Northern Great Plains Research Laboratory

NORTHERN GREAT PLAINS
INTEGRATOR

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

February 2011

Soil Biology Improves Soil Aggregation and Soil Quality

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

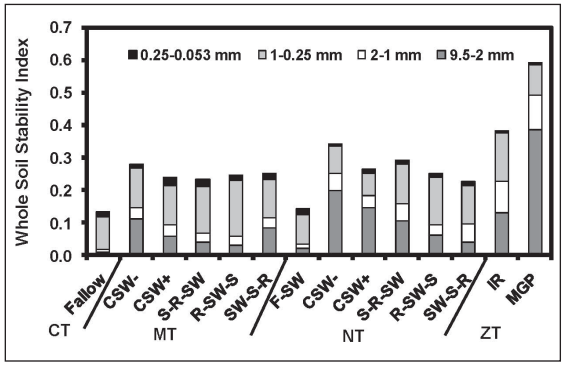
Soil quality and soil health are defined by how well a soil functions. These functions include resistance to erosion, water infiltration, water retention, gas exchange, biological activity, and nutrient cycling which impact plant growth and health. Soil aggregates, or small pellets of soil ranging in 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).



The WSSI for each treatment — conventionally-tilled (CT) chemical fallow (Fallow); minimum (MT) and no (NT) till continuous spring wheat with residue removed (CSW-), continuous spring wheat without residue removed (CSW+), and spring wheat – safflower-rye (SW-S-R) crop sequences (SW-S-R, S-R-SW, R-SW-S); the NT fallow-spring wheat (NT, F-SW); and never been tilled (ZT) idle rangeland (IR) and moderately grazed pasture (MGP). Columns are separated into four aggregate size classes: 9.5-2, 2-1, 1-0.25, and 0.25-0.053 mm.

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.

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Welcome Dr. Matt Sanderson

I am very pleased and excited to be serving as the Laboratory Director and Research Leader here at Mandan. In this brief article I would like to tell you a bit about my background and also relay some thoughts on the future direction of research at the 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 research associate at the University of Missouri in Columbia 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 (big dairies – 2000 to 3000 cows; everything is bigger in Texas!) 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 adds tremendous value to our research and outreach efforts. The involvement of our customer partners through the customer focus group and the Area 4 SCD Cooperative Research Farm 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. 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. Among these are using agricultural systems to mitigate greenhouse gases and sequester carbon in the soil. An important part of this research is understanding the effects of land use change on surrounding natural ecosystems. 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 to effort to quantify the environmental effects and ecosystem services of conservation practices implemented on the Nation's grazing lands. More details on CEAP are in an accompanying article in this issue of the Integrator.

This is an ambitious future that requires sustained support from a broad range of customers. It also requires sustained and adequate resources, both fiscal 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.

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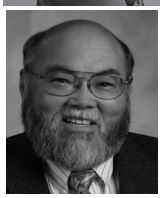
NGPRL Staff News

Gordon Jenson, Agricultural Science Research Technician, has retired from NGPRL after 34 years of service.

Katrina Wilke, NRCS Soil Scientist and **Patrick Schuet**t, NRCS Biological Science Tech, have offices at NGPRL for the NRCS "Rapid Carbon Assessment" project. The objectives of the project are to develop an inventory of soil carbon stocks for the conterminous US, evaluate differences in soil carbon associated with differing soil properties and land uses, and analyze the soil in the laboratory for bulk density and carbon. Approximately 10,000-12,000 samples per NRCS Major Land Resource Area (MLRA) will be taken and housed at NGPRL for future research opportunities. The data will be uploaded to a national database for climate change and conservation planning.

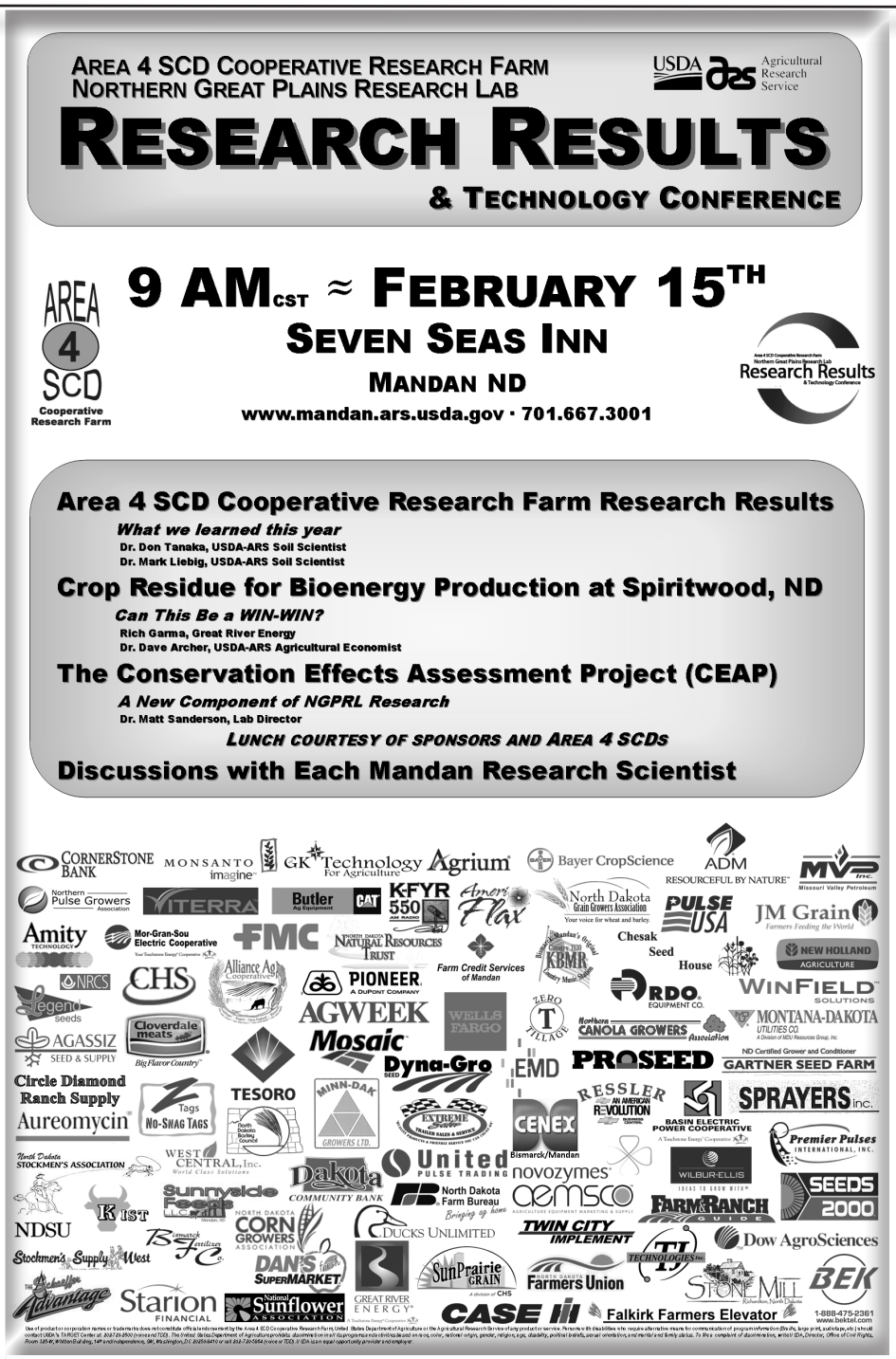


Dr. Donald Tanaka, NGPRL Research Soil Scientist, received the 2010 Professional Award from the North Dakota Association of Soil Conservation Districts. He was honored for excellence in conservation research, extensive public presentations of his research results, and significant contributions to soil and water conservation. The award was presented in Bismarck in November.

Cal Thorson, NGPRL Technical Information Specialist, was presented the Fellow Award by the International Soil & Water Conservation Society in St. Louis in July. The award was given in recognition of leadership in perpetuating sustainable practices for the enhancement of soil and water quality in both the private sector and with USDA-ARS.

Dr. Rebecca Phillips, NGPRL Plant Physiologist, has been awarded the prestigious OECD Research Program on Biological Resources in Agriculture Fellowship. The multi-disciplinary agri-food research addresses the gaps in knowledge, deepens understanding, and enhances the scientific base of policy. During the fellowship, Dr. Phillips will work with Dr. Griffith at the University of Wollongong Laboratory and Dr. Macdonald at the Australian National University in Canberra for 16 weeks to configure and develop methods for one of the first in situ, automated, multiple-port systems for measuring soil fluxes of carbon dioxide, methane, carbon and nitrogen isotopes, etc. The mission of the Organization for Economic Co-operation and Development (OECD) is to promote policies that will improve the economic and social well-being of people around the world.

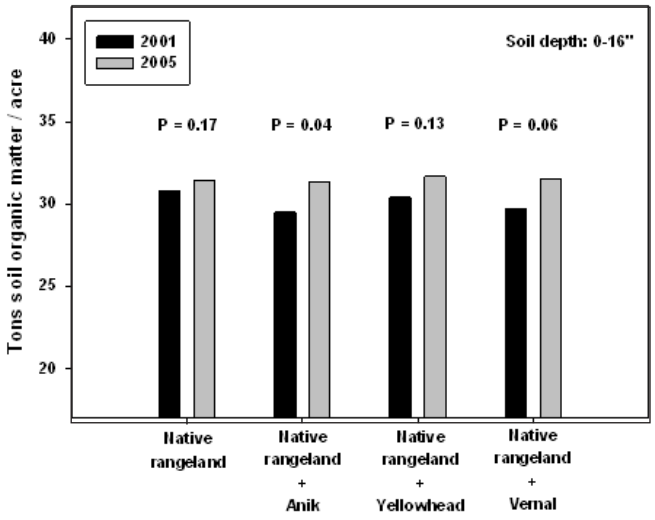
Dr. Kris Nichols, NGPRL Soil Microbiologist, and **Holly Johnson**, NGPRL Range Scientist, are being recognized by USDA-ARS for significant contributions to the agency and effort leading to the success of the Diversity Task Force of the Northern Plains Area.



Incorporating Alfalfa in Grassland Increases Soil Organic Matter

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 SOM content than the non-alfalfa control (6.1% and 6.2% SOM, respectively, vs. 5.9% SOM), but only in the surface four inches of soil. Between 2001 and 2005, total SOM stocks increased significantly under native rangeland interseeded with Anik and Vernal, but not under interseeded Yellowhead or the unseeded control.

Increased SOM 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 SOM inputs to the soil. Furthermore, fibrous root density from alfalfa is often greatest in the surface four inches of soil.

Previous research by 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 SOM 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.

Liebig, M.A., J.R. Hendrickson, and J.D. Berdahl. 2010. Response of soil carbon and nitrogen to transplanted alfalfa in North Dakota rangeland. Can. J. Soil Sci. 90(3): 523-526.

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

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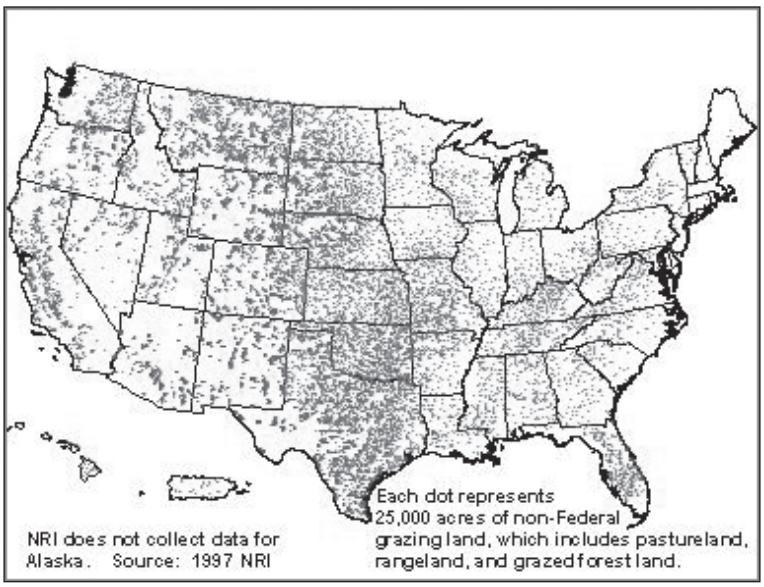
Secretary of Agriculture Briefed on NGPRL

Dr. Dave Archer, NGPRL Agricultural Economist, briefs Secretary of Agriculture, Tom Vilsack and Congressman Earl Pomeroy on the lab's mission, how Mandan research supports national objectives, and meets the needs of family farmers and ranchers. Several members of the NGPRL Customer Focus Group and staff also attended the September briefing.

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

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.

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Feel free to pass on this issue of Northern Great Plains Integrator to others interested in agricultural research in the northern Great Plains. Northern Great Plains Integrator is published and distributed by the USDA-ARS, Northern Great Plains Research Laboratory, PO Box 459, 1701 10th Avenue S.W., Mandan, ND 58554. Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at 202-720-2600 (voice and TDD). The United States Department of Agriculture prohibits discrimination in all its programs and activities on the basis of race, color, national origin, gender, religion, age, disability, political beliefs, sexual orientation, and marital and family status. To file a complaint of discrimination, write USDA, Director, Office of Civil Rights, Room 326-W, Whitten Building, 14th and Independence, SW, Washington, DC 20250-9410 or call 202-720-5964 (voice or TDD). USDA is an equal opportunity provider and employer. Mention of trade or manufacturer names is provided for information only and does not constitute endorsement by USDA-ARS. To be added to our mailing list, request a copy through our website or contact editor: Cal Thorson, Technical Information Specialist, USDA-ARS Northern Great Plains Research Laboratory, 1701 10th Ave., S.W., Mandan, ND 58554. Office:701 667-3018 FAX:701 667-3077 Email: cal.thorson@ars.usda.gov

INTEGRATOR Going Electronic Only

It is the end of an era for the INTEGRATOR tech transfer publication of the USDA-ARS Northern Great Plains Research Laboratory (NGPRL). This will be the last paper INTEGRATOR to be mailed out. The INTEGRATOR debuted in May 2000 with Dr. Mark Liebig as Editor. Since the NGPRL Customer Focus Group asked for it to be created, over 60,000 paper copies have been distributed to customers. We hope you will continue to follow the Ag and natural resources research here at NGPRL by going to **http://www.ars.usda.gov/Main/docs.htm?docid=19343** and providing your email contact information so you will receive this product electronically.

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