the premier land use research institute in the United Kingdom and provides research on issues for the Scottish Executive Environment and Rural Affairs Department. At both the Northern Great Plains Research Laboratory and the Macaulay Land Use Research Institute, agricultural sustainability is an important topic. The 300 people who work at the Macaulay Institute contribute research in areas including grazing ecology, watershed management, landscape change, soil-plant-microbial interactions and socio-economic research.

Aberdeen is located on the east coast of Scotland. The city of Aberdeen is primarily known as a center of the North Sea oil production but surrounding countryside has a strong agricultural component. The coastal areas in Scotland are known as the lowlands and much of the more intense arable farming occurs in these areas. Primary crops include barley, root crops such as turnips, and also grass silage. The area around Aberdeen receives about 32 inches of rainfall per year evenly distributed throughout the year. Temperatures are relatively mild throughout the year with highs from 40° in the winter to 65° in the summer. The mild temperatures mean that the growing season is not limited by temperature but rather by the farmers' ability to get into the fields with equipment. West of Aberdeen the elevation increases. This transition zone between the coast and the Highlands is hillier with more mixed crop livestock farms. The hills of the Scottish Highlands are covered in heather. These hills, which can be as high as 3,000 to 4,000 feet, are primarily managed for hunting with some light grazing. Land managers use fire to create a mosaic in the landscape to promote the numbers of game birds.



Great Plains Farmers are Diversifying

The days of growing wheat every other year or two and leaving the ground bare the rest of the time are a thing of the past. Agricultural Research Scientists are giving farmers more than a dozen crops to choose from each year, and the means to make choices from among more than 100 possible combinations.

The ARS scientists have also developed a free CD farmers can insert in their computers to calculate which crops to plant after inputting the latest market prices.

Jon Hanson, Research Leader of the ARS Northern Great Plains Research Laboratory in Mandan, North Dakota, calls this new approach 'dynamic farming.'

Dynamic farming systems provide a diversified portfolio of crops for farmers in the northern Great Plains to choose. Farmers can change crops quickly in response to sudden changes in market conditions, weather or government policy.

Read more about the research in Agricultural Research magazine: http://www.ars.usda.gov/is/AR/archive/jun_05/wheat0605.htm.

From Farm & Ranch Guide, December 9, 2005

While at the Macaulay Institute, Drs. Hanson and Hendrickson interacted with scientists in disciplines ranging from soil microbiology to policy analysis. These scientists are conducting research in the areas of climate change, landscape change, soil conservation, understanding biodiversity, water resources and rural sustainability. These highlighted research areas show the current switch in research focus in the United Kingdom from production to management. A virtual landscape theater in operation at the Macaulay Institute allowed scientists to present the public with different land use options and gain their feedback.

Drs. Hanson and Hendrickson also gave two seminars while at the Macaulay Institute. These seminars allowed the staff at Macaulay to become familiar with both agriculture in the northern Great Plains and the research focus at the Northern Great Plains Research Laboratory. The first seminar focused on challenges in U.S. agriculture. Although Scottish agriculture differs from agriculture in the northern Great Plains, there were similarities in the trends and future challenges. As with U.S. farmers, Scottish farmers were concerned with remaining sustainable in a rapidly changing environment and unsure of the impacts that recent changes in government policy would have on their farms. The second seminar focused on Research in Integrated Agricultural Systems. This seminar focused on past and current research efforts of

both ARS and the Northern Great Plains Research Laboratory. Although Macaulay is a larger research institution than NGPRL, both laboratories are multi-disciplined and concerned with similar problems. Contacts made during this visit will allow scientists at both institutions to more closely interact. Future interactions may include joint projects as well as scientist exchanges.

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Delayed Haying of Grass and Grass-Alfalfa Mixtures

Nesting success of waterfowl, pheasants, and other upland nesting birds would be greatly improved if haying were delayed until mid-July or later. Studies conducted by the U.S. Fish and Wildlife Service near Jamestown, ND documented that hatching occurred in over three-fourths of the duck nests by July 20 in an average year. The purpose of this study was to determine if hay of adequate nutritional quality for beef cattle could be produced from a mid-July harvest.

Four grass cultivars were grown in pure stands and in mixtures with Rangelander alfalfa, a cultivar with moderately indeterminate growth habit, similar to yellow-flowering *Medicago falcata* alfalfa. Grass cultivars included in this study were Manska and Reliant intermediate wheatgrass, Nordan crested wheatgrass, and Lincoln smooth brome-grass. In vitro dry matter digestibility (IVDMD), neutral detergent fiber (NDF), and crude protein (CP) were measured at a single mid-July harvest for 2 years. The study was conducted at a dryland site on a sandy-loam soil, and no fertilizer was applied. At the mid-July cutting, crested wheatgrass seed heads were mature, smooth brome-grass was at the hard-dough stage of seed maturity, intermediate wheatgrass was at soft-dough, and alfalfa was at late-bloom to early-pod stage of development. Crested wheatgrass had lower IVDMD than the alfalfa component of mixtures, but digestibility of the other grasses was approximately equal to alfalfa (data not shown). Averaged over all four grass cultivars, grass-alfalfa mixtures were lower in NDF ($P \leq 0.05$) than grasses grown in pure stands (Table 1). Neutral detergent fiber is associated with bulkiness

of hay and is related to forage intake. Hay from all of the grass-alfalfa mixtures was in excess of the 8.6 to 8.9% CP concentration (Table 1) that is required for pregnant dry cows during the last 2 months before calving, according to National Research Council recommendations. In contrast, none of the grass cultivars grown in pure stands provided adequate CP concentrations for cows just before calving, and CP for lactating cows was clearly inadequate.

Although hay quality was compromised with delayed harvest, grass-alfalfa mixtures included in this study would provide beef cow-calf producers with the option to defer hay harvest until mid-July and meet the nesting requirements of most waterfowl and upland game birds when bird reproduction is of economic or aesthetic importance. The U.S. Fish and Wildlife Service has determined that intermediate wheatgrass provides tall, dense cover that is better for nesting than smooth brome-grass or crested wheatgrass. Intermediate wheatgrass became dominant over alfalfa in our study when hay harvest consisted of a single mid-July cutting. We found that earlier cutting was needed approximately once every 3 years to maintain a favorable balance of intermediate wheatgrass and alfalfa in a mixture

Table 1. Forage quality characteristics of hay harvested in mid-July from pure stands of grass and grass-alfalfa mixtures.

Type of hay	IVDMD	NDF	CP
	-----%-----		
Grass, pure stands	61.4	65.4a	7.4c
Grass-alfalfa mixtures	61.7	60.9b	10.9b
Grass component	60.6	65.8a	8.5c
Alfalfa component	62.1	56.0c	14.8a

a-c Means within a column followed by a different letter are significantly different at $P=0.05$.

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Crop Residue Remaining at Seeding Time

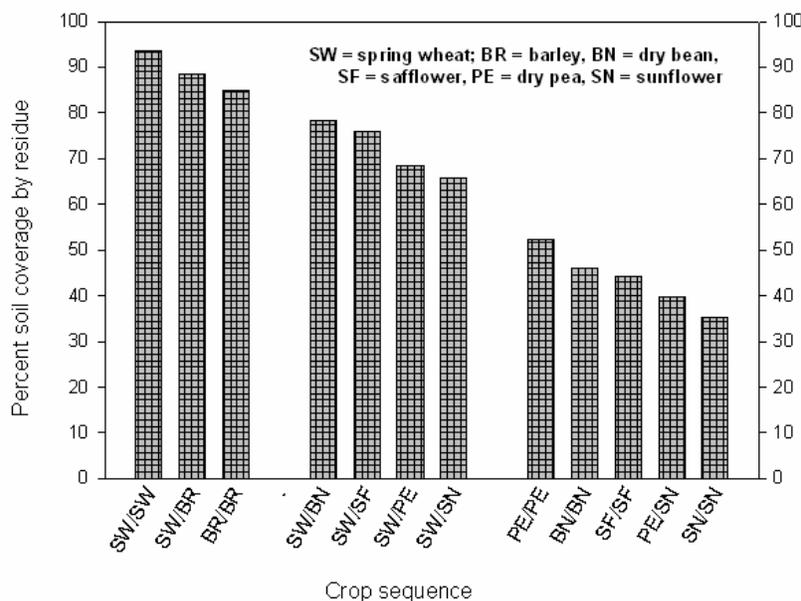
Three ARS Mandan scientists and one ARS Brookings SD scientist are the co-authors of a journal article on the effects of different kinds of crops on a vital part of soil health – the extent that soil is covered by crop residues in the spring at seeding time.

The article was published in the Jan.-Feb. issue of *Journal of Soil and Water Conservation*, and NGPRL authors were Steve Merrill, Joe Krupinsky, and Don Tanaka, who were joined by co-author Randy Anderson at Brookings.

The work grew out of a crop sequence experiment in which all 100 2-year combinations of 10 crop types were studied using no-till management. Measurements of percent residue cover were made with both a marked cable and with a photographic technique.

Results from the project indicated 2-year crop sequences fall into three groups when it comes

to residue coverage percentages measured in the spring. Highest residue coverage followed sequences with small grain crops – spring wheat or barley. Intermediate levels were found where spring wheat preceded crops that are lower residue providers, such as sunflower and some grain legume crops, like dry pea. The relatively lowest levels were measured following sequences with combinations of lower residue providing crops.



Because the work was done under no-till, the lowest levels of residue coverage -- about 35% following sunflower -- were fair to marginally sufficient for erosion protection. However, sunflower residue is not durable, and a wind erosion study at NGPRL has shown that tillage and chemical summer-fallowing in the season following no-till sunflower can lead to considerably elevated levels of measured soil loss during a relatively dry summer.

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Greenhouse Gases and Agriculture: A Primer

Last year was the warmest year on record. There were also some devastating weather events in 2005, causing billions of dollars in damage worldwide. These events have many people suggesting that global warming is causing the earth's climate to change. Fueling this change in climate is the increasing concentration of greenhouse gases in the atmosphere.

What are greenhouse gases?

Greenhouse gases are gases capable of absorbing infrared radiation. Infrared radiation is created when some of the sunlight that strikes the earth's surface is reflected back towards space. Greenhouse gases absorb this reflected infrared radiation. In doing so, they trap heat in the atmosphere (hence, the term greenhouse effect, because the gases trap heat like the glass walls of a greenhouse). Greenhouse gases essentially act as an insulating blanket in the atmosphere, trapping sufficient solar energy to keep the earth's average temperature within a pleasant range.

On one hand, we should be thankful for greenhouse gases, because without them, our planet would be inhabitable (such as Mars, which has a surface temperature of minus 63°F...That's cold, even by North Dakota standards!). On the other hand, when the concentration of greenhouse gases increases, so does the amount of trapped infrared radiation, meaning more heat in the atmosphere. The long-term effects of this trapped heat on the earth's climate is the source of debate among scientists, but most agree that global warming and a greater frequency of severe weather events are eventual consequences of this atmospheric trend.

Major greenhouse gases include carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O). Each of the gases differ in their capacity to trap heat in the atmosphere. The capacity of a greenhouse gas to trap heat in the atmosphere is referred to as global warming potential (GWP). GWP values are expressed relative to CO₂ for a 100-year time horizon. CO₂ is assigned a value of 1, CH₄ a value of 23, and N₂O a value of 296. So, to think of it in a different way, one molecule of N₂O is equivalent to 296 molecules of CO₂ with respect to its capacity to trap heat in the atmosphere. This makes N₂O a very strong greenhouse gas.

Can agriculture benefit by mitigating the greenhouse effect?

Agricultural activities account for approximately 9% of all U.S. greenhouse gas emissions. Among the three greenhouse gases, CO₂ represents a small proportion of the total agricultural greenhouse gas emissions (9%), while shares of CH₄ (31%) and N₂O (60%) are far more significant. Major sources of CH₄ emissions from agriculture include enteric fermentation (i.e., digestion by ruminant livestock),

manure management, and rice cultivation, while sources of N₂O emissions emanate almost entirely from applications of N fertilizer.

With agricultural activities responsible for only 9% of all U.S. greenhouse gas emissions, one might think there's little incentive for agriculture to reduce greenhouse gas emissions. In fact, the opposite is true. Not only can agriculture minimize its impact on the global environment by reducing greenhouse gas emissions from current

levels, but there are significant productivity and environmental quality benefits to be realized from doing so.

For example, management practices that take up more CO₂ than they release sequester carbon, thereby increasing soil organic matter. Increases in soil organic matter improve soil quality, as expressed through better soil structure, improved water flow into and through the soil, and increased nutrient cycling capacity. These improvements in soil attributes generally have a positive effect on productivity and environmental quality, benefiting both

the producer and society. Management systems that limit the amount of soil compaction (say, from either hoof or tractor traffic) reduce the potential for CH₄ and N₂O emissions, and also create a better soil environment for root growth and water infiltration. Agricultural practices that limit the amount of available N in the soil not only reduce N₂O emissions, but can lower input costs and improve N-use efficiency. Collectively, then, reducing greenhouse gas emissions from agriculture can significantly improve production efficiency on the farm/ranch, while having positive effects on the local, regional, and global environment.

In the future issues of the *Integrator*, we'll review how different agricultural production systems in the northern Great Plains affect the flux of greenhouse gases.

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Glossary

Climate – The average condition of the weather at a place over a period of years exhibited by temperature, wind velocity, and precipitation.

Global warming potential – The potential for global warming per unit mass relative to carbon dioxide.

Carbon dioxide – A colorless, odorless gas found in the air. Absorbed by plants and exhaled by animals. Carbon dioxide a global warming potential of 1 over a 100-year time period.

Carbon sequestration – Refers to the process by which atmospheric carbon is absorbed into carbon sinks such as the oceans, forests, and soil.

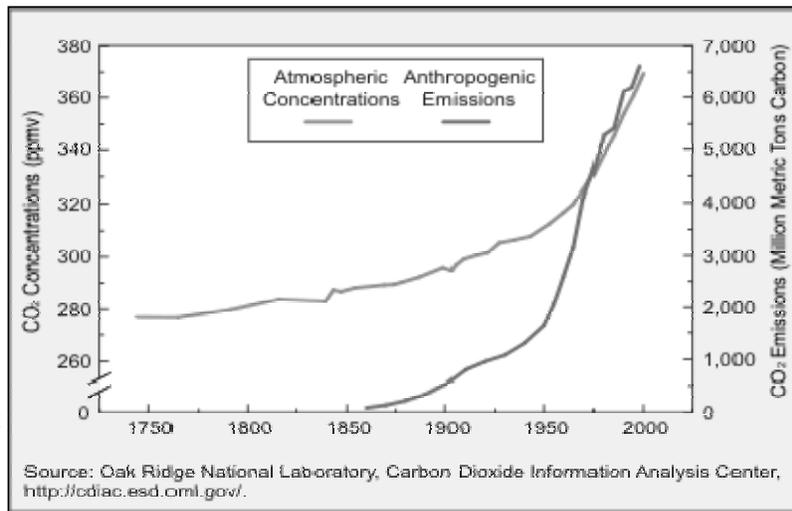
Greenhouse effect – The warming of the atmosphere by the trapping of longwave radiation being radiated to space.

Greenhouse gas – A gas that has the capacity to trap infrared radiation. CO₂, CH₄, and N₂O are greenhouse gases.

Infrared radiation – Electromagnetic radiation whose wavelength is longer than that of visible light, and is responsible for the transmission of radiant heat.

Methane – A colorless, odorless, and flammable gas. A major hydrocarbon component of natural gas. Methane has a global warming potential of 23 over a 100-year time period.

Nitrous oxide – A colorless, nonflammable gas with a slightly sweet odor. Commonly known as "laughing gas", and sometimes used as an anesthetic. Nitrous oxide has a global warming potential of 296 over a 100-year time period.



What about water vapor?

Water vapor is a natural greenhouse gas which, of all greenhouse gases, accounts for the largest percentage of the greenhouse effect. Water vapor levels fluctuate regionally, but in general humans do not have a direct effect on water vapor levels. In climate models, an increase in atmospheric temperature caused by the greenhouse effect due to anthropogenic gases will in turn lead to an increase in the water vapor content in the atmosphere. This in turn leads to an increase in the greenhouse effect and thus a further increase in temperature, and thus an increase in water vapor, until equilibrium is reached. Consequently, water vapor acts as a positive feedback to the greenhouse effect caused by anthropogenic-released greenhouse gases such as CO₂, CH₄, and N₂O.

Adapted from the National Oceanic and Atmospheric Administration.



Kolberg Joins the Team

Robert Kolberg joined the NGPRL staff in October 2005. Robert was born and raised in North Dakota on a small grains and beef cattle farm near Pettibone, ND. He received his B.S. degree in biology education from Moorhead State University followed by a two year assignment in the Peace Corps as an agricultural teacher in the Kingdom of Tonga, South Pacific. Robert first joined ARS at the Sidney, MT lab working with Don Tanaka as a biological aide and science technician. He then decided to continue his studies, namely in soil science earning a master's degree from NDSU and a doctorate from Colorado State University in Ft. Collins, CO. He returned to the Sidney lab to conduct cropping systems and weed management research as a Research Agronomist. However, he has found the role of technician is more to his liking, especially working in the cropping systems program with Dr. Tanaka.



Klein Retires

Curt Klein assisted research at the Northern Great Plains Research Laboratory for 35 years. Supporting several different innovative research programs at the lab, Curt served six different supervisors under six lab directors.



Tanaka recognized as ASA Fellow

Dr. Donald Tanaka has received the honor of Fellow of the American Society of Agronomy for 2005. The prestigious award was presented at the 2005 ASA Annual Meetings held in conjunction with the Crop Science Society of America (CSSA) and Soil Science Society of America (SSSA) on Nov. 6-10 in Salt Lake City, Utah. Dr. Tanaka's current research focuses on evaluating interactions of multiple factors for long-term, dryland integrated agricultural systems. He developed sophisticated techniques incorporating a multi-disciplinary team approach to determine the sequence of crops in cropping systems that take advantage of soil and crop ecological interactions. This innovative crop by crop residue matrix research approach exemplifies the interactions of crop sequencing in cropping systems. The data set from this project was used to develop the Crop Sequence Calculator, an interactive CD, so producers could develop their own management and goal-specific cropping systems.

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