ANNUAL REPORT OF ACCOMPLISHMENTS AND RESULTS

North Dakota State University
North Dakota State University Extension Service
North Dakota Agricultural Experiment Station

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Goal 1. An Agricultural System That Is Highly Competitive in the Global Economy

Overview *- Changing climate conditions, pests and prices make crop production a challenge. In addressing these challenges, NDSU specialists and researchers help the state's producers find ways to improve the profitability and sustainability of crop production.*

In 2005, North Dakota led the nation in production of spring wheat, durum wheat, barley, oats, canola, all sunflower, flaxseed, all dry edible beans, pinto beans, navy beans, dry edible peas, lentils, and honey. The state ranks second in production of all wheat; third in sugarbeets; and sixth in potatoes. Exports of North Dakota commodities and products are valued at more than $2 billion. Crop production is critically important to the economy of the Northern Great Plains. Cash receipts from crops provided more than 3.2 billion to the economic base of North Dakota in 2004. A short growing season and low rainfall limits diversification, yields and cropping potential. Still, North Dakota is one of the most agriculturally diverse states in the nation with more than 40 different crops grown.

Similarly, livestock production is big business in North Dakota, accounting for nearly 20 percent of total agricultural cash receipts--$962 million in 2004. Livestock production is the original value-added enterprise adding value to the state's abundant crop forage and rangeland resources. More than 44 percent of North Dakota's land use is associated with rangeland, pasture land and hayland. NDSU programs help producers cut costs, boost returns and fund new opportunities.

In recent years, disease problems in hard red spring wheat, durum wheat and barley have increased dramatically and reduced acreage, yield and quality. As economic returns from the major crops were reduced, minor crops became increasingly important in North Dakota as producers sought to increase returns or incorporate additional crops into rotations to reduce insect and disease buildup. Development of a pilot process for canola biodiesel resulted in production of 1020 liters of canola biodiesel that was used in field equipment demonstrations. This biodiesel successfully passed key ASTM standards for total and bound glycerine, acid number, sulfated ash content, and flash point.

North Dakota based research on spearmint N requirements indicates that N rates may be reduced by more than 60 percent relative to the current recommendations that are derived from Montana or Oregon. Spearmint growers will realize a significant savings in fertility input costs due to these revised guidelines. Chickpea research has identified that crop density and weed control methods were generally the most important factors in achieving higher yields. The NDSU corn-breeding program has identified and developed five late-generation blue corn lines and 31 early-generation blue corn lines that are under second-year testing. The current high demand for blue corn hybrids makes NDSU an essential player with recognized breeding capacity.

NDSU researchers continue to develop genetically improved varieties of major crops as well. Those varieties possess improved agronomic performance and quality and have a major economic impact on the state and region through increased yield, improved disease resistance and quality and improved access to markets. In 2005, 50.2 percent of ND wheat acreages were

grown to Alsen, Reeder, Parshall and other cultivars released by NDSU. The recently released HRSW Dapps and Steele-ND are grown on significant acreages, replacing old varieties. Glenn, a 2005 NDSU HRSW release, is in high demand because of its high resistance to scab, leaf disease, high quality and yield. The impact of the new HRSW cultivars on the economy of the State and nation is tremendous.

Fusarium head blight (FHB) is a fungal disease of small-grain crops that causes yield loss and poor grain quality. NDSU is developing durum and bread wheat lines better adapted to North Dakota's growing environment and tolerant to prevalent diseases. The ultimate aim is to provide N.D. growers' wheat crops with new commercial applications for increased premiums.

In 2004, North Dakota ranked fourth in U.S. potato production. In 2005, 48 percent of the crop was planted to russets, 32 percent to white cultivars and 20 percent to reds. Predominant cultivars included Russet Burbank, Red Norland, Frito-Lay, Shepody and Dakota Pearl. Norland and Dakota Pearl are NDSU releases. Packing reds for the tablestock market during the 2004-05 season was a very strong segment of the N.D. industry. It is expected that Dakota Jewel, a 2004 release with excellent storage qualities, will make significant contributions to this effort in the 2005-06 marketing season. In 2005, 4,962 ha were accepted for certification by the North Dakota State Seed Department, making N.D. the third largest seed producer in the U.S., behind Idaho and Colorado. Potato production for all market types and uses exceeded $153 million in 2004. The potato continues to be the most important horticultural crop produced in North Dakota. National and regional chip manufacturers for large-scale use are evaluating Dakota Crisp.

The release of Maida, a new oat variety, provides growers with a cultivar resistant to the prevalent stem rust race. The variety HiFi provides growers with a crown rust resistant, high-yielding cultivar with a 30 percent increase in soluble fiber concentration. The higher soluble fiber concentration increases the human nutritional value of milled oat products.

North Dakota is the primary production area for flax in the U.S. NDSU developed flax varieties that are high- yielding, disease resistant and have high oil and linolenic acid content. The demand for flax seed is increasing. Flax production in North Dakota in 2005 was more than 800,000 acres. Based on its performance in 2005 yield trials, a full waxy wheat line, NDSW0481, exhibited promise as a specialty wheat release.

In 2005, the first yield trials of hard white commercial spring wheat varieties were grown at several research centers and provided valuable comparisons of the agronomic performance of commercial hard white and red spring wheat varieties. The evaluation of sawfly lines under infestation and for the solid-stem trait identified several potentially resistant breeding lines. Research indicated that durum wheat would lose vitreousness if exposed to high relative humidity. Vitreous kernel content below 90 percent generally results in price discounts. In 2005, 44 percent of the crop had some level of price discount due to low vitreousness. Information on crop quality is important for marketing durum wheat to domestic and foreign buyers.

Soybean acreage in North Dakota has grown from about 600,000 acres to more than 3 million acres in less than a decade. Iron deficiency chlorosis is a widespread problem in many

production areas. Results of chlorosis screening studies are widely used by farmers, seed dealers and agronomists in managing this difficult problem. The chlorosis studies have become an essential part of the soybean production system. North Dakota ranks second in sugar beet acreage, providing 17 percent of the nation's supply. In 1998, sugar beet growers in North Dakota and Minnesota lost $113 million to a Cercospora leaf spot epidemic. From 1999 through 2004, the EPA granted requests by our sugar beet Extension specialist to use Eminent, a tetraconazole fungicide, to control Cercospora leaf spot. EPA provided a full label for Eminent in 2005. The average number of fungicide applications applied per acre was reduced from 3.74 in 1998 to 2.06 in 2005, with 97 percent of surveyed respondents indicating good to excellent disease control.

Weed control is a big part of our scientist's work to improve crop management. Downy brome infestation is increasing in North Dakota. Awareness is a key component to slowing or stopping the spread. Research has identified several herbicide options, other than glyphosate, that could be used to control downy brome on the thousands of acres infested with this weed.

Wild oat has been a persistent problem in small grain fields for many years and has developed resistant biotypes to several herbicides. Research has demonstrated that pinoxaden will control several populations of resistant wild oats. Research has confirmed that cutting rates of wild oat herbicides often can save producers $2 to $4 per acre and still control wild oat. However, under several circumstances, including high wild oat populations, poor weather conditions, and the addition of some broadleaf herbicides, wild oat control was reduced. The additional $2 to $4 per acre investment in wild oat herbicide provided $12 to $24 per acre return. The new Roundup Ready event for sugar beets received full governmental approval in 2005. Use of soil-applied ethofumesate increased from 3 percent of the acres in 2002 to 15 percent of the acres in 2004. The average cost of hand weeding sugar beets was $34 per acre in 1995 and $13 per acre in 2004.

Extension specialists and researchers in southwestern North Dakota developed a demonstration using a soil fumigant to show producers yield and quality losses that can be expected in continuous wheat, wheat every other year and when at least a two-year break occurs between wheat crops. Producers who are including a two-year break in their crop rotation are seeing an increase in gross income of $36 per acre when wheat is grown compared with continuous wheat. Producers also are financially benefiting from alternative/specialty crops seeded during the two years between wheat crops. Some producers have reported up to $40 per acre return on specialty crops. Producers have also learned they can produce yields comparable to and sometimes greater than those from fallow. Fallow acreage in southwestern North Dakota has declined by 604,000 acres since the demonstration was initiated. In addition, wheat and barley acreages have each decreased by 300,000. This decrease indicates that fewer acres of continuous wheat and barley are being sown. In 2004, weather conditions over much of southwestern North Dakota was dry, but those producers utilizing good rotations experienced an increase in wheat yield of about 3 to 4 bushels per acre over continuous wheat rotations. In 2005, some producers who used rotations where there was a minimum of two years between wheat crops, wheat grain yield averaged more than 90 bushels per acre compared with monoculture yields in the same neighborhood that yielded 50 to 70 bushels per acre. At current

wheat prices, the difference between adequate rotations and monoculture rotations was $76 to $152 per acre.

NDSU specialists work directly with producers to improve their farms. The North Dakota Dairy Diagnostic program helps producers assemble teams of experts that will help identify key production and profitability roadblocks. The program's intent is not only to enhance dairy farm profit, but also to develop strategic alliances between the dairy and its many providers. Additional benefits include: methods of evaluating business growth, establishing long-term business relationships, reducing professional barriers, and improving communication with business partners. Since the inception of this program, more than 15 percent of North Dakota dairy farms have participated in the program. Gross annual economic impacts have ranged from $11,250 to $71,958.

In 2001, a voluntary Johne's control program was implemented to help those producers wanting to "clean up" their herds. The Office of the State Veterinarian administrated the program and the North Dakota Extension veterinarian provided educational materials and clinics for veterinarians and producers. During this initial year, 19 herds were enrolled in the program. In 2003, 78 producers were enrolled followed by 140 producers in 2004. Two were goat herds, 93 were beef herds and 45 were dairy herds. In 2005, 157 producers were enrolled in the program. One was a goat herd, 115 were beef herds and 41 were dairy herds.

An additional initiative, called the "C-punch" was implemented with the 2001 voluntary Johne's control program. To control Johne's in cattle, a permanent identification needs to be placed on the animal. Some states have instituted a "J-punch" program whereby infected cattle are ear notched with a letter "J" to signify Johne's. In North Dakota, we were concerned about stigmatizing producers and their cattle by placing a "J" in the cattle's ear. In response, the "C-punch" was developed. The letter "C" stands for cull. Animals ear notched by this means signify to sale barns, order buyers and other potential purchasers that cattle marked with a "C" are intended only for the slaughter market and are not to be put into a production unit. Multiple states have contacted North Dakota with the desire to start a "C-punch" program. The long-range impact of this program will be national.

In 2005, more than 500 animals were lost to anthrax in North Dakota. In conjunction with regulatory, public health and Extension veterinarians in Manitoba, Minnesota, North Dakota, and South Dakota, North Dakota State University entered into a regional program to assess the current knowledge about anthrax and develop recommendations for a unified anthrax education and control program for the region. A regional meeting of regulatory, public health and Extension veterinarians along with international anthrax experts was convened in October 2005. Information was exchanged on current anthrax recommendations from each state/province. Commitments were made to try to establish unified recommendations on the education and control efforts among the participants.

The NDSU Extension Service showed that it cost up to 3 cents less per pound to finish cattle in North Dakota compared with an out-of-state feedlot. Cattle producers are participating in feedout projects where they commingle groups of 3 to 6 cattle per consignor at a university feedlot for finishing. While cattle returns over expenses have averaged more than $100 per head

for spring marketed calves during the past three years, the range between the most profitable group and the least is more than $200 per head.

More than 450 producers attended Extension feedlot schools in the last five years. Cattle producers in central North Dakota realized that working as a group would provide more economic development than could be accomplished individually. Through educational sessions and continued facilitation and instruction, producers were able to develop several new vertically integrated cattle business ventures. The cooperative cattle feedlot plan has constructed a 7,000-head cattle feedlot located in a cow-calf region where feed grains are traditionally low-priced. The limited liability partnership that owns cattle for custom feeding has returned a 23.5 percent return on equity during a one-year period for the 23 cattlemen involved. A cattle-financing cooperative was developed for local producers and now provides financing for 95 percent of the calf purchase price with low-interest notes. The finance cooperative has grown 25 percent per year for cattle financed. Fifty-six cattle producers wanted to develop an outlet for supplying finished cattle at a 10 percent added-value premium and opened a 5,000 head capacity beef processing plant. Forty-four producers developed a limited liability company to sell fresh and processed meats to a regional market.

Program 1: Competitive and Profitable Crop Production

Key Theme - Agricultural Profitability: Assessment of Minor Crops
Much of the agronomic assessment of minor crops is conducted at NDSU research extension centers located throughout the state and by one or two research projects located at the main station in Fargo. Efforts can be divided into minor crops, which involve both research and extension, and new crops, which typically involve research only because these crops are not commercially grown. Research and subsequent extension training on minor crops are typically directed toward answering producers' problems. These include variety evaluation for agronomic performance and quality, disease and insect resistance and information on agronomic practices including stand establishment, weed control, harvesting procedures and storage. Agronomists, plant pathologists, entomologists and extension personnel located at the research extension centers and at the main station and cereal scientists at the main station are involved in all aspects of the work. One of the major factors that limit the production of new crops is that available varieties are not adapted to the region's growing conditions and markets are not always available.

Screening of nine new crop species was conducted near Prosper, ND. The new crops were adzuki bean, mung bean, borage, camelina, cuphea, echium, evening primrose, guar, and quinoa. Borage, cuphea, echium, evening primrose, mung bean and quinoa exhibited agronomic deficiencies such as poor emergence, plant lodging, late and prolonged flowering and maturity, seed shatter, and low yield. Adzuki bean and camelina produced moderate yields with fewer agronomic concerns. Crop modeling for cuphea seed development indicated physiological maturity required approximately 270 Celsius growing degree days post-anthesis.

Impact: Development of a pilot process for canola biodiesel resulted in production of 1020 liters of canola biodiesel that was used in field equipment demonstrations. This biodiesel successfully passed key ASTM standards for total and bound glycerine, acid number, sulfated

ash content, and flash point. Flaxseed milling represents an excellent opportunity for economic development in North Dakota. Milling technology is relatively accessible to small businesses, even businesses based in rural areas. North Dakota based research on spearmint N requirements indicates that recommends that N rates may be reduced by more than 60% relative to the current recommendations that are derived from Montana or Oregon. Spearmint growers will realize a significant savings in fertility input costs due to these revised guidelines. Chickpea research has identified that crop density and weed control method were generally the most important factors in achieving higher chickpea yields. The NDSU corn-breeding program has identified and developed five late generation blue corn lines and 31 early generation blue corn lines that are under second-year testing. The current high demand for blue corn hybrids makes NDSU an essential player with recognized breeding capacity. Sensory evaluation of fermented chickpea fortified breads showed that a 5% addition to the bread formula did not impact the sensory characteristics when compared to the control. A supplement of low-grade chickpeas for use in a higher value food product would increase the value back to farmers.

Screening of potential new crops is crucial for identifying those that show potential for future commercialization. This may require years or perhaps even decades in a new region. Such is the history of sunflower, dry bean, soybean, and more recently canola in North Dakota. These were new crops 15 to 40 years ago, but they are now major crops grown in North Dakota and the surrounding region contributing to the states strong agricultural economy.

Source of Federal Funds: Smith-Lever and Hatch

Scope of Impact: Multi-state

Key Theme - Plant Production Efficiency: Develop Management Strategies to Sustain Crop Productivity

Many nutrition-related constraints to crop production remain in North Dakota. Iron deficiency chlorosis, a micronutrient deficiency related to poorly-drained soils, is a common and destructive disorder in North Dakota**.** North Dakota soybeans are among the lowest in the nation in protein content, causing marketing concerns. Enhancing nitrogen fixation will, by necessity, be part of any solution to this problem. Barley production, because of wet years and head diseases, is moving west. Nitrogen fertilizer recommendations appropriate for northeastern North Dakota may over-recommend fertilizer for western North Dakota, resulting in unacceptable quality, due to high protein and low kernel plumpness. Spring wheat varieties differ in the amount of phosphorus needed for adequate tillering and yield. Farmers could save money on inputs, and help preserve the environment, if varieties with a lower phosphorus requirement were identified. Cultural practices that reduce iron deficiency chlorosis, such as improved varieties and fertilizer treatments need to be identified. Nitrogen fixation effectiveness, especially early in the growing season, need to be evaluated. The nitrate soil test for malting barley in western North Dakota is being recalibrated, so that farmers do not overapply nitrogen for this crop. Spring wheat varieties will be screened for ability to grow and tiller well at lower soil phosphorus levels. The potential savings to farmers could be significant.

In another area of research, significant efforts have been made to reduce the amount of herbicides applied for weed control. The technique is called micro-rate application and consists of using an adjuvant to increase the activity of the herbicide along with a reduced herbicide rate. The end result is a reduction in herbicide costs to the producers and reduced amounts of total herbicide use, resulting in a more environmentally friendly agricultural production system.

Impact: Soybean acreage in North Dakota has grown from about 600,000 acres to over 3 million acres in less than a decade. Iron deficiency chlorosis is a widespread problem in many production areas. The results of our chlorosis screening studies are widely used by farmers, seed dealers, and agronomists, in managing this difficult problem. Our chlorosis studies have become an essential part of the soybean production system of the state. Our screening of future NDSU varieties helps support an alternative to the commercial breeding industry. Our evaluation of iron fertilizers and alternative cultural practices continues, as no variety is immune to this problem. Regarding our work with reducing P requirements for adequate tillering in wheat, our preliminary studies suggest that it should be possible, through variety selection and possibly with hormonal seed treatments, to reduce P fertilizer requirements for wheat.

The new Roundup Ready event for sugarbeet received full governmental approval in 2005. Use of soil-applied ethofumesate increased from 3% of the acres in 2002 to 15% of the acres in 2004. The average cost of hand weeding sugarbeet was $34/A in 1995 and $13/A in 2004.

Source of Federal Funds: Smith-Lever and Hatch

Scope of Impact: Multi-state integrated research and extension, MN

Key Theme - Plant Production Efficiency: Developing Hard White Spring Wheat, Specialty Wheat and Sawfly Resistant Wheat

North Dakota spring wheat producers require an alternative to the traditional hard red spring wheat. Specialty spring wheats must have improved agronomic, quality, and pest resistance characteristics.

Goals of our research project are to develop white, specialty, and sawfly resistant wheat varieties for North Dakota and the surrounding region. There remains substantial interest in the production of specialty wheats, and both domestic and export end-users especially desire the development of high protein hard white spring wheat varieties. Fusarium head blight (FHB) research involved the continued rapid development of specialty spring wheats with diverse sources of FHB resistance. Different sources of resistance are being pyramided into single genotypes in an effort to elevate the level of durable resistance. Additional backcrosses (BC4 and BC5 generations) were made to 'Alsen', an adapted FHB variety, using Alsen backcross-derived lines that were previously confirmed as having both a 'Sumai 3' and a Triticum dicoccoides source of resistance. Doubled-haploid (DH) lines were produced from these backcrosses and other lines, including hybridizations with resistant 'Frontana' disomic chromosome substitution lines. In 2005 advanced yield trials at seven different ND locations, one full waxy line (NDSW0481) exhibited grain yields that equaled or exceeded the yields of spring wheat check varieties at many locations. Rating lines for stem-solidness at North Dakota locations and testing lines under sawfly

infestation at Beach, MT practiced indirect selection for advanced lines with resistance to the wheat stem sawfly. If the lines exhibit a higher level of FHB resistance, other breeders will release them as valuable spring wheat germplasm for use, because they combine two different sources of resistance. Greenhouse trials of FHB resistant 'Alsen' BC lines are being completed by a graduate student.

Impact: Based on its performance in 2005 yield trials, a full waxy wheat line, NDSW0481, exhibited promise as a specialty wheat release. A decision on its release will be made based on results of additional 2006 yield trial tests and end-use quality tests for non-food and food additive products. Approximately 900 unique hybridizations were made during this reporting period. Hybridizations were made among hard white and red spring wheat genotypes with disease resistant traits, solid-stem traits, and unique, waxy starch and high grain protein traits. A Uniform Regional Hard White Spring Wheat Nursery with 25 entries was coordinated and implemented for the second straight year and grown at 7 locations. This nursery has proven to be very valuable to breeders evaluating advanced breeding lines from around the region and as a means for exchanging seed of hard white wheat genotypes. In 2005, the first yield trials of hard white commercial spring wheat varieties were grown at several ND RECs. At least 22 entries were included in these trials, and this nursery provided valuable comparisons of the agronomic performance of commercial hard white and red spring wheat varieties in ND. A specialty wheat website was established at: specialtywheat.ndsu.nodak.edu. The evaluation of sawfly lines under infestation and for the solid-stem trait identified several potentially resistant breeding lines. A study in collaboration with a molecular geneticist in Australia was initiated to use markers to verify genotypes with the solid-stem trait.

Source of Federal Funds: Hatch

Scope of Impact: Multi-state

Key Theme - Plant Production Efficiency: Durum Wheat and Pasta Quality
Growing environment can affect the quality of durum wheat and subsequent end-use products. New tests are needed to evaluate the quality of durum wheat for pasta. The effect of growing environment during grain maturation on the quality of durum wheat and pasta will be studied. Additionally, the suitability of alveograph and gluten index as predictors of durum wheat quality for pasta will be explored.

Quality of durum wheat harvested in 2005 from Montana and North Dakota was determined from 233 samples. The average crop grade was U.S. No. 1 hard amber durum, with 79.2 kg/hl test weight, 2.2% total defects, and 91% vitreous kernel content. Research was conducted to determine the effect of high relative humidity just before harvest on kernel quality. Kernels in spikes from ten durum wheat cultivars absorbed moisture when exposed to high relative humidity. Absorption of moisture by wheat kernels caused changes to the bran layer and to the endosperm that resulted in a weathered appearance to the kernel. For all cultivars, exposure to high relative humidity resulted in increased kernel moisture content and kernel size and decreased vitreous kernel content. The loss of vitreousness varied with cultivar. Kernel color changed when exposed to high relative humidity. Appearance based on the color score did not

relate to the decline in vitreousness. For example, Ben showed the maximum decline in vitreous kernel content but its kernel color did not change when exposed to 88% rh for 1 d. Concentrations of pigment, free fatty acids, and conjugated diene were not changed after exposure to high moisture conditions for 24 hr. The lack of change in free fatty acid content and in conjugated diene content over time indicates that moist conditions of up to 1 d were insufficient for any adverse effects on lipid stability of the kernel. Research was conducted to evaluate the relative suitability of mixograph, gluten index, and glutograph as predictors of durum wheat quality for pasta. All three methods identified weak and strong gluten/dough semolinas. However, only the glutograph consistently detected varying levels of gluten/dough strength among samples identified as being strong. Preliminary results indicate that the glutograph might be most useful (relative to mixograph and gluten index) in identifying processing properties of semolina.

Impact: Research indicated that durum wheat would lose vitreousness if exposed to high relative humidity. The loss of vitreousness due to damp conditions varied with cultivar. Vitreous kernel content below 90% generally results in price discounts. In 2005, 44% of the crop had some level of price discount due to low vitreousness. If similar results are obtained in subsequent tests, this information could aid durum producers in selecting cultivars and could be used by durum breeders in developing cultivars that resist loss of vitreousness during damp conditions. The ability to predict processing properties of semolina would be of economic interest to the pasta processing industry. This information could be used to create standardized semolina blends that would be unique to each pasta company and that would improve the consistency of production and the product. Information on crop quality is important for marketing durum wheat to domestic and foreign buyers.

Source of Federal Funds: Hatch

Scope of Impact: Multi-state

Key Theme - Plant Production Efficiency: Evaluation of Hard Red Spring and Hard White Spring Wheat Quality in Relation to End-Use Functionality

Limited information is available regarding the quality requirements for certain specialty wheat-based products such as frozen doughs and Asian noodles. Cultivars with specific starch and protein characteristics are responsible for imparting desirable quality traits. The proposed project is aimed at identifying interesting genotypes from our existing pool of HRS and HWS wheat lines that could then be developed into high quality cultivars that could be sold in an identity-preserved basis for use in a wide selection of wheat-based products other than leavened bread.

Gel model systems were used to investigate the effect of amylose/amylopectin ratio, and the effect of starch and gluten interaction on the retrogradation of starch. Gel model systems were used in order to investigate the effect of amylose/amylopectin ratio and the effect of starch and gluten interaction on retrogradation of starch. Blends of non-waxy wheat starch and 0, 12.5 and 25% waxy tetraploid wheat starch, as well as blends of these starches and gluten (70:30 ratio) were gelatinized using the Rapid Visco Analyzer (RVA) and stored at 4 C for 0, 5, 10, 15 and 20 days. Soluble starch from gels was extracted with water and analyzed using gel permeation

chromatography. Gels firmed slower when they contained
12.5 and 25% waxy starch than when they contained only normal non-waxy starch. RVA pasting properties, thermal properties, measured by Differential Scanning Calorimeter (DSC) and textural properties differed significantly between these gel samples. These changes are probably due to the structural differences in normal and waxy wheat amylopectin, as shown by the maximum absorption (lambda max) of iodine-complexes of these starches. Non-waxy starch gels exhibited significant increase in firmness after five days of storage, whereas firmness of gels made with 12.5 and 25% waxy starch had slower rate of firmness increase. Higher amount of waxy starch in blends resulted in higher values for enthalpy of gelatinization, with starch/gluten gels having lower enthalpies that their corresponding starch blends. Presence of gluten affected all analyzed properties of starch (thermal, firmness, structural) regardless of the amount of waxy starch in a blend. At the beginning of the storage (day 5 to 10), retrogradation was faster with starch samples containing gluten than with starch samples without gluten. However, at longer storage times, the retrogradation rate was similar for starch samples with and without gluten. DSC results indicated that the dynamics of retrogradation with and without gluten was different. Gluten-starch samples showed lower lambda max during storage than their corresponding nongluten-starch samples. Although the mechanisms are not known, the presence of gluten appears to alter the behavior of starch, probably both gelatinization and retrogradation properties. After 5 days of storage lambda max leveled off for all samples; however, for 25% waxy starch with and without gluten the lambda max value was actually typical of amylopectin and waxy starch, indicating that mainly amylopectin remained in the soluble starch. The amylopectin in the gel had shorter chains than the amylopectin in the corresponding native starch, which indicates that amylopectin branch chains are possibly breaking off due to heat and mechanical force (stirring) during preparation of starch pastes. The short-chain amylopectin could be the reason for low gel firmness of samples containing waxy starch. Lambda max of amylose decreased during storage, which means that longer amylose chains reassociated and remained in the gel during soluble starch isolation.

Impact: Staling has an economic impact on bread manufacturers and grocery stores. Staling is a complex process that is associated with a change in flavor and texture. Starch retrogradation is the main cause of bread staling, and it has been investigated extensively by using mainly pasting, thermal and rheological methods. The effect of starch structure and the effect of gluten on starch retrogradation still remain subject of research. Waxy and partial waxy wheat offer unique starch functional properties that might extend the use of wheat in many food and non-food applications.

Source of Federal Funds: Hatch

Scope of Impact: Multi-state

Key Theme - Agricultural Competitiveness: Increase the Agricultural Producer, Consumer, Government and Social Sector Awareness, Understanding and Information Regarding Agricultural Systems

Extension specialists, with assistance from research scientists, developed several programs to describe varieties, production and maintenance practices and products available. These programs are designed to address problems by the urban and rural client. Information on the global

economy and the opportunities and pitfalls associated with it are being provided. Information that involves case studies of real situations is being taught in classrooms. The objective is to stimulate independent thinking and develop teamwork by asking students to address problems that require the interpretation of concepts from several disciplines.

Impact: Clientele of the NDSU Extension Service and the North Dakota Agricultural Experiment Station are well served by the faculty and staff of the Plant Sciences, Soil Science, Entomology and Agricultural and Biosystems Engineering Departments. All faculty, both research and extension, provide current and unbiased information to specific producers and commodity and business groups upon request. In addition, information on general problems, practices and procedures are available to the general public for farm, rural, urban, commodity and private industry.

For instance, a computer program known as Weed It, (weed information transfer), has been developed to summarize more than 30 years of weed control research results. A land manager can determine the optimum weed control methods by entering known variables such as crop, weed species and growth stage, soil type, etc. The program then shows the user chemical and cultural control options, expected cost and potential affect on yield. The Pesticide Program at NDSU routinely trains 1,500 to 2,000 commercial and private applicators per year in the proper handling and application of crop and home use pesticides. This program is recognized nationally for the high quality of its training programs and the resulting outstanding safety record for pesticide use in the state. This program has trained more than 25,000 commercial and private applicators.

Several methods of information dissemination are used, including radio, television, magazines and newspapers, the Internet, consumer service and printed material. In addition, faculty and staff who are directly accessible receive numerous phone calls.

Source of Federal Funds: Smith-Lever and Hatch

Scope of Impact: Multi-state integrated research and extension, MN, MT and SD

Key Theme - Plant Germplasm: Genetic Improvement of Major Crops

The North Dakota Agricultural Experiment Station has breeding and genetic research programs in most of the region's major crops with the goal of releasing new varieties or develop genetic materials for use by other programs. Germplasm from these research programs is shared with public and private breeders worldwide. USDA scientists provide basic genetic information and, in some cases develop and provide germplasm to assist the NDSU breeding programs. In some crops, the USDA coordinates regional trials that allow plant breeders to determine the adaptability of their genetic material across a wide range of environments outside North Dakota. The NDSU plant breeders and cereal scientists, located in the Department of Plant Sciences, cooperate with their counterparts in the departments of Plant Pathology, Entomology and the research extension centers in varietal development and genetic research. Crosses made by breeders are evaluated for agronomic characteristics by breeders, for quality characteristics by cereal scientists and for disease and insect resistance by plant pathologists and entomologists.

Based on that information, breeders make decisions on which material to discard and which to move forward in the program. The extension service has a major role in educating the producers about new varieties.

Impact: Genetically improved varieties that possess improved agronomic performance and quality have a major economic impact on the state and region. Varieties that have increased yield and improved disease resistance and quality provide producers with the opportunity to increase their economic potential through wider accessibility to markets and improved prices. The genetic improvement of major crops requires research effort by the scientist and subsequent dissemination of the knowledge to producers, product purchasers and end users of the finished product by extension personnel. Extension efforts are directed at the state, county, national and international levels.

In 2005, 50.2% (3.54 million acres) of ND wheat acreages were grown to Alsen, Reeder, Parshall, and other NDSU released cultivars. In addition, others acreages in neighboring states (MN, SD, and MT) were grow to these NDSU cultivars. The recently released HRSW Dapps and Steele-ND are grown on significant acreages, replacing old varieties. Glenn, the 2005 NDSU HRSW release is on high demand due to its high resistance to scab, leaf disease, high quality and good grain yield. Therefore, the impact of the new HRSW cultivars released by this program on the economy of the State and nation is tremendous. The release of new improved HRSW cultivars with high quality enhances ND wheat production and market ability of the grain produced. The use of genetic pest resistance and stress tolerance aids the stability of production for producers' economic return and for export market development, while protecting our environment and natural resources.

Fusarium head blight (FHB) is a fungal disease of small-grain crops that causes yield loss and poor grain quality. NDSU is developing durum and bread wheat lines better adapted to North Dakota’s growing environment and tolerant to prevalent diseases. The ultimate aim is to provide N.D. growers’ wheat crops with new commercial applications for increased premiums.

In 2004, North Dakota ranked fourth in US potato production. In 2005, 48% of the crop was planted to russets, 32% to white cultivars, and 20% to reds. Predominant cultivars included Russet Burbank, Red Norland, Frito-Lay varieties, Shepody and Dakota Pearl. Norland and Dakota Pearl are ND releases. Packing of reds for the tablestock market in the 2004-05 season was a very strong segment for the ND industry. It is expected that Dakota Jewel, a 2004 release with excellent storage qualities, will make significant contributions to this effort that early in the 2005-06 marketing season appears to be repeating itself. In 2005, 4,962 ha were accepted for certification by the North Dakota State Seed Department, making ND the third largest seed producer in the U.S. behind Idaho and Colorado. Potato production for all market types and uses exceeded $153 million in 2004; the potato continues to be the most important horticultural crop produced in North Dakota. National and regional chip manufacturers for large-scale use are evaluating Dakota Crisp.

The release of oat variety 'Maida', provides growers with a cultivar resistant to the prevalent stem rust race. The variety HiFi provides growers with a crown rust resistant, high yielding cultivar with a 30% increase in soluble fiber concentration that increases the human nutritional value of milled oat products.

North Dakota is the primary production area for flax in the United States an has developed flax varieties that are higher yielding with disease resistance, high oil content, and high linolenic acid content. The demand for flax seed is increasing. Production of flax in North Dakota in 2005 was over 800,000 acres.

Source of Federal Funds: Smith-Lever and Hatch

Scope of Impact: Multi-state integrated research and extension, SD, MN and MT

Key Theme - Plant Germplasm: Oat Cultivar Improvement

North Dakota (ND) ranked first in the nation for oat grain production, by producing 205,700 metric tons of oats from 97,200 ha harvested for grain during 2005. Approximately 57,000 ha of oats were harvested as forage. Selected parents were used in 405 hybrid combinations involving parental lines with effective resistance to virulence prevalent in the crown rust and stem rust populations in ND. 306 F2:3 populations were advanced via single seed descent accompanied by seedling crown rust and stem rust screening to eliminate susceptible plants from the populations. Nearly 20,000 F3-F5 lines were evaluated in hill plots for disease resistance and agronomic characteristics and individual panicles were harvested from selected hills. 10,500 F5 and 1,700 F6 lines were evaluated in unreplicated augmented trials at one location. 421 lines were evaluated in replicated preliminary yield trials at 2 locations. 136 lines were evaluated at 4 locations in advanced yield trials. Ten lines were entered in the Tri State Oat Nursery, 12 elite experimental lines were evaluated at 10 ND locations in Oat Variety Trials (OVT), and 6 lines were entered in the Uniform Midseason Oat Performance Nursery (UMOPN). 'Morton' and 'HiFi', released in 2001 exhibited excellent crown rust resistance and performed very well in 2004 field production. 'Killdeer', released in 2000 produced the highest grain yield of any genotype tested in ND OVT. Stark, a naked cultivar released in 2004 exhibited a 12% grain yield advantage relative to 'Paul'. 'Beach', released in 2004, continued to produce high grain yield with large white kernels and high stable test weight. ND010264, a line resistant to stem rust race NA67 and grain yield and quality superior to 'AC Assiniboia' was released in 2005 as 'Maida'. A preliminary increase of ND961161 was made in preparation for potential release in 2007. We determined a component of pga stem rust resistance is closely linked in repulsion with a factor conferring crown rust resistance in Morton. We also determined the gene conferring the naked character in Paul is linked in coupling with pga.

Impact: Release of 'Maida', provides growers with a cultivar resistant to the prevalent stem rust race. HiFi provides growers with a crown rust resistant, high yielding cultivar with a 30% increase in soluble fiber concentration that increases the human nutritional value of milled oat products.

Source of Federal Funds: Hatch

Scope of Impact: Multi-state

Key Theme - Plant Germplasm: Corn (Zea Mays L.) Breeding in the Northern Corn Belt

North Dakota (ND) average grain yield was 8 Mg ha-1 and total maize production for grain was 3.6 million Mg, the largest ever achieved in ND. This sudden economic benefit is due to the current availability of productive early-maturing lines.

We have acquired, maintained, and characterized 152 GEM accessions (Early GEM Project) and have adapted 26 to ND conditions; four stiff stalk accessions were selected for testcrossing in 2005. The result of three years of work on stratified mass selection was tested in 2005. Preliminary data suggest good average progress in earliness (1.3 days year-1) and grain moisture at harvest (20 g kg-1 year-1) while maintaining or even improving grain yield thus confirming enough genetic diversity to newly identified sources of high grain yield and earlier maturity. Choice of germplasm was performed after extensive testing. As a consequence, alternative heterotic patterns were identified and three reciprocal full-sib recurrent selection programs were initiated for genetic improvement on top population hybrids. In order to reduce GxE interactions and be able to accurately predict genetic gain a new method was develop to increase the amount of seed production for trials by planting S1 lines of each population in pair-crosses. Seed was produced for our cold tolerance project. S1 line progeny selection was conducted at a rate of one year per cycle utilizing a new methodology for recombination while testing. More than 100,000 pollinations were made in our 6.2-Ha nursery field including 11,516 rows (most of them early generation lines = 2,924 replicated across locations). Two winter nurseries and our summer nursery allowed us to produce 1,116 testcrosses for elite line combining ability testing and the number of locations for single-cross testing was kept at 15. We are in the final stages of creating two new
early-maturing SSS and non-SSS synthetic varieties with newer elite lines. Five recurrent selection trials have developed six new advanced populations. Two new diallel mating designs (one with reciprocals) were produced to exploit new elite heterotic combinations and to understand maternal and reciprocal effects in our maize population hybrid project. In addition, we are in the process of developing new groups of genetic diversity for grain quality. Potential elite lines at final stages (17) are being considered for release after four and five year testing with commercial testers. NDSAB (MER-FS) C13 population was developed as a result of long-term germplasm improvement. It was released on 13 Dec 2004 due to its unique performance per se, in hybrid combination, and as source of outstanding early-maturing lines.

Impact: The NDSU maize breeding program is the national program focused on early maturity. We develop elite populations, inbreds, and their respective hybrids. The financial impact of our program and cooperators has been the largest ever in 2005 as a consequence of the significant increased in average productivity of early-maturing corn in ND. New sources of valuable traits were identified. NDSAB (MER-FS) C13 elite population was developed, released, and entered in national databases. Although this is a genetically broad-based population there have been 10 requests for licensing it. After 38 environments of testing four maize population hybrids were identified as alternatives to commercial hybrids having the potential to save millions of dollars in farmer seed purchases and in participatory plant breeding systems. As a consequence, three field days, one session, and one panel discussion have been organized on this subject for the benefit of farmers and small businesses. This re-direction of the public sector has the potential to make a large difference to the producer. Hybrid corn performance trials included for the first time low-risk hybrids (<95RM) to benefit the producer and challenge the industry.

Source of Federal Funds: Hatch

Scope of Impact: Northern Corn Belt

Key Theme - Plant Germplasm: Breeding and Genetics of Flax
ND produces more than 90% of the flaxseed in the United States. The value of the flaxseed crop in ND is estimated at $45 million per year. In recent years, the United States has been a net importer of flaxseed. At present, the only flax breeding and genetics program in the United States is at the N.D. Agricultural Experiment Station. The value and markets for flaxseed as a healthy food continues to develop. A major baby food manufacturer will be adding an enriched Omega-3 product to its products. Research with flaxseed as a feed for beef cattle has generated renewed interest.

The primary objective is to develop and evaluate genetic material to improve yield potential while maintaining resistance to pests, maintaining oil content and oil quality, and maintaining other agronomic characteristics for potential cultivars. Because producers have historically planted later than would be expected to produce greatest yields, a part of the breeding effort will be devoted to evaluation at a delayed seeding date. With the interest in flax as a human food, a minor effort will continue to evaluate material with a yellow seed coat color that is preferred for "eye appeal."

The regional flax nursery was seeded at six locations in ND, with both early and late seedings at Fargo, for yield and other agronomic evaluations. A nursery was planted and evaluated on historic 'Plot 30' for wilt tolerance. N0010 was named 'Carter' and released in 2004. Seed of 'Carter' is being increased for distribution. In 1998 the USDA-ARS discontinued research in flax, regional responsibility for coordinating an advance variety trial for the North Central Region (including Canada) was transferred to my leadership. Results of the World Collection Cd evaluation were completed - crosses were made for planting in 1999-2000. Dr. Chaney agreed to assist in the genetic evaluation of Cd uptake in flax. Crosses made in the spring greenhouse were not seeded in the field in 2001. They were sent to Dr. Chaney for growing in growth rooms and to be analyzed for Cd content. In early June 2004, Dr. Chaney returned the seed to Fargo as a result of lack of funds. They were never grown in his lab. Plans were made to grow the material in the greenhouse in the winter of 2004-2005. In late 2005, Dr. Chaney has requested that we remade the crosses for evaluation. Materials were planted in an attempt to make the crosses again. The project on the effect of latitude on oil content and oil quality is near completion. A new program to evaluate the potential of increasing the ALA content of flaxseed has been initiated.

Impact: North Dakota is the primary production area for flax in the United States. This project develops flax varieties that are higher yielding with disease resistance, high oil content, and high linolenic acid content. The demand for flax seed is increasing. Production of flax in North Dakota in 2005 was over 800,000 acres.

Source of Federal Funds: Hatch

Scope of Impact: Multi-state

Key Theme - Plant Germplasm: Wheat Germplasm Enhancement
Wheat yield is reduced each year by infestation of various fungi, bacteria, viruses and insects. DNA marker technologies are being used in the wheat germplasm enhancement project to accelerate identification and transfer of genes from wild and related wheat species into adapted germplasm of durum, hard red spring, and hard white spring wheat.

Fusarium head blight (FHB) is a fungal disease of small-grain crops that causes yield loss and poor grain quality. Molecular markers were used to introgress the linked region from resistant species/cultivars into cultivated durum and hexaploid wheat. Molecular markers were also utilized to transfer high grain protein content, yellow pigment, altered starch characteristics, and added gluten strength in to durum wheat. Chromosome asynapsis and hybrid sterility are major obstacles to alien gene transfer, and genes affecting nuclear-cytoplasmic (NC) interactions are directly or indirectly involved. Several ongoing studies are directed at better understanding this phenomenon and harnessing what is learned in development of wheat with higher yield potential. We are exploiting other genomics technologies to better understand the wheat crop to develop better-adapted cultivars.

Impact: This project's focus is developing durum and bread wheat lines better adapted to North Dakota's growing environment and tolerant to prevalent diseases. The ultimate aim is to provide N.D. growers' wheat crops with new commercial applications for increased premiums.

Source of Federal Funds: Hatch

Scope of Impact: Multi-state

Key Theme - Plant Germplasm: Development of Potato Cultivars for North Dakota Utilizing Germplasm Enhancement and Selection
About 60% of potato production is used for frozen processing and dehydration. Potatoes are produced for a variety of end uses. Diseases and insects present challenges for producers and require chemical inputs, as resistant cultivars are unavailable. Stress resistance and quality continue to be issues for the industry. Researchers focus on germplasm enhancement, identification of superior genotypes, and development of multi-purpose cultivars with improved pest and stress resistance, enhanced nutrient-use efficiency, and superior quality that meet consumer needs.

Approximately 100, 402 ND seedlings were evaluated at Langdon, and 19,600 seedlings from CO, ID, and TX were evaluated at Browerville, MN in 2004. Unselected seedlings (80,105) were exchanged with CO, ID, MI, MN, TX, and WI. Yield trials were grown at four sites in ND and western MN; 2 were irrigated. The site at Grand Forks was lost due to flooding. More than 17, 8 and 14 advanced chip processing, red fresh market, and frozen processing selections, respectively, were evaluated in replicated trials at these sites. In an effort to address industry needs for cultivars that will reliably and consistently process from long-term cold storage, chip

and frozen processing selections were sampled, stored at 5.5C and 3.3C for 8 weeks and processed; additional samples from 5.5C will be processed after 7 months. Clones (chip and frozen) with good potential including ND8304-2, ND8305-1, ND8331Cb-2, ND7443Ab-180, ND7443Ab-181, AOND95249-1Russ and AOND95292-3Russ, amongst others. In cultivar development trials, some collaborative, 16 selections were evaluated for disease reaction to bacterial ring rot in the field. Three did not express typical foliar and tuber symptoms; all had a common parent, ND5256-7R, which was identified in this screening as lacking symptom expression. Thirteen ND advanced selections and cultivars were evaluated for sensitivity to metribuzin; Dakota Jewel, AND97279-5Russ, ND5255-59, and ND7192-1 exhibited some sensitivity. Sixty-five families (nearly 6,500 individual genotypes) were evaluated for resistance to late blight (US8) using a detached leaf assay in the greenhouse; families ranged from 0 to +40% resistance. All resistant selections were retained for field evaluation in 2006. Sixty seedling families were evaluated for defoliation levels in a
Colorado potato beetle (CPB) resistance screening nursery. Defoliation data for families was used in determining selection intensity of the same families at the seedling site of Langdon. ND grew 2 locations of the North Central Regional Potato Variety Trials, 1 irrigated and 1 non-irrigated; ND had no entries due to a seed issue. ND5822C-7 was evaluated in its final year in the USPB/SFA trial. Seed and commercial operations in 2005 evaluated seven advanced selections. In the greenhouse, 720 new families were created and about 110,000 seedlings were planted. The focus continues to be late blight, cold processing, CPB, and aphid resistance; 59.5, 34.5, 33.0, and 17.0%, respectively of crosses, possessed resistance breeding. Sugar end and Verticillium wilt resistance continue as concerns. The ND Agricultural Experiment Station released Dakota Crisp (ND2470-27) in March. Attributes include high yield potential, a very high percentage of uniform and marketable eggshell colored tubers, and processing ability from 7.2C. The ND Agricultural Experiment Station released Dakota Diamond (ND5822C-7) in December. It is an exceptionally high yielding, attractive, bright white skinned chipping cultivar with resistance to common scab and late storage potential.

Impact: Potatoes were harvested on 40,873 ha in 2004, and North Dakota ranked fourth in US production (National Agricultural Statistical Services, 2005). In 2005, 48% of the crop was planted to russets, 32% to white cultivars, and 20% to reds. Predominant cultivars included Russet Burbank, Red Norland, Frito-Lay varieties, Shepody and Dakota Pearl. Norland and Dakota Pearl are ND releases. Packing of reds for the tablestock market in the 2004-05 season was a very strong segment for the ND industry. It is expected that Dakota Jewel, a 2004 release with excellent storage qualities, will make significant contributions to this effort that early in the 2005-06 marketing season appears to be repeating itself. In 2005, 4,962 ha were accepted for certification by the North Dakota State Seed Department, making ND the third largest seed producer in the U.S. behind Idaho and Colorado (Colorado Potato Seed Certification Service, 2005). Potato production for all market types and uses exceeded $153 million in 2004 (National Agricultural Statistical Service, 2005); the potato continues to be the most important horticultural crop produced in North Dakota. National and regional chip manufacturers for large-scale use are evaluating Dakota Crisp.

Source of Federal Funds: Hatch

Scope of Impact: Multi-state

Key Theme - Plant Germplasm: Improving Hard Red Spring Wheat Germplasm and Cultivars

In changing wheat production and export market environments, developing new adapted HRSW cultivars with acceptable agronomic and quality characteristics to replace non-adapted cultivars is essential to sustain future wheat productivity in North Dakota. This project aims to develop and provide wheat growers in North Dakota and neighboring states in the North Central region with new adapted HRSW cultivars that will meet their needs and the wheat industry and export market requirements.

Elite and improved germplasm generated by NDSU HRSW breeding program and introduced material from many spring and winter-wheat breeding programs worldwide, and from various collections will be evaluated on an ongoing basis for desirable agronomic, pest resistance and quality characters. Selected genotypes will be used to cross with North Dakota adapted spring wheat germplasm for sexual recombination to develop breeding populations from which advanced lines leading to variety release will be identified. Classical breeding methodologies and modern tools such as molecular markers will be used to achieve the targeted goal. Studies to understand the genetics of most valuable and economic traits will be conducted to generate powerful tool to achieve efficiently the development of improved wheat germplasm. Recently developed transgenic wheats (genetically modified wheat) for specific traits are being explored within the HRSW breeding program activities to face the endless challenges for wheat productivity and endues.

Impact: The NDSU-released hard red spring wheat (HRSW) cultivars have been historically, a hallmark cultivars in the wheat industry. They still continue to dominate the overall acreage grown to wheat in North Dakota and expand to neighboring states. During the last five years, more than 50 percent of N.D. acreage was grown to NDSU HRSW wheat cultivars. This includes Alsen, Reeder, and Parshall. Dapps, Steele-ND, and Glenn released in 2003, 2004, and 2005 are steadily gaining acreage. Dapps is an excellent high quality cultivar with average yield and test weight. It has a good package of resistance to foliar diseases but is susceptible to scab disease. Steele-ND is a high yielding cultivar with very good quality and good scab resistance. Steele-ND's resistance to scab is different from the one included in Alsen, which is a very important from the standpoint of breeding strategy to diseases resistance. Glenn is the new cultivar that may expand in most HRSW growing area replacing Alsen and Parshall. The reasons why this may happen is because Glenn combines both Aslen and Steele-ND resistance for scab; has higher yield than grown cultivars; has better resistance to foliar disease; and most importantly, it has excellent milling and baking characteristics. In 2005, Dapps and Steele-ND were grown on relatively significant acreages in ND. Similarly, the seed of Glenn is in very high demand for 2006 crop cycle. In 2006, a new HRSW cultivar 'Howard' was released. Howard has good quality and higher yield than Reeder, Alsen, and Parshall. It has similar level resistance to scab than Steele-ND. It is expected that Howard and Steele-ND will be grown mostly in the North Dakota Western areas where Reeder is a dominant cultivar. The release of new improved HRSW cultivars with high quality enhances N.D. wheat production and marketability of the grain produced. The use of genetic pest resistance and stress tolerance aids the stability of production

for producers' economic return and for export market development, while protecting our environment and natural resources.

Source of Federal Funds: Hatch

Scope of Impact: Multi-state

Key Theme - Ornamental/Green Agriculture: Woody Ornamental Evaluation
Climate and certain soil conditions present a challenge in growing landscape plants in the northern plains. Only a small % of genotypes may perform satisfactorily due to insufficient winter hardiness, pest susceptibility, lack of resistance to drought, desiccating winds and unfavorable soil conditions; e.g., alkaline (pH) and saline soils. Resistance to insect or disease attack should be a major consideration in **woody** plant improvement and planting decisions. There is a real need to breed, evaluate and introduce adapted **woody** plants for this region to avoid monoculture disasters in the future.

Four superior winterhardy woody plants were named and introduced. Prairie Expedition(TM) American Elm-Ulmus americana 'Lewis & Clark' is a rapid growing, umbrella-crowned clone with apparent high resistance to Dutch elm disease. Prairie Spirit(TM) Juniper-Juniperus x 'Bison' is a joint NDSU-University of NB-Lincoln introduction. Its striking mature foliage is brilliant green contrasting with gray-blue juvenile growth, creating a bicolor effect. Plants grow 1 to 1 3/4 feet in height, densely spreading in form. Silvery-blue, berrylike cones contrast with the foliage. Prairie Refection(TM) Laurel Willow-Salix pentandra 'Silver Lake' has high survival rate throughout ND, improved adaptation in alkaline pH soils, a dense, rounded form and dark green, highly glossy foliage. Prairie Stature(TM) Oak - Quercus x bimundorum 'Midwest' is being introduced by NDSU in collaboration with the USDA-ARS, North Central Regional Plant Introduction Station, Iowa State University, Ames, IA. This hybrid oak has quality emerald-green, semi-glossy, leathery foliage, red autumn color, retention of tannish leaves into winter, and a fairly pyramidal growth habit. Commercial wholesale nursery production has begun with the willow and elm cultivars and production of the other two introductions is anticipated in 2006. US trademark registrations were granted for Prairie Dream(R) Paper Birch, Prairie Vision(R) Asian White Birch, Prairie Torch(R) Hybrid Buckeye, Prairie Horizon(R) Manchurian Alder, Northern Acclaim(R)Thornless Honey-locust and Prairie Statesman(R) Swiss Stone Pine. Plant patents were issued for Betula papyrifera 'Varen' and B. platyphylla 'VerDale'. A patent application was filed for Syringa pekinensis 'SunDak'. The NDSU Research Foundation licensed additional nurseries to commercially propagate and distribute NDSU woody plant introductions. Field evaluations of a hardier Cercis canadensis-Eastern Redbud selection are planned. Our entire Birch and Elm collections in the NDSU Research Arboretum were evaluated. Based upon hardiness evaluation and exceptional fall color, Pyrus faurei 'Westwood'-Korean Sun(TM) Flowering Pear will now be recommended for landscape planting in ND. Two superior selections show promise for release, including a Magnolia x loebneri seedling and a Betula nigra seedling. Fifteen of the hardiest Magnolia spp./cvs. were planted for evaluation. Six new tree accessions were planted in the all-state cooperative evaluation program, and many new woody plants in the NDSU Research Arboretum. One, 5, and 10-year NC-7 project reports were submitted and nine

new accessions planted at two sites. Evaluation reports were submitted to nursery collaborators on 168 cultivars. New accessions obtained for trial totaled 260.

Impact: Evaluation recommendations for woody plants are making a significant impact on a large clientele who use landscape plants in the Northern Plains. With the introduction of 30 superior plants from this project, the inventory of hardy plants for production and sale in the nursery industry and use by landscape architects/designers, developers, city arborists, foresters, horticulturists, parks and sports facilities, conservationists, and public consumers has been markedly increased. NDSU's woody plant improvement program is recognized in North Dakota, the Northern Plains states/provinces, the Midwest, and nationally.

Source of Federal Funds: McIntire-Stennis, Hatch and Smith-Lever

Scope of Impact: Multi-state integrated research and extension, MN and SD

Key Theme - Agricultural Competitiveness: County Cropping Systems
Extension staff developed a comprehensive program to provide LaMoure County producers up-to-date and local information on cropping systems while helping them make transitions from one crop to another with as little negative impact on profitability as possible.

To help producers with information on soybeans, small grain, and sunflower varieties, staff work with area groups and establish variety plots. An addition in 2005 was working with a few seed corn dealers in the county helping with establishment of corn comparison trials, while not quite set up in the traditional university trials these smaller plots across the county did provide corn producers with information on which corn hybrids do best in the area. Annual plot tours feature a review of varieties/hybrids and topics of interest to producers, such as insect problems, crop rotations, production practices, markets, herbicide comparisons and plant population studies. After the plots are harvested, data is disseminated to producers in LaMoure and neighboring counties. Results are published in the annual Crop Production Guide and variety trial bulletins. Throughout the winter meeting season, staff invites producers to area meetings to fine-tune their production skills.

Cooperating institutions and organizations: LaMoure County Extension Office, Allied Agronomy Services of Edgeley, Larson Grain Company, Witt Consulting of LaMoure, Dakota Prairie Ag, Edgeley, National Sunflower Association, North Dakota Soybean Council, soybean and sunflower seed companies, NDSU oat breeder Mike McMullen, NDSU soybean breeder Ted Helm, NDSU Carrington Research and Extension Center, ADM Plant of Enderlin, LaMoure County Ag Improvement Association and producers Tom Kiecker of Edgeley, Dennis Feiken of LaMoure and Kerry Ketterling of Marion.

Impact: With more favorable prices and reduced problems with insects and disease, many producers were looking to switch from sunflower and hard red spring wheat to soybean and corn production. Most had little or no experience growing these crops. Because of crop tours, workshops and seminars, most producers made the switch and successfully increased gross revenues. In 1994, LaMoure County had fewer than 9,000 acres in soybeans, 3500 aces in corn

and more than 228,000 acres in hard red spring wheat and 187,000 acres of sunflowers. In 2005, soybean acreage had increased to more than 253,000 acres corn to just over 110,000 acres and hard red spring wheat acres had decreased to 80,000 and sunflower acres to 3200 acres. Not only have soybean and corn acres increased, so have yields. In 1994 county average soybean yields were 26.8 bushels per acre, in 2005 the county average increased to 35.8 bushels per acre. Corn yields have also improved from a county average of 83.4 bushels per acre in 1994 to 118 bushels per acre in 2005.

The economic impact from this change in 2005 was approximately $5.1 million of additional gross revenue for LaMoure County producers.

Source of Federal Funds: Smith-Lever

Scope of Impact: State specific

Key Theme - Plant Health: Diagnosis and Management of Root Disease in Western North Dakota

The area extension cropping systems specialist, state extension plant pathologist and county agents in southwestern North Dakota developed a demonstration using a soil fumigant to show producers yield and quality losses that can be expected in continuous wheat, wheat every other year and when at least a two-year break occurs between wheat crops. Also, nitrate levels in the root zone were compared between fumigated and non-fumigated soils to illustrate the potential environmental impact that continuous wheat may have should nitrates leach below the root zone. These demonstrations were observed and discussed with producers at field days and county agricultural improvement tours. Presentations were developed and given to producer groups and were included in the NDSU Extension Service CD distributed to county agents across the state.

Cooperating institutions and organizations: North Dakota State University Extension Service, Montana State University Extension Service, Dickinson Research Extension Center, Hettinger Research Extension Center, county extension services and county crop improvement Associations in Adams, Golden Valley, Hettinger, Mercer, McLean, Morton, Oliver and Sioux counties and the Sustainable Agriculture Mini-grant Program administered by NDSU Extension Service.

Impact: Producers who are including a two-year break in their crop rotation increased gross income $36 per acre when wheat is grown in comparison to continuous wheat. Producers are also financially benefiting from alternative and specialty crops planted during the two years between wheat crops. Some producers have reported up to $40 per acre return on specialty crops grown. Producers have also learned they can produce yields comparable to and sometimes greater than those from fallow. Fallow acreage in southwestern North Dakota has declined by 604,000 acres since the demonstration was initiated. In addition, wheat and barley acreage has decreased by 300,000 acres each, indicating that fewer acres of continuous wheat and barley are being sown in this part of the state. In 1996, 72 percent of the wheat planted in southwestern North Dakota was on wheat, barley or durum stubble. Acres planted to other crops have increased. In 2002, 67%, in 2005 65% of the wheat grown in southwestern North Dakota was grown on wheat, barley or

durum stubble. In 2005 wheat prices were favorable compared to other cropping alternatives. These data would indicate that producers are increasing the use of crop rotations to improve efficiency in crop production. In 2003, producers utilizing good rotations to control soil-borne fungal diseases reported 80 bushels per acre of barley that met malting standards. Malting barley will bring about 50 cents per bushel premium or in this case, $40 per acre return over feed barley. In 2004, weather conditions over much of southwest North Dakota was dry but those producers utilizing good rotations experienced an increase in wheat yield of about 3 to 4 bushel per acre over continuous wheat rotations. In 2005 some producers who use rotations where there is a minimum of two years between wheat crops wheat grain yield averages of over 90 bushels per acre compared to monoculture yields in the same neighborhood were 50 to 70 bushels per acre. At current wheat prices the difference between adequate rotations and monoculture rotations was $76 to $152 per acre.

Source of Federal Funds: Smith-Lever

Scope of Impact: Multi-state extension, MT and SD

Key Theme - Plant Production Efficiency: Improving Forage Production and Quality in North Dakota

Alfalfa productivity is limited by poor management practices and variety selection. Soil subsidence caused by alfalfa production may be reducing productivity of subsequent crops. This project examines new management for forage crops, primarily alfalfa and determines if soil subsidence is detrimental to subsequent crop production.

Alfalfa forage yields (mean of 2001 and 2002 exp.) were similar among 4 to 32-lb/a seeding rates in 2005 and across the 3 and 4 production years, supporting seeding rate recommendations of 6 to 8 lb/a when established with a companion crop. Forage yield and RFV was highest from Paul oat (naked) over 3 yr at Fargo due to a lower NDF content. AC Assiniboia was the best grain type in forage quality. ND000461, a low ADL breeding line, had forage yield similar to Paul but a greater
IVDMD making it a candidate for release as a forage oat. Late-maturing grain oat cultivars were higher in yield and forage quality than early, forage types (Ensiler, ForagePlus) were similar in yield and quality to early maturing cultivars. Similar results were found across 3 locations. Feeding trials will be conducted in 2006. AC Ronald was lower than AC Assiniboia in ADL. Barley cultivars with the hooded characteristic like Bestford and Westford appear lower in ADL than normal 6-rowed cultivars. The variety Hays had the lowest ADL and highest IVDMD. The orange lemma character seems to be associated with reduced lignin in 1-yr data. Autotoxicity occurred each year (5-yr exp.) on spring-tilled alfalfa stands, but the days after tillage for maximum autotoxicity varied with year. Fall harvest of alfalfa was the highest yielding treatment after 5 years of production compared to no fall harvest if plants reach 40 to 50% bloom or is initiating regrowth. This is the sixth year where such treatment was either greater yielding or equal to uncut treatments in the fall. Traffic 5 days after harvest reduced alfalfa forage yields by 12%. Sulfur deficiency on alfalfa has been documented at 3 sites, fertilization increased forage yield by nearly100%. Zinc fertilization did not increase forage yield when the soil test was 0.3ppm.

Impact: Selection of Paul oat as a forage cultivar could increase animal performance on the 125,000 acres of oat hay produced in North Dakota. ND000461 has good potential as a new forage oat cultivar that could increase animal performance further. Hays barley should be used on the 50,000 acres of barley hays in North Dakota due to the high digestibility. Adapting fall harvest of alfalfa on 25% of the acreage could increase alfalfa productivity by at least 0.75 tons/acre/year for an additional 280,000 tons or 14 million dollars.

Source of Federal Funds: Hatch

Scope of Impact: Statewide

Key Theme - Plant Health: Plant Diagnostic Lab in Southwest North Dakota
Growers and the agricultural industry expect fast and accurate response in identifying agricultural pests and potential pests. Proper identification of pest problems is important for implementing effective corrective actions or avoiding costly and unnecessary pesticide applications. Five satellite plant diagnostic labs were initiated around the state of North Dakota.

Cooperating institutions and organizations: NDSU Extension Service, NDSU plant pest diagnostician, extension service plant pathologist, extension service entomologist and participating area extension specialists.

Impact: Thirty-seven agricultural problems were identified using the plant diagnostic equipment at the Dickinson Research Extension Center. An elevator brought in one insect that had originally been identified as a confused flour beetle. Under close examination with a stereoscope, the insect was identified as a fungus beetle and treatment of grain with a fumigant was avoided, saving the elevator $1,500. Wheat curl mites were identified on Wheat Streak Mosaic Virus (WSMV) symptomatic plants using the diagnostic equipment. In the summer of 2002, several producers lost entire fields or suffered yield and quality losses from WSMV. Seven producers are known to have delayed seeding of winter wheat, a recommended practice for the control of WSMV, because of the diagnosis. WSMV was not found in 2003 in fields where producers applied the recommended practices for controlling this disease. In 2003, adult Dectes longhorn beetles were identified using equipment in the Plant Diagnostic Lab. Pesticide applications are not an option for controlling this pest. It was recommended to the four producers who participated in the identification to not spray for the pest but to harvest early to avoid severe yield lost. Producers saved $11 per acre from ineffective pesticide applications on 800 acres of sunflower, reduced harvest losses from and saved an estimated 250 pounds per acre to 100 pounds per acre. Tan spot in spring wheat was identified early in 11 producer fields. It was recommended that the addition of a fungicide at $5 per acre be included with their herbicide applications. Producers claim that yields in treated fields were 3 to 5 bushels higher than untreated fields. These 11 producers treated a total of 6,000 acres of wheat for tan spot. In 2004, Tan spot was identified for 25 producers using the diagnostic equipment. Twenty-four of these producers included a fungicide with there herbicide. Even though the weather was dry, producers felt that they increased yield by 3 to 4 bushels per acre over their untreated fields. In 2005, Tan spot was a serious problem throughout southwest North Dakota. One hundred sixty-three producers contacted the area extension agronomist for identification and assistance in

determining what could be done to protect the wheat and durum fields from tan spot. Producers interviewed after harvested indicated that they produced 3 to 6 bushels more per acre on treated fields compared to untreated fields. At current wheat prices producers netted between $6.40 to $17.80, more per acre than untreated fields where tan spot was identified as a significant yield-limiting factor. The diagnostic equipment was also used to identify mites and insects brought in by producers, IPM field scouts, and crop consultants. Identification of these pest problems provided the necessary information needed to make effective recommendations for 12 fields representing over 7,600 acres. A producer brought in sunflower heads for analysis of a problem where the head was malformed in August 2005. Sunflower moth larva were found in the flower head and the producer told that an insecticide application would not be of benefit for control of this moth. The producer saved the cost of the insecticide, about $6.80 per acre plus the cost of an aerial application on 160 acres.

Source of Federal Funds: Smith-Lever

Scope of Impact: Statewide extension

Key Theme - Innovative Farming Techniques: No-till Equipment Selection and Management Practices

The area extension cropping systems specialist, Hettinger County extension agent, NDSU extension agriculture engineer, and a Dickinson Research Extension Center scientist developed a demonstration no-till drill designed to incorporate the most current ideas known about the biology of seed germination and its response to the environment during early growth and establishment. John Baker, New Zealand inventor of the cross-slot opener, addressed the direct seeding seminar. A demonstration was conducted in an indoor arena because of winter weather in November 2003.

Low-disturbance no-till demonstrations were held in cooperation with the Oliver County extension agent, Hettinger County extension agent, Dunn County extension agent and the Stark County extension agent in the summer of 2004. Presentations on no-till were given during county agriculture improvement summer tours and the Dickinson Research Extension Center Field Day. A presentation by Keith Saxton, Agriculture Research Service Scientist (retired), was on germination requirements and how equipment design affects crop stand establishment. A second low-disturbance no-till demonstration was developed which terminated established alfalfa/grass hay and established sudan-sorghum grass that was hayed late summer. This demonstration was used during the Dickinson Research Extension Center Field Day as well as county programs.

In January 2005 a program on no-till featuring university and Ag Canada scientists addressed soil management, rotations, and weed control concepts. Experienced no-till producers served on a panel providing answers to participant questions.

Fumigated plots in two locations provided an indication of the importance of beneficial microorganisms in soils during 2004. Corn, which is very dependent on arbuscular mycorrhizal fungi for supplying phosphorous and water showed severe phosphorous deficiency and yielded

little. This has provided an opportunity to discuss with producers and the general public the importance of maintaining healthy, productive soils.

Two PowerPoint presentations were developed in cooperation with the extension agronomist at the Carrington Research Extension Center on no-till system practices. Another PowerPoint presentation on terminating alfalfa/grass hay and establishing an annual forage crop was developed for the state agent program CD. A Chapter on no-till was written for the Minnesota-North Dakota Small Grains Handbook in 2005. Provided pictures of a demonstration to an author for inclusion in a book on no-till commissioned by the Food and Agriculture Organization, United Nations. The book is scheduled for publication in spring 2006.

Cooperating institutions and organizations: Hettinger County Extension Service, Oliver County Extension Service, Dunn County Extension Service, Stark County Extension Service, North Dakota Barley Council, North Dakota Dry Pea and Lentil Association, Dickinson Chamber of Commerce and Agriculture, Dickinson Research and Extension Center, Carrington Research Extension Center, NDSU Extension Service.

Impact: The 2003 direct seeding seminar drew 225 producers. Three traveled from northeast Colorado to attend. Twenty-two producers from adjacent states attended. Of the producers surveyed after the program, 87 percent expressed the desire to learn more about low-disturbance seeding and to view a demonstration of various styles of drill openers. Five demonstrations using the cross-slot plot drill were conducted in 2004. The drill was shown to establish consistent stands of pea, oat, wheat, and flax in conditions that were drier and colder than normal. More than 300 producers viewed demonstrations and attended agriculture improvement tours and attend the field day in 2004. Producers from Canada, Montana, South Dakota, and the Ukraine as well as from North Dakota viewed the demonstrations. One producer indicated he switched from a high-disturbance direct seeding drill to a low-disturbance direct seeding drill based on his attendance of the previous year's direct seeding seminar and the summer of 2004 demonstrations. Producers who viewed the fumigated soil plots saw the importance of arbuscular mycorrhizal fungi particularly in corn. Producers have seen how no-till systems maintain these beneficial organisms and improve the soil's productive capacity and sustainability of cropping in southwest North Dakota. The PowerPoint presentation has been used for in-service training of six county agents. The program and portions of the program has been used to teach producers about no-till practices at county producer meetings as well as the Western Pest Management School. The no-till alfalfa/grass termination program was used with four county agriculture improvement meetings where 125 producers viewed the program. Eleven producers indicated that they were interested in using the methods described in the program on their farms in spring 2006. The 2005 seminar on no-till drew 180 producers from North Dakota, Montana, South Dakota, Nebraska, and Canada. The 2005 Field Day drew 56 producers interested in forage production.

Source of Federal Funds: Smith-Lever

Scope of Impact: Multi-state ND, MT, and SD

Key Theme - Innovative Farming Techniques: Spatially Managed Farms
The area extension cropping systems specialist along with county agents from Adams, Golden Valley, Slope, and Stark Counties as well as the extension geospatial technology specialist, area farm management specialist initiated a program involving five southwest North Dakota producers to compare spatially managed variable rate application fields with whole field management systems and to improve the understanding of the economic and environmental factors important to farms who adopt geospatial technologies to produce agricultural crops. This interdisciplinary research, extension and education project will compare at least 160 acres on each of five farms. The program was initiated in March 2005.

Selected five producers in a four county area with the assistance of the county agents. Producers were provided geographical information systems software specifically designed for agricultural uses along with personal digital assistants with global positioning systems hardware and software for capturing data in the field on pest and other notable agronomic problems. Producers were required to have yield monitors, GPS, data loggers the interest in maintaining the extra records needed for program analysis. One field was selected for spatial and variable fertilizer rate practices to compare to a field managed with traditional whole field management practices. Both fields had the same crop and previous crop history.

Impact: The first year, 2005, of the project proved to be challenging in developing producer skills in using both the software and the hardware required in the project. One producer was able to get all of the equipment and software working correctly, so the comparison could be made. A comparison of yield points and input costs between the two fields showed the variable rate field net return was $9.00 to $15.00 per acre more for spatially managed fields compared to the traditional whole field management system.

Source of Federal Funds: Smith-Lever

Scope of Impact: Statewide extension

Key Theme - Plant Health: Improved Sampling Procedures and Economic Injury Levels
An improved set of techniques to sample banded sunflower moth populations and to make treatment decisions to limit yield loss in oilseed sunflower were developed. A procedure to sample populations of banded sunflower moth eggs was developed. The technique is more accurate and time efficient that the existing adult (moth) sampling procedure. Samples taken within a 400 m span of field margin accurately described the egg population within that span with an error rate of 7%. Next, egg populations were related to seed weight reduction to give an economic injury level (EIL) in units of banded sunflower moth eggs. The EIL was then combined with a new concept, economic distance, to delineate areas of the field at or above the EIL extending into the field interior from field edge sample points. The combined techniques allow fast, accurate sampling along field margins and gives sufficient time to determine if an insecticide treatment is justified. Further, the procedures map field areas needing and not needing treatment interventions. This will result in reduced management and inputs costs by more efficient sampling and decision-making and by limiting insecticide applications to portions of fields rather than entire fields.

Impact: The techniques of sampling for banded sunflower moth eggs along field margins will reduce management costs and will increase sampling accuracy. The improved accuracy will provide better yield protection by reducing risk of unnecessary treatment or of not treating when warranted. In addition, by mapping fields into treat and no-treat areas input costs in terms of insecticide and application costs will be reduced.

Source of Federal Funds: Hatch

Scope of Impact: Statewide

Key Theme - Plant Health: Integrated Disease Management of Dry Edible Beans in North Dakota

Diseases limit productivity of dry beans in North Dakota. New pathogens are being detected in North Dakota. This project evaluates novel approaches to manage these diseases and works to improve screening techniques to identify resistant germplasm. This project studies pathogenicity of newly introduced organisms and evaluates screening techniques to help identify resistant germplasm.

Identification of alternate hosts for Sclerotinia sclerotiorum, the causal agent of white mold, is important to determine what kind of crops could be used in rotations with dry bean or any other known host of this pathogen. To this effect, two new hosts have been identified. The impact of discontinuous moisture periods on the development of diseases caused by S. sclerotiorum was studied using dry bean flowers. It was concluded that intermittent wet and dry periods, as long as 8 hours wet and 24 hours dry, delay the onset of epidemics and can reduce the amount of final disease, but it will not control it completely. The information generated by these experiments will be included in forecasting models. A field survey was conducted in the fall of 2005. This is the third consecutive year of this activity. A total of 60 fields were visited; in previous years, 90 and 110 fields had been visited. The most prevalent disease observed in 2005 was common bacterial blight (CBB) with 100% prevalence and a mean incidence of 20%. Common bacterial blight has been the most prevalent disease in all surveys conducted so far. The pathogen that causes CBB is carried in or on infected seeds, although it can also be present in volunteer plants in the field. A field trial that evaluated the impact of copper fungicide applications in CBB seed transmission was conducted for the second time in 2005. A single or double applications of Copper hydroxide at the beginning of the flowering period reduced seed transmission significantly compared to the untreated control; however, it did not eliminate it completely. The second most prevalent disease was white mold caused by S. sclerotiorum. Field evaluation of Contans, a biological control agent for S. sclerotiorum, continued this year. Experimental plots were installed at two locations. Plots treated with 2 lb of Contans early in the spring of 2005 showed similar levels of disease than those protected with fungicides applied at flowering time. Soil samples collected from plots treated in previous years indicated that C. minitans, the active ingredient of Contans was still present in the soil and provided some level of residual control. Studies on biological control continued with the evaluation of ten strains isolated from highly alkaline soils from North Dakota. One of the isolates, ND6 produced similar levels of control than the commercial strain that is the active ingredient of Contans. Results of this study suggest

that strains with adaptation to North Dakota conditions exist. Future experiments will be oriented to identify practices that enhance natural control levels. Additional breeding lines with resistance to anthracnose race 73 have been identified. Preliminary data has been produced on three greenhouse screening methods that will help identify dry bean breeding lines with enhanced root rot resistance. Activities in this area will continue in the future.

Impact: Epidemiological research will be used to develop a forecasting program that will help growers make better-informed decisions on white mold management. Field surveys help breeders and extension specialists to focus on diseases considered of importance. Most dry bean cultivars planted in North Dakota are susceptible to common bacterial blight (CBB), and the disease is endemic to the region. Due to its ubiquitous presence, all is needed to have epidemics of catastrophic consequences is conducive weather conditions. Currently, no concerted efforts are conducted to screen materials for resistance and most of the data is obtained with natural levels of infection. The identification of chemical treatments that help reduce CBB seed transmission will help seed producers increase the amount of disease-free seed stocks available for growers. Research conducted in biological control is providing growers with an alternative weapon to manage white mold. Contans not only gives control levels comparable to those provided by foliar fungicide applications, but also has a residual effect that could increase levels of control over time. Root rots are a complex disease with potential to drastically reduce yields. Traditionally, root rots have been considered a problem of sandy soils; however, data collected during the field surveys indicate that the disease is also present in heavier soils across the bean growing regions in North Dakota. Efforts are being conducted to develop a greenhouse screening methodology that will help breeders speed up the process of identifying resistant materials.

Source of Federal Funds: Hatch

Scope of Impact: Statewide

Key Theme - Plant Health: Biology and Management of Soybean Diseases
Soybean is a major oilseed crop in North Dakota. There are soybean diseases that can seriously reduce yield and quality of soybean and affect grower decisions on soybean production. The purpose of this project is to understand the biology of soybean diseases and develop management practices that can reduce losses from diseases. There is emphasis on the development of disease-resistant soybean cultivars through cooperation with the soybean breeder.

Phytophthora root rot of soybean, caused by *Phytophthora sojae,* is an important soil borne disease. In 2005 we screened 1515 soybean lines for resistance and identified 666 resistant lines for the soybean breeding program. The success of the screening program is shown by the release of cultivars with resistance to the common races of the pathogen in North Dakota. Other studies on the biology of this pathogen were conducted. The sensitivity of *P. sojae*, to metalaxyl/mefenoxam was investigated. One hundred fifty one isolates of *P. sojae* representing 16 pathotypes from 75 North Dakota fields were evaluated for sensitivity to the fungicides at 5 micrograms a.i./ml. In 14 of the 151 isolates hyphal growth began after two weeks on these compounds. When hyphae on amended agar were used to inoculate plants, nine of the isolates were pathogenic, but they were less virulent than when growing on non-amended agar. The results indicate the pathogen has an unknown mechanism that allows growth and pathogenicity

in the presence of these fungicides. The genetic transformation of *Sclerotinia sclerotiorum,* the cause of white mold, with a reporter gene was undertaken to provide a tool to study the interaction of the pathogen with its hosts. Two isolates were transformed using constructs pCT74 and gGFP both containing genes for the green fluorescent protein (GFP) and hygromycin B phosphotransferase. A protoplast-PEG (polyethylene glycol) transformation method was employed. Stable transformants with strong fluorescence were obtained and all were pathogenic on soybean, bean, canola and sunflower. Infected tissues were examined and hyphae of transformants fluoresced in and on host tissue and could be distinguished from the plant cells. These GFP transformants are currently being used to examine host resistance in a variety of crops. Studies were conducted on the effect of *Fusarium solani* on pre- and post-emergence damping off of soybean. The results demonstrated that high soil inoculum density (ID) results in pre-emergence damping-off of soybean, but no significant post-emergence damping-off. With strain 31-2F in a fine sandy loam, an ID of 25,000 spores per gram of dried soil reduced emergence by 25% while the reduction was 50% with isolate 115-3. Reductions up to 90% were observed in some experiments with densities of 1,000,000 spores per gram of soil. The effect of inoculum density on seedlings was greater in a fine sandy loam than in a heavy clay soil. This is the first conclusive evidence that *F. solani* is involved in damping-off of soybean seedlings. A study is underway to determine the effect of crop rotation on soybean cyst nematode (SCN) egg levels in 15 naturally infested commercial soybean fields. Crop rotation will be one of the tools to control this new disease that was recently found in North Dakota. In addition, in cooperation with the soybean breeder, we are screening lines for resistance to SCN.

Impact: This research has a major impact on reducing losses from disease through incorporating resistance to Phytophthora root rot and SCN into soybean cultivars. Public cultivars with resistance to Phytophthora have been released by NDSU. In addition, understanding the effect of cultural practices on populations of pathogens will lead to strategies which growers can use to control important diseases.

Source of Federal Funds: Hatch

Scope of Impact: Statewide

Key Theme - Plant Health: Resistance of North Dakota Wheat to Tan Spot and Leaf Rust
Leaf rust and tan spot are two serious leaf diseases of wheat in the United States. Combined yield losses can exceed $100 million in North Dakota alone. Genetic resistance in the host is the efficient and safe way to control plant disease. This project will assist in the development of wheat varieties resistant to these two diseases. Breeder's lines and commercial cultivars of durum, hard red spring, and winter wheats were evaluated in three nurseries for resistance to the natural population of leaf rust (Puccinia triticinia). Most widely grown commercial cultivars are either susceptible or moderately susceptible to T races of the fungus. This means that North Dakota wheat production is at risk to devastating rust epidemics. However, newer varieties, such as ND Steele, Glenn, and Howard appear to possess excellent resistance against the T races. This resistance probably comes from the Lr21 gene. Greenhouse and field experiments suggest that several advanced breeding lines appear to possess this gene. In other experiments conducted in collaboration with USDA-ARS, a toxin-insensitivity gene associated with resistance to

Stanonospora nodorum, was mapped to chromosome 1B. This gene, designated SnTox1, was identified in a segregating population derived from W-7984 and Opata 85. Chromosomal location was confirmed with Chinese spring wheat nullisomic-tetrasomic lines. A population of HRSW derived from a cross between a Brazilian wheat and the ND cultivar Grandin was shown to segregate for resistance to tan spot and leaf rust. The resistance to leaf rust may be conditioned by a gene not currently in the North Dakota breeding program.

Impact: This research will enhance farm productivity in the short- and long-term by identifying and incorporating disease resistance genes into adapted cultivars and by enhancing our basic understanding of plant/pathogen interactions.

Source of Federal Funds: Hatch

Scope of Impact: Multi-state

Key Theme - Plant Health: Annual Weed Control in Crops
Spring application of clethodim and quizalofop provided 95% control of downy brome. This is greater than other reports of ACCase activity on downy brome, but sethoxydim and clodinafop gave ineffective control downy brome control. Imazamox provided 91% control and propoxycarbazone gave 83% control of downy brome.

Pinoxaden, fenoxaprop, and clodinafop provided excellent control of wild oat, but control with flucarbazone and mesosulfuron was marginal because of cool, wet growing conditions. Pinoxaden control of wild oat was not antagonized by bromoxynil&MCPA5 or thifensulfuron&tribenuron. However, bromoxynil&MCPA5 and other broadleaf herbicides reduced control of wild oat with fenoxaprop or clodinafop by 5 to 25 percentage points and reduced control with flucarbazone by 3 to 15 points.

Flucarbazone applied 7 days before seeding or the day of seeding provided 75 to 85% control of yellow foxtail and wild oat, indicating soil activity in addition to the known post-emergence activity on grass weeds. Flucarbazone also controlled wild mustard pre-emergence but only had activity on Canada thistle when applied post-emergence, providing 83 to 86% control of Canada thistle.

Control of wild buckwheat is important to prevent yield loss by competition and harvest inefficiency. Treatments containing clopyralid and fluroxypyr provided 92% control or better of wild buckwheat. DE-750&fluroxypyr alone or with 2,4-D provided 97% control or better, but DE-750&fluroxypyr plus tribenuron or thifensulfuron reduced the control achieved. Thifensulfuron and tribenuron gave 80 to 90% control of wild buckwheat.

Impact: Range of downy brome infestation is increasing in North Dakota. One favorable outcome of research has been the education of land managers that downy brome is a threat in North Dakota. Awareness is a key component to slowing or stopping the spread of downy brome into cropland. Research has identified several herbicide options other than glyphosate that could be used to control downy brome on the 1000s of acres already infested with this weed.

Wild oat has been a persistent problem in small grain fields for many years and has developed resistant biotypes to several herbicides. Research has demonstrated that pinoxaden will control several populations of resistant wild oat. Therefore, pinoxaden will be a useful new technology for wild oat control programs that deal with resistant biotypes of wild oat.

Research has confirmed that cutting rates of wild oat herbicides often can save producers $2 to $4 per acre and still control wild oat. However, under several circumstances, including high wild oat populations, poor weather conditions, and the addition of some broadleaf herbicides, wild oat control was reduced. The additional $2 to $4 per acre investment in wild oat herbicide provided $12 to $24 per acre return.

Source of Federal Funds: Hatch

Scope of Impact: Multi-state

Key Theme – Emerging Infectious Diseases: Sugarbeet Disease Research
North Dakota ranks second in sugarbeet acreage, providing 17 percent of the nation's supply. In 1998, sugarbeet growers in North Dakota and Minnesota lost $113 million to a Cercospora leaf spot epidemic. Isolates of Cercospora were found to be resistant and/or tolerant to the benzimidazole and triphenyltin hydroxide (TPTH) fungicides. From 1999 through 2004, the EPA has granted our sugarbeet extension specialist request to use Eminent, a tetraconazole fungicide, to control Cercospora leaf spot. EPA provided a full label for Eminent in 2005. The average number of fungicide applications applied per acre was reduced from 3.74 in 1998 to 2.06 in 2005, and 97% of surveyed respondents indicated good to excellent disease control. Rhizoctonia, Rhizomania and Fusarium are also becoming more severe in sugarbeet fields. Management strategies are being developed to better manage these diseases using resistant varieties and fungicides where applicable.

Impact: Researchers tested different fungicides to control Cercospora including resistant and/or tolerant strains. This has led to the full registration of two new effective strobilurin fungicides, Headline and Gem, in addition to Eminent. The use of Eminent and the strobilurins fungicides in an alternation program with TPTH has resulted in improved efficacy of TPTH, and *Cercospora beticola* populations that are more sensitive to TPTH. Specialists have also determined that azoxystrobin should be applied when the temperature at the four inch soil depth is between 62 and 73ºF for best control of Rhizoctonia crown and root rot. Researchers in North Dakota, Minnesota and Montana are also looking at control strategies that integrate disease-resistant crops and timely fungicide applications to manage new and emerging diseases.

Source of Federal Funds: Hatch and Smith-Lever

Scope of Impact: Multi-state research and extension, MN and MT

Key Theme - Niche Market: Feasibility of Biodiesel from Minor Oil Crops

Tools are needed to evaluate and compare different available raw materials, and process parameters and modifications for biodiesel production. To address this need, a biodiesel process model was developed last year with commonly used spreadsheet software and process-engineering principles. The basis of the model is a continuous process with two stirred-tank reactors and sodium methoxide catalysis. The model can be readily adapted for use on most personal computers, and requires little training compared to specialized process modeling software. The biodiesel process was represented as 27 units with 51 flows and 18 components. Process flows were calculated for a small biodiesel plant with a capacity of 5 million gallons/yr, and from these results, process equipment was sized and overall process costs predicted. Simultaneously, a pilot process for producing 20-gallon batches of biodiesel was developed. A total of 270 gallons of canola biodiesel was produced for use in demonstrations in field equipment used at the North Central RE Center. This biodiesel successfully passed key ASTM standards for total and bound glycerine, acid number, sulfated ash content, and flash point (independently tested by Intertek Caleb Brett, Deer Park, TX). The experience gained in producing biodiesel helped strengthen the model.

Impact: Biodiesel use is established in the United States; however, a more efficient process to use different fats and oils is needed. This will ensure that the biodiesel industry will be competitive with other transportation fuels and meet sizable future demand. A number of alternative processes and raw materials for biodiesel have been proposed in recent years, but models such as the one just developed will permit much more than the previous superficial analyses of alternative processes.

Source of Federal Funds: Hatch

Scope of Impact: Multi-state

Program 2: Competitive and Profitable Animal Production

Key Theme - Agricultural Profitability: North Dakota Dairy Diagnostic Program
The North Dakota Dairy Diagnostic Program's (ND3P) central focus is to sustain and grow the state's dairy industry. Enhancing the income and changing the lifestyles of our dairy farm families are accomplishing this. Using self-chosen advisory teams, these participants are transitioning their dairy enterprise and whole farm operations to meet personal and business goals.

Dairy is the original value-added agricultural industry. According to various economic impact reports, for every one dollar spent in dairying, a rural community can expect it to be reinvested from 2.67 to 7 times in the form of locally purchased supplies to support of infrastructure. In addition, intangible benefits include the development of strategic alliances among dairy operators and their many service providers. The experience also provides on-the-job training in methods to evaluate progress, to establish long-term business relationships, to reduce professional barriers, to improve communication, and to set personal goals and professional growth strategies.

Impact: Directed by the NDSU Extension Dairy Specialist and coordinated by ND3P facilitators, dairy families monitor and measure the impact of decisions formulated by their

advisory boards. Since the inception of this program, over 15% of North Dakota dairy farms (based on: NDDA, January, 2006) have participated in the program.

Accomplishments from selected farms (57 farms have been involved in the program):

Gross Annual Economic Impact --

Farm #1: In three years lowered debt to equity ratio from 4.96:1 to 1.4:1; repayment capacity went from 0.94:1 to 2.57:1. **Annual Impact =** Improved debt service.

Farm #2: Instituted a calf health and vaccination program that helped to lower dairy enterprise death loss from 20% to 2%. Reduced the number of calves treated for sickness from 30% to 1%. **Annual Impact =** $11,250 plus the value of the calves.

Farm #3: Developed a management and nutrition plan which discontinued a herd injection strategy with minimal loss of milk production. = **Annual Impact:** $49,550.

Farm #4: Reorganized labor arrangements over a 2-year period to lower costs and improve overall labor efficiencies. **Annual Impact:** = $71,958.

Farm #5: Improved management of calf-rearing facilities raised the quality of replacement heifers and resulted in an increase in milk yield for first-calf heifers (compared to the previous year) by 5 pounds per cow per day. **Annual Impact:** = $52,613.

Farm #6: Coordinated expansion plan increased milking herd from 47 to 82 head and cash inflows. **Annual Impact =** $20,372.

Farm #7: Implemented a dairy diagnostic plan that helped increased the net worth (difference between beginning and ending balance sheets) to over $25,000 for the 2005 production year. **Annual Impact:** = $25,000.

Impact on Net Income --

Farm #8: Implemented advisory plan increased the dairy enterprise net income, after inventory change and depreciation, from $25,221 to $436,850 in 3 years (includes total of three years income). **Annual Impact:** = $953,573.

Dairy Marketing Club:

The state's only dairy marketing club, the South central Dairy-Marketing club is lead by a ND3P facilitator who assists in addressing current topics related to the dairy industry that affects dairy markets, animal health, records, contract arrangements, and price risk protection.

Source of Federal Funds: Smith-Lever

Scope of Impact: State specific

Key Theme - Agricultural Competitiveness: Dairy Retention and Sustainability

The North Dakota Dairy Coalition (NDDC) is a grass roots organization dedicated to the revitalization of our dairy industry. The NDSU Extension Service, the Animal and Range Sciences Department, the North Dakota Department of Agriculture – Dairy Division and the North Dakota Association of Rural Electric Cooperatives provided momentum and support for the evolution and formation of the Dairy Coalition.

Impact: Dairy ranks second in gross cash receipts from North Dakota animal agriculture. Dependant on agriculture sustainability, the future of rural North Dakota is at stake. Future projections suggest the Upper Midwest will be the region of choice for dairy growth by the year 2020. Unfortunately, an aging industry has the state's dairy infrastructure at significant risk. Decisive action is essential in order to position our state to capture the opportunities for future dairy development.

The action of the NDDC is a long-term effort that is quickly gaining momentum. Many of our rural communities are now beginning to understand the significance of the dairy economic multiplier. Moreover, requests for more detail by producers from other states are a strong indication that North Dakota is serious about dairy growth. For example, the Dairy Coalition currently has 13 pre-permitted sites near communities that welcome new dairy farm families to their area (map available at http://www.nddairy.com/sites.htm). Equally notable is that people respect the approach we use, appealing to both dairy farm families from other states, and to support our existing dairy producers. The NDDC has made a lot of progress in laying the groundwork for future growth in the ND dairy industry.

Source of Federal Funds: Smith-Lever

Scope of Impact: State specific

Key Theme - Animal Health: Volunteer Johne's Program for North Dakota
In conjunction with the Office of the State Veterinarian, we assessed and developed a voluntary Johne's control program for North Dakota dairy and beef producers to help control Mycobacterium avium paratuberculosis in cattle.

Impact: Through the combined efforts of the Office of the State Veterinarian and the NDSU Extension Service, the confidentiality laws of North Dakota were changed in 1999 so that testing results for Johne's disease status were exempt from public disclosure. From 1984 to 1994, approximately 25 cases of Johne's disease were reported in cattle. In the year 2000, 370 herds were tested for Johne's and 210 were positive, indicating that more producers are willing to have their herds tested and control of the disease will be improved.

In 2001, a voluntary Johne's control program was implemented to help those producers wanting to "clean up" their herds. The Office of the State Veterinarian administrated the program and the North Dakota extension veterinarian provided educational materials and clinics for veterinarians and producers. During this initial year, 19 herds were enrolled in the program. In 2003, 78 producers were enrolled in the program. In 2004, 140 producers were enrolled in the program and of these, two were goat herds, 93 were beef herds and 45 were dairy herds. In 2005, 157

producers were enrolled in the program and of these, one was a goat herd, 115 were beef herds and 41 were dairy herds.

An additional initiative, called the “C-punch” was implemented with the 2001 voluntary Johne's control program. To control Johne's in cattle, a permanent identification needs to be placed on the animal. Some states have instituted a "J-punch" program whereby infected cattle are ear notched with a letter "J" to signify Johne's. In North Dakota, we were concerned about stigmatizing producers and their cattle by placing a "J" in the cattle's ear. In response, the "C-punch" was developed. The letter "C" stands for cull. Animals ear notched by this means signify to sale barns, order buyers and other potential purchasers of livestock that cattle marked with a "C" are intended for the slaughter market only and are not to be put back into a production unit. The "C-punch" does not imply a production unit is infected with Johne's. "C-punches" have been provided to all livestock auction markets across the state and to veterinarians and producers who wish to use the device. Multiple states have contacted North Dakota with the desire to start a "C-punch" program. The long-range impact of this program will be national. Many states (e.g. Hawaii) have contacted North Dakota with the hopes of following North Dakota's lead in establishing a voluntary Johne's control program and the use of the "C-punch."

Source of Federal Funds: Smith-Lever

Scope of Impact: Multi-state research and extension

Key Theme - Animal Health: West Nile Virus
In conjunction with the State Veterinarian's office, the North Dakota Dept. of Health and the NDSU Veterinary Diagnostic laboratory, a surveillance system for West Nile Virus and an education initiative were implemented.

In the summer of 2002, West Nile Virus spread across the Upper Great Plains. In North Dakota, 579 horses were affected and 35 percent of those died. The first case was reported on June 30. August had the most cases with 350. In response to this emerging disease, a conference was organized to educate veterinary practitioners on West Nile Virus and appropriate response and treatment. In the winter and early spring of 2003, a major education initiative was conducted by the extension service including county agents, private veterinary practitioners and the extension veterinarian. The major focus of the education initiative was appropriate vaccination of horses. In 2004 the surveillance system was continued during the vector season. West Nile programming aimed at the horse owner was continued in an effort to educating producers for the need to continue vaccination in order to protect their horses. In 2005 the surveillance system was continued during the vector season. West Nile programming aimed at the horse owner was continued in an effort to educating producers for the need to continue vaccination in order to protect their horses.

Impact: An outbreak in 2003 never occurred. For the longer term, West Nile Virus will now be considered endemic and will become a routine vaccination protocol unless some unknown adverse event occurs.

Source of Federal Funds: Smith-Lever

Scope of Impact: Multi-state research and extension

Key Theme - Animal Health: Regional Anthrax Control Program
In 2005, over 500 animals were lost to anthrax in North Dakota. In conjunction with regulatory, public health and extension veterinarians in Manitoba, Minnesota, North Dakota, and South Dakota, North Dakota State University entered into a regional program to assess the current knowledge about anthrax and develop recommendations for a unified anthrax education and control program for the region.

Impact: A regional meeting of regulatory veterinarians, public health veterinarians, extension veterinarians and international experts in anthrax was convened in Fargo, ND in October of 2005. The attendees were from Louisiana, Manitoba, Minnesota, North Dakota, and South Dakota. Information was exchanged on current anthrax recommendations from each state/province. Commitments were made to try to establish unified recommendations on the education and control efforts among the participants. Subsequent to this meeting, NDSU extension personnel received funding from the ND State Board of Agricultural Research and Extension to study the anthrax outbreak of 2005 from which recommendations can be made to this regional consortium for a unified anthrax education and control program.

Source of Federal Funds: Smith-Lever

Scope of Impact: Multi-state research and extension

Key Theme - Agricultural Profitability: Feedlot Development in North Dakota
Numerous research and demonstration projects were conducted to determine the value of feeding producer- owned cattle in North Dakota and demonstrate that cattle can be cost-effectively fed to finish in North Dakota. NRCS Equip funds and EPA 319 watershed funds have been used to build numerous 1000+ head feedlots designed for manure and water run off control. The NDSU Extension Service continues to deliver the North Dakota feedlot school, advanced cattle-feeding workshops (Feedlot MDA) and many backgrounding/feeding seminars for lenders and feeders to enhance feedlot management skills and improve knowledge of feeding and marketing.

Impact: The NDSU Extension Service showed that it cost up to 3 cents less per pound to finish cattle in North Dakota compared to an out-of-state feedlot. Cattle producers are participating in feedout projects where they commingle groups of 3- 6 cattle per consignor at a university feedlot for finishing. While cattle returns over expenses have averaged over $100 per head for spring marketed calves during the past three years, the range between the most profitable group and the least is over $200 per head. More than 450 producers attended extension feedlot schools in the last five years. Lenders are exploring additional financing of cattle, feed, and cattle feeding facilities in North Dakota and have creatively increased funds for expanding feedyards including a feedlot loan guarantee program. One participant estimated that better health practices, bunk management and feeding practices cut cost of gain by up to 5 cents per pound. Another participant has increased the number of cattle owned for feeding from 1000 head to 5000 head

through the use of custom feedlots. Privately owned custom feedyards are being built in a response to increased education and public funds for improving water quality with reduced manure runoff.

Source of Federal Funds: Smith-Lever

Scope of Impact: Multi-state integrated extension and research, KS, MT, SD, MN, WI and WY

Key Theme - Agricultural Competitiveness: Leadership and Economic Development
Through a series of hands-on leadership development classes, cattle producers continue to develop business plans for economic development opportunities. Cattlemen then explore implementing the plans and assessed community and economic feasibility. Through continued extension facilitation and guidance and informational assistance, business plans, financing packages and equity drives and management strategy were developed for cooperative cattle feedlots, a limited liability partnership that owns cattle for custom feeding, a cattle financing cooperative, a limited liability company owning a local meat processing plant with sole-source delivery rights, a limited, limited liability partnership (LLLP) for owning cattle for feeding to finish and a marketing company for merchandizing locally grow, fed, and processed beef. Producers involved in the program have emerged as directors and managers of the proposed plans.

Impact: Cattle producers in central North Dakota realized that working as a group would provide more economic development than could be accomplished individually. Through educational sessions and continued facilitation and instruction, producers were able to develop several new vertically integrated cattle business ventures. The cooperative cattle feedlot plan has constructed a 7,000-head cattle feedlot located in a cow-calf region where feed grains are traditionally low-priced. The limited liability partnership that owns cattle for custom feeding has returned a 23.5 percent return on equity during a one-year period for 23 cattlemen involved. Other cattle feeding alliances have been developed as limited liability partnerships (LLP) and limited, limited liability partnerships (LLLP).

A cattle-financing cooperative was developed for local producers and now provides financing for 95 percent of the calf purchase price with low-interest notes. The finance cooperative has grown 25 percent per year for cattle financed. Fifty-six cattle producers wanted to develop an outlet for supplying finished cattle at a 10 percent added-value premium and opened a 5000 head capacity beef processing plant. Forty-four producers developed limited liability company to sell fresh and processed meats into a regional market.

Source of Federal Funds: Smith-Lever

Scope of Impact: Multi-state extension. Cooperative feedlot owners are from ND, MT, SD and WY. Financed cattle are marketed to IA, SD, NE and MN. Processed meat products have markets in ND, MN, WI, SD, CA, IL, MI, NJ, NY, LA, CO, IA and internationally.

Key Theme - Adding Value to New and Old Agricultural Products: Dakota Heritage Beef, Sheyenne Valley Brand Beef, and North Dakota Beef LLC

Two surveys and a focus group were conducted for Dakota Heritage Beef, a group of southwestern North Dakota and northwestern South Dakota ranchers. The purpose of the first survey was to determine consumer interest and potential for a test market in a branded beef product. The second survey was to gauge consumer satisfaction of their purchase. Important findings included: Consumers indicated they were interested in buying locally produced beef (64.3 percent would pay a premium). Quality was more important than price as the determining factor in buying beef (85.8 percent). More than 77 percent of the survey respondents found the product through in-store promotions. And more than 91 percent were interested in future purchases. Producers are considering purchasing shares in a multi-state beef processing cooperative. A meat processing company developed by local cattle producers has started marketing fresh and processed 'natural, age and source verified beef' via the Sheyenne Valley brand label. Another group of investors is developing a natural beef and bison product line for national markets

Impact: Consumer willingness to pay for locally produced food products is an important element in determining the feasibility of value-added ventures. Impacts of the survey indicate further analysis is warranted in determining the feasibility of facilities for producing branded beef products. New jobs were created construction and operation of a processing facility for harvesting, processing and cooking meat from animals grown in the local community. Also sales and marketing jobs were created when a marketing company was established to develop and service a larger market area. This specialty market development has led to an increase the number of feedyards and the number of cattle fed special diets to cattle for specific companies and their markets.

Source of Federal Funds: Smith-Lever

Scope of Impact: State specific

Key Theme - Animal Production Efficiency: Improving the Reproductive Performance of Livestock

Economic analysis has shown that a critical aspect of reducing the high input costs of livestock production is to improve reproductive efficiency. Because maintenance of reproductively sound females is the primary expense for livestock producers, reproductive failure remains one of the most costly factors facing the livestock industry. Therefore, reproductive performance of farm animals is a major limiting factor in efficient production of meat animals. Studying the growth and development of the blood vessels in ovarian tissues is an important aspect of understanding the basic mechanisms that regulate reproductive processes and will lead to the development of improved methods of controlling ovarian function in cattle and sheep. Evaluation of the role of placental size and blood vessel growth in fetal growth and development in cattle and sheep is necessary to understand how placental growth influences both prenatal and postnatal health and postnatal growth and development. A recent focus of nutritional effects on pregnancy outcome and fetal and placental growth increases the scope of this research area. The long-term objectives of this project are: 1) to optimize assisted reproductive technology (ART) techniques to obtain

large numbers of good quality oocytes and embryos for embryo transfer programs, 2) to evaluate the mechanisms resulting in the development of healthy oocytes and embryos for increasing reproductive efficiency in domestic livestock, 3) to evaluate the role of gap junctions in the regulation of reproductive function in domestic animals, and 4) to evaluate the role of placental size and blood vessel growth in fetal growth and development in cattle and sheep.

Impact: The improvement and optimization of assisted reproductive procedures and better understanding of mechanisms resulting in the development of healthy oocytes and embryos for increasing reproductive efficiency may lead to practical and/or commercial applications in domestic livestock production and human medicine. There is a growing demand among farm animal producers for modern methods to improve reproductive efficiency and lower the cost of producing better quality animals. Improved embryology/ART methods will provide the means to help producers apply modern biotechnologies such as cryostorage of embryos, preimplantation genetic diagnosis, and embryo cloning to meet their needs. Modernization and/or adoption of existing techniques and discovery of new ones could have immediate benefits to animal production. Improvements in methods of regulating ovarian function, of obtaining large numbers of high-quality embryos for use in embryo transfer programs and of optimizing placental function and fetal growth in livestock will ultimately give livestock producers' important tools to improve the reproductive management of their animals and increase overall efficiency of livestock production.

Source of Federal Funds: Hatch

Scope of Impact: Multi-state research

Key Theme - Animal Production Efficiency: Enhancement of Reproductive Parameters in Domestic Livestock

Economic analysis has shown that a critical aspect of reducing the high input costs of livestock production is to improve reproductive efficiency. Because maintenance of reproductively sound females is the primary expense for livestock producers, reproductive failure remains one of the most costly factors facing the livestock industry.

The long-term objectives are: 1) to optimize assisted reproductive technology (ART) techniques to obtain large numbers of good quality oocytes and embryos for embryo transfer programs, 2) to evaluate the mechanisms resulting in the development of healthy oocytes and embryos for increasing reproductive efficiency in domestic livestock, and 3) to evaluate the role of gap junctions in the regulation of reproductive function in domestic animals. In Experiment 1, we demonstrated that overnutrition and undernutrition of donor ewes resulting in changes of BW and BCS, has a negative effect on oocyte quality that results in lower rates of cleavage, and morula and blastocyst formation. These data demonstrate that nutrition levels substantially affect in vitro fertilization and early embryonic development. In Experiment 2, we have shown that the rates of gap junctional intercellular communication (GJIC), progesterone secretion, and gap junctional protein connexin (Cx)43 mRNA expression in luteal cells were affected ($P<0.0001$-0.05) by the day of the estrous cycle, cell density, and treatments (luteinizing hormone or dbcAMP). Progesterone secretion was positively correlated ($P<0.0.001$) with the

rates of GJIC (r^2=0.421) and Cx43 mRNA expression (r^2=0.598), and the rates of GJIC were positively correlated (P<0.001) with Cx43 mRNA expression (r^2=0.482). Cx43 was detected on the luteal cells borders. These data demonstrate a relationship between progesterone secretion by luteal cells and gap junction function. Thus, gap junctions are likely involved in regulation of steroidogenesis in the CL. In Experiment 3, we demonstrated that expression of Cx37 depends on the stage of luteal development, differentiation and regression and suggests a role of Cx37 in luteal function. Knowledge of the pattern of connexin expression, coupled with studies of the functional consequences of connexin expression, may lead to improved methods of estrous cycle regulation and ways to influence fertility in humans and domestic livestock.

Impact: The improvement and optimization of assisted reproductive procedures and better understanding of mechanisms resulting in the development of healthy oocytes and embryos for increasing reproductive efficiency may lead to practical and/or commercial applications in domestic livestock production and human medicine. There is a growing demand among farm animal producers for modern methods to improve reproductive efficiency and lower the cost of producing better quality animals. Improved embryology/ART methods will provide the means to help producers apply modern biotechnologies such as cryostorage of embryos, preimplantation genetic diagnosis, and embryo cloning to meet their needs. Modernization and/or adoption of existing techniques and discovery of new ones could have immediate benefits to animal production.

Source of Federal Funds: Hatch

Scope of Impact: Multi-state research

Key Theme - Rangeland/Pasture Management: Evaluating the Effects of Drought and Grazing on Rangeland

Rangelands of the upper Great Plains region are important to the well-being of the livestock industry and wildlife populations. There are nearly 1 million beef cows in North Dakota comprising nearly a $750 million contribution to the agricultural income of the state. Many of these beef cows forage on rangelands for much of their annual dietary needs. Drought is a common occurrence in the upper Great Plains region historically occurring in 20-40% of years in the past century. Controlling drought is not a possibility, but proper livestock management during drought periods should temper the impacts of drought. NDSU researchers are using automated rainout shelters to simulate drought on mixed grass prairie.

Impact: Researchers found that heavy grazing leads to declines in herbage biomass, root biomass and randomness in distribution of forb populations after 12 years of season-long grazing. Moderate grazing intensity appears to maintain plant species diversity and allows deeper rooting of plants compared to the heavy grazing intensity which should be beneficial to proper rangeland ecosystem functioning, health, and sustained yield. After 15 years of continuous grazing and two years of simulated drought, basal cover of green needlegrass decreased while total and sedge basal cover increased. Total herbaceous yield decreased under intensive grazing and consecutive years of simulated drought. Drought treatments were monitored for recovery in 2005 under natural rainfall conditions. Total herbaceous yield recovered on the drought

treatments under both grazing intensities to pre-drought levels. The mixed-grass prairie of the upper Great Plains is a highly resilient grassland to grazing intensity and drought.

Source of Federal Funds: Hatch

Scope of Impact: Multi-state research, SD and MT

Key Theme - Bioterrorism: Preparing for Biological Terrorism
Homeland security and more specifically biological terrorism are real threats for an agriculturally based state like North Dakota. There were two primary areas of programming in bioterrorism, the North Dakota Reserve Veterinary Corps and the training of all livestock and agronomic agents in bioterrorism.

In conjunction with the State Veterinarian's office, a plan of action was implemented to raise the awareness of veterinary practitioners about homeland security and then develop the concept of the North Dakota Reserve Veterinary Corps. As a continuation of efforts initiated in 1998, the office of the extension veterinarian helped to plan, coordinate and deliver a bioterrorism preparedness and response training initiative for veterinary practitioners within North Dakota. In 2004 an auto-tutorial and training materials were created for use by county agents and others. These educational materials are available via the extension web site and offer PowerPoint presentations for use by the individual or in a classroom setting. This was a collaborative project with the USDA: APHIS Veterinary Services and the N.D. State Veterinarian. In 2005 bioterrorism awareness and training sessions were conducted throughout the state. Because agricultural agents reside in every county of the state, they are a key resource in the monitoring, surveillance, and recovery efforts involved in a bioterrroristic event. All agricultural agents were trained utilizing a two-day course developed by the extension service.

Impact: A North Dakota Reserve Veterinary Corps was initiated. In 2003, twenty-four practitioners were trained and equipped through the Corps. The veterinary practitioners were trained in the use of laptops, GPS units and digital photography to be able to investigate unusual cases rapidly and send those findings electronically to any expert in the world for consultation and verification. This is a model program for the nation. Other states such as Maryland are organizing private veterinary response teams. Agents were familiarized with animal and plant diseases, trained in incident command and familiarized with the extension disaster recovery plan. County agents were not trained to be first-responders, but were trained to assist the county incident commander with education, communication, and recovery efforts.

Source of Federal Funds: Smith-Lever

Scope of Impact: Multi-state extension

Key Theme - Animal Production Efficiency: Feed Utilization
Animal feed utilization studies have focused primarily on cattle and sheep. In addition to productivity realized by traditional, co-product and new feed regimens, considerable attention

has been directed at sources, intake, and fates of metabolizable protein. Research has also addressed selenium metabolism and interactions between nutrition and pregnancy in domestic livestock.

Impact: Inclusion of a seaweed extract in cooked molasses blocks increased forage digestibility when low quality forages were fed. Inclusion of flax seed in cooked molasses blocks did not improve performance of calves during the receiving period.

Processing sprouted feed barley in backgrounding and finishing diets resulted in improved feedlot performance. Addition of wet corn gluten feed, a co-product of high fructose corn syrup production, to barley-based finishing diets resulted in improved performance compared to diets based on dry-rolled barley.

Source of Federal Funds: Hatch and Smith-Lever

Scope of Impact: Statewide research and extension

Key Theme - Animal Production Efficiency: Supplementation Strategies to Improve Cow-Calf Production Efficiency and Profitability

Many forages do not contain enough nutrients for gestating or lactating beef cows, making supplementation necessary. The purpose of this project is to determine the effect of supplementation on cow weight gain and digestibility of the forage.

Inclusion of a seaweed extract in cooked molasses block supplements for cattle fed low-quality forages resulted in improved forage digestibility. This may be one means to improving performance of livestock fed or maintained on low quality forages for a portion of the production cycle.

Inclusion of corn dried distillers grain with solubles, a byproduct of the ethanol industry, in creep feeds appears to be a viable alternative to traditional byproduct based creep feeds. Similar digestibility and ruminal fermentation parameters were achieved when corn dried distillers grains with solubles replaced a proportion of the wheat middlings, soybean meal, and soybean hulls in creep feeds for calves grazing native range.

Corn condensed distillers solubles appear to be a useful protein supplement for cattle fed low-quality forages. Inclusion of up to 15% of the diet with corn condensed distillers solubles resulted in no apparent negative effects on ruminal fermentation and digestion. In fact, additions of this co-product improve digestion of protein and resulted in more microbial protein production in the rumen when fed as a supplement to low quality forages.

Impact: Research in this area will increase understanding of forage supplementation strategies for cow-calf producers in the northern plains area. In addition, identifying co-products that are suitable supplements increases the number of options producers can choose from as they make supplementation decisions. This will lead to increased competitiveness and enhanced profitability for ranchers in the region.

Source of Federal Funds: Hatch

Scope of Impact: Statewide

Key Theme - Animal Production Efficiency: Role of Compensatory Growth in Lactation Persistency

The success of replacement heifer programs is measured in terms of efficiency of body growth, and more importantly, by the milk-yield potential of the heifer. The capacity to produce milk in turn is largely influenced by the degree of mammary development. Nutritional management during gestation is critical to mammary development and life-long lactation performance. This research will examine the effectiveness of compensatory mammogenesis induced nutritionally during late gestation on permanent enhancement of lactation persistency.

To better understand the role of nutrition in regulating mammary gland development and lactation, we designed a novel stair-step compensatory nutrition regimen that is a unique combination of dietary energy restriction and realimentation (refeeding) phases; the basic concept of this regimen is to exploit the biological nature of the compensatory growth phenomenon in concert with one or more hormone-sensitive allometric phases of mammary development (i.e., peripuberty through gestation). Nutritionally induced compensatory growth during different developmental stages before first parturition positively affects mammary development and life-long lactation performance. This permanent enhancement of mammary gland growth and lactation potential strongly suggests a possible mechanistic link between nutritionally induced compensatory growth, epigenetic control of mammary gene expression, and metabolic imprinting. Thus, we hypothesize that compensatory-directed metabolic imprinting once set during late pregnancy prior to the first parturition persistently maintains and exerts its adaptive response on mammogenesis and galactopoiesis (i.e., maintenance and/or enhancement of milk secretion). The ability to influence heritable genes regulating milk synthesis may be used to improve the quality and quantity of milk (e.g., infant health, the secretion of certain immunoglobulins or growth factors) as well as the longevity of lactation.

Impact: We have established that the stair-step compensatory nutrition regimen has lasting effects on mammary development, differentiation, and lactation. Thus, the principal challenge will be to document the extent to which nutritionally directed compensatory mammary hyperplasia induced once during the first gestation affects methylation status, thereby producing stable epigenetic changes in genes, the result being a metabolic imprinting process. If heritable genes regulating milk synthesis are identified, the possibility exists to manipulate genes to further improve lactation as well as the longevity of lactation. In the biomedical field, the ability to influence heritable genes regulating milk synthesis may be used to improve quality and quantity of milk (e.g., infant health, the secretion of certain immunoglobulins or growth factors); in the animal industry, an increase in lactation efficiency could increase profits without increasing cow number, which has economic as well as environmental impact (e.g., land use).

Source of Federal Funds: Hatch

Scope of Impact: Statewide

Program 1

Allocated Resources ($ x $1,000)		**FYO5**
1862 Extension ($)	Smith-Lever	616
	State	924
	FTE	22.0
1862 Research ($)	Hatch/McIntire	1,360
	State	2,000
	FTE	40.0

Program 2

Allocated Resources ($ x $1,000)		**FYO5**
1862 Extension ($)	Smith-Lever	336
	State	504
	FTE	12
1862 Research ($)	Hatch	170
	State	250
	FTE	5

Goal 2: A Safe and Secure Food and Fiber System

***Overview**: There is an increased awareness of food safety issues in North Dakota and the country. Large-scale food production and marketing systems and food prepared in institutional or restaurant settings have the potential for large-scale outbreaks of foodborne illness.*

At the same time, food-related businesses are a growing sector of the North Dakota economy. Also, North Dakota producers play a key role in supplying food for the nation and world. Efforts to safeguard the food supply at the consumer level by improving food safety during food processing and protecting crops are important functions of NDSU research and Extension.

The NDSU Extension Service has developed materials based on the national Fight BAC produce safety and BAC Down campaign. Extension has partnered with other agencies to help ensure the safety of North Dakota-produced foods for the past 11 years. "Nutrition Facts" labeling of North Dakota food products has been provided since 1994. NDSU has tested more than 175 food products for acidity and water activity for compliance to federal regulatory standards. Several products did not meet the federal government standards for acidity and were re-formulated for safety. "Nutrition Facts" labels have been developed for more than 400 North Dakota food

products on the market. On-line modules promoting food safety in temporary food stands and farmers' markets have been developed and are being pilot-tested.

Initiated in 2002, the "Wash Your Hands" project has involved more than 4,500 children in grades K-12 throughout North Dakota. About 91 percent said they would wash their hands more often and 93 percent said they would wash their hands more carefully as a result of participating in the lesson.

Nearly 40 percent of U.S. seed potatoes have originated in North Dakota and Minnesota. In recent years, nearly a third of the seed potatoes from the region have been rejected because of disease problems leading to a decline in seed potato production. A promising source of resistance has been derived from a wild potato. The development of virus-resistant potato cultivars could help restore the Red River Valley of North Dakota and Minnesota as a leading supplier of seed potatoes to major potato-producing states.

The sugar beet root maggot is the most serious insect pest in the beet producing areas of the Red River Valley in North Dakota and Minnesota. It also is a major pest on more than two-thirds of the sugar beet-producing acres of the U. S. Sugar beet producers in the north-central and western U. S. have relied on the same chemical insecticide mode of action for controlling this pest. The threat of insecticide resistance development is a major concern, so alternative control strategies are needed. Host plants resistant to insect injury are an attractive insect management strategy because of the direct benefits that include reduced applicator exposure to insecticides and a lower risk to nontarget organisms. Extensive grower adoption of resistant varieties for sugar beet root maggot control could potentially allow for major reductions in the overall pesticide load on the environment in areas infested by the insect.

In the last decade, the wheat midge and Hessian fly have emerged as serious durum and hard red spring wheat pests in North Dakota. The 1995 wheat midge outbreak in northeastern and north-central North Dakota caused estimated revenue losses of $30 million to wheat farmers. Management practices, such as planting dates, scouting, and insecticide treatments, have mitigated the impact of these pests somewhat, but the best long-term solution is the introduction of insect-resistant wheat varieties. Multiple sources of that resistance would help prevent adaptations that might help the pest overcome resistance. When scouting reveals infestation, producers spend an estimated $10 per acre to control the wheat midge. That cost could all but be eliminated by the introduction of resistant varieties. For the Hessian fly, insecticides can be used to kill the pest, but by the time the pest is found in the crop, it is usually too late to reduce crop losses.

An unprecedented epidemic of Fusarium head blight (FHB or scab) occurred in eastern North Dakota in 1993. Severe outbreaks have occurred each year since then in many areas of the state resulting in more than a $3 billion loss to North Dakota's economy. In 2005, record rainfall in June across the state resulted in severe FHB in some areas once again. The estimated loss as a result of the disease in wheat, durum and barley to the state's economy was $162 million. Losses would have been greater if management options developed by NDSU had not been in place. Management options that limited the overall impact of FHB in 2005 were: the availability of more resistant cultivars, the availability of a FHB risk forecasting model, a Web site that informed producers about the risk of FHB, the availability of effective fungicides and

information about the best fungicide application techniques. Growers were provided information about wheat variety response. Producers responded by growing more tolerant varieties, on at least 25 percent of the acres statewide and about 40 percent in areas of high risk for the disease. Producers utilized fungicides as a management strategy on 1.2 million acres of wheat and realized an average return of $30 to $36 per acre. Total estimated producer monetary gains were $36 million to 43.2 million.

Based largely on NDSU research and outreach programs, the biological control of leafy spurge is expected to be valued at $58 million per year by 2025. This will be accomplished by restoring thousands of acres of rangeland to productivity and by reducing herbicide costs. Once established, the biological control of leafy spurge and other pests will provide self-sustaining control without further input cost to the grower.

Mycotoxin contamination, the result of a mold infection, in grains and food products is a persistent food safety concern for which the only available effective control is testing and diversion or dilution. Post-harvest controls have focused on chemical, physical and biological approaches with limited success. For the tri-state region of North Dakota, South Dakota, and Minnesota, barley has an estimated annual impact of $1.5 billion and represents about 40 percent of the U.S. malting capacity. Mycotoxin contamination results in lost sales to the malting industry and is detrimental to the brewers and maltsters, who must pay higher prices for imported barley. The only major market for FHB infected barley is livestock feed. Feeding of mycotoxin and mold-contaminated barley is not without risks. Using alternative treatments, such as ozone, hot water, and irradiation, to reduce mycotoxin contamination have been encouraging. The potential improvement in the quality of malt may add value to portions of the affected U.S. barley crop.

Impacts of functional food attributes and health claims in beef marketing are not well defined or integrated into valuation models. The changing structure of the beef industry may have conflicting impacts on traceability, disease risk factors and valuation of associated meat products. What would be the overall economic losses in North Dakota if a catastrophic event, such as a BSE outbreak, were to occur? If a catastrophic cattle disease event were to occur and there was a reduction in cattle prices, the associated loss in value of pasture ranges from $5.90 to $8.35 per acre. Given that there are approximately 12.4 million acres of rangeland in the state, the loss in value ranges from $73.1 million to $103.5 million.

Key Theme - Food Safety: Consumers

Increasing numbers of food borne illnesses are being linked to produce. Safe refrigeration temperatures and cooling practices are an issue in households across the United States. In 2005, two campaigns were introduced to North Dakota: the “Fight BAC” and the “BAC Down” campaign. The “Fight BAC” produce safety campaign promotes concepts such as checking fruits and vegetables for bruises or damage; proper rinsing/cleaning of produce; avoiding cross-contamination; cooking or throwing away fruits or vegetables that have touched raw meat, poultry or their juices. The “BAC Down” campaign promotes the use of refrigerator thermometers and safe storage temperatures and cooling procedures for perishable foods. To promote these campaigns, lesson plans, displays and games were developed, and training

sessions were held with staff across North Dakota. As incentives for the participants, refrigerator thermometers and produce brushes were provided to the participants

Impact: About 174 people have participated in the evaluation process. The follow-up surveys are given at least one month after the educational session. On the pre-survey, 53 percent reported "always" checking produce for bruises compared to 70 percent on the follow-up survey. About 26 percent reported "always" rinsing produce under running water before eating compared to 41 percent on the follow-up survey. On the pre-survey, 54 percent reported "always" separating their fruits and vegetables from household chemicals and raw food compared to 78 percent on the follow-up survey. On the pre-survey, 45 percent reported "always" cooking or throwing away fruits or vegetables that have touched raw meat, poultry, seafood or their juices compared to 73 percent on the follow-up survey. On the pre-survey, about 33 percent of participants reported "always" chilling cut produce within two hours compared to 55 percent on the post-survey. On the pre-survey, about 55 percent of participants "always" throw away any fruit or vegetable that will not be cooked if has touched red meat, poultry or seafood compared to 75 percent on the post-survey.

About 245 participants have participated in classes based on the BAC Down campaign. In follow-up surveys with 120 participants, 98 percent were able to correctly identify 40 F or lower as the recommended refrigerator temperature, 83 percent "always" refrigerate perishable foods within two hours of purchase/use, and 16 percent "usually" follow this recommendation. About 81 percent were using the refrigerator thermometer they received.

Source of Federal Funds: Smith-Lever

Scope of Impact: Statewide Extension

Key Theme - Food Safety: Food Processing

Because food-related businesses are a growing sector in the North Dakota economy, the NDSU Extension Service has developed materials and partnered with other agencies to help ensure the safety of North Dakota-produced foods for the past ten years. A resource binder, "Starting Your Food Business in North Dakota," was developed by the NDSU Extension Service and the Institute for Business and Industry Development in partnership with the North Dakota Department of Agriculture. Available in all county extension service offices, the resource binder includes information on food industry rules and regulations regarding food safety/quality control. A Web site, "Food Entrepreneur: Guide to the Food Industry," is regularly updated with information on food safety, testing/labeling and other issues:
http://www.ag.ndsu.nodak.edu/cdfs/foodent/entrpnr.htm

"Nutrition Facts" labeling of North Dakota food products has been provided since 1994. Participants in the most recent FDA-sponsored "acidified foods" training showed increased knowledge in these areas: microbiology of processed foods, safe food handling/processing procedures, acidity testing and acidity levels of various foods, processing equipment, registration and process filing with the FDA and regional/state food processing issues. On-line modules have been developed and are in the pilot-test phase.

Impact: More than 175 food products have been tested for acidity and water activity for compliance to federal regulatory standards. Several products did not meet the federal government standards for acidity and were re-formulated for safety. “Nutrition Facts” labels have been developed for more than 400 North Dakota food products currently on the market.

Source of Federal Funds: Smith-Lever

Scope of Impact: Statewide Extension

Key Theme - HACCP: Foodservice
Increases in daycare, hospital and nursing home populations as well as a growth in restaurant and deli businesses means a growing portion of the population is at risk from outbreaks of foodborne illness. In addition, quantity food preparation presents unique challenges for safe food handling and preparation. In this environment, government regulation is demanding more attention to the development of food safety practices. As a result, there is high demand for training and educational materials in food safety.

In the past eight years, more than 2,200 food service managers and employees from restaurants, nursing homes, senior centers, hospitals, daycare centers and schools in more than 100 different North Dakota cities have attended NDSU Extension Service food safety workshops held across the state. The workshops focus on the Hazard Analysis and Critical Control Point (HACCP) approach to food safety that was developed by NASA to ensure safe food for its astronauts. In addition, the National Restaurant Association's ServSafe certification program has been implemented in North Dakota food safety workshops.

Impact/ HACCP: In 2005, about 75 restaurant managers received ServSafe certification as evaluated by a national exam. Ten people received “HACCP Manager” Certification in 2005 after completing an on-line series of modules and certification exam.

Source of Federal Funds: Smith-Lever

Scope of Impact: Statewide Extension

Key Theme – Food Safety: Teen Food Handlers
“Teens Serving Food Safely” is a statewide NDSU Extension Service food safety education effort designed to improve young food handlers’ food safety knowledge and skills and decrease risk of foodborne illness outbreaks associated with food service establishments. According to a 2000 U.S. Department of Labor report, 32% of employed 15- to 17- year olds work in eating and drinking establishments. Teaching young food handlers the “rules” could have significant public health implications. The pilot-tested “Teens” curriculum consists of five lessons based on the Fight BAC™ and Thermy™ national food safety campaign concepts. Youth benefit from the curriculum’s experiential learning model, obtaining information and tools to share with their families. A grant from the U.S. Department of Agriculture made the project possible

Each summer about 60 students participate in the 2005 North Dakota Governor's School, an eight-week campus-based program with science, math, business and arts "tracks." The students meet four times weekly for "Life and Leadership" training. In 2005, during the "Life and Leadership" training the students participated in food safety education and the creation of a food safety video for children. They were provided training and information based on the Fight BAC food safety campaign, which promotes the four steps to food safety: clean, separate/don't cross-contaminate, cook and chill. A video was created and disseminated to all counties in North Dakota.

Impact -Teens Serving Food Safely: Since 2001, more than 4,000 students have completed the lessons and passed the exam with a score of 80 percent or higher. Knowledge scores, measured by pre/post testing, increased from 56% correct on the pre- test to 88% on the post-test. About 64% of participants had been involved in food preparation for the public. In a follow-up survey one month later, 83% reported washing their hands more often when preparing food, 53% had shared their knowledge about food safety with others, and 40% had applied what they learned when preparing food for the public. This project represents an opportunity to create a model system to change how food safety education is accomplished for youth.

Impact - food safety/North Dakota Governor's School: As a result of participating in food safety education and the creation of a video, 86 percent of the participating teens reported washing their hands more often, 76 percent reported using water AND soap when washing their hands, and 76 percent reported washing their hands longer (at least 20 seconds). About 83 percent reported avoiding cross contamination more often, 21 percent were using a food thermometer more often and 45 percent had checked that their home refrigerator temperature was 40 F or lower. About 38 percent planned to teach their siblings about safe food handling and 17 percent planned to teach their friends about safe food handling.

Source of Federal Funds: Smith-Lever

Scope of Impact: Statewide Extension

Key Theme - Food Safety: Children

According to the Centers for Disease Control and Prevention (CDC), hand washing is the single most important means of preventing the spread of disease. Studies in schools and childcare centers have shown links between improper or infrequent hand washing and colds, flu and foodborne illness outbreaks.

Initiated in 2002, the "Wash Your Hands" project has involved over 4,500 children in grades K-12 in schools throughout North Dakota. The instructors used a fluorescing dye and ultraviolet light to show areas the students missed washing. The students were provided a handout showing a hand and asked to mark the spots they missed washing (where the dye remained).

Impact: Based on "seeing" where "germs" might hide on hands using a fluorescing dye and ultraviolet light, the "Wash Your Hands" project has reached over 4,500 children in grades K-12

in schools throughout North Dakota. Fingertips, back of hand and wrists were commonly missed areas. According to post-surveys, about 91 percent said they would wash their hands more often, and 93 percent said they would wash their hands more carefully.

Source of Federal Funds: USDA

Scope of Impact: Statewide Extension

Key Theme - Food Security: Protecting Potato through Pest Resistance
Crops resistance to insect and plant pathogenic pests is an integral component in sustainable agriculture production. A team of scientists from entomology, plant sciences and pathology are researching potato resistance for managing green peach aphid (GPA) and a virus vectored by GPA, potato virus Y (PVY). PVY infections have resulted in rejection rates at 30-40 percent of certified seed potato fields and the decline of seed potato production in the Red River Valley of North Dakota and Minnesota. Germplasm derived from Solanum etuberosum, a wild potato, is a potential source of resistance to PVY as well as its vector GPA.

Evaluate biology and population development of green peach aphid on selected potato breeding germplasm: In laboratory studies green peach aphid survival rate was only 0-10% on 17 genotypes across 7 potato families. On another 4 lines in 4 families, GPA fecundity was significantly reduced.

Impact: A high incidence of PVY in potatoes has a great impact in North Dakota where the state ranked sixth in the United States in potato production during the 2001 production season. Nearly 40 percent of the U.S. supply of seed potatoes has been derived from North Dakota and Minnesota. However, rejection rates of 37.7 percent, 32.3 percent and 31.6 percent of certified seed fields from 1999 to 2001 have resulted in the decline of seed potato acreage in the Red River Valley.

Source of Federal Funds: Hatch

Scope of Impact: Multi-disciplinary (entomology, plant sciences and plant pathology) research. The seed potato industry will benefit from virus resistant potato cultivars, restoring the Red River Valley of North Dakota and Minnesota as a leading supplier of seed potatoes to the major potato producing states.

Key Theme - Food Security: Managing Field and Storage Diseases of Potatoes
NDSU researchers are studying seven key storage and field diseases of potato: late blight, early blight, pink rot, black dot, silver scurf, ring rot and dry rot that are important to producers, industry and consumers. In addition, they are studying two emerging diseases including recombinant tuber necrotic strains of potato virus Y and a disease complex called zebra chip. Zebra chip is a disease complex associated with at least two unique bacteria. One is a previously unknown Phytoplasma most closely related to the Stolbur Phytoplasma. The other is *Xylella fastidiosa*, the cause of many diseases including Pierce's disease of grape. These two pathogens

are restricted to the vascular system of plants and are transmitted by insects. The ZC disease complex has cased millions of dollars of losses to table and processing potatoes in numerous Midwest and southwestern states in the US. *Fusarium graminearum*, a fungus that is the cause of wheat scab, has recently been identified as a cause of dry rot of potato and associated with wilt and decay of sugar beets in the north central region. This finding has important epidemiological and food safety implications. Researchers will screen germplasm for resistance to many of these diseases and evaluate field and storage conditions and management techniques for reduction of disease incidence and severity. Control measures are targeted for diseases that affect fresh and stored potatoes and include resistant varieties, fungicides, cultural practices and biological control. The researchers are also studying how and why pathogens that cause disease are becoming resistant to the fungicides used to control them.

Impact: Results from the research will help the potato industry implement control measures that improve quality and quantity of fresh and processed potatoes, and provide better and safer fresh and processed potatoes to the consumer.

Source of Federal Funds: Hatch

Scope of Impact: Multi-state research

Key Theme - Food Security: Biological Control - Sugarbeet Root Maggot
This research has two main objectives. The first is to survey for and screen native isolates of entomopathogenic fungi for pathogenicity to the sugarbeet root maggot. One key finding of this work has been the discovery of a strain of *Fusarium solani* that infects and kills root maggot larvae. The isolate had not been identified before, and NDSU has deposited it as an accession in the USDA-ARS Entomopathogenic Fungi Collection (Cornell University) as ARSEF 7382. Future work will include more virulence testing on other stages of the insect, and possibly other soil insects of sugarbeet. The second portion of this work is focused on development of a truly integrated pest management system that combines the use of another insect-pathogenic fungus, *M. anisopliae*, with cover cropping as a cultural control strategy, for control of the root maggot. Preliminary findings suggest additive root protection results from combining the two control strategies. A new federally registered and commercially produced strain (F-52) of this fungus has been demonstrated as having high virulence to the root maggot. One year of testing produced very encouraging results. Under moderate root maggot infestations, the integrated system of the fungus and cover crops (oat or rye) provided protection from root maggot feeding injury and allowed for comparable sugar and root tonnage yields as conventional chemical insecticide programs.

Impact: The sugarbeet root maggot is the most serious insect pest of sugarbeet in the Red River Valley of North Dakota and Minnesota. It is also a major pest in over 2/3 of the sugarbeet-producing acres of the United States. Sugarbeet producers in the north central and western United States have relied on the same chemical insecticide mode of action for controlling this pest. The threat of insecticide resistance development in these populations is a major concern, and alternative control strategies are needed. In addition, grower adoption of alternative root maggot management tools also would allow for less use of conventional nerve poison insecticides for control of this insect, thus potentially causing less harm to the environment and

to non-target organisms.

Source of Federal Funds: Hatch

Scope of Impact: Multi-state integrated research and extension. This insect is a major pest in over two-thirds of the sugarbeet growing areas of the United States. Growers in ND, MN, CO, ID, MT, NE and WY are likely to benefit from this program.

Key Theme - Food Security: Genetic Resistance to Pests - Sugarbeet Root Maggot
The potential for insecticide resistance in sugarbeet root maggot populations, as well as the possible removal of conventional chemical insecticides from federal registration, combine to form a strong impetus for the development of alternative strategies to manage this major insect pest of sugarbeet. In this long-term ongoing project, annual evaluations are carried out on cultivated varieties of sugarbeet, *Beta vulgaris*, and on wild accessions from the world collection of *Beta* germplasm to identify native sources of host plant resistance to feeding injury from the sugarbeet root maggot. Much of this work is carried out in collaboration with colleagues at the USDA-ARS, NCSL (Fargo, ND). If successful, genetic material from these evaluations will be made available for incorporation into elite commercial lines.

Impact: Host plant resistance to insect injury is an attractive insect management strategy, most notably due to its direct benefits that include reduced applicator exposure to insecticides, and low risk to nontarget organisms. Insect-resistant varieties would also add simplicity to production systems because the previous requirements of pesticide calibration and correct application timing would no longer be necessary. Also, extensive grower adoption of resistant varieties for sugarbeet root maggot control could potentially allow for major reductions in the overall pesticide load on the environment in areas infested by the insect.

Source of Federal Funds: Hatch

Scope of Impact: Multi-state integrated research and extension. This insect is a major pest in over two-thirds of the sugarbeet growing areas of the United States. Growers in ND, MN, CO, ID, MT, NE and WY are likely to benefit from this program.

Key Theme - Food Security: Preventive Pest Management - Lygus Bug
Since 1998, Lygus bug (*Lygus lineolaris*) infestations have been sporadically causing significant late-season injury in North Dakota and Minnesota sugarbeet fields. Tens of thousands of Red River Valley sugarbeet acres have been treated with foliar-applied insecticides to control the insect; however, its economic impact on the crop is not well understood. This research is being carried out to quantify the effects of feeding injury on sugarbeet yield and quality, and to develop safe, cost-effective tools for controlling Lygus in sugarbeet.

Impact: Results from seasonal abundance/activity monitoring indicate that Lygus adults invade sugarbeet fields after leaving “reservoir habitats” (e.g., alfalfa, canola, dry beans, patches of small-seeded broadleaf weed species, etc.) when these habitats become less attractive due to senescence, harvest, or plant stress associated with drought or water damage. Experiments

involving controlled infestations in cages indicate that economic injury to sugarbeet can occur if infestations average at least 1.7 Lygus bugs per plant. Field testing of foliar-applied insecticides has indicated that several materials are capable of controlling this insect. Tankmixing foliar insecticides with fungicides used for Cercospora leaf spot disease can result in yield losses of up to 1,500 lb of sucrose per acre. An Extension circular is being developed to provide a matrix of treatment recommendations based on infestation levels, control costs, and crop value. This information will equip growers with important aids to decide when it is appropriate to apply control measures and prevent economic injury. It also could reduce the incidence of unnecessary insecticide applications when Lygus infestations are at subeconomic levels.

Source of Federal Funds: Hatch

Scope of Impact: Multi-state integrated research and extension. This insect has been a problem for producers throughout the sugarbeet growing areas of eastern North Dakota and all of western North Dakota.

Key Theme - Food Security: Preventative Pest Management - Sunflower Crop
Many insects attack the sunflower crop In North Dakota. Pests of this crop are unpredictable, varying from year to year and among localities. It is therefore desirable to develop new methods for pest control that are both preventative of damage and environmentally sustainable. We are identifying and developing sunflower-produced chemicals that may be able to be used for specific control against various crop pests. During the 2005 season we analyzed field-grown plants of five cultivars of sunflower (*Helianthus annuus*) for content of various diterpenoids that either stimulate egg-laying by female banded sunflower moth or are known to be toxic to various insect species and compared this with egg-laying and insect damage on the same plants. The data showed a strong effect of cultivar on egg-laying, although this did not correlate with quantities of stimulatory chemicals. There was also a strong effect of cultivar on larval survival and this correlated with the total amount of toxic diterpenoids in the cultivar bracts. This study shows that there is potential for developing resistance in sunflower based on specific diterpenoid content.

Impact: Insects can have very significant impacts on the sunflower crop. For example, in 2001, roughly 70 percent of sunflower heads surveyed in North Dakota had some damage by caterpillars, and consequent loss of seed yield. Knowledge of the host-plant chemicals that influence these pests could lead to the development of new methods for insect control.

Source of Federal Funds: Hatch

Scope of Impact: Sunflowers are grown extensively throughout the mid-central states. This research is of potential benefit to sunflower growers from Manitoba to Texas.

Key Theme- Food Security: Breeding North Dakota Wheat For Resistance to Insect Pests
Farmers growing wheat in North Dakota face many challenges, two of which are the wheat midge and Hessian fly. The 1995 wheat midge outbreak in northeastern and north-central North Dakota caused estimated revenue losses of $30 million to wheat farmers. As well as being a pest and causing yield and quality losses to North Dakota farmers, the wheat midge may play a role in

the spread of wheat scab (pers. Comm.. Bob Lamb, AgCanada). The Hessian fly appeared in North Dakota wheat during the summer of 2003 when farmers in two areas, one northwest of Devil's Lake and one north of Minot, reported Hessian fly in both Hard Red Spring (HRS) and durum wheat fields.

For wheat midge, we have made progress in collaboration with NDSU plant breeders and NDSU microscopy specialists towards the development of North Dakota spring and durum wheat with resistance to wheat midge. Major accomplishments were: 1) testing of spring and durum wheat genotypes in the spring of 2004 for the transfer of a resistance gene effective against the wheat midge, 2) microscopy studies to determine the method of feeding of the wheat midge and the mechanism whereby wheat carrying a major resistance gene inhibits feeding by the wheat midge, and 3) behavioral studies to determine what plant factors stimulate adult females to select a head for egglaying.

For the Hessian fly, we are using a colony of a North Dakota population of Hessian fly to determine whether there is any resistance present in currently grown North Dakota HRS, white and durum wheats. We also have obtained 30 wheat genotypes with the 30 known *R* or resistance genes for the Hessian fly. We are testing our North Dakota Hessian fly population for virulence to each of the 30 resistance genes. Preliminary results suggest that our North Dakota population is highly virulent for many resistance genes. This result is unexpected because most of the R genes have not been deployed in North Dakota wheat genotypes.

Impact: In the last decade, the wheat midge and Hessian fly have emerged as serious pests of durum and hard red spring wheat grown in North Dakota. Management practices including planting dates, scouting, and insecticide treatments, have mitigated the impact of these pests somewhat, but the best long-term solution is the introduction of insect-resistant wheat varieties. Multiple sources of that resistance would help prevent adaptations that might help the pest overcome resistance. When scouting reveals infestation, producers spend an estimated $10 per acre to control the wheat midge, a cost that would be all but eliminated by the introduction of resistant varieties. For the Hessian fly, insecticides can again be used to kill the pest; however, by the time the pest is found in the crop, it is usually too late to reduce crop losses.

Source of Federal Funds: Hatch

Scope of Impact: Statewide research

Key Theme - Food Security: Fusarium Head Blight in Wheat

Fusarium head blight (FHB or scab) is a major disease of spring wheat and durum wheat in North Dakota. An unprecedented epidemic of this disease occurred in eastern North Dakota in 1993, with an estimated $1 billion lost to the agricultural economy that year in the region. Severe outbreaks also occurred since 1993, resulting in more than a $3 billion loss to North Dakota's economy from 1993-2004. In 2005, record rainfall amounts in June across the state resulted in severe FHB in some areas once again, with an estimated $162 million loss to ND's economy as a result of the disease in wheat, durum and barley. Losses would have been greater if management options had not been in place for this disease. Management options that limited

the overall impact of FHB in 2005 were: the availability of more resistant cultivars; the availability of an FHB risk forecasting model and web site that informed producers about the risk of FHB; and the availability of effective fungicides and information about the best application techniques. Growers were provided information about wheat variety response and growers have responded by growing more tolerant varieties, on at least 25% of the acres statewide, and about 40% in areas of high risk for the disease. Fungicide trials conducted by the NDSU Extension Service and Research Extension Centers have shown the most efficacious products and application procedures for FHB control. Fungicide trials established in the affected regions have indicated that proper timing of an appropriate fungicide resulted in yield increases averaging 10-12 bushels/acre, with corresponding increases in test weight and market grade. Economic return from use of the fungicides was between $30-36/acre in 2005, because of yield and quality improvements (increased test weight, reduced damage, and reduced DON toxin). Extension specialists provided this information on fungicide results to growers via numerous county and regional meetings, demonstrations and news releases. In 2005, the extension plant pathologist once again applied for a Section 18 emergency exemption for a specific fungicide with the best efficacy against the disease, and EPA granted it. The fungicide was applied to approximately 1.2 million acres of wheat and 150,000 acres of barley in 2005. Use and economic return per acre translates to a positive economic impact of $36-43.2 million for wheat producers in 2005.

Impact: Producers utilized fungicides as a management strategy on 1,200,000 acres of wheat realized an average return of $30-36 per acre, resulting in $36-43.2 million revenue to producers who used this strategy in 2005. The Extension Specialist wrote the Specific Exemption for use of the fungicide, which was sent to the ND Dept. of Agriculture and subsequently approved by EPA. Producers were provided training on use of the FHB disease forecasting model and web site to determine need for use of fungicide and also were trained on the proper use of the fungicide and how this strategy should be integrated with other management strategies for optimum control of FHB. Producers were provided information on wheat variety response to FHB.

Source of Federal Funds: Smith-Lever

Scope of Impact: Statewide extension.

Key Theme - Food Security: Sclerotinia Disease Development in Sunflower
Sclerotinia is a major disease of broadleaf crops in northeastern North Dakota. Because of the increased acreage of susceptible broadleaf crops, this particular disease is becoming a greater problem over larger areas. For example, in the fall of 1999 wet weather resulted in statewide problems with Sclerotinia head rot disease of sunflower causing losses reaching 60 to 70 percent in some areas. A similar situation was also observed in the fall of 2004. The National Sunflower Association estimated losses in 1999 alone at $1 million. Especially hard hit were confectionary sunflower producers who produce seeds for human consumption and bird feed. Sclerotinia tolerance levels are very low for confection seed producers and if sclerotia bodies or damage to the seeds exceeds 3 percent, the field is rejected for human consumption. Producers in 1999 and 2000 were faced with the problem of what to do with highly contaminated confection sunflower

seeds. Extension specialists worked with a group of farmers in north central North Dakota to determine if significant reductions in sclerotia contact could be obtained through harvest machine adjustments or in cleaning of the grain sample after harvest. Field studies in the fall determined that some techniques might reduce harvested sclerotia body content, but a more thorough cleaning with specialized equipment would be necessary to reduce sclerotia content, and to some degree dark seed content, in confection seeds. Information gathered in the study was ultimately compiled into an extension publication that was widely used in the fall of 2000 as this problem reoccurred. Surveys of sunflower fields for Sclerotinia and other diseases have been conducted in 2001 to 2003, and 2005. Additional information on the field surveys and biology and management of Sclerotinia in sunflower and other susceptible crops was made available in 2001 to 2003, and 2005 via training sessions and contributions to a CD-ROM provided to county and area Extension personnel for grower training. Training sessions on how to deal with the large amount of sclerotia returned to the field after harvests have been ongoing in winter meetings from 2001 to present.

Impact: Producers in the north central region who stored sunflower seed following best harvest practices were able to clean the seed and many producers were able to market clean loads that sold for contracted price of 13 cents per pound versus 5 cents per pound for bird seed or confection market. Producers were trained on the biology and management of Sclerotinia for sunflower and other susceptible crops.

Source of Federal Funds: Smith-Lever

Scope of Impact: Statewide extension.

Key Theme - Food Security: Biological Control - of Weeds, Pathogens and Insect Pest
Natural enemies of weeds, pathogens, and insect pests are a potentially important component of Integrated Pest Management strategies. These biological control agents offer a mechanism to reduce the impact of weed, diseases, and insect pests without the use of expensive and potentially dangerous chemical controls. A major research and extension effort involving the Departments of Entomology, Plant Sciences, and Animal and Range Sciences is under way to manage leafy spurge, a key weed pest of rangelands. Leafy spurge causes over $23 million in losses each year in North Dakota. Insect predators of leafy spurge, such as the *Aphthona* flea beetle, are being evaluated for impact and adaptability to local environments. Although adult *Aphthona* flea beetle populations are substantially higher in insect only and insect plus competitive grass species treatments, leafy spurge stem density is substantially lower in the treatments with a fall herbicide application. Snow cover may not provide sufficient protection for overwintering *Aphthona* larvae when mean winter soil temperature drops below approximately 4 C. Overwintering success of *Aphthona* larvae was not different among snow-covered treatment plots with or without a grass debris covering. Fourteen years after their release, *Aphthona* flea beetle populations were very low and uniformly distributed among habitats of high-prairie, mid-prairie, thicket, forest, and wetland in a wildlife management area and a pasture. Biocontrol programs using predators, parasites and pathogens of insect pests such as banded sunflower moth, sunflower midge, sugar beet root maggot, Colorado potato beetle, and crucifer flea beetle on canola are all under way. In one line of research, laboratory research

demonstrated that the ecorational insecticide SpinTor might be a suitable alternative to neonicotinoid and pyrethroid insecticides for crucifer flea beetle management in canola. Field studies indicate that SpinTor may be a good fit for crucifer flea beetle management where populations are moderate to low. Sclerotinia, the causal agent of white mold, is a fungus that limits production capacity of many row crops including sunflower, dry beans, canola, and soybean. The application of 2 lbs of Contans to canola fields prior to planting in the spring provided significantly better control of disease than did Rovral fungicide applied at flowering. In a parallel study, a biocontrol fungus isolated from North Dakota soils was more effective than Contans for control of this disease in alkaline soils found in the Red River valley.

Impact: Biological control of leafy spurge is expected to be valued at $58 million per year by 2025 by restoring thousands of acres of rangeland to productivity and by reducing herbicide costs. Once established, biological control of leafy spurge and other pests will provide self-sustaining control without further input cost to the grower.

Source of Federal Funds: Smith-Lever and Hatch

Scope of Impact: Multi-state integrated research and extension. Growers in North Dakota and the surrounding states benefit from the leafy spurge biological control program. Leafy spurge flea beetles are redistributed in ND, MN, WY, SD, NB and MT.

Key Theme - Food Security: Genetic Resistance to Pests - Genes

A major objective of crop plant research involves the identification, characterization, and use of resistance genes effective against insect and disease problems. Fusarium head blight (FHB) has caused over $150 million in combined small grains losses for producers in North Dakota in 2005 alone. Plant pathologists developed screening techniques for use in the greenhouse and in the field to test thousands of lines of small grains for resistance to the disease. The HRSW "Glenn", released in 2005, has genetic resistance to FHB, leaf rust, and stem rust. Recently, other scab-resistant varieties (Steele ND and Howard) were developed with this approach. Pathologists are also working to identify potential new sources of resistance to problematic races of the leaf rust fungus now firmly established in the northern Great Plains. Future goals are to work with breeders to combine FHB and rust resistance into new cultivars. One objective of dry bean pathology is to identify new sources of resistance to rust and white mold for use by the bean breeding program. Incorporating root rot disease resistance genes into soybean cultivars has major impact on improving soybean production and profitability for growers. This is especially pertinent now because soybean is the most widely grown row crop in North Dakota and Minnesota and because soybean cyst nematode, the most destructive disease of soybean, is now in both states. Extensive research in this area is now producing soybean cultivars with disease resistance. Sources of resistance to Hessian fly are being sought in wild relatives and ancestors of wheat and in cytogenetic stocks of wheat. In other studies, a recently-identified resistance gene, designated *Sn1*, effective against wheat midge, is being incorporated into wheat breeding lines and other germplasm as a first step toward incorporating this gene into new cultivars. Similarly, new sources of resistance to sunflower midge are being sought from wild relatives and other genetic stocks.

Impact: Genetic resistance is the most efficient and safe way to control diseases and pests of crops. Genetic resistance eliminates or reduces the need for other pest management inputs and reduces grower expense. Genetic crop resistance saves growers management time because of reduced need for monitoring of pest populations. The economic impact of the FHB resistant wheats should result in millions of dollars saved over growing FHB susceptible cultivars. This will also save huge amounts in reduced fungicide sprays. Late blight resistance in commercial potato production could save millions in reduced spray applications and improved yields. Resistance to rust and white mold in dry beans would be elimination of two of the major problems in the dry bean industry. Incorporating disease resistance in soybean cultivars has had a major impact on improving soybean production especially in the area of root rot.

Source of Federal Funds: Smith-Lever and Hatch

Scope of Impact: Multi-state integrated research and extension. Growers in the tri-state area of MN, ND and SD and in Manitoba profit from resistance to pests in the major crops. Resistance to FHB alone is worth millions to cereal growers. In addition, breeders and pathologists have added resistance to important pests in the minor crops.

Key Theme - Food Security: Mycotoxins in Cereal Grains
Viable Fuarium spp. can become post-harvest food safety and quality problems in cereals, particularly in malting barley. To find, evaluate and develop technologies to allow utilization of Fusarium-head-blight-infected cereal grains.

We evaluated electron-beam irradiation for preventing Fusarium growth and mycotoxin production while maintaining barley-malt quality characteristics. Four barley lots with varying deoxynivalenol (DON) concentrations were irradiated at 0, 2, 4, 6, 8, and 10 kGy. Treated barley was malted in a pilot-scale malting unit. Barley and malt were analyzed for Fusarium infection (FI), germinative energy (GE), aerobic plate counts (APC), mold and yeast counts (MYC), and DON. Malt quality parameters included malt extract, soluble protein, wort-color, wort-viscosity, free amino nitrogen, alpha-amylase, and diastatic power. FI, APC, and MYC decreased in barley with an increase in dosage. The APC and MYC for malts from barley exposed to 8-10 kGy were slightly higher than in other malted samples indicating that irradiation resistant microflora could flourish during malting. Barley GE significantly decreased (3-15%) at 8-10 kGy. Irradiation had no effect on DON in raw barley. DON decreased significantly (60-100%) in finished malts prepared from treated barley (6-10 kGy). Malt quality parameters were slightly affected by electron-beam radiation. The results suggest 6-8 kGy may be effective for reducing FI in barley and DON in malt with minimal effects on malt quality.

Impact: Mycotoxin contamination, the result of a mold infection, in grains and food products derived from grains is a persistent food safety concern for which the only available effective control is testing and diversion or dilution. Post-harvest controls have focused on chemical, physical and biological approaches with limited success. For the tri-state region of North Dakota, South Dakota, and Minnesota, barley has an estimated annual impact of $1.5 billion, and represents about 40% of the U.S. malting capacity. Mycotoxin contamination results in lost sales to the malting industry and is detrimental to the brewers and maltsters, who must pay higher prices for imported barley. The only major market for FHB infected barley is livestock feed.

Feeding of mycotoxin and mold-contaminated barley however, is not without risks. Using alternative treatments such as ozone, hot water, and irradiation to reduce mycotoxin contamination, we have encouraging results with barley. The potential improvement in the quality of malt may add value to portions of the United States barley crop affected. The potential reduction of toxin-producing mold would prevent post-harvest production of mycotoxins during malting and would be beneficial for food-grade malts.

Source of Federal Funds: Hatch

Scope of Impact: Multi-state research

Key Theme - Food Quality: Influence of Storage Conditions on Soybeans for Tofu
Soybeans are stored on the farm or during shipping after harvest until they are processed for foods. Tofu is a key value-added soy food. Under certain environmental conditions, the food and nutritional qualities of soybeans deteriorate and lead to tremendous economical loss if they have reduced processing yield of tofu. NDSU researchers are studying the molecular and functional changes of soybeans stored under various temperatures and humidities to learn how these changes influence the texture, color and flavor of tofu products.

Soybean is stored and transported under various humidity and temperature conditions. Adverse storage environment caused biochemical changes that affected food and nutritional qualities of soybean. The relationships between tofu quality changes and molecular changes of glycinin and beta-conglycinin, and non-protein components such as acidity, sugar, lipids, phytate and isoflavones in soybeans subject to storage under selected conditions of relative humidity (50-84 percents), temperature (4 C to 40 C) and time periods were characterized. When humidity was high, humidity effect was more important than temperature. When humidity was low, temperature effect was more pronounced. In short, when temperature exceeded 30 C and relative humidity exceeded 70 percents, the soymilk protein recovery and tofu yield were lowered substantially. During adverse storage, titratable acidity increased, phytate content decreased, isoflavone glycosides were hydrolyzed, and the secondary structures of the proteins changed and disulfide linkages were changed. In the meantime, proteins became unextractable. There was a differential changes in protein subunits in extractable proteins. Cultivar had a definite effect on the storage-ability of the soybeans. Lipoxygenase-null cultivar had the best storage ability. Color darkened and was correlated with changes in protein solubility and tofu yield. Some kinetics analyses on the changes of quality attributes during the course of time/temperature storage conditions are still being analyzed. Such mathematical equations if validated could assist farmers and processors in monitoring quality changes of soybeans during storage.

Impact: Our results have advanced significantly the science of the roles of the biochemical components on the food quality changes and made a significant impact to the soybean industry worldwide in the preservation of soybean during post-harvest storage and shipping. In the Northern plains, the winter is cold and summer is short. Soybeans, if harvest moisture is low and ventilation is appropriate, could be stored in this climate for more than one year without significant changes in soybean quality. Total soybean production has exceeded 3.5 million acres. It has become the second largest group of crops produced in North Dakota. Characterizing physical, chemical, nutritional and microbiological properties of the soybean will lead to better

utilization of this crop. Soybeans are well known for their health benefits and the consumption in the Western world is increasing quickly. Our work on storage effect contributed to the quality improvement of soybean and soy food products and, therefore, will lead to the improvement in the utilization of food soybean, and will benefit both the growers and the consumers.

Source of Federal Funds: NRI-CGP

Scope of Impact: Multi-state research

Key Theme - Food Safety: Development of Intelligent Quality Sensors

The long-term goal of our research projects is to develop miniaturized portable sensors to provide quality information about specific food and agricultural products. This project involves a multidisciplinary team of researchers and the three ongoing research project focuses on the development and evaluation of intelligent sensors (based on electronic nose technology) for evaluation of quality and safety of selected food products, spoilage of beef, contamination of beef (with *Salmonella* and *E. Coli*), mold growth in barley. In our study, the Sensor-fusion concept was included to investigate the capability of infrared gas sensing mechanism for quality and safety characterization of the selected food products. For the proposed intelligent sensors, a modular approach for developing and/or evaluating different sensor/sensing modules has been adopted including a commercially available electronic nose system, Cyranose 320^{TM} and IR (infra-red)-based olfactory sensing. Each sensing module has its different sensing mechanism or characteristics. Experiments were conducted using GC-MS and SPME (solid phase micro extraction) technique identification of volatile compounds of fresh meat (beef) during contamination with *Salmonella* in laboratory conditions. Meat samples were stored at 20 degrees C. Acetic acid and ethanol have been found as potential indicator compounds. Experiments have been conducted to acquire the responses of M (metal oxide) electronic nose module for ethanol and acetic acid with different concentrations (10- 500) ppm. For evaluation of the IR-based olfactory sensing technique, headspace of packaged meat was sensed using specially designed sensing system connected to a FTIR (Fourier Transform Infrared) spectrometer. For meat packages stored at 37 degrees F, the maximum average weighted classification for classifying spoiled meat samples was 97.9%. It was obtained using linear discrimination method and bootstrap. For meat samples stored at 50 degrees F, the maximum average weighted classification accuracy for classifying spoiled meat samples was 99.3%. Parallel investigations have been conducted to develop a framework for NDIR (non-dispersive infrared) sensor that can be used as cost-effective sensors for meat quality and safety. Thin-film (TF) has been developed using commercially procured detectors and customized heater as well as data acquisition circuits. This module has been designed to be user friendly to operate and is portable. This module shows potential and current work is ongoing to evaluate its performance. The combinations of M (metal-oxide) and P (Cyranose 320 ^{TM}) modules provided average accuracies in the range of 80-90% for discriminating spoiled and unspoiled meat samples based on quadratic and bootstrap analysis. The commercially available electronic nose (Cyranose 320 ^{TM}) provided an overall average accuracies of 80-86% for classifying barley samples based on ergosterol contents using leave-one-out and linear discrimination method.

Impact: Miniaturized sensors can help provide consumers with safe and high quality food products. The proposed intelligent sensors, based on electronic nose technology, show promise. The proposed sensors could alert consumers of possible safety risk before the food is consumed.

Source of Federal Funds: USDA-CSREES-Special Grant

Scope of Impact: Multi-state Research

Key Theme: - Food Safety: Enhancing the Competitiveness of U.S. Meats
Impacts of functional food attributes and health claims in beef and bison marketing are not well-defined or integrated into valuation models. The changing structure of the beef industry may have conflicting impacts on traceability, disease risk factors and valuation of associated meat products. This project determines the value consumers place on meat product health claims and associated functional food attributes. The project examines beef supply chain structures and how shocks impact channel participants.

This study investigated a need for tools that address the risk of low prices and asset value losses due to catastrophic disease-induced market events, such as BSE outbreaks. Further we suggest ways that USDA Risk Management Agency could alter existing insurance programs to cover this eventuality. In the absence of such a program, there is little doubt that ad hoc disaster payments will be required if disease-induced catastrophic event is realized. Our proposed product would shift at least part of these payments to private insurers. Disease outbreaks, such as BSE in Canada, Japan and Great Britain, demonstrate how lost market access and lost domestic consumer confidence can devastate a livestock sector. A decline of $1/cwt in beef price will result in a $0.78/acre decrease in pastureland value. The associated reduction in ND pastureland value ranges from $5.90 to $8.35/acre. This study also investigated the possible impacts of a catastrophic disease event on beef cattle producers in North Dakota. The financial characteristics and classifications of representative North Dakota farms were analyzed to determine the overall financial conditions of agricultural producers in the event of a BSE outbreak. According to the National Agricultural Statistics Service, there were approximately 11,800 cow/calf producers in 2002 in North Dakota. This represented 91 percent of cattle enterprises and 39 percent of total agricultural operations. The USDA reported total cattle and calves inventory for the U.S. in 2003 of 96.1 million head. The state of North Dakota represented 2 percent of the total U.S. inventory or approximately 1.9 million head of cattle and calves. Data from 482 producers were used and grouped into beef producers, crop producers, beef and crop producers, and other producers. The BSE outbreak scenarios utilized in the model are indicative of potential economic consequences. Impacts of twelve BSE outbreak scenarios and price factor fluctuations were analyzed. The corresponding price reductions resulting from the BSE outbreaks reflect scenarios ranging from a decrease in demand of 5 percent and a reduction in exports of 50 percent to a decrease in demand of 20 percent and a reduction in exports of 100 percent. The price factor fluctuations are representative of beef cattle prices ranging from low prices received during the expansion phase to high prices received during the current liquidation phase of the cattle cycle. Beef producers are significantly, adversely affected by even a minimal BSE outbreak given average beef cattle prices over the past 9 years. Beef producers did not receive revenues that adequately covered operating expenses, and, on average, are unable to meet all term-debt obligations as they come

due. An extensive BSE outbreak results in massive losses to beef producers in terms of profitability and credit quality with average return on equity of -30% and ending cash balances of -$20,477. The financial performance results for this scenario indicate serious short- and long-term financial difficulty and numerous potential loan foreclosures.

Impact: This research has provided North Dakota's beef producers with a better understanding of how significantly they may be impacted financially in the event of a catastrophic event such as a BSE outbreak and what actions can be taken to help limit overall economic losses. Currently, there is not an insurance program that protects producers from losses such as diminished values of breeding cattle herds, pastureland, and hay land that have the potential to diminish their credit qualities. Given a possible catastrophic cattle disease event and reduction in price of cattle expected, the associated reduction in ND pasture and value ranges from $5.90 to $8.35/acre. Given that there are approximately 12.4 million acres of pastureland in ND, the loss in pasture value ranges from $73.1 million to $103.5 million. The LGM and LRP products offer producers protection against income and price risks, but, as experienced in Canada, producers also face asset value and equity losses as livestock prices fall drastically. Given the demonstrated relationship between beef prices and pasture land values and likely relationships between beef prices and other assets, it is possible to employ the LRP in a cross hedge strategy to insure against asset value losses. This would involve a livestock producer insuring multiples of his/her calf crop or fed cattle, something that is not currently allowed under LRP and would be cost prohibitive under the current LRP premiums. LRP insurance could be modified to cost effectively protect calf price and equity of beef producers.

Source of Federal Funds: Hatch

Scope of Impact: Multi-state Research

Key Theme - Food Quality: Feedlot MBA
County extension agents and beef cattle specialists developed a unique program aimed at feedlot operators in the region. The program was developed based on the results of survey work of people who had attended previous feedlot programs in the state. The program has been held annually since 2004.

Impact: Producers attending these sessions received training and educational sessions related to improving consumer acceptance of end products, improving animal health and reducing antibiotic usage, and ‘natural’ beef production. Over 130 feedlot operators, nutritionists, feed company personnel, veterinarians, and others have attended these sessions. Post attendance survey work indicated many had changed or were intending to change production practices to improve quality and consistency of beef cattle produced in their feedlots. Many operators also indicated the need for additional programs in this area. This should help program planners develop more effective programs in the future.

Source of Federal Funds: Smith-Lever

Scope of Impact: Statewide extension.

Key Theme - Food Quality: North Dakota Beef Quality Assurance
Beef Quality Assurance (BQA) training sessions have been held throughout North Dakota for the past six years to improve the quality, safety and consistency of beef, resulting in a more consumer-acceptable product. A recertification program has been developed to allow producer to become recertified using a variety of methods, including attending a BQA training session or becoming recertified over the Internet.

Impact: As a result of these training sessions, 2,000 operations have been certified, and more than 2,800 cattle producers were educated in beef quality assurance practices. These operations produce more than 549,000 head annually, 55 percent of the state's calves. Comparison of pre- and post-tests taken by participants at each session found an average improvement of 24 percent in test scores. Producers and marketing organizations report a heightened interest in North Dakota BQA certified cattle by alliance programs and feedlots requiring source and age verification and animal health records. These groups have also reported some increased prices for calves certified in the North Dakota BQA Program. To improve the visibility of BQA certified feeder cattle, a "Feeder Fax" website was developed in 2002. This site allows producers to list their feeder calves for sale. Included in the listing is number of cattle, sex, approximate weight, breed composition, past production and carcass data, prevention animal health program, and date and location of sale. The number of cattle listed on this site has increased over the past year.

Producers have reported receiving up a $7 per hundredweight premium on their feeder cattle because they were certified through the BQA program. As a result of the BQA training program, both county extension agents and veterinarians report a change in producer's behavior in how they administer injections and in their record keeping practices. They report producers are moving their injection site from the hind quarters to the neck, and are keeping more detailed animal health, husbandry, and production records.

Source of Federal Funds: Smith-Lever

Scope of Impact: Statewide extension.

Key Theme - Food Quality: The Impact of Micronutrients on Meat Quality and Safety
Increasing the selenium (SE) content of meat could contribute to healthy diets of humans. This project investigates the quality and safety of natural incorporation of selenium in retail meat cuts.

Selenium contains antioxidant properties that may increase meat quality for human health. Forty-three crossbred steers were stratified by body weight and assigned to one of four treatments: Se adequate; or supranutritional Se provided as high Se wheat; high Se hay; or sodium selenate. At the conclusion of the trial, steers were slaughtered and a shank muscle sample obtained for Se analysis. At 48h postmortem, NAMP #180 strip loins were removed from the carcass. 2.5 cm thick steaks were cut from the cranial end and used for retail shelf studies and nutrient analysis. Additional steaks were utilized for in-house and consumer sensory evaluation. No differences

were detected among treatments for muscle dry matter, ash, crude protein, or fat. Shank selenium concentrations were different among treatments where the Se Control was equal to sodium selenate, but less than hay and wheat (28.3, 39.3, 90.3, and 108.6 ppm, respectively). Expressible moisture, ph, cooking loss, and drip loss were not different among treatments. There was a reduction in overall quality as indicated by a change in color. However, no differences were found between treatments for nutritive analysis or shelf life of product. For in-house or consumer sensory evaluation of flavor, tenderness, juiciness, and overall acceptability, the participants found the product acceptable in all aspects approximately 80% of the time. This leads us to conclude that increased levels of Se in the meat did not have deleterious effects on the overall taste. We also asked consumers specific questions about selenium to see how aware they were of this mineral and its relation to health. Sixty eight % were not aware of the benefit of selenium as it may be related to the incidence of heart disease and cancer, probably through its antioxidant functions. Another 79% were not aware of the fact that increased selenium in the diet can reduce the risk of heart disease and another 85% were not aware that selenium supplements can lower cancer and death rates from lung, prostate, and colon cancer.

Impact: Selenium content can be increased in beef by feeding an organic source of selenium. In turn, the nutritive value of beef can be improved without deleterious effects on shelf life or consumer acceptance of beef products.

Source of Federal Funds: Hatch

Scope of Impact: Multi-state

Allocated Resources ($ x $1,000)		**FYO5**
1862 Extension ($)	Smith-Lever	812
	State	1,218
	FTE	29
1862 Research ($)	Hatch	527
	State	775
	FTE	15.5

Goal 3: A Healthy, Well-Nourished Population

Overview*: As reported by the National Centers for Disease Control, nearly a third of all adults in the U. S. are classified as obese (NHANES, 1999-2002). In 2003, 63 percent of adults in North Dakota were overweight or obese (CDC, BRFSS, 2003). Between 1990 and 2003, the percentage of adults in North Dakota who were overweight increased from 35 percent to 39 percent (11 percent increase) and the percent of those obese increased from 12 percent to 14 percent (100 percent increase). Nationally, 31 percent of the children ages 6 to 19 were overweight (16 percent) or at-risk of becoming overweight (15 percent) (NHANES, 1999-2002).*

In 2005, 24 percent of North Dakota high school students were overweight (11.2 percent) or at-risk of becoming overweight (12.8 percent) (CDC, YRBS).

Diet and physical activity behaviors are related to the development of obesity and at risk for contracting several chronic diseases such as heart disease, cancer, type 2 diabetes and osteoporosis. These health conditions cost society an estimated $200 billion a year in medical expenses and lost productivity. Despite strong evidence supporting the health benefits of a healthy lifestyle, Americans, including North Dakotans, do not meet national nutrition and health goals.

In North Dakota, more than two-thirds of adults do not meet the recommended amount of vigorous physical activity and half do not meet the recommended amount of moderate physical activity (CDC, BRFSS, 2003). No leisure-time physical activity was reported by 24 percent of adults. Heart disease is the leading cause of death in North Dakota. Thirty percent of North Dakotans report elevated cholesterol levels and 24 percent report elevated blood pressure, both risk factors for heart disease (CDC, BRFSS, 2001). Cancer is the second leading cause of death in North Dakota. For 2004, cancer was newly diagnosed for about 3,250 individuals in North Dakota with about 1,340 cancer deaths. Most deaths are due to cancers found in the lung, colon-rectum, breast and prostate. Despite research on the health benefits of fruits and vegetables, particularly for reducing the risk of cancer, about 80 percent of North Dakota adults do not consume the recommended daily servings of five or more fruits and vegetables. In North Dakota, 6.2 percent of adults report having diabetes. This is up from 3.6 percent in 1994 (72 percent increase). The rate of diabetes rises to more than 14 percent for those 64 and older. Among Native Americans in North Dakota, more than 15 percent have diabetes.

Participation in all types of physical activity declines as age and grade in school increases. Among North Dakota high school students, 33 percent did not participate in either moderate level physical activity (5 or more days a week) or more vigorous levels (3 or more days a week) and 63 percent did not attend daily physical education classes in school (CDC, YRBS, 2005). Vigorous physical activity was defined as an activity making you sweat or breathe hard 20 minutes or more on three of the seven days preceding the survey. Moderate physical activity was defined as activity that did not make them sweat or breathe hard 30 minutes or more on five or more of the 7 days preceding the survey. New guidelines indicate children need at least 60 minutes of physical activity per day, which is spaced throughout the day. Recommendations discourage extended periods of inactivity during the day (no longer than 2 hours). Nearly 47 percent of North Dakota high school students report they are trying to lose weight and 86 percent do not eat the recommended five daily servings of fruits and vegetables. About 73 percent said they drink less than three glasses of milk per day, while more than 50 percent drank more than 13 fluid ounces of sweetened beverages each day. Habits begun in childhood often persist in adulthood.

The NDSU Extension Service has helped form 20 "5 Plus 5" community coalitions across the state to bring together local experts to increase the consumption of fruits and vegetables to five to nine servings daily and increase physical activity levels to at least 30 minutes of moderate activity on five or more days of the week.

"On the Move to Better Health" is a school-based collaborative program of public health and extension targeting fifth grade students and promoting a variety of healthy lifestyle behaviors. The month-long program promotes fruit and vegetable consumption, physical activity, and healthy snacking/drink choices. In the past five years, more than 3,000 children have completed the program. Surveys of fifth grade students in a two-school effort indicated increased knowledge, increased milk consumption, decreased soda pop consumption and increased physical activity. On the pre-test, 64 percent of children reported consuming three or more glasses of milk compared to 75 percent on the post-test. The number of children who reported drinking no soda pop increased from 26 percent to 37 percent. The percentage of children reporting two hours or less of "screen time" increased from 62 percent on the pre-test to 76 percent on the post-test.

A folic acid campaign features displays, handouts, posters and public service announcements based on the national Centers for Disease Control and Prevention "Ready or Not" campaign and is directed toward women statewide. Awareness of folic acid has significantly increased based on random surveys. A statewide task force has implemented the campaign statewide. According to the most recent national Gallup Survey, of the total population, folic acid awareness increased to 79 percent from 52 percent in 1995. Among women ages 18-44, 80 percent of North Dakota women were aware of folic acid compared to 70 percent of U.S. adults nationally.

For some families, education in basic food shopping, selection, budgeting, menu planning, and safety practices are needed to improve health and nutrition. In six North Dakota counties and one tribal college, the Expanded Food and Nutrition Education Program teaches limited-resource audiences how to improve their dietary practices and become more effective managers of available food resources. Evaluations show 85 percent of homemakers showed improvement in one or more nutrition practices such as planning meals, making healthy food choices, preparing foods without adding salt, reading nutrition labels or having children eat breakfast. Evaluation of food safety education shows 58 percent of homemakers showed improvement in one or more of the food safety practices such as thawing and storing foods properly. Surveys show a new curriculum entitled "Money for Food" helped 81 percent of homemakers improve one or more food resource management practices, such as meal planning and making price comparisons.

In a partnership with the North Dakota Department of Health and the Dakota Diabetes Coalition, NDSU Extension has mapped the location by county in North Dakota of health professionals working in diabetes (dietitians, certified diabetes educators and physicians). The curriculum developed by WV University Extension called "Dining with Diabetes," was introduced to North Dakota with the goal to provide diabetes nutrition education for medically underserved areas. This curriculum partners local Extension agents with dietitians or certified diabetes educators to present the food-based curriculum to help diabetics make better food choices for improved disease management.

North Dakota is the leading producer of several crops which are important in helping to provide Americans with a balanced diet as suggested in the USDA Dietary Guidelines: flaxseed, canola, sunflowers (both oil and confection), dry beans and peas, spring wheat, durum wheat, oats and

barley. The variety of crops grown in North Dakota presents opportunities for producers and processors to look for innovative ways to market the health qualities of regional foods locally, nationally, and internationally.

Key Theme - Human Health: Adult Fruit and Vegetable Consumption and Inactivity
Cardiovascular disease is the leading cause of death in North Dakota. Nationally, 40 percent of the deaths in the United States are due to heart disease and stroke, with a national annual health care cost of $260 million. Proper nutrition and regular physical activity are two ways to reduce the risk of cardiovascular disease and other illnesses. According to results of a North Dakota Department of Health survey, only 18 percent of North Dakota adults eat five servings of fruits and vegetables per day and 34 percent of North Dakotans are completely physically inactive outside of work.

"MyPyramid" was introduced in Spring 2005. A statewide training session was held for Extension staff, and several lessons and other educational tools were provided to staff for use in providing education across North Dakota.

The North Dakota *5 Plus 5 Program*, modeled after the Iowa program of the same name, began in 1998 and has grown each year. The "fives" in *5 Plus 5* come from the guidelines for the national 5 A Day Program, which encourage five to nine servings of fruits and vegetables each day, and from guidelines that recommend that every American adult accumulate 30 minutes or more of moderate physical activity five or more days of the week. Community coalitions are working to reduce their residents' chronic disease risks by promoting awareness, helping to build skills, and adapting the community environment and policies to encourage lifestyle change. Specific activities of *5 Plus 5* community coalitions include working with local school districts to implement nutrition and physical activity policies and practices, implementing community-wide nutrition and physical activity motivation/promotion and challenge programs, designing and providing educational materials for native communities, and helping make communities more pedestrian friendly. Participants in 5 Plus 5 programs range in age from children to adults. Programming has varied from school-based educational activities to formation of walking groups to classes in businesses and community settings. As an example, members of the *Fargo Five* coalition are actively involved with city planners to help enhance the walkability of Fargo and surrounding communities.

Fitness education is part of community "5 Plus 5" programs. "WalkND" is a statewide walking program that uses an interactive Web site for data collection and assessment. The program also provides educational e-mails and provides incentives to participants.

The "NDPERS 5 A Day Challenge" is a collaborative effort of the North Dakota Department of Health, North Dakota Public Employees Retirement System (Health Insurance) and the NDSU Extension Service. The program promotes fruit and vegetable consumption and getting at least 30 minutes of moderate physical activity on most days of the week. Participants receive a packet of information, two sessions from a trained member of a cadre of nutrition educators and follow-up e-mails. In addition, they can participate in additional activities planned by the worksite coordinator. For further information, see http://www.state.nd.us/ndpers/insurance-plans/pers-5-

a-day.html. Website with tools can be found at http://www.ag.ndsu.edu/pers/.

The on-line eight-week 5 A Day Cyber Challenge was piloted with adults in 2005. It consists of an interactive Web site where participants receive on-line education via seven weekly "modules" plus interactive Web site explorations. Participants can log their fruit and vegetable intake and pedometer readings and get immediate feedback.

Impact: Pre/post/follow-up surveys were conducted with over 350 participants in MyPyramid education programs. Participants gained knowledge and all participants indicated intentions to make choices more consistent with MyPyramid recommendations immediately following the lessons. On follow-up surveys, about 36 percent reported "always" eating at least three vegetables daily, 93 percent reported "always" eating two fruits daily, 50 percent reported eating at least one whole grain food daily and 50 percent reported being physically active 30 minutes on most days of the week.

5 Plus 5 Programs: In 2005, 18 community coalitions are recognized for their efforts to improve health through the encouragement of increased physical activity and consumption of fruits and vegetables with the potential to reach 74 percent of the state's population. The North Dakota Cardiovascular Health Program, with funding from the Heart Disease and Stroke Prevention Program funding from the Centers for Disease Control and Prevention, has made $1250 available to each community. Ten communities were awarded grants for supplemental funding awarded from the North Dakota Department of Healthy using the Preventive Health and Health Services Block Grant Cooperative Agreement 2005-BI-NDPRVS from the Centers for Disease Control and Prevention. Following are impacts related to 5 Plus 5 programs.

Walk ND: In the past two years, 1949 people have participated in the WALKNWND program. Since May 2004, participants have walked a total of 682,949,160 steps or about 341,475 based on a web-based data collection system. According to on-line post-survey results of the "Walk ND" multi-county walking program, participants increased knowledge and improved their level of physical activity. In a 2005 survey, about 83 percent used pedometers as a tool to monitor daily steps; of those, 80 percent reported an increase in overall activity based on step counts. About 96 percent planned to continue their walking program. Success stories such as the following also were captured via the Web site: "When I started walking in November of 2003 I was only averaging 3300 steps a day, now I get over 10,000 steps at least 4 days a week with the other 3 days at least at 8000. Thanks!" Another participant said, "I have lost a few pounds and brought my blood sugar down a few points!" The program survey also gathered information to make their communities more "walkable."

NDPERS 5 A Day Challenge: Two hundred twenty six people in worksites have registered for the PERS 5 A Day Challenge and completed the pre-test. According to post-tests with one-fourth of the participants responding, 63 percent reported eating more fruits and 57 percent reported eating more vegetables. The variety of fruits and vegetables being chosen has increased, with 41 percent eating more orange/yellow/gold fruits and vegetables, 39 percent eating more green fruits and vegetables and 29 percent eating more red fruits and vegetables. On the pre-test, 41 percent of participants reported bringing fresh fruit for snacks compared to 60 percent on the post-test. On the pre-test, about 16 percent reported consuming three to five

servings of vegetables daily compared to 33 percent on the post-survey. About 91 percent of participants are trying to eat 5-9 servings of fruits and vegetables daily, compared to 59% who were trying prior to completing the *PERS 5 A Day Challenge Program.* Two-thirds of those completing the program are "very likely" to participate in another worksite wellness program.

5 A Day Cyber Challenge: Over 90 people participated in the pilot project. Pre/post testing was used to evaluate the program. On the post-test, 85 percent of participants reported improved food choices, 60 percent reported a more varied diet, 60 percent reported a sense of personal accomplishment, 40 percent reported more energy/stamina, 30 percent reported better fitting clothes and 20 percent reported weight loss. On the pre-test, 69 percent reported spending three or more hours watching TV or sitting at a computer compared to 5 percent on the post-test. On the pre-test, about 75 percent of participants reported eating fresh fruit like apples and bananas as snacks compared to 96 percent on the post-test. On the pre-test, about 17 percent of participants reported eating five or more servings of fruits and vegetables compared to 43 percent on the post-test.

Source of federal funds: Smith Lever

Scope of Impact: Statewide extension

Key Theme - Human Health: Calcium Consumption among Youth
Calcium is the nutrient most likely lacking in the American diet. According to the USDA, 70 percent of pre-teen girls and 60 percent of pre-teen boys do not meet daily calcium recommendations. Calcium-rich foods benefit overall bone health, which is important for growing children and teens. This in-school educational intervention used education and promotion to increase calcium consumption and knowledge/awareness among pre-teens and their parents of the role 3-A-Day of dairy plays in building strong bones. The five-week effort included weekly classroom lessons with participation incentives, educational materials in the libraries, taste testing activities in the cafeterias for all students, and activity booths at school carnivals. Parents received newsletters designed to improve knowledge of calcium-rich foods' health benefits. Over 1,000 children in grades four and five from 13 counties participated.

Impact: Over 1,000 children participated in multi-session calcium education project conducted in 13 counties in 2005. Pre/post surveys indicated increased knowledge and improved attitude toward milk and dairy products. About 63 percent of the participants reported drinking three or more glasses of milk per day compared to 46 percent on the pre-test. On the pre-test, 16 percent of the participants reported drinking soda pop every day compared to 8 percent on the post-test. About 92 percent planned to drink more milk in the future, 74 percent planned to eat more cheese and 73 percent planned to drink less soda pop.

Source of federal funds: Smith-Lever

Scope of Impact: Multi-county level extension

Key Theme - Human Health: Folic Acid Consumption
Research shows that folic acid intake prior to pregnancy and throughout the first trimester can prevent 50-70 percent of neural tube defects. Because half of all pregnancies are unplanned, the Centers for Disease Control and Prevention (CDC) recommends all women of childbearing age consume 400 mcg of folic acid each day. Two-thirds of women in the United States report consuming insufficient levels of folic acid. Preventing birth defects would ultimately have a significant impact on the reduction of health care costs. According to the CDC, the average lifetime health care cost to society for a child born with spina bifida is more than $530,000. In addition to prevention of birth defects, a growing body of scientific research links adequate folic acid with reduced risk for heart disease, certain types of cancer and possibly, Alzheimer's disease.

This project targeted 18-24-year-old women across North Dakota with folic acid education based on the CDC's "Ready or Not" national campaign. Collaborators included extension agents, public health nutritionists, college wellness coordinators, nurses, pharmacists, and dietetics students from two campuses. The multi-faceted campaign used newspaper columns, radio public service announcements, brochures and displays to reach the target audience. Campus promotions were held in cafeterias, libraries, health centers, dorms and sororities.

Impact: Over 2,000 people have participated in interactive educational displays at health fairs, bridal shows and other events, and thousands of people have been exposed to the messages in a variety of settings. The March of Dimes conducted a nationwide Gallup Organization random telephone survey with 20,903 adult participants, including 400 in North Dakota. Awareness of folic acid was higher in North Dakota than nationally. Of the total population, 63 percent of North Dakota adults were aware of folic acid compared to 60 percent of U.S. adults nationally. Among women ages 18-44, 80 percent were aware of folic acid compared to 70 percent of U.S. adults nationally. About 33 percent of North Dakota respondents reported taking a vitamin supplement containing folic acid or a folic acid supplement daily compared to 24 percent nationally. As a result of education and fortification of grain-based foods, birth defects have significantly decreased nationwide in the past five years. According to health department data, birth defects have decreased in North Dakota.

Source of federal funds: Smith-Lever

Scope of Impact: Statewide Extension

Key Theme - Human Nutrition: Expanded Food and Nutrition Education Program
The Expanded Food and Nutrition Education Program (EFNEP) teaches limited-resource audiences how to improve their dietary practices and become more effective managers of available food resources. The nutrition education assistant (NEA) helps families to increase knowledge of the essentials of human nutrition, helps in their ability to select and buy foods that satisfy nutritional needs, and improves practices in food production, preparation and food safety.

Impact: A variety of delivery methods are used to improve nutrition practices in each of the six counties and one tribal college where we reach adults and youth through EFNEP education.

Evaluations show 85 percent of homemakers showed improvement in one or more nutrition practices such as planning meals, making healthy food choices, preparing foods without adding salt, reading nutrition labels or having children eat breakfast.

Source of federal funds: Smith Lever

Scope of impact: Six counties, four of the sites are located at tribal reservations

Key Theme - Human Nutrition: Food Safety
The EFNEP Program focuses on increasing the ability of families receiving food stamps to make wise use of their food dollars. This is accomplished by providing classes to low-income audiences on nutrition and meal planning; food purchasing, preparation, and safety; and food resource management. In 2005 staff received training in food safety involving sanitizing food preparation surfaces. Participants in the food safety classes received small spray bottles, funnels and the appropriate water/bleach ratio to ensure proper sanitizing of food preparation surfaces.

Impact: Follow-up evaluations show 58 percent of homemakers showed improvement in one or more of the food safety practices. Also, 58 percent of participants at entry into the EFNEP program demonstrated acceptable food safety practices. At the end of the program, 81 percent of the participants demonstrated acceptable food safety practices.

Source of federal funds: Smith-Lever

Scope of impact: Six counties, four of the sites are located at tribal reservations, and one tribal college

Key Theme - Human Nutrition: Food Resource Management
One of the overall goals in the area of food resource management for the past year was to help clients manage their food budget. Staff used the curriculum developed by the University of Wisconsin entitled "Money for Food."

Classes are often held at a variety of cooperating agencies such as tribal organizations, WIC or Head Start.

Impact: North Dakota residents attended food resource management programming. Participants defined a variety of means to help them effectively manage their limited resources. Surveys show 81 percent of homemakers showed improvement in one or more food resource management practices, such as planning meals, comparing prices, avoiding running out of food or using a grocery list. Also, 26 percent of the participants at entry level demonstrated acceptable practices of food resource management, compared to 56 percent at the end of their series of classes.

Source of federal funds: Smith-Lever

Scope of impact: Six counties, four of the sites are located at tribal reservations, and one tribal college

Key Theme - Human Health: Childhood Obesity
Obesity is on the rise among children. National data indicates that for youth 6-19 years of age that approximately 15 percent are obese and another 15 percent are overweight (National Health & Nutrition Examination Survey, NHANES). The percentage of children who are above the 95th percentile for BMI has nearly tripled in the past three decades from 4-5 percent in the early 1970s to 15 percent in 1999-2000 (NHANES data). Children who are overweight have an increased incidence of type 2 diabetes and risk factors associated with heart disease such as elevated blood pressure and blood cholesterol.

"On the Move to Better Health" is a school-based collaborative program of public health and extension targeting fifth grade students and promoting a variety of healthy lifestyle behaviors. The month-long program promotes fruit and vegetable consumption, physical activity, and healthy snacking/drink choices. The program includes a parent component and is evaluated using pre and post-test surveys. A variety of community-partners help implement the programs. The program has been packaged and distributed for statewide use, and a video was created featuring North Dakota teenagers enrolled in the "Governor's School," an eight-week campus-based program.

The Centers for Disease Prevention and Control has established Coordinated School Health Grants (CSHG) that includes evaluation of health practices within schools including nutrition and physical activity. In North Dakota and across the nation schools have CSHG to pursue the evaluation and improvement of school health. More recently, the United States Department of Agriculture has mandated that all schools that receive money for the school lunch program must develop a "school wellness policy" by September 2006 to address the child obesity problem through changes in the school nutrition and physical activity environment. Assessment is needed by all school districts to determine direction for changes needed in both policy and curriculum related to nutrition and physical activity. Extension can utilize school assessments to determine focused interventions related to nutrition and physical activity for school-aged children.

In 2005, a pilot project, "Healthy North Dakota 4-H Clubs" was initiated to encourage regular physical activity and proper nutrition among children in 4-H clubs. To earn recognition as a "Healthy North Dakota 4-H Club, the groups must meet established criteria, including having a nutrition education activity or physical activity in three-fourths of their regular meetings. A leader's guide and member's guide were created, and many clubs are currently working on the project.

Impact: In the past four years, more than 3,000 children have completed the "On the Move" program. Pre- and post-test results have indicated increases in knowledge of nutrition and physical activity. In 2005, surveys of fifth grade students in a two-school effort indicated increased knowledge, increased consumption of fruits and vegetables and decreased soda pop consumption. On the pre-test, 38 percent reported consuming one to two servings of fruits and vegetables per day and 42 percent reported consuming three to four servings daily. On the post-

test, 27 percent reported consuming one to two servings daily of fruits and vegetables daily, and 60 percent reported consuming three to four servings daily. The number of children who reported drinking no soda pop increased from 26 percent to 37 percent. On the pre-test, 64 percent of children reported consuming three or more glasses of milk compared to 75 percent on the post-test. The percentage of children reporting two hours or less of "screen time" increased from 62 percent on the pre-test to 76 percent on the post-test.

In 2005 an "On the Move" three-month program was completed with 93 children in grades four and five on an American Indian Reservation. The children set goals for nutrition and physical activity and tracked their progress in journals. On the post-test, 60 percent of the children reported drinking less soda pop, 61 percent reported drinking more water, 58 percent reported eating more fruits and vegetables, 80 percent set regular goals with their families, 76 percent reported increasing the amount of time they were physically active, and 91 percent reported meeting their goals

Extension developed methodology to assess food intake and physical activity behaviors as a component of a Coordinated School Health Grant (CSHG, CDC) under a sub-contact from Fargo Public Schools [(FPS), with a total student enrollment of ~11,000] The trend data for nutrition and physical activity behaviors was analyzed from a district-wide sample of grades 7-12 utilizing the Youth Risk Behavior Survey (YRBS) from 1999, 2001, 2003. Results indicated that students from FPS compared to national had a lower prevalence of both overweight and at-risk of overweight. In addition, the proportion of students from FPS who participated in the following food and physical activity related behaviors were better than national (higher milk intake, lower television viewing on a school day, higher moderate activity, higher daily physical education). However, overtime the trend was for a lower proportion of students to meet milk recommendations. Gender differences were seen with females having a lower prevalence of overweight but also a lower proportion consuming the recommended amounts of milk/fruits and vegetables or engaged in vigorous activity. A reduced proportion of students met recommendations for behaviors related to nutrition and physical activity with increasing grade level.

During spring of 2005 all 6th grade students in FPS (N=890) were surveyed about food and physical activity behaviors by use an adapted Youth Risk Behavior Survey (CDC) tool. The survey data was paired with height, weight, fitness tests and academic measures for each student. The fitness tests included: cardiovascular fitness (a timed mile run); muscle endurance (curl-up); muscle strength (push-up), and flexibility (sit and reach). Selected results include the following: significantly higher mean intake of milk (2.38 glasses) from schools with only a school lunch option (n=350) when compared (2.05 glasses) to schools with ala carte/vending options (n=540); significantly higher proportion getting 3 or more glasses of milk each day when only school lunch was offered (54 percent) compared to ala carte (40.7 percent); significantly lower proportion drinking one or more cans of sweetened beverages each day with only school lunch (38.8 percent) compared to the proportion with ala carte (48.1 percent). Only 32.2 percent of the 6th grade students reported 5 or more servings of fruits and vegetables with no differences between students in school lunch-only option versus those with ala carte options. The combined proportion of 6th grade students, who were classified as either overweight (15.2 percent) or at-risk of overweight (18.1percent), was 33.3 percent. Higher aerobic fitness was found to be

positively associated with higher math scores.

Both assessments done with FPS can serve as models for other school districts to help direct policy and curriculum changes related to nutrition and physical activity and to provide Extension with direction for school-based interventions.

Source of federal funds: Smith-Lever

Scope of impact: Statewide Extension

Key Theme – Human Health: Diabetes Education

Diabetes is the sixth leading cause of death in the United States. Adults with diabetes have heart disease related death rates 2 to 4 times higher than those without diabetes. The risk of stroke is 2 to 4 higher among those with diabetes. The prevalence rate of diabetes is 6.2 percent of the total adult population of North Dakota rising to greater than 14 percent in the 65- to 74-year-old population (2003, BRFSS, CDC). Diabetes is on the rise in North Dakota from 3.6 percent of the population in 1994 to 6.2 percent in 2003. National data from the Indian Health Service for 2000 (NIDDK, NIH) indicates that about 15 percent of the American Indians and Alaska Natives have diabetes that is similar to the prevalence rate of diabetes (15.1 percent) among Native Americans in North Dakota. National data from 2002 estimated that diabetes cost the country $132 billion considering both direct medical and indirect expenditures. Medical expenses were estimated to be $13,243 per year for persons with diabetes and $2,560 for those without the disease. There is increasing concern with the rising numbers of persons with pre-diabetes. Progression from the pre-diabetic condition to diabetes can be prevented by lifestyle intervention including a balanced diet and increased exercise. It has been estimated from national data that about 21 percent of adults are pre-diabetic.

Impact: A statewide workshop was conducted to train NDSU Extension Agents and local dietitians about the West Virginia University Extension's Dining with Diabetes curriculum. A four county pilot (Foster, Grand Forks, Richland, and Walsh) was implemented during the fall of 2005 to determine the feasibility of using this community-based curriculum in North Dakota to help fill the gap in diabetes nutrition education for medically underserved rural North Dakota. Previous assessment by NDSU Extension found several counties in the southern and the western part of North Dakota with few if any identified health professionals who can provide diabetics with the necessary basic nutrition knowledge and skills to manage their disease. Local Extension agents partner with dietitians or certified diabetes educators to present a food-based curriculum to help diabetics make better food choices. Overall assessment of the four county pilots will be completed in 2006 and includes information about changes in behavior, knowledge and attitudes as well as hemoglobin A1c and blood pressure measures both pre- and post-intervention. Partners include the North Dakota Department of Health and the Dakota Diabetes Coalition: Dakota Medical Foundation.

Source of federal funds: Smith-Lever

Scope of impact: Statewide Extension

Key Theme – Human Health: Agriculture to Health
The Dakota Diet concept suggests that foods produced in the Dakotas and Northern Plains, when incorporated into the framework of the Dietary Guidelines, will promote health and reduce chronic disease. Some crops produced on the Northern Plains are known to contain nutrients or phyto-chemicals that may reduce the risk of chronic disease. For example, beans contain a high amount of plant protein, dietary fiber (especially soluble fiber), folate (a B-vitamin); potassium and other minerals as well as being low in fat, saturated fat and calories. The nutrient and chemical profile of beans allows them to play an important role when used as a component of a healthy diet pattern to reduce the risk of being overweight, developing type 2 diabetes, heart disease or colon cancer. The region is also a top producer of a number of healthy plant oils such as canola, flaxseed, soybean, and sunflower. Whole grains such as whole wheat, oats, barley, and buckwheat have been implicated in reducing the risk of diabetes, heart disease and some types of cancer.

Impact: Dry beans were featured for the second lesson for an educational series called "Agriculture to Health" which promotes the health benefits of foods produced in North Dakota and the northern plains when consumed within the context of the Dietary Guidelines. Following training, the educational materials for the lesson were utilized during 2004-05 by NDSU Extension Agents. Pre- and post-session feedback was provided by 11 counties representing 161 participants with 120 responding to the pre-survey and 161 to the post-survey. Prior to the lesson 28 percent of the participants reported intake of 2 or more servings of beans each week and 40 percent reported less than one serving per week. Immediately following the lesson the intentions for future consumption of 2 or more servings a week increased to about 71 percent of the participants. One serving was considered ½ cup of cooked dry beans. The 2005 Dietary Guidelines suggest at least 3 cups of beans each week for adults. About 67 percent of participants preferred to use canned beans and about 15 percent preferred dry beans. Knowledge about the health benefits of beans was initially high but increased significantly more after attending the lesson. A one-lesson format resulted in increased awareness and knowledge of the health benefits of beans with intention to increase bean intake in the future. The nutrition education lesson has potential for future application with low-income women and children. Collaborating agencies included the following: ARS, USDA Human Nutrition Research Center in Grand Forks, ND; NDSU Plant Sciences Department; and the Northarvest Bean Growers Association.

Source of federal funds: Smith-Lever

Scope of impact: Statewide Extension

Allocated Resources ($ x $1,000)		**FYO5**
1862 Extension ($)	Smith-Lever	560
	State	840

	FTE	20
1862 Research ($)	Hatch	0
	State	0
	FTE	0

Goal 4: Greater Harmony Between Agriculture and the Environment

Overview: *Agricultural pollution primarily from non-irrigated cropland, grazing land and feedlots presents a significant threat to North Dakota's surface waters. According to the North Dakota Department of Health, 58 percent of the state's assessed river and stream miles and about 56 percent of the assessed lakes and reservoirs are either threatened or impaired for aquatic life use. The primary reasons for impairment of stream and rivers were total fecal coliforms, physical habitat alterations, and sedimentation. The main sources for these impairments were riparian grazing, animal feeding operations, crop production, and loss of riparian habitat impairments. The primary reasons for impairment lakes and reservoirs were oxygen depletion, elevated temperatures, and elevated nutrients. Agriculture also threatens ground water. Over- application of fertilizer and runoff from farm fields can result in degradation of ground and surface water. Livestock waste has been identified as an important source of pollutants. The area occupied by feedlots and other concentrated production units is currently relatively small; however, the proximity of animal operations to surface water resources and/or aquifers makes them a possible source for pollution.*

In 2005, Extension programs on site-specific management reached over 5,000 producers in the region. It is estimated that an additional 20,000 growers were reached indirectly about some aspect of site- specific farming/N management in 2005. In studies using zone management of N in sugarbeets, economic advantages when there is sufficient variability of N range from $10-$100/acre. A recent American Crystal survey based on harvest receipts and grower practices showed a $45/acre advantage over conventional soil testing based on zone management and zone management with a $20/acre advantage over grid sampling. On wheat and sunflowers, net returns are in the range of $5-$15/acre when field N variability exists, which would roughly double profit margins in these crops. In addition, the use of some form of zone N sampling reduces the need for "insurance" rates of N, which are often 40-50 lb. N/acre ($10-$16/acre current price). Comparison of site-specific N management in corn with an adjacent grower field showed 60 lb N per acre less leaching on the site-specifically managed corn compared to a conventionally managed field.

Effective irrigation water management requires accurate daily crop water use estimates. Since 1995, the NDSU Extension Service has had a Web site that displays the crop water use for the 10 major irrigated crops in North Dakota. The water use for each crop is calculated using data from the 67 automated weather stations on the North Dakota Agricultural Weather Network (NDAWN). During June, July, August and September of the 2005 growing season, the crop water use Web site handled more than 50,000 successful requests for pages. The Web site was accessed the most in August (over 20,000 requests), which is not surprising since it was the hottest and

driest month. Over 900 distinct computers accessed the Web site. The crop water use numerical tables were requested about ten times more often than the crop water use maps. There are about 1,500 irrigators in North Dakota. Many contract with crop consultants for information services. Most consultants working with irrigators access the Web site at least twice per week and increase the impact of the irrigation water management information by providing a multiplier effect.

Prior to the time when NDSU launched research and extension programs on controlling leafy spurge in 1998, the number of acres infested with the weed was doubling every decade. Today, the leafy spurge infestation in North Dakota has held steady to declining in the state over the last few years. An integrated management program using herbicides, grazing, and Aphthona spp. flea beetles may provide the best long-term control of leafy spurge in the region. This research resulted in the first known establishment of Aphthona species flea beetles in the habitat of the western prairie fringed orchid, an endangered species. Success of biological control for leafy spurge control will allow land managers to reduce production costs and increase production values of land infested with leafy spurge. Sheep effectively controlled leafy spurge after one year using a single species grazing approach and after three years using a multi-species grazing approach. Leafy spurge stem densities were reduced by 98 percent and 96 percent on single-species and multi-species grazing treatments, respectively, after eight years. Season long grazing using a multi-species approach provided a quicker, more efficient grazing of leafy spurge than rotational grazing; however, both reduced leafy spurge stem densities by 99 percent and 75 percent, respectively, after eight years. The research provides new options for North Dakota livestock producers who want to control this invasive weed. Chemical control on large patches of the weed is seldom cost effective. The research shows that sheep can provide some financial return while providing control. Reduced herbicide use will enhance environmental quality of natural lands through reduction in herbicide contamination of ground and surface water and reduced effects on nontarget organism.

The NDSU Extension Livestock Waste Technical Information and Assistance program addresses address manure nutrient utilization, livestock feeding, housing, and management impacts on livestock waste and defines and delineates the non-point pollution rules and the economics of proper livestock waste management. In the past year this program has provided education to producers, NRCS employees, 319 Watershed Coordinators, County Extension Agents, commodity association members, regulators and policy makers through 30 workshops, 25 on-farm producer consultations, and development and distribution of four new Extension publications. The requests to present livestock manure nutrient management information to audiences outside of ND show that this program is gaining regional and national attention.

Key Theme - Water Quality: Nutrient Management

Extension specialists and experiment station researchers have developed methods to compare various types of zone delineation methods, which increases the effectiveness of soil testing and nitrogen fertilization efficiency. Tools that were evaluated included aerial photography, satellite imagery, soil EC sensor measurements, topography and yield monitor data. Sugarbeet growers in the Red River Valley use satellite imagery and aerial photography to map 200,000 areas of sugarbeet fields and then give an N credit or adjustment for subsequent crops based on relative canopy N content. Wheat and sunflower growers in central and western North Dakota are using

topography, satellite imagery, multiple-year yield maps and electrical conductivity sensors to locate homogeneous zones within fields. These zonal boundaries are used as guides for soil sampling. The move to site-specific approaches to nutrient management is progressing west of the Red River Valley with an estimated 150,000 now being affected by these methods.

Impact: In 2005, programs focusing on site-specific management totaled about 2,000 attendees at various presentations around North Dakota. In addition, site-specific soil testing has been woven into nearly all presentations given, amounting to about 3,500 other attendees. News releases on radio and in the press have been provided for people who do not attend meetings. Four circulars were printed in 1999 to provide general site-specific information regarding sampling, fertility, concepts and environmental benefits. These have been well received by growers and received a national award from the American Society of Agronomy in 2000. It is estimated that an additional 20,000 growers were reached indirectly about some aspect of site-specific farming/N management in 2005. In studies using zone management of N in sugarbeets, economic advantages when there is sufficient variability of N range from $10-$100/acre. A recent American Crystal survey based on harvest receipts and grower practices showed a $45/acre advantage over conventional soil testing based on zone management and zone management with a $20/acre advantage over grid sampling. On wheat and sunflowers, net returns are in the range of $5-$15/acre when field N variability exists, which would roughly double profit margins in these crops. In addition, the use of some form of zone N sampling reduces the need for "insurance" rates of N, which are often 40-50 lb. N/acre ($10-$16/acre current price). Comparison of site- specific N management in corn with an adjacent grower field showed 60 lb N per acre less leaching on the site-specifically managed corn compared to a conventionally managed field.

Source of Federal Funds: Smith-Lever and Hatch, USDA-ARS IFAFS

Scope of Impact: Multi-state research and extension, MN and MT, MN and SD

Key Theme - Water Quality: Irrigation Technical Information and Assistance
Effective irrigation water management requires accurate daily crop water use estimates. Since 1995, the NDSU Extension Service has had a Web site that displays the crop water use for the 10 major irrigated crops in North Dakota. The water use for each crop is calculated using data from the 67 automated weather stations on the North Dakota Agricultural Weather Network (NDAWN). During the growing season, the crop water use data is updated daily. The user can view the daily water use of each crop as color-coded maps or as numerical tables. To use the maps for irrigation management purposes, the irrigator or crop consultant selects both the crop and the nearest emergence date.

Recently, the crop water use model has been fully integrated into the NDAWN website. The look and feel of the crop water use section matches the other parts of the website so a visitor to the website will have the same experience whether accessing crop water use data or finding out the latest small grain Fusarium head blight infestation potential.

Additional features have been added to help the irrigator or crop consultant make better, more informed irrigation decisions. For instance, when accessing the crop water use numerical tables, daily rainfall, total rainfall, daily crop water use, total crop water use and deficit conditions are all presented. In addition, a simple click of an icon at the top of each column will bring up a graph of the data. To trace the progress of water deficit (which applies to both irrigated and dryland conditions), a user can obtain a color-coded map showing the difference between the crop water use and rainfall. As the growing season progresses, these maps clearly show the areas of the state with deficit water conditions.

Since 1977, extension has had a bulletin on irrigation scheduling by the Checkbook method. This bulletin has been very popular with growers. In 2000 a computerized version of the checkbook was developed in cooperation with the Minnesota Extension Service. The program was revised in 2001 and has been distributed throughout both states. In 2003, a version of the checkbook program was developed that would run on a Palm Pilot.

Impact: The crop water use maps and numerical tables are used extensively for irrigation scheduling. For example, during June, July, August and September of the 2005 growing season, the crop water use Web site handled more than 50,000 successful requests for pages. The average daily requests were more than 500. The busiest day of the week was Monday with more than 20,000 requests during the growing season. The Web site was accessed the most in August (over 20,000 requests), which is not surprising since it was the hottest and driest month. Over 900 distinct computers accessed the Web site. The crop water use numerical tables were requested about ten times more often than the crop water use maps. There are about 1,500 irrigators in North Dakota. Many contract with crop consultants for information services. Most consultants working with irrigators access the Web site at least twice per week and increase the impact of the irrigation water management information by providing a multiplier effect.

Every year since 1977, between 500 and 800 of the Irrigation Scheduling by the Checkbook Method (AE-792) bulletins have been distributed. Over the years, this bulletin has been copied by the extension services of other states. Since development of the computerized version, more than 100 copies have been distributed in North Dakota and Minnesota.

The NRCS has adopted the computerized irrigation-scheduling program to support the irrigation water management portion of their Environmental Quality Incentive Program (EQIP). The program provides documentation showing irrigation management decisions made by the cooperator that the NRCS need to evaluate the impact of their water conservation programs. Since the inception of this program in 2003, over 50 copies of the program have been distributed to EQIP participants. Copies were also provided to many county NRCS offices and the state irrigation engineer.

Source of Federal Funds: Smith-Lever

Scope of Impact: Statewide extension

Key Theme - Natural Resources Management: Development of water management practices and tools for improved crop production and natural resource management
Researchers at NDSU have begun a watershed-scale study of soil and water compatibility and evapotranspiration for water resources management. Another project is developing modeling capabilities in the area of nonpoint source hydrologic modeling of agricultural watersheds.

Impact: The evapotranspiration research is expected to provide information regarding possible expansion of irrigation in the state as well as information useful for the management of existing water resources. The hydrologic modeling effort is expected to enable the ND Department of Health to conduct modeling studies of additional watersheds as part of its charge to conduct total maximum daily load studies on impaired watersheds in the state.

Source of federal funds: Hatch

Scope of impact: Statewide research

Key Theme - Integrated Pest Management: Insect Pest and Disease Information for Producers
The statewide IPM crop and pest survey has evolved into a more comprehensive program for obtaining crop and pest information. Beginning in 2002, the survey was expanded to include five crops and their key pests. In 2003, the state was divided into five regions. Six crops and their key pests were surveyed from the last week of May until the end of August. The survey was limited to five crops again for 2005. A total of 1,917 fields were visited from late May until the end of August. Information from these surveys is summarized in geo-referenced maps for use in newsletters, reports, and web information. The survey can be found at: http://www.ag.ndsu.nodak.edu/aginfo/ndipm/. The maps summarizing the sampling data were used to graphically illustrate where pest problems were developing in the region. Crops include wheat, barley, soybean, sunflower, and canola. Pests include grasshoppers, cereal aphids, cereal leaf rust, *Fusarium* head blight, soybean aphid, flea beetles, white mold/sclerotinia, and more that are specific to the crops. This survey program has evolved during the past five seasons, incorporating the geo-referencing of data, mapping, to expansion of crops and focus of pest issues. Pests of regulatory importance are also recorded to assist detection efforts of the State Department of Agriculture and USDA APHIS, such cereal leaf beetle.

Regional surveys for detection of overwintering larvae of the orange wheat blossom midge have been conducted for ten years. These surveys identify locations of high populations of overwintering midge, and provides an estimate of the risk that wheat midge represent to the wheat/durum producers. Producers and managers use the information to help plan for the up coming season. The project has been funded through the North Dakota Wheat Commission since 1995. Members of the commission continue to support the effort and have expressed a desire to continue funding the project. Funds were reduced beginning with the 2002 survey, limiting the scope to counties only in the northern half of the state where midge risk is greatest.

Canola Insect Pest Trapping Network was conducted in the major canola growing areas of North Dakota for the past eight years. Pheromone traps are used to monitor for two insect pests of

canola: Bertha armyworm *(Mamestra configurata*), and Diamondback moth (*Plutella xylostella*). Trap data provides growers, Ag consultants, field researchers, and county extension agents/specialists with an "early" risk warning system of when these insect pests are active and their population levels. A total of 12 trap sites in 9 counties in North Dakota and 3 sites in northwestern Minnesota were monitored. Overall, the average bertha armyworm moth per trap day was about 35% lower than the averages in 2004, and populations did not need to be controlled in the 2005 canola crop. Diamondback moth arrived in higher densities and earlier than 2004. Severe larval feeding injury was observed in seedling canola fields in the north central region of North Dakota. However, the above average rainfall during June throughout most of North Dakota drowned larvae of the first generation and reduced populations. As a result, the majority of canola fields did not require any insecticide spraying.

Extension Entomology actively participates in the National Plant Diagnostic Network (NPDN) of the USDA, CSREES. The network is a collective of Land Grant University plant disease and pest diagnostic facilities from across the United States. The mission of the network is to enhance national agricultural security by quickly detecting introduced pests and pathogens. This will be achieved by creating a functional nationwide network of public agricultural institutions with a cohesive, distributed system to quickly detect deliberately introduced, high consequence, biological pests and pathogens into our agricultural and natural ecosystems. It provides a means for quick identifications and establishing protocols for immediate reporting to appropriate responders and decision makers. The network will allow Land Grant University diagnosticians and faculty, State Regulatory personnel, and first detectors to efficiently communicate information, images, and methods of detection throughout the system in a timely manner. The establishment of the network will provide the means necessary for ensuring all participating Land Grant University diagnostic facilities are alerted of possible outbreaks and/or introductions and are technologically equipped to rapidly detect and identify pests and pathogens. This will be accomplished by establishing an effective communication network between regional expertise, developing harmonized reporting protocols with the national diagnostic network participants, and cataloging pest and disease occurrence to be included in national database. (Source: Mission statement of NPDN - http://www.npdn.org/)

Impact: The crop and pest surveys have provided valuable information about current crop and pest situations as they develop in the region. With the survey information, extension specialists have been able to develop programming needs to address the issues that were being faced by agriculture in a proactive fashion rather than after the fact. The proactive programming provides the tools to make timely management decisions that produce economic return during the current production season.

Source of Federal Funds: Smith-Lever

Scope of Impact: State Specific

Key Theme - Conservation of Biodiversity: Evaluation of Transgenic Corn
Corn rootworms cost U.S. producers about $1 billion annually in yield losses and control costs. Transgenic corn varieties, genetically engineered to express a beetle-specific crystalline protein

(Cry3Bb) that is toxic to corn rootworms, have recently been developed for use in U.S. production systems. It is conceivable that some non-target organisms could ingest pollen, silks, or other residual plant materials from these varieties. An investigation is being carried out to determine whether this material is likely to pose a significant threat to the abundance or species diversity of non-target Coccinellidae (Lady beetles), Anthocoridae (i.e., pirate bugs and flower bugs), or Chrysopidae (green lacewings) common to many midwestern cornfield habitats.

Impact: Rootworm-resistant Cry 3Bb corn is anticipated to have a rapid adoption rate among U.S. corn producers affected by the pest; however, the potential effects of this new Cry protein on non-target insect taxa, especially those genetically similar to corn rootworms, are not well understood. Phase I of this work has been completed. It was concluded that monocultures of corn expressing the Cry3Bb protein are not likely to pose any negative impacts on the lady beetle complex of species monitored in this study. Moreover, the transgenic corn was as safe and, in some cases, safer than the conventional soil-applied insecticide tefluthrin. This information will be helpful in understanding the overall environmental impact of this promising pest management strategy on important beneficial organisms. Further study is being carried out on other taxa. If found to be environmentally compatible and benign to non-target organisms, transgenic rootworm-resistant varieties will allow for major

Source of Federal Funds: Hatch

Scope of Impact: Multi-state integrated research and extension. The insects are widely distributed from the central plains between Texas and North Dakota to the northeastern seaboard. Currently, more pounds of insecticide material are applied for control of corn rootworms than for any other insect pest in the United States. Transgenic technology has the potential for allowing major reductions in use of conventional insecticides for this key pest of corn.

Key Theme - Integrated Pest Management: Invasive Weeds
Invasive weeds are one of the greatest threats to croplands, rangelands, and wildlands, not only in the region, but also in the United States. Leafy spurge alone currently infests more than 4 million acres in the Northern Great Plains and Intermountain West and causes an estimated $195 million annual loss due to decreases in forage and livestock production, wildland- and wildlife-associated recreation, and soil and water conservation.

Long-term leafy spurge control has been most successful when more than one method is used to control the weed. Incorporation of *Aphthona* biological control agents with herbicides resulted in a more rapid and higher level of control compared to either method used alone. The *Aphthona* spp. population also increased rapidly following application of herbicides. The least successful integrated program has been incorporation of leafy spurge biological agents with revegetation programs. The intensive tillage and often-repeated use of herbicides to ensure establishment of seeded grasses and forbs have not been compatible with biological agents. Biological control agents alone did not provide complete leafy spurge control. Leafy spurge stem density and foliar cover were assessed 5 yr or more after release in the Little Missouri River drainage of North and South Dakota, Montana, and Wyoming. Leafy spurge stem density was reduced approximately 75% to fewer than 25 stems per sq m and foliar cover reduced to less than 5% on over two-thirds of the sites. Field studies were conducted to evaluate the impact of ground cover, winter soil

temperature on the over wintering success of *Aphthona* flea beetles. During all study years, *Aphthona* flea beetle spring emergence was lower than the population entering the over wintering period. A snow only cover was effective at protecting the *Aphthona* larvae from winter mortality only when the mean soil temperature did not fall below -5 C. A snow plus debris ground cover provided similar protection as snow alone. Twelve years after the initial release of *Aphthona* spp. at one study site, the flea beetle populations and leafy spurge stands were lower in thicket, forest, and meadow habits compared to high and mid prairie habitats. At a second study site, the leafy spurge stem count was significantly lower in the mid prairie habits compared to the high prairie, forest, and meadow habitats.

Impact: The leafy spurge infestation in North Dakota has held steady to declining in the state over the last few years. This is a major accomplishment as prior to 1998 leafy spurge was doubling in acreage in North Dakota every 10 years. An integrated management program using herbicides, grazing, and *Aphthona* spp. flea beetles may provide the best long-term control of leafy spurge in the region. This research resulted in the first known establishment of *Aphthona* species flea beetles in the habitat of the western prairie fringed orchid, an endangered species. Improved information for ranchers and range managers concerning economics of alternative means of controlling leafy spurge have been distributed in paper formats which they preferred compared to electronic media.

Source of Federal Funds: Smith-Lever and Hatch, federal grants

Scope of Impact: Multi-state in the North Central and Rocky Mountain Regions

Key Theme - Integrated Pest Management: Characterizing Weed Population Variability for Improved Weed Management Decision Support Systems to Reduce Herbicide Use
Weed management decision-making is complex, requiring integration of weed biology, environmental risks, labor needs, crop yield potential, efficacy of a given control measure, and economics. Researchers are working to better understand: variability from weed competition studies for development of a decision support system; the basis and relative importance of spatial, temporal, and biological variability in weed/crop competition; and the spatial, temporal, and biological variability of weed seed in the soil seedbank and its impact on weed/crop competition.

Experiments were conducted near Fargo, ND in summer 2005 to address sub-objective 1D that was designed to determine corn and soybean grain yield loss associated with four cohorts of a multi-species weed community. These data, along with data from several other sites in the north central region, are to be used as validation data sets for a weed management decision support system. Glyphosate-resistant corn was seeded on May 5 at a density of 79,000 seeds ha^{-1} in rows spaced 76 cm apart, and glyphosate-resistant soybean was seeded on May 20 at a density of 500,000 seeds ha^{-1} in rows spaced 18 cm apart. The major weed species in the studies were: common lambsquarters (*Chenopodium album*), redroot pigweed (*Amaranthus retroflexus*), Venice mallow (*Hibiscus trionum*), wild buckwheat (*Polygonum convolvulus*), wild mustard (*Brassica kaber*), foxtail (*Setaria* spp.) and nightshade (*Solanum* spp.). Glyphosate was applied at the V2, V4, and V6 growth stages of corn and at the VC, V1, and V3 growth stages of soybean. Weed-free and weedy treatments were included in each study. Subsequent to each

glyphosate application weed escapes were monitored weekly in two 0.1 m^2 quadrats per plot. Weed biomass was harvested from each quadrat when crops reached physiological maturity, dried, and biomass and seed production determined. The center two rows of each plot were harvested on Oct. 18 (soybean) and Oct. 20 (corn). Each experiment was a randomized complete block design with four replicates. When glyphosate was applied up to the V2 or V4 corn stages, average weed biomass and seed production was 41 kg ha^{-1} and 3,724 seeds m^{-2}, respectively; whereas when glyphosate was applied up to the V6 corn stage weed biomass and seed production was 2.3 kg ha^{-1} and 53 seeds m^{-2}, respectively, and similar to the weed-free treatment. Average corn yield was 10,340 kg ha^{-1} among the glyphosate treatments and was equivalent to the weed-free treatment and greater than the weedy treatment of 8,990 kg ha^{-1}. Glyphosate applied up to the VC soybean stage resulted in weed biomass of 26 kg ha^{-1} which was similar to the weedy treatment, but with fewer weed seeds produced per m^{-2} (386) compared to the weedy treatment (1,895); and soybean yield of 2,480 kg ha^{-1} and was higher than the weedy treatment (1,925). Soybean yield, weed biomass and seed production for the V1 and V3 soybean treatments averaged 2,294 kg ha^{-1}, 0.4 kg ha^{-1} and 0 seeds m^{-2}, respectively, and were similar to the weed-free treatment.

Impact: This research will also allow us to determine the degree of spatial variability within a field and between fields with various cropping systems and soils for weed species of agronomic importance in the north central region.

Source of Federal Funds: Hatch

Scope of Impact: Multi-state

Key Theme - Integrated Pest Management: Biological Control in Pest Management Systems of Plants

Although chemical pesticides have had a beneficial impact on agriculture, their attendant side-effects, such as target pest resurgence, secondary pest outbreaks, pest resistance, and environmental contamination, demand that more ecologically sound methods of pest suppression, such as integrated pest management (IPM), be developed. The mission of this regional project is to facilitate research and implementation activities among the participating institutions and organizations in applied biological control. Objectives are to evaluate natural enemy efficacy and study ecological/physiological basis for interactions; identify and assess factors potentially disruptive to biological control and implement and evaluate habitat modification, horticultural practices and pest suppression tactics to conserve natural enemy activity.

Aphthona population development and leafy spurge stem density when flea beetles are combined with herbicide and competitive grass species: although the adult *Aphthona* flea beetle population is substantially higher in insect only and insect plus competitive grass species treatments, leafy spurge stem density is substantially lower in the treatments with a fall herbicide application. *Aphthona* flea beetle species overwintering success and leafy spurge stand density in ground cover versus no ground cover treatments: Snow cover may not provide sufficient protection for overwintering *Aphthona* larvae when mean winter soil temperature drops below approximately

4^{o} C. Overwintering success of *Aphthona* larvae was not different among snow-covered treatment plots with or without a grass debris covering. Leafy spurge stand density was not significantly different among ground cover treatments. *Aphthona* flea beetle species distribution among ecological habitats fourteen years after their release: Flea beetle populations were uniformly distributed among different habitats in a pasture consisting of high prairie, mid prairie, thicket, tree, and wetland. In a second pasture, a significantly higher number of beetles occurred in mid-prairie habitat compared to high-prairie, tree and wetland habitats.

Impact: Success of biological control in IPM systems for leafy spurge control will allow land managers to reduce production costs and increase production values of land infested with leafy spurge. Reduced herbicide use will enhance environmental quality of natural lands through reduction in herbicide contamination of ground and surface water and reduced effects on nontarget organism. A reduction in leafy spurge infestations will reduce the detrimental impact of this invasive species on native plant species. A better understanding of ecological and environmental mechanisms that effect habitat distribution, establishment, and population development of *Aphthona* flea beetle species is important in improving the success rate of these biological control agents for leafy spurge control.

Source of Federal Funds: Hatch

Scope of Impact: Multi-state

Key Theme - Natural Resource Management: Renewable Resources
An integrated extension and research program was developed to improve rangeland management across the state. Key components of the effort included:
Extension
One of the main efforts was the development and publication of the third edition “Rancher’s Guide to Grassland Management III". This book encompasses 27 chapters including sections on plant identification, noxious weed identification and control, poisonous plants, grazing management, riparian grazing management, forage and pasture development, and drought management.

Cow/calf and 12-month grazing and forage planning workshop (two- and three-day): Three intensive grazing, forage and livestock management sessions were held in Dickinson, Killdeer and Carson for livestock producers. Ranchers learned to improve their rangeland management skills, develop yearlong forage use strategies, and improve overall management of their beef herd. One-day range management and/or natural resource workshops were conducted at 28 locations in North Dakota, including 1 via the polycom video system. These one-day programs are designed to introduce ranchers, farmers, conservationists, and youth range management principles that can enhance grazing management, conservation programs, and economic efficiency. Educating youth on the importance of the range resource: A four-day range youth camp was conducted in western North Dakota for youth interested in the range resource and range judging. Youth learned the importance of range to livestock producers, the environmental community, and wildlife enthusiasts. They learned basic fundamental range management practices and how to judge the resource for health and value for forage and wildlife habitat.

Conduct one to two-day natural resource management programs on tribal lands in North and South Dakota: These programs were conducted at Fort Berthold, N.D., and Mission, S.D.; and concentrated on local ranchers and farmers, professionals in the region, and students at the colleges. Conduct 1 three-day in-service training session for North and South Dakota extension agents/educators and North and South Dakota Natural Resource Conservation Service conservationists in Madison, SD. Thirty-seven educational professionals (Extension agents and NRCS Staff) in North and South Dakota were taught using classroom and field activities under a sustainable agricultural program for western rangeland.

Impact: The first edition of "Rancher's Guide to Grassland Management" was published in January 2003 and out of print by March, distributing over 400 copies to eastern North Dakota and western Minnesota farmers and ranchers, and natural resource professionals. The second edition of "Rancher's Guide to Grassland Management" in June 2004 with 1,960 copies distributed through North Dakota, eastern Minnesota, and southeastern South Dakota, and out-of-print by August of 2004. The third edition was published in December 2005 with 810 copies distributed through North Dakota and eastern Montana. Over 3,260 land managers and ranchers received this book for educational and hands-on use to impact an estimated 3,595,000 acres of land. Ninety-one ranchers participated in the cow/calf and 12-month forage planning workshops. These two workshops impacted over 191,100 acres of native rangeland, pastureland, and hayland and 12,161 animal units of livestock. More than 85 percent of the participants were planning to add new range improvement practices or cattle nutritional programs.

One-day range and forage management workshops and schools were conducted for 1,024 participants in North Dakota, bordering counties of South Dakota and Montana, Wyoming, and Manitoba, Canada. These programs were designed to introduce and teach ranchers, farmers, land managers, and youth the proper resource management tools and management strategies to improve efficiencies of the land base. The producers were then introduced to the more intensive two- or three-day workshops that would concentrate on their land base. Twenty-nine youth ages 13-18 participated in the four-day range camp and 171 participated in the State Range Judging Contest. Seven other educational programs were taught to youth ages 10 through 18 and undergraduate college students, totaling 214 students. We believe any involvement of youth in the importance of the range resource and fundamental needs for managing these lands will create a better-rounded adult.

Ten and 22 people participated in the two natural resource educational programs associated with tribal lands on Fort Berthold in North Dakota and Pine Ridge Reservation in South Dakota. These programs were developed to help guide us in developing educational programs, demonstration projects, and research projects on tribal lands in North and South Dakota. Results from previous needs assessments indicate a need for natural resource educational material and programs to enhance use for small and mid-size ranchers and farmers. There is also a need to be more sustainable on the Tribal lands and using their commodity products within the Tribal areas more effectively. A better understanding and marketability of bison and the natural resources well addressed as well.

Thirty-seven county agents/educators and Natural Resource Conservation Service staff

participated in a one-day sustainable agricultural program. This program was the second phase of a four-phase grant to help educate professionals on range management, livestock nutritional needs, range habitat assessment, and mentor development. By teaching the sustainable range management to professionals that are the key contact personnel in a county, we can provide educational tools and materials to potentially thousands of land managers impacting hundreds of thousand acres in North and South Dakota. This program is part a 2-year project that will finish in 2007 and funded by the NCC SARE program.

Research

1) Effects of sheep grazing using a multi-species and single-species grazing approach on leafy spurge infested rangeland: NDSU Extension Service, in cooperation with the Animal and Range Sciences Department and Hettinger Research Extension Center have conducted grazing trials on leafy spurge infested rangeland throughout North Dakota.

Impact: Sheep effectively controlled leafy spurge after one year using a single species grazing approach and after three years using a multi-species grazing approach. Leafy spurge stem densities were reduced by 98 percent and 96 percent on single-species and multi-species grazing treatments, respectively, after eight years. Season long grazing using a multi-species approach provided a quicker, more efficient grazing of leafy spurge than rotational grazing; however, both reduced leafy spurge stem densities by 99 percent and 75 percent, respectively, after eight years. The research provides new options for North Dakota livestock producers who want to control this invasive weed. Chemical control on large patches of the weed is seldom cost effective. The research shows that sheep can provide some financial return while providing control.

2) Effects of dormant season grazing on native rangeland in western North and South Dakota: NDSU Extension Service, in cooperation with the Animal and Range Sciences Department and Hettinger Research Extension Center has conducted grazing trials on western rangelands in North and South Dakota.

Impacts: Dormant season grazing (mid November through mid January) at moderate and full use did not effect herbage production the following compared to standard full use summer grazing (June 1 through November 1). Double use of two weeks grazing in mid June followed by dormant season grazing from mid November through mid January enhance subsequent years herbage production by 0 to 26 percent. These results are from years 1, 2, 3, 4 and 5 of a projected 10-year study. Initial results would indicate ranchers and land managers could graze their winter pastures for two weeks in June at 50 percent use of standing herbage and fully graze (50 percent) the dormant season forage and enhance subsequent year's growth.

3) Impacts of dormant season prescribed fall fire on herbage production and plant community dynamics of native rangeland managed using seasonlong or twice-over rotation grazing and nonuse in western North Dakota: NDSU Extension Service, in cooperation with the Animal and Range Sciences Department and USDA Forest Service has conducted this trial in western rangelands of North Dakota.

Impacts: Twenty-one months post prescribed October dormant season fire decreased herbage production on the season long and twice-over rotation grazing treatment, and control; however,

no significant reductions occurred after 33 months on the any treatment. Almost a 100 percent kill of club moss occurred from the prescribed fire at 9 and 21 months post fire, irrelevant of treatment; with 82 percent control achieved 33 months after treatment.

Source of Federal Funds: Hatch and Smith-Lever

Scope of Impact: Multi-state research and extension

Key Theme - Water Quality: Livestock Manure Nutrient Management Technical Information and Assistance

Educational programs are being developed to address manure nutrient utilization, livestock feeding, housing, and management impacts on water quality. Educational workshops targeted to ND producers were held across the state. Locations included Jamestown, Dickinson, Minot, Carrington, Stanley, Fargo, Bismarck, Linton, Hettinger, Towner, McClusky, Larimore, New Rockford, Granville, Mandan, Valley City, New Salem, Bantry, Lisbon, Bowman and Fessenden. Nearly 1000 individuals were reached at these meetings. Audiences included producers, crop consultants, industry representatives, NRCS, SCD, NDSU Extension personnel and research personnel. The objective of each workshop varied slightly, but all presentations focused on manure nutrient utilization in cropping systems as well as how livestock facility management can lower the risk of runoff that can impact surface water. This same type of information was presented at out of state workshops by request. These workshops were held in Brandon, MB, Denver, CO, and Buffalo, NY. The target audience at these workshops was producers, regulators and extension employees for a total number of nearly 150 people reached.

Impact: In the past year this program has provided education to producers, NRCS employees, 319 Watershed Coordinators, County Extension Agents, commodity association members, regulators and policy makers through 30 workshops, 25 on-farm producer consultations, and development and distribution of four new Extension publications. Increased awareness of this key theme is reflected by numerous newspaper, television, and radio interviews conducted in the past year to clarify the issues for the general public. The requests to present livestock manure nutrient management information to audiences outside of ND show that this program is gaining regional and national attention.

Source of Federal Funds: Smith-Lever and EPA

Scope of Impact: State specific

Allocated Resources ($ x $1,000)		**FYO5**
1862 Extension ($)	Smith-Lever	378
	State	567
	FTE	13.5

1862 Research ($)	Hatch	204
	State	300
	FTE	6

Goal 5: Enhanced Economic Opportunity and Quality of Life for Americans

Overview. *The Great Plains has struggled with rural population loss for decades. Nearly two-thirds of the counties in the region have a smaller population base than they did in 1950. In the last half century, the overall loss in rural counties has been more than 34 percent – more than a half million people. Significantly, the largest loss of population has been those in their twenties and early thirties, reducing the proportion of youth and increasing the proportion of the elderly remaining. In North Dakota counties, 35 of 53 counties lost young adults at rates that exceeded 50 percent. In the 21st century, shaping forces will include information technology, agricultural technology, changes in federal policies, and international trade policy. Major changes in the rural landscape are causing great stress as well as creating new opportunities.*

Economic development also has been a long-standing concern for North Dakota policymakers. Farming, once the backbone of the rural economy, has dwindled in economic strength. Nearly 90 percent of total income earned by farm households comes from off-farm sources. In North Dakota, the service industry accounts for the largest share of the gross state product at 19 percent. Government follows at 16 percent and Finance, insurance and real estate at 15 percent. Agriculture generates just over 5 percent.

Extension has organized agencies and organizations to develop and deliver a statewide curriculum and program for community strategic planning to help rural communities. In two two-day workshops, 102 facilitators were trained for the strategic planning process. Of those facilitators, 72 attended another one-day session for pilot program updating and specific facilitator skills training. Ninety-three communities are currently in the process or have concluded conducting strategic planning programs with the assistance of the trained facilitators. An additional 15 communities were identified and participated as three member teams in a Heartland Center training sponsored by Federal Land Bank. If you calculated the total of volunteer time dedicated to the strategic planning process in the ninety-three communities by taking an average of 15 hours per steering committee member times 12 or the average size of a committee times $17.19 (value of one hour of volunteer time according to Independent Sector) times 93 communities you would get $287,760.60 total value of volunteer time spent on strategic planning in ND communities. The strategic plans that have been completed are currently being analyzed by the ND State Data Census Center to determine begin to look at what has been done, what were the factors for successful planning and what has been completed. This began in 2005 and will continue into 2006 and 07.

450 people have participated in 12 agritainment workshops. Of those participating, 197 completed the post-workshop evaluations. Results include: 99 percent gave the program an overall rating of useful to very useful; 114 people indicated that the workshop did help them to make a decision as to whether or not they would pursue starting a recreation business, 33

percent were already in business; 90 participants plan to start a business; of those already established 31 indicated that they would make changes in their current operation because of what was learned. Follow-up surveys were sent to 306 of the extension agritainmnet workshop participants. Fifty-three responded. Of the respondents, 24 had a business. Thirteen of 24 businesses said that the workshop had a direct positive impact on their business.

Rural communities in the Great Plains need to diversify their economic development options, specifically natural resource-based tourism and tapping the economic potential generated by seniors. Analysis of outdoor recreation and nature-based tourism in North Dakota shows a continued rise in activity. Economic modeling demonstrates its value relative to other industries. In the Southwest region of North Dakota, recreation and nature-based tourism contributed $223.6 million to the regional economy, a level on par with agriculture ($226.1 million). Efforts to document the impact of this industry on the state's economy suggest that it is a viable strategy for economic development, especially in rural, sparsely populated areas. Even in modest sized communities, nature-based tourism plays an important role in the economy. Survey results from birding festivals in two of North Dakota's median size communities demonstrated the positive economic impact. Attendees were largely non-local (76%) and produced a total economic impact of $64,000 for a three-day festival in one community.

Examination and modeling of the economic impact of the state's elderly reveals significant contributions by seniors. Currently, 14% of the state's population is at least 65 years of age and this is projected to increase to 23% in less than 15 years. Census data indicates that 16.5% of the state's total income was generated by seniors including 58% of all interest, dividends and rent. Analyses of census data over the past three decades reveals a very stable per-capita distribution of income generated by seniors that will allow us to model the economic effect of the babyboom generation for North Dakota.

North Dakota has tremendous potential for capitalizing on the emerging biobased products and fuels industry. NDSU specialists have helped develop a strategic plan for establishing a biomaterials industry from crop residues, specifically wheat straw. The cellulose nanowhiskers (very small fibers) would be processed from wheat straw and mixed with a biobased polymer to form a low cost, biodegradeable replacement for glass fibers in polymer composites. Over the next 10 years, the growth of bio-based chemicals and materials is expected to generate $160 billion in new revenues annually. As one of the top three ranking states for available low-cost biomass, North Dakota is uniquely positioned to become a key player in this emerging industry. By adding value to what is now basically a waste material (wheat straw), the development of a biomaterials industry could offer an additional income source for North Dakota wheat producers, as well as new jobs in the processing activity and general economic stimulus for rural areas of the state.

Food-related businesses are a growing sector in the North Dakota economy and NDSU Extension specialists have developed materials and partnered with other agencies to help ensure the safety of North Dakota produced foods for the past ten years. More than 175 food products have been tested for acidity and water activity for compliance to federal regulatory standards. "Nutrition Facts" labels have been developed for more than 400 North Dakota food products currently on the market.

Developing skills to prepare youth for the workforce is one of the underlying goals of many 4-H activities. More than 5000 youth are involved in conference judging interviews in county programs, helping them build communication skills with adults and youth. 580 youth practiced presentation and speaking skills through participation in judging contests at the state level. Management of financial resources is an important aspect of work force readiness and skills needed by youth as they move into adult life. The High School Financial Planning Program continues to reach a significant number of youth. During January through December 2005, 1700 students from 35 schools participated in this program that has shown significant improvement nationally in student's behavior to set aside money for future needs and wants and has helped participants to distinguish the difference.

Over 650 youth have participated in outdoor skills events/activities and have increased their knowledge in: Responsible Sportsmanship; Ethical Outdoor Skills Behavior; Respect for safe conduct of shooting sports activities, and environmental stewardship. Technology skills are an important aspect of career readiness and work force preparation. Five North Dakota schools reaching about 40 students in the Red River Basin are part of a school based River Watch, citizen monitoring program. The students' use monitoring equipment and protocols based on the same methodologies used by the watershed science community. Each school is connected directly to a local scientist mentor and data collected is useable as part of North Dakotas state ambient monitoring program.

The ability to follow through and complete tasks is evident by the completion of a project as demonstrated by more than 11,561 exhibits at the 2005 North Dakota State Fair by youth enrolled in 4-H programs. 102 youth participated in the project expo at the North Dakota State Fair. This involved sharing information from their projects or research and practicing communication skills with the public as wells as officials of the event.

Key Theme - Community Development: Rural Economic Development
The Extension specialist co-developed a comprehensive Business Retention and Expansion visitation program to help interested community leaders identify existing business issues and needs. Research specialists in the NDSU Department of Agribusiness and Applied Economics analyze and present the data to community leaders. The NDSU Institute for Business and Industry Development follows up with individual requests from manufacturers. Annual progress surveys are conducted.

Partners: Local Economic Development and Chamber of Commerce Staff, State Department of Economic Development and Finance, NDSU - IBID and local county or city economic development groups and chambers of commerce.

Impact: Fourteen county and city based programs have been conducted since 1995. Eleven of the first 13 program coordinators responded to a follow-up survey conducted in this program the first survey year. Results included: of the 176 projects planned, 43 percent or 75 projects were in progress, 23 percent or 41 projects had been completed, 11 percent or 20 projects were dropped, and 23 percent or 40 projects had no indication as to progress. The last county conducting the

BR&E visitation program completed its program in January of 2001. A survey conducted after three months indicated that of the fifteen action items that were identified in four major issue areas, only six items had no action while three had already had substantial progress or already implemented. The other items were in the process of being worked on. A six-month evaluation of progress for implementation resulted in an overall lower degree of implementation. This would seem to go against logic but upon further questioning of participants it was felt that some of the momentum had been lost resulting in lower scores. Follow-up evaluation of participating counties shows that most have either completed their plans of work as outlined in their original plan and/or are continuing to work on items that are ongoing. Approximately 52 percent of the projects identified were completed.

A targeted industry BR&E project has been conducted to determine higher education educational programs and workforce skill needs. ND Job Service is compiling results of this survey. The study was conducted under the ND Workforce Development Council of which extension played a critical role in organizing and training in the BR&E process and took leadership for the state industry visioning session.

Source of Federal Funds: Smith-Lever and CSREES Fed. Admin.

Scope of Impact: Integrated Research and Extension

Key Theme - Impact of Change on Rural Communities: Strategic Planning
The Extension specialist chaired a committee consisting of multiple agencies and organizations to develop and deliver a statewide curriculum and program for community strategic planning. Extension specialists also provided facilitation training for staff from the following agencies and organizations: USDA Rural Development, USDA Rural Development Council, State Department of Economic Development and Finance, State Department of Community Services, Governor's Office, Regional Planning Councils, North Dakota State Department of Health and local economic development professionals.

Impact: In two two-day workshops, 102 facilitators were trained for the strategic planning process. Of those facilitators, 72 attended another one-day session for pilot program updating and specific facilitator skills training. Ninety-three communities are currently in the process or have concluded conducting strategic planning programs with the assistance of the trained facilitators. An additional 15 communities were identified and participated as three member teams in a Heartland Center training sponsored by Federal Land Bank. If you calculated the total of volunteer time dedicated to the strategic planning process in the ninety-three communities by taking an average of 15 hours per steering committee member times 12 or the average size of a committee times $17.19 (value of one hour of volunteer time according to Independent Sector) times 93 communities you would get $287,760.60 total value of volunteer time spent on strategic planning in ND communities. The strategic plans that have been completed are currently being analyzed by the ND State Data Census Center to determine begin to look at what has been done, what were the factors for successful planning and what has been completed. This began in 2005 and will continue into 2006 and 07.

Source of Federal Funds: Smith-Lever and CSREES Fed. Admin.

Scope of Impact: State Specific

Key Theme - Supplemental Income Strategies: Rural Economic Development
Extension specialists and county extension agents conducted educational agritainment workshops in areas of the state. The goal of the program was to provide information to help families decide if a recreation business was feasible for their individual location and operation. Partners: Local economic development staff, Southwest Area REAP board, North Dakota Department of Tourism.

Impact: Approximately 450 people have participated in 12 agritainment workshops. Of those participating, 197 completed the post-workshop evaluations. Results include: 99 percent gave the program an overall rating of useful to very useful; 114 people indicated that the workshop did help them to make a decision as to whether or not they would pursue starting a recreation business, 33 percent were already in business; 90 participants plan to start a business; of those already established 31 indicated that they would make changes in their current operation because of what was learned. Samples of businesses started as a direct result of attending the workshops include a pumpkin and corn maze business, lake cabins and fishing guide, bed and breakfasts plus numerous business owners have contributed increased success of their business to what was learned in the workshop.

Surveys were sent to 306 of our extension agritainmnet workshop participants. Fifty-three responded. Of the respondents, 24 had a business. Thirteen of 24 businesses said that the workshop had a direct positive impact on their business. Comments included: decision to start a business, decision to expand a business, awareness of their business in the state, ideas for promotion, information on how to start a business, better ways to market my business, resource directory is a valuable tool for resources, networking opportunities, etc. One of our most successful businesses whose owners attended one of our first workshops is West Bay Resort, LLC by Devils Lake, ND. In follow-up to their survey I made a direct contact. They informed me that not only have their cabins been very successful but also they have decided to build an RV park for the more than 40 people who contact them every week during the summer asking for this kind of accommodation.

The extension service and partners were instrumental in the organizational phase of establishing a state tourism association for rural and nature based tourism businesses and organizations. The organization began taking memberships in 2004. This is a great accomplishment and a huge step forward for our fledgling rural and nature based tourism industry. Extension provided leadership for the second annual Marketplace for Entrepreneurs preconference nature and rural tourism event. Approximately 150 people attended in the 05 conference.

Source of Federal Funds: Smith-Lever and CSREES Fed. Admin.

Scope of Impact: Multi-state Extension - ND and MT

Key Theme - Promoting Business Programs: E-Commerce for Small Business
Information technology holds the promise of reducing the disadvantages of distance and low population density that have long held back rural communities relative to their urban counterparts. Survival of rural enterprises and communities depends greatly on how rural people are prepared to deal the Information Technology revolution, where services are available 24 hours a day, 7 days a week. Rural residents must develop the necessary skills for employability of entrepreneurship in an evolving industry. They also need the skills to market their products in a competitive area.

Impact: Five classes were offered in 2003 in Fessenden, Hettinger, Watford City, Devils Lake and Langdon. Two additional classes were held in 2004 in Oakes and Ellendale. The hands-on, computer-based workshop was offered as a one-day workshop from 9 - 5 instead of as a multi-date program as has been done elsewhere. 68 individuals have received this daylong program since its inception in October of 2003 with 37 individuals participating in Access North Dakota Mainstreet in 2004. The course is designed to help people determine their need for a Web presence and a large majority of participants reported plans to either start a website, begin to participate in online auctions, or participate in other portal-type sites to market and sell their product. A six-month follow-up survey was done in March and April for all participants that had taken the course in the fall of 2003. Participants have reported the development of business websites and increased research on products and supplies because of the course.

Source of Federal Funds: Smith-Lever and Dept. of Commerce

Scope of Impact: State

Key Theme - Impact of Change on Rural Communities: Population Change in Rural Communities
Rural regions of the U.S. are being transformed as a result of changing demographic patterns including migration, natural increase, and shifting age distribution. The changing demographic patterns present unique challenges to policymakers, businesses, community leaders, and residents including labor force issues, economic development concerns, and problems with the delivery of services. This project explores the socio-demograhic changes in the region in order to examine resulting shifts in social and economic conditions for rural communities.

The projected future of population dynamics in the Great Plains has been the focus of this year's activity. County-specific population projections from state demographers for each of the 12 states in the region were compiled and analyzed for the period from 2000 to 2020. The results reveal three notable shifts in the region. First, aggregate gains are predicted for pre-school children in both metropolitan and nonmetropolian counties. Second, a dramatic reduction is predicted in the prime working age population (i.e., 35-54). Finally, the number of elderly age 65 and over is expected to increase by more than 3.3 million. The main policy implications include heightened labor force pressures, shifts in demand for housing, and increased challenges for rural economic development.

Impact: This project is expanding policy makers' understanding of the underlying reasons for the population decline in rural areas of the Great Plains. It is expected that the results will provide insight into ways to improve rural community economic development.

Source of Federal Funds: Hatch

Scope of Impact: Multi-state research

Key Theme - Impact of Change on Rural Communities: Regional Center for Rural Development in North Dakota-2004 Special Grant
Rural communities, especially those in the Great Plains, need to explore new economic development strategies. This project examines the viability of two economic development opportunities for rural communities in the Great Plains.

Intercept surveys were conducted at a birding festival held in Carrington, ND in June of 2005. Findings from a similar survey conducted in 2004 at a Festival held in Jamestown, ND were published in Great Plains Research. The 2004 Festival attendees were largely non-local area residents (76%). They spent an average of 3.1 nights in Jamestown in connection with the Festival, with average local expenditures per person of $160. The total direct economic impact of the Festival for the Jamestown area was estimated at $26,000, and the total (direct plus secondary) impact was $64,000. Participants expressed a high level of satisfaction both with the event and with the Jamestown area as a place to visit. Analyses of the impact of elderly on the state’s economy also are progressing. Data collected from the Census Bureau's microdata files have been used to examine the economic contribution of seniors (i.e., age 65 and over) to the state's economy. Findings reveal that seniors account for 16.5% of total state income and 58% of all interest, dividends, and rent income generated in North Dakota. Demographic and economic modeling will be conducted to determine the future contribution of senior to the state in light of the dramatic increase in elderly population predicted.

Impact: It is expected that this project will increase economic information available to numerous decision makers concerning economic trends in the state and the impacts of various agricultural and resource development activities along with demographic shifts on the state economy.

Source of Federal Funds: CSREES Grant

Scope of Impact: Statewide

Key Theme - Impact of Change on Rural Communities: Regional Center for Rural Development in North Dakota-2005 Special Grant
Rural communities in the Great Plains need to diversify their economic development options. This project explores the value of two different economic development strategies for rural communities in the Great Plains, specifically natural resource-based tourism and tapping the economic potential generated by seniors.

Analysis of outdoor recreation and nature-based tourism in North Dakota shows a continued rise in activity. Economic modeling demonstrates its value relative to other industries. In the Southwest region of North Dakota, recreation and nature-based tourism contributed $223.6 million to the regional economy, a level on par with agriculture ($226.1 million). Our efforts to document the impact of this industry on the state's economy suggest that it is a viable strategy for economic development, especially in rural, sparsely populated areas. Even in modest sized communities, nature-based tourism plays an important role in the economy. For example, survey results from birding festivals in two of North Dakota's median size communities demonstrated the positive economic impact. Attendees were largely non-local (76%) and produced a total economic impact of $64,000 for a three-day festival in one community.

Examination and modeling of the economic impact of the state's elderly reveals significant contributions by seniors. Currently, 14% of the state's population is at least 65 years of age and this is projected to increase to 23% in less than 15 years. Census data indicates that 16.5% of the state's total income was generated by seniors including 58% of all interest, dividends and rent. Analyses of census data over the past three decades reveals a very stable per-capita distribution of income generated by seniors that will allow us to model the economic effect of the babyboom generation for North Dakota.

Impact: This research is increasing the information available to policy makers regarding the economic contribution of natural resource-based tourism through presentations to academic audiences and local and state decision makers. In addition, it is expanding decision makers understanding of seniors economic contributions to the state.

Source of Federal Funds: CSREES Grant

Scope of Impact: Statewide

Key Theme - Promoting Business Programs: Developing a Nanocomposite-Based Biomaterials Industry in North Dakota

North Dakota has tremendous potential for capitalizing on the emerging biobased products and fuels industry. Utilizing technologies to produce bioproducts from crop residues, specifically wheat straw, North Dakota State University, Agribusiness & Applied Economics, in conjunction with MBI International, is currently engaged in a project that would commercialize the use of very small cellulose fibers (nanofibers) to make a bio-based cellulose reinforced composite that could be used in place of fiberglass reinforced composites. The cellulose nanowhiskers (very small fibers) would be processed from wheat straw and mixed with a biobased polymer to form a low cost, biodegradeable replacement for glass fibers in polymer composites. Over the next 10 years, the growth of bio-based chemicals and materials is expected to generate $160 billion in new revenues annually. As one of the top three ranking states for available low-cost biomass, North Dakota is uniquely positioned to become a key player in this emerging industry.

The aim of the project is to commercialize MBI's technology for producing bio-based cellulose nanofibers (nanowhiskers) from wheat straw with ethanol and high-value chemicals as co-

products. The first major milestone in the effort is to address key engineering and economic questions to determine the technical and economic feasibility of a pilot scale production process while at the same time analyzing the integration of components made from biomaterials into the automotive supply chain. The critical next step in a North Dakota-based biomaterials industry is the construction and operation of a pilot plant (in North Dakota) to demonstrate the commercial potential of this technology. With this information and expertise, full-scale commercialization can commence.

Work supported by funding received to date has focused on (1) development and scale up of nanofiber production, (2) exploring the feasibility of incorporating the nanofiber production process into a biorefinery, and (3) developing a strategic plan for commercializing the industry in North Dakota. Additional funding is being sought for (1) applied research to optimize the nanofiber production process, produce samples of the biobased nanocomposite material, and verify yields and production costs; (2) development/engineering to evaluate questions related to scale-up of processes, leading to an engineering design for construction of a pilot plant, as well as further testing and refinement of the biocomposite material; and (3) developing an investment analysis/prospectus.

Impact: Technologies identified, developed, demonstrated, and transferred to commercial application under this program may be expected to use a variety of renewable resources such as wheat straw and other grasses to produce higher value products while generating little or no waste. By adding value to what is now basically a waste material (wheat straw), the development of a biomaterials industry could offer an additional income source for North Dakota wheat producers, as well as new jobs in the processing activity and general economic stimulus for rural areas of the state.

Source of Federal Funds: CSREES Grant

Scope of Impact: Statewide

Key Theme - Promoting Business Programs: Food Entrepreneurship
Because food-related businesses are a growing sector in the North Dakota economy, the NDSU Extension Service has developed materials and partnered with other agencies to help ensure the safety of North Dakota- produced foods for the past ten years. The NDSU Extension Service and the Institute for Business and Industry Development in partnership with the North Dakota Department of Agriculture developed a resource binder, “Starting Your Food Business in North Dakota”. Available in all county extension service offices, the resource binder includes information on food industry rules and regulations regarding food safety/quality control. A Web site, “Food Entrepreneur: Guide to the Food Industry,” is regularly updated with information on food safety, testing/labeling and other issues:
http://www.ag.ndsu.nodak.edu/cdfs/foodent/entrpnr.htm

“Nutrition Facts” labeling of North Dakota food products has been provided since 1994. Participants in the most recent FDA-sponsored “acidified foods” training showed increased knowledge in these areas: microbiology of processed foods, safe food handling/processing

procedures, acidity testing and acidity levels of various foods, processing equipment, registration and process filing with the FDA and regional/state food processing issues. On- line modules have been developed and are in the pilot-test phase.

Impact: More than 175 food products have been tested for acidity and water activity for compliance to federal regulatory standards. Several products did not meet the federal government standards for acidity and were re-formulated for safety. "Nutrition Facts" labels have been developed for more than 400 North Dakota food products currently on the market.

Source of Federal Funds: Smith-Lever

Scope of Impact: Statewide extension

Key Theme - Consumer Management: Improving Decision-Making Among Consumers
North Dakota consumers are faced with increased decision-making responsibilities regarding new products and services, new ways of purchasing, and new ways of receiving product and service information and support. Understanding these trends and providing unbiased information to assist consumers in making these decisions requires continuous development and dissemination of research and fact-based educational materials and delivery formats. Such information has been historically sought from land-grant institutions, such as NDSU.

Extension specialists, faculty and extension agents are instrumental in providing this resource to citizens. Educational programs and materials on topics such as identity theft and privacy, choosing long-distance phone service, shopping from home, and financial services are only a few of NDSU's recent consumer education resources. Other agencies, such as the Consumer Protection Division of the North Dakota Attorney General's office will collaborate to provide a comprehensive source of consumer information. The goal is to help consumers make informed choices in the market place, understand their redress options, and improve their overall quality of life. A challenge for NDSU Extension is to help citizens be able to determine the validity and reliability of consumer information in an information-rich society.

Impact: Through these programs and relationships, North Dakota consumers will understand their rights and responsibilities as consumers. Collaborative relationships with other consumer education organizations will be strengthened and consumers will improve their decision-making skills. While all consumers in North Dakota will benefit, certain audiences will be targeted, such as limited resource audiences that are prone to predatory lending practices. In addition, the elderly population is growing in the state and special efforts will be made to provide information for their needs, and for the people who work with, and care for them.

Source of Federal Funds: Smith-Lever

Scope of Impact: Statewide extension

Key Theme - Estate Planning: Financial Security Later in Life

As North Dakota's population ages, individuals and families have increased need to prepare for financial security in later life. The national CSREES initiative, "Financial Security in Later Life," has been developed to address these issues. North Dakota Extension family economics programming for the next several years will complement this initiative. The research-based framework provides a solid conceptual foundation on which to build needed educational resources. A review of the protective factors identified in the existing literature suggests that there are three key "stops" involved in achieving financial security in later life. Consumers who plan, act, and evaluate are more likely to achieve a financially secure later life.

A Roadmap to Financial Security in Later Life curriculum was developed in 2001 to introduce consumers to the importance of achieving financial security for themselves and others and what critical stops they must make along that road. In addition, packaged programs have been developed annually to present the information in a logical order using user-friendly format. "Money Attitudes, Values and Goals" and "Communicating About Money" were developed and taught statewide using a train-the-trainer format in 2001-2002. In 2002-2003, "North Dakota Saves," "The Basics of Bonds", and "Saving and Investing" were developed and taught. "Welcome to Wall Street," "Mutual Fundamentals" and "Starting an Investment Club" were developed and taught in 2003-2004. Programs being developed for 2004-2005 are: "Planning for Long-Term Care" , "Post Secondary Education Planning", and "Forecasting Retirement Income and Expense."

Impact: Implementing this program will increase the number of North Dakota residents who:
- engage in activities which increase their financial literacy related to later life issues,
- utilize recommended practices in managing their use of credit in light of long-term goals for later life,
- initiate contributions to a retirement savings plan or increase contributions to retirement plans,
- determine retirement income needs and/or future income needs,
- develop a plan to achieve retirement and/or future income goals,
- establish or revise investment goals,
- participate in employer-provided retirement plans,
- increase their contributions to employer-provided retirement plans,
- increase their knowledge of risks, costs and financing options for health, including long-term care,
- develop a plan for managing long-term health care needs, and
- develop an integrated plan for accumulating, protecting, and distributing/transferring assets.

Source of Federal Funds: Smith-Lever

Scope of Impact: Statewide extension

Key Theme - Family Resource Management: Helping Families become Money Wise
Most Americans are not satisfied with their current economic situation and do not feel in control of their personal finances. Many rely on sales-oriented information to make decisions concerning significant resources or have unwise credit use practices. Others let compulsive behaviors interfere with their financial goals.

North Dakota's economy has depended traditionally on agriculture and energy and these two sectors have been depressed in recent years. In addition, agriculture is undergoing considerable change. Farm families, as well as other families within the state, need to adjust and adapt to these rapid changes that are occurring throughout the state, nation, and world. Educational programs are needed to help individuals, farmers, ranchers and families develop competencies to remain financially secure members of North Dakota's economy.

Recent studies have documented a lack of financial literacy among youth and adults of all ages in our country: increased personal debt, bankruptcies, lack of emergency savings, and failure to attain financial goals such as an economically secure retirement are a threat to our state's financial well-being. In addition, productivity in the workplace is affected when workers are experiencing financial stress and lack of work/family options.

Impact: Implementing this program will increase the number of North Dakota citizens who:
- engage in activities which increase their financial literacy,
- utilize recommended practices in managing their use of credit,
- establish or revise investment goals,
- increase their knowledge of risks, costs and financing options for health care, and
- increase their knowledge of risks, costs and financial options for insuring property and automobiles.

While the program will provide useful information for all individuals and families, various programs and activities will have targeted audiences. For example, the High School Financial Planning Program will target high school students and educators, and the Becoming Money Wise will target limited resource audiences.

Source of Federal Funds: Smith-Lever

Scope of Impact: Statewide extension

Key Theme - Parenting: Bright Beginnings Parent Education Program
Children learn and develop in safe, supportive environments where they have the opportunity to experience caring relationships with a variety of adults. Many citizens in the state of North Dakota have identified parent education as a critical need and resource. Parents and communities must begin with an understanding of children in infancy and early childhood that then extends to the creation of healthy, enabling environments through the early years and adolescence. The Bright Beginnings: Parenting Young Children educational program is an integrated educational curriculum taught by extension educators and other community professionals. Topics addressed include attachment, brain development, social and emotional development, childcare, play, reading, and other issues.

A one-day regional training session in the Bright Beginnings parent education program was offered in New Town, ND on the Fort Berthold Reservation in January 2005. Sixty-five participants from the Native American community participated in the training. Participants

completed a post-conference survey to assess the value of training in the program for their planned work in parent education.

Impact: A post-training evaluation was administered to assess the impact of the training and materials in the Bright Beginnings parent education program. Among the participants surveyed, 100 percent of them indicated that the Bright Beginnings training workshop was useful or very useful for them. Also, 100 percent of the participants indicated that the Bright Beginnings program would be useful or very useful to them in their community work with parents and families. Eighty-seven percent of respondents indicated they were much to very much more knowledgeable about specific issues related to parenting young children. These results suggest a positive outcome for the participants regarding their knowledge about parenting young children and their ability to use the training provided to assist parents in meaningful ways in their communities.

Source of Federal Funds: Smith-Lever

Source of Impact: State specific extension

Key Theme - Parenting: Family Life Education - NDSU Extension Parent Resource Centers

The NDSU Extension Service supports and operates four regional Parent Resource Centers in Fargo, Grand Forks, Mandan, and Dickinson. These centers provide quality educational resources on parenting and family life, delivering educational programs, and building collaborative partnerships. Collaboration with the North Dakota Department of Human Services, Children and Family Services Division, targets some funding for program activities designed to prevent child abuse and neglect and promote healthy parenting skills. This profile highlights selected activities and impacts at two of the Extension Parent Resource Centers in North Dakota.

Impact: The Region IV Parent Resource Center in Grand Forks provides parenting resources and educational programs in a 4-county region of northeast North Dakota (Grand Forks, Nelson, Pembina, and Walsh). Among its varied activities, the Parent Resource Center provides a regular newsletter to community professionals, parents, and others in the community to share parenting information and furnish updates on parent education events and opportunities. A survey evaluation showed the following impacts of this effort:

- 91.4 percent of respondents indicated that the newsletters are a valuable resource to them in their parenting or their professional work.
- 61.1 percent of respondents stated that they their knowledge of healthy parenting had increased a lot or very much as a result of reading the newsletter.
- 54.1 percent of respondents stated that they had significantly changed behavior to use more positive guidance and discipline with a child as a result of reading the newsletter.

Based in Dickinson, the West Dakota Parent & Family Resource Center is a collaborative project between Dickinson Public Schools and the NDSU Extension Service to provide parent education and resources to residents of eight counties in southwest North Dakota (Adams, Bowman, Dunn, Golden Valley, Hettinger, Slope, and Stark/Billings). This center offers the Children of Divorce

program at multiple times throughout the year for parents who are divorced or those that are contemplating divorce. Recent evaluations with class participants indicated the following results:

- 57 percent of participants think the workshop should be mandatory for all divorcing parents.
- 79 percent of participants agreed that the session helped them to understand how children are affected by divorce.
- 93 percent indicated that the information presented would have an influence on the decisions they will make regarding their children.
- 78 percent of participants planned to make a stronger effort to work with an ex-spouse for the children's sake.

These impact examples illustrate the strength and importance of the resources, educational programs, and partnerships developed through the Extension Parent Resource Centers to work toward creating a better life and future for North Dakota's children, families and communities.

Source of Federal Funds: Smith-Lever

Source of Impact: State specific extension

Key Theme - Parenting: Parent Involvement - The Father Times Newsletter

Father involvement in family life is a major need for the healthy development of young children. To aid families in encouraging parent involvement, a parenting newsletter series for fathers and father figures of young children was developed and implemented in specific sites in North Dakota. The NDSU Extension Service partnered with Head Start programs in North Dakota and South Dakota to implement and evaluate the Father Times parenting newsletter series.

Impact: Over 1,000 Head Start families in North Dakota and South Dakota received issues of the Father Times parenting newsletter every other week during a four-month period. A survey was conducted to determine impacts of the newsletter. The findings showed that:

- 9 out of 10 fathers and father figures reported reading a significant portion or all of the Father Times parenting newsletter when they received it.
- 9 out of 10 fathers and father figures reported that the Father Times parenting newsletter was easy to read and understand.
- 9 out of 10 fathers and father figures agreed or strongly agreed that the Father Times parenting newsletter was useful in their everyday parenting.
- 8 out of 10 fathers and father figures indicated they had increased understanding about their children's needs for growth and development as a result of reading the Father Times parenting newsletter.
- 8 out of 10 fathers and father figures stated they were more attentive to the needs of their children as a result of reading the Father Times parenting newsletter.
- 8 out of 10 fathers and father figures reported they had increased knowledge of good parenting as a father due to reading the Father Times parenting newsletter.

- 7 out of 10 fathers and father figures reported changing their behavior to use more positive guidance or discipline with their child as a result of reading the Father Times parenting newsletter.
- 7 out of 10 fathers and father figures said they had done some of the father-child activities from the Father Times newsletter with their own child.
- 7 out of 10 fathers and father figures indicated they had read more to or with their child as a result of reading the Father Times parenting newsletter.

These findings suggest the value of educational resources that meet the needs of specific audiences and encourage a focus on child and family well-being.

Source of Federal Funds: Smith-Lever

Source of Impact: State specific extension

Key Theme – Strengthening Families: CYFAR New Community Project, Building Connections at Standing Rock

The purpose of the Building Connections Strengthening Families Program at Standing Rock, ND is to strengthen families and foster positive youth development in a culturally sensitive way. This project is funded and operated as a CYFAR New Community Project. Approximately 433 participants (adults, adolescents, and children) on the Standing Rock Indian Reservation have been involved in the parent education and programs focusing on positive youth development.

Impact: Preliminary evaluation of the adult program indicated the following:

- 86 percent of parents/caregivers found the information useful—all the time.
- 6 percent of parents/caregivers found the information useful—most of the time.

Analysis of pre and post-program responses by parents who have participated in the program are promising. Findings showed that parents significantly decreased in their use of corporal punishment and inconsistent discipline practices. There was also improvement shown by parents on all other scales on the Alabama Parenting Questionnaire (parent involvement, positive parenting, and monitoring of children). Further, there was also a significant increase over time in parents reporting exploration of their ethnic identity and a sense of belonging with their ethnic group. Parents on Standing Rock also reported in their own words about topics they learned about. 57 percent of parents reported an increase in general parenting skills; 29 percent reported an improvement in parent-child relationships; 91 percent reported an increase in knowledge on how they can help a child's development. Parents/caregivers also indicated in response to open-ended survey questions that as a result of attending this program they saw improvement in parent-child relationships, increased their knowledge about nutrition, and improved their parenting skills.

Source of Federal Funds: Smith-Lever

Source of Impact: State specific extension

Key Theme – Youth Development/4-H: Asset Building in Youth/Career Readiness/Preparing North Dakota Youth

Youth in North Dakota benefit from opportunities to explore career possibilities, to view education as a tool to success, and learn the attitudes, skills, and work habits valued by employers and needed by entrepreneurs. Experiences build assets valuable to the workplace. Added to knowledge of what to expect in the workplace, these assets will contribute to successful workforce experiences.

Science and information technology affect the career opportunities and the decisions relating to future education and careers. The 4-H program can supplement and enhance science and technology education now offered in schools for youth and adults.

The effort to complete a project, planning and organization skills, respect for others when a young person works on a project or competes in an activity are all characteristics that will help the individual in the world of work. Employees need specific subject matter knowledge and skills. Successful employment is often an outcome of life skills such as follow through on commitment, the ability to communicate and get along with others.

Impact: Developing skills to prepare youth for the workforce is one of the underlying goals of many 4-H activities. More than 5000 youth are involved in conference judging interviews in county programs, helping them build communication skills with adults and youth. 580 youth practiced presentation and speaking skills through participation in judging contests at the state level. Local club meetings and communication arts events add to the development of communication skills and leadership roles in both individual and group situations.

The Richland County After-school Program in its sixth year of operation serves five rural school districts. High school tutoring remains in 3 of the schools with all schools supporting K-6 after-school activities. The program has leveraged resources by joining Americorp and has several volunteers working in the program. Spring 2005 survey results of parents, students, and teacher reports show a high level of satisfaction. Participating students (167) reported that 65% feel they do better in school because of the program with 70% of students feeling more prepared for school after joining the program. Parent surveys included 110 families with 90% indicating they are satisfied with offerings and 10% are somewhat satisfied. Thirty elementary teachers completed surveys comparing non-program student improvement to program student improvement. Teachers indicated 100% more improvement in program students than non-program students in turning in homework on time, 98% more improvement in program students in completing homework on time, 84% more improvement in being attentive in class, 36% more improvement in achieving satisfactory performance, 76% more improvement in coming to school ready to learn, and 88% more improvement in getting along with others. The teacher survey included 167 program students and 364 non-program students in 5 elementary schools.

Management of financial resources is an important aspect of work force readiness and skills needed by youth as they move into adult life. The High School Financial Planning Program continues to reach a significant number of youth. During January through December 2005, 1700 students from 35 schools participated in this program that has shown significant improvement

nationally in student's behavior to set aside money for future needs and wants and has helped participants to distinguish the difference.

Over 650 youth have participated in outdoor skills events/activities and have increased their knowledge in: Responsible Sportsmanship; Ethical Outdoor Skills Behavior; Respect for safe conduct of shooting sports activities, and environmental stewardship. Participants are more aware and gained appreciation of shooting sports and outdoor activities as life-long leisure or career opportunities for youth and families. They developed life skills through shooting sports experiences and environmental education. They practice safe handling and storage of firearms in the home, on the range or in the field.

Technology skills are an important aspect of career readiness and work force preparation. Five North Dakota schools reaching about 40 students in the Red River Basin are part of a school based River Watch, citizen monitoring program. The students' use monitoring equipment and protocols based on the same methodologies used by the watershed science community. Each school is connected directly to a local scientist mentor and data collected is useable as part of North Dakotas state ambient monitoring program. In addition to surface water quality education, the students are exposed to career fields and post secondary education options available to them in this region as they explore future watershed science related job opportunities. Technology training in GPS/GIS, data management and interpretation and video/green screen production are a sampling of the specialized skills learned by participants. Early evaluation efforts indicate that female students report having a relatively low interest in science and technology, yet they score consistently higher than their male counterparts in science and technology knowledge. Native American students who have taken the survey indicate the highest level in "hands-on-learning as their preferred method of learning new skills in science and technology.

Ft. Berthold 4-H is combining science and technology in their after-school program with use of Lego robotics and digital photography. They are also incorporating community service. In cooperation with a high school science teacher, students developed a data sheet and used GPS to collect data on location of trees with Dutch elm disease for the city.

Service projects are a significant part of the 4-H experience. 4-H clubs in North Dakota continue to participate in community service projects. In addition, North Dakota 4-H ambassadors continued their effort to service with an average of 18 hours per ambassador or a total of 891 hours in 2005. Service included making and distributing crafts to youth and to nursing homes, partnering with Boy Scout to collect for the food pantry, cleaning the Women's Shelter in Devils Lake, assembling Hero Packs for families of deployed North Dakota military, assisted elderly in Oakes with yard clean-up.

Citizens in Beach are addressing the issue of youth leaving the area for greener pastures elsewhere. The Horizons Leadership program in Beach provided the vehicle to move youth into the spotlight by encouraging their involvement in community development. Because of the community's efforts to engage youth, the Prairie West Development Foundation for Golden Valley County passed a resolution creating a youth relations committee for the purpose of creating a youth voice on the board for the betterment of Golden Valley County. Four young people joined the board in the fall of 2005.

Youth/adult partnerships build youth assets leading to community pride and career readiness. The Adult/Youth Coalition in Watford City is working to create a healthy community that values youth. For example, student council members are now partnering with adults to plan the Watford City High School Wellness Policy and youth spearheaded the formation of a committee of adults and youth who successfully proposed changes in the food program. Partnering with adults to address community needs resulted in benefits to the community and led to some career decisions and opportunities for youth. For example, Brianna Bohmbach, a Mckenzie County ND 4-H member, led an effort to preserve her progressive ranching community's Wild West past to guarantee its future. Through an Engaging Youth, Serving Community rural youth development grant, Brianna and other 4-H'ers collaborated with representatives of the Three Affiliated Tribes, local historians, Economic Development, FFA, the county commission and city councils in the county to create new exhibits in the new Long X Visitor's Center and Pioneer Museum. This group researched the county's history and developed displays explaining significant happenings from the early 1800's to present day. Brianna has decided to pursue a college degree that will support her continuance of the type of work she has started here.

The ability to follow through and complete tasks is evident by the completion of a project as demonstrated by more than 11,561 exhibits at the 2005 North Dakota State Fair by youth enrolled in 4-H programs. 102 youth participated in the project expo at the North Dakota State Fair. This involved sharing information from their projects or research and practicing communication skills with the public as wells as officials of the event.

Source of Federal Funds: Smith-Lever

Scope of Impact: Statewide extension

Key Theme - Youth Development/4-H: Mini-Society

Youth have a strong interest in entrepreneurship or starting their own business. National Gallup surveys (sponsored by the Ewing Marion Kauffman Foundation) in 1994, 1995 and 1999 concluded that six out of ten young people wanted to start a business. When students were asked to rate their knowledge and understanding of starting a business most (76 percent) rated themselves fair to very poor. Youth recognized the importance of education for preparation of starting a business. The predominant response that significantly outweighed all others was “education in school.” (Source: “The E Generation” by Marilyn Kourilshy and William Walstad, 2000) Mini-Society®, or the entrepreneurship course that we implement in North Dakota is designed for 3-7th grades.

Impact: Two hundred fifty-eight young people participated in 30 hours each of entrepreneurship "hands on" learning in 2005 in classrooms, after school programs and 4-H clubs in North Dakota. There was a definite decline in the use of the program with the "No Child Left Behind Act," so we are currently pursuing ways in which to incorporate the lessons from program into the North Dakota academic standards. Current train-the-trainer programs do incorporate the standards. The value of volunteer hours given to this program is more than $1

million when $17.19 is used as the value for one hour. This number does not include preparation and other time spent outside the classroom on the program.

Source of Federal Funds: Smith-Lever and Ewing Marion Kauffman Foundation

Scope of Impact: State

Key Theme – Youth Development/4-H: CYFAR New Community Project, Building Connections at Home on the Range

The purpose of the Building Connections Youth Development Program at Home on the Range, ND is to provide the opportunity for positive youth development by focusing primarily on life skill enhancing activities, improved communication between youth and parents, and support and information to parents. This project is funded and operated as a CYFAR New Community Project. Approximately 129 participants (children and adolescents) have been involved in a youth program in Home on the Range, an in-home youth facility in western North Dakota.

Impact: Evaluation of responses from youth participating in the program indicated the following:

- 79 percent of youth participants found the information useful—most or all of the time.
- 19 percent of youth participants found the information useful—some of the time.

Analysis program responses by youth participants who have participated in the program are promising. Findings showed that 75 percent of youth reported learning new skills (working independently, working together, learning about specific crafts, etc.). One in five youth reported learning how to work with people and help others. Youth participants also indicated in response to open-ended survey questions that as a result of engaging in this program they learned to be more respectful and listen more, to not do drugs, to work things out with their parent, to stay calm and control anger, and to trust others.

Source of Federal Funds: Smith-Lever

Scope of Impact: Statewide extension

Allocated Resources ($ x $1,000)		**FYO5**
1862 Extension ($)	Smith-Lever	784
	State	1,176
	FTE	28.0
1862 Research ($)	Hatch	68
	State	100
	FTE	2.0

B. STAKEHOLDER INPUT PROCESS

Building linkages with the public enable us to discover information about community/county/district/state assets and needs. Various methods for stakeholder input are utilized on an on-going basis. The input from stakeholders plus input from the general public and from targeted audiences is used to develop our long range four year plans of work along with adjustments to the plan based on crisis situations that may develop in the state (drought, flood, insect infestations, plant diseases, high-risk issues of youth, food borne illnesses, security issues). Using several methods to collect data insure that high priority issues are identified, people that have a self-interest in the issue are brought to the planning meetings, and an educational design is developed to address the issue using a variety of delivery methods. The following are examples of stakeholder groups or organizations that inputs are solicited from and utilized for programming direction.

State Board For Agricultural Research and Education (SBARE)

Duties of the State Board of Agricultural Research and Education are to:

- determine the causes of any adverse economic impacts on crops and livestock produced in this state;
- develop ongoing strategies for the provision of research solutions to negate adverse economic impacts on crops and livestock produced in this state;
- develop ongoing strategies for the dissemination of research information through the Extension Service;
- annually evaluate the results of research and extension activities and expenditures and report the findings to the Legislative Council and the State Board of Higher Education;

SBARE holds monthly meetings during the fiscal year that include attendance by agriculture department chairs and research/extension center directors. The meetings focus on assessing current programs and identifying issues and needs for new programs. The purpose of SBARE is to determine how Experiment Station and Extension budget dollars are allocated for programming. Individual citizens and commodity group representatives provided direct input. Membership is composed of the President of North Dakota State University; five persons appointed by the state Ag Coalition; five persons appointed by the Extension Service's multi-county program units; two members of the legislative assembly appointed by the chair of the legislative council (one member from each political faction); North Dakota Agriculture Commissioner (serves as a nonvoting member); Vice President for Agriculture and University Extension (serves in a nonvoting capacity); Director of the N.D. Agricultural Experiment Station (serves in a nonvoting capacity); and, Director of the NDSU Extension Service (serves in a nonvoting capacity).

Citizens' Support Group for Nutrition, Youth and Family Science

The Citizens' Support Group for Nutrition, Youth and Family Science meets quarterly. The group meets face-to-face twice a year and by conference call or other technology twice a year. The membership of this group is based on the following criteria: state geographic representation, diversity, content expertise, and leadership roles. Current citizens, Extension agents, Extension specialists, and others place names in nomination for a three-year term on the advisory group. The role of this group is to:

- identify emerging areas of research and educational program needs for North Dakota individuals and families;
- disseminate and promote information focusing on cutting-edge research, recent initiatives, and Extension programs in the areas of nutrition and health, family financial management, family living and parenting, policy education, leadership and community development, and youth development, and;
- serve as advocates for research and educational programs in Nutrition, Youth and Family Science; and, share with decision makers the impact of these programs at the local and state levels.

Members of the Citizens' Support Group represent the following areas: 4-H youth development, economic development, elementary and secondary education, youth, faith communities, legislators, grant consultants, government officials, health professions, housing authority, military, value-added agriculture, violence prevention, and the legal professions. The Extension Director, Dean of the College of Human Development and Education, Chair for the Center of 4-H Youth Development, and the Assistant Director for Nutrition, Youth and Family Science are ex-officio to the advisory group. Extension specialists and agents provide periodic updates to the advisory group using North Dakota data. Members testify before the legislature for funding support for Extension Service programs in Nutrition, Youth and Family Science programs. We have one member of the Citizens' Support Group for Nutrition, Youth and Family Science who also serves on the State Board for Agriculture Research and Education.

County Government Oversight
County commissioners actively participate in county extension program reviews. The county extension budgeting process also results in strong engagement from county government. This arrangement helps assure that extension programs are grass roots driven and are focused on local issues and needs.

Research Extension Center Advisory Committees
The seven research extension centers (RECs) hold winter meetings with their citizens’ advisory boards that focused on issue identification for both research and extension programming. REC staff not only used this input to set program direction for the center but also conveyed it to main station researchers and to SBARE.

Livestock Commodity Organizations
NDSU faculty and administration meet on a regular basis with the North Dakota Stockmen's Association, the Lamb and Wool Growers, Milk Producers, and Pork Producers. This interaction is used to reaffirm that livestock program priorities are addressing the needs of North Dakota livestock producers.

North Dakota Nutrition Council
North Dakota Nutrition Council, established in 1980, has more than 180 members who identify nutrition education needs. The council has representation from several agencies and organizations, each with a specific nutrition focus. North Dakota nutrition issues are identified by the membership and directed to the appropriate agency or organization for action. NDSU

Extension Service specialists and agents have taken the lead educational role in addressing several nutrition issues identified by the council.

Family Life Education Committee
In 1992, the North Dakota Department of Human Services and NDSU Extension Service were legislated by the North Dakota state legislature to form a statewide Family Life Education Committee. The purpose of this committee is to provide guidance for the parenting education needs and support of individuals at all points within the family life cycle. The committee is composed of state legislators, an Extension specialist, an Extension Human Development Agent, citizens with a parenting self-interest, two administrators from the Child Division of the State Department of Human Services and the Extension Assistant Director, Nutrition, Youth and Family Science. The committee meets six times per year to identify issues, plan, implement, and evaluate parenting education programs.

The NDSU Extension Service is the primary source of direction for the parenting education programs and outreach to the state. The NDSU Extension Service partially funds three area Parenting Resource Coordinator positions. The three professionals meet with local people, develop a program based on grass roots needs, and deliver the program using various methods acceptable to a parenting audience and report to the Family Life Education Committee.

As a result of this partnership, the state Department of Human Services provides funding opportunities to six state family life education centers through a request for proposal process. The availability of designated funds also directs the focus of the parenting education programs provided through the six family life education center coordinators. The six family life education coordinators provide evaluation feedback to the Family Life Education Committee of the state Department of Human Services on program impacts. These impacts are then shared with state legislators.

C. PROGRAM REVIEW PROCESS
No significant change in program review processes since five-year Plan of Work.

D. EVALUATION OF THE SUCCESS OF MULTI AND JOINT ACTIVITIES
County and multicounty program unit advisory councils, specific boards and groups like SBARE, and our own extension staff identified the issues addressed in most “multi and joint” activities. The targeted audiences for these programs were inclusive of all people with a vested interest in the issue. Many programs are on going or multiple years in length; however, specific impacts were noted where applicable. Most of these activities resulted in time efficiencies for the extension educator, and they provided a complete educational experience for the end user. The following is a partial listing of multi-state and multi-institution activities undertaken.

Great Plains States Collaboration

Extension program leaders from North Dakota, South Dakota, Nebraska and Kansas continually interact on programming and staff development issues that address needs in all four states. The logic model continues to be utilized as a program planning/ program performance indicator in all four states. Areas that have been identified are cropping systems and public policy.

Cropping systems specialists and agents from the four Great Plains states have hosted an in-service workshop designed to foster multi-staff program collaboration and subject matter training for agents. These have alternated between the four states utilizing the host state researchers as new presenters on new topics. In 2005, the workshop was held in North Dakota. These workshops have fostered the development of on-going communications linkages, the sharing of educational resources and the exchange of programming ideas.

The four Great Plains states are also collaborating on public issue education. Recent demands on extension personnel to get involved in public issues prompted the four states to hold a conference with topics covering water issues, livestock waste, obesity, and aging. Most of the follow up training is still in the planning stages but will ultimately result in enhanced awareness for extension agents.

Strengthening Families: Building Connections

Two programs around building connections with families and youth were carried out under different settings. The first was a program is to strengthen families and foster positive youth development in a culturally sensitive way on the Standing Rock Indian Reservation. Approximately 433 participants (adults, adolescents, and children) were involved in the parent education and programs focusing on positive youth development.

Analysis of pre and post-program responses by parents who have participated in the program were promising. Findings showed that parents significantly decreased in their use of corporal punishment and inconsistent discipline practices. There was a significant increase over time in parents reporting exploration of their ethnic identity and a sense of belonging with their ethnic group. Parents on Standing Rock also reported in their own words about topics they learned about. 57 percent of parents reported an increase in general parenting skills; 29 percent reported an improvement in parent-child relationships; 91 percent reported an increase in knowledge on how they can help a child's development. Parents/caregivers also indicated in response to open-ended survey questions that as a result of attending this program they saw improvement in parent-child relationships, increased their knowledge about nutrition, and improved their parenting skills.

The second program was on the Home on the Range, an in-home youth facility in western North Dakota. The program's purpose was to provide an opportunity for positive youth development by focusing primarily on life skill enhancing activities, improved communication between youth and parents, and support and information to parents. Approximately 129 participants (children and adolescents) were in the program.

Analysis of program responses by youth participants in the program was promising. Findings showed that 75 percent of youth reported learning new skills (working independently, working together, learning about specific crafts, etc.). One in five youth reported learning how to work

with people and help others. Youth participants also indicated in response to open-ended survey questions that as a result of engaging in this program they learned to be more respectful and listen more, to not do drugs, to work things out with their parent, to stay calm and control anger, and to trust others.

Northern Plains Sustainable Agriculture Society and Organic Agriculture
The Northern Plains Sustainable Agriculture society (NPSAS) contains members from North Dakota, South Dakota, Montana, Nebraska, Minnesota and Canada. The group's goal is to promote sustainable food production systems in agriculture. While many of the members are organic producers, it welcomes all those interested in producing food in sustainable systems. NDSU Extension Service staff has been active in developing educational programs for NPSAS. More than five years ago NDSU extension was instrumental in developing the beginning organic farming program for NPSAS. It started out with 10 new producers and now annually draws a crowd of over 60 producers from surrounding states. In 2005, the NDSU Extension Service worked with NPSAS in defining the visions and values of Direct and Local marketing of Agricultural products for North Dakota and surrounding states.

National Farmers Market Association
An Extension Specialist from North Dakota worked with Extension Specialists, Direct Marketers and Farmers Market managers to start a national Farmers Market association. The new group was formed at a breakout session (full day) that was held during the North American Farmers Direct Marketing Association meeting held in Charlotte, North Carolina. Over $20,000 was raised from 14 states in attendance. In 2005, a Farmers Market and Growers Association in ND held it’s first annual meeting with eighty people registered. Farmers markets are being established in the larger cities in North Dakota, providing an outlet for producers to sell.

4-H Cooperative Curriculum System
A North Dakota 4-H Extension specialist chairs one of the development work team for the CCS system. The individual participates in at least two monthly phone calls, reviews curriculum proposals and prepares materials for review by a development team. This work amounts to about 30 percent of this individual's time. Our state has committed three years of this specialist’s time to manage the national development work team. Several North Dakota extension agents have committed to the Cooperative Curriculum System. There are three agents serving on curriculum design teams for beef, leadership, and geospatial literacy. Each design team includes members from at least six states.

Minnesota/North Dakota Extension Partnership for Curriculum Revision
Family Life and Child/Adolescent Development Extension Specialists, from Minnesota and North Dakota respectively, have partnered to research and rewrite the Children of Divorce curriculum. The two states shared resources by providing half the funding and the faculty expertise to accomplish the project. Curriculum materials are now being revised. Training and educational materials will be offered to agents once the curriculum is completed and they in turn will do programming at the county level.

E. MULTISTATE EXTENSION ACTIVITIES

Sugarbeet Program
North Dakota ranks second in sugarbeet acreage, providing 17 percent of the nation's supply. In 1998, sugarbeet growers in North Dakota and Minnesota lost $113 million to a Cercospora leaf spot epidemic. Isolates of Cercospora were found to be resistant and/or tolerant to the benzimidazole and triphenyltin hydroxide (TPTH) fungicides. From 1999 through 2004, the EPA has granted our sugarbeet extension specialist request to use Eminent, a tetraconazole fungicide, to control Cercospora leaf spot. EPA provided a full label for Eminent in 2005. The average number of fungicide applications applied per acre was reduced from 3.74 in 1998 to 2.06 in 2005, and 97% of surveyed respondents indicated good to excellent disease control. Rhizoctonia, Rhizomania and Fusarium are also becoming more severe in sugarbeet fields. Management strategies are being developed to better manage these diseases using resistant varieties and fungicides where applicable.

Researchers tested different fungicides to control Cercospora including resistant and/or tolerant strains. This has led to the full registration of two new effective strobilurin fungicides, Headline and Gem, in addition to Eminent. The use of Eminent and the strobilurins fungicides in an alternation program with TPTH has resulted in improved efficacy of TPTH, and *Cercospora beticola* populations that are more sensitive to TPTH. Specialists have also determined that azoxystrobin should be applied when the temperature at the four inch soil depth is between 62 and 73ºF for best control of Rhizoctonia crown and root rot. Researchers in North Dakota, Minnesota and Montana are also looking at control strategies that integrate disease-resistant crops and timely fungicide applications to manage new and emerging diseases.

The sugarbeet root maggot is the most serious insect pest of sugarbeet in the Red River Valley of North Dakota and Minnesota. It is also a major pest in over 2/3 of the sugarbeet-producing acres of the United States. Sugarbeet producers in the north central and western United States have relied on the same chemical insecticide mode of action for controlling this pest. The threat of insecticide resistance development in these populations is a major concern, and alternative control strategies are needed. Host plant resistance to insect injury is an attractive insect management strategy, most notably due to its direct benefits that include reduced applicator exposure to insecticides, and low risk to nontarget organisms. Extensive grower adoption of resistant varieties for sugarbeet root maggot control could potentially allow for major reductions in the overall pesticide load on the environment in areas infested by the insect.

In 2005, Extension programs on site-specific management reached many producers in the region. In studies using zone management of N in sugarbeets, economic advantages when there is sufficient variability of N range from $10-$100/acre. A recent American Crystal survey based on harvest receipts and grower practices showed a $45/acre advantage over conventional soil testing based on zone management and zone management with a $20/acre advantage over grid sampling.

Value-Added Programs
This effort focuses on three phases of value added agriculture development. The first is to assist producers, industry, etc., identify the strengths and opportunities in the region. The second is to educate clients on constraints and requirements to develop an identified value-added venture.

The third is to serve as a resource for implementing identified value added agriculture opportunities.

Several events aimed at educating the public on the strengths and identified opportunities for the region are held during the year. These events include: MonDak Ag Open, MonDak Value Added Ag Conference, Research Extension Center field days, Wheat Show, MonDak Pulse Day, Sidney Ag Days and Gateway of Opportunities in Glendive, MT. Interest in value-added agriculture is high. The outcome of these efforts included identification of areas that participants felt had the best opportunity for success. These included: potential for high value crop development with the vast irrigation resources in the region (potatoes, onions, and alfalfa were singled out); developing niche crops to be used in rotation with high value crops (malting barley, soybeans and corn were identified); attracting food/ag processing firms for better markets; and the development of higher value dryland crops (chickpeas, other legumes, and oilseed crops have seen dramatic acreage increases in the past three years).

Impact in North Dakota and neighboring states is demonstrated by the changes in acreage. In North Dakota, lentil acreage increased from about 2,500 acres in 1993 to 150,000 acres in 2005. Dry peas have increased from about 2,000 acres to 540,000 acres during the same period. Canola increased from 20,000 acres to 1,040,000 acres. Potato is the highest volume vegetable crop grown in the North Central region. With over 150,000 acres of legume crops (chickpeas, field peas, lentil, etc.) and over 2 million oilseed acres (canola, mustard, flax, etc.) many new processing facilities have developed. In the region, there was one processor in 1995, now there are 5 processing/marketing facilities.

Cattle producers in central North Dakota realized that working as a group would provide more economic development than could be accomplished individually. Through educational sessions and continued facilitation and instruction, producers were able to develop several new vertically integrated cattle business ventures. The cooperative cattle feedlot plan has constructed a 7,000-head cattle feedlot located in a cow-calf region where feed grains are traditionally low-priced. The limited liability partnership that owns cattle for custom feeding has returned a 23.5 percent return on equity during a one-year period for 23 cattlemen involved. A cattle-financing cooperative was developed for local producers and now provides financing for 95 percent of the calf purchase price with low-interest notes. The finance cooperative has grown 25 percent per year for cattle financed. Fifty-six cattle producers wanted to develop an outlet for supplying finished cattle at a 10 percent added-value premium and opened a 5000 head capacity beef processing plant. Forty-four producers developed limited liability company to sell fresh and processed meats into a regional market. Cooperative feedlot owners are from ND, MT, SD and WY. Financed cattle are marketed to IA, SD, NE and MN. Processed meat products have markets in ND, MN, WI, SD, CA, IL, MI, NJ, NY, LA, CO, IA and internationally.

Institution: NDSU

State: North Dakota

Check one:

X Multistate Extension Activities
__ Integrated Activities (Hatch Act Funds)
__ Integrated Activities (Smith-Lever Act Funds)

Title of Planned Program/Activity	Actual Expenditures FY 2005
Sugar Beet Program	51,000
Value Added Programs	42,000
Total:	93,000

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F. INTEGRATED RESEARCH AND EXTENSION ACTIVITIES

Renewable Resources
An integrated extension and research program was developed to improve rangeland management across the state. Key components of the effort included research on the effects of dormant season grazing on native rangeland in western North and South Dakota and the impacts of dormant season prescribed fall fire on herbage production and plant community dynamics of native rangeland managed using seasonlong or twice-over rotation grazing.

Impact: Dormant season grazing (mid November through mid January) at moderate and full use did not effect herbage production the following compared to standard full use summer grazing (June 1 through November 1). Double use of two weeks grazing in mid June followed by dormant season grazing from mid November through mid January enhance subsequent years herbage production by 0 to 26 percent. These results are from years 1, 2, 3, 4 and 5 of a projected 10-year study. Initial results would indicate ranchers and land managers could graze their winter pastures for two weeks in June at 50 percent use of standing herbage and fully graze (50 percent) the dormant season forage and enhance subsequent year's growth.

Twenty-one months post prescribed October dormant season fire decreased herbage production on the season long and twice-over rotation grazing treatment, and control; however, no significant reductions occurred after 33 months on the any treatment. Almost a 100 percent kill of club moss occurred from the prescribed fire at 9 and 21 months post fire, irrelevant of treatment; with 82 percent control achieved 33 months after treatment.

Distribution of these results was accomplished thru different means. The third edition of "Rancher's Guide to Grassland Management" was published in December 2005 with 810 copies distributed through North Dakota and eastern Montana. Over 3,260 land managers and ranchers received this book for educational and hands-on use to impact an estimated 3,595,000 acres of land. Ninety-one ranchers participated in the cow/calf and 12-month forage planning workshops. These two workshops impacted over 191,100 acres of native rangeland, pastureland, and hayland and 12,161 animal units of livestock. More than 85 percent of the participants were planning to add new range improvement practices or cattle nutritional programs.

Beef Research/Education
Animal feed utilization studies have focused primarily on cattle and sheep. In addition to productivity realized by traditional, co-product and new feed regimens, considerable attention has been directed at sources, intake, and fates of metabolizable protein. Research has also addressed selenium metabolism and interactions between nutrition and pregnancy in domestic livestock.

Impact: Inclusion of a seaweed extract in cooked molasses blocks increased forage digestibility when low quality forages were fed. Inclusion of flax seed in cooked molasses blocks did not improve performance of calves during the receiving period. Processing sprouted feed barley in backgrounding and finishing diets resulted in improved feedlot performance. Addition of wet corn gluten feed, a co-product of high fructose corn syrup production, to barley-based finishing diets resulted in improved performance compared to diets based on dry-rolled barley.

Scientists and extension personnel at North Dakota State University have used this information extensively in producer meetings throughout the state.

Entomology Research/Education
The development of a truly integrated pest management system that combines the use of another insect-pathogenic fungus with cover cropping as a cultural control strategy is being evaluated as a protection of fields from yield losses associated with sugarbeet root maggot feeding injury. One objective is to survey for and screen native isolates of entomopathogenic fungi for pathogenicity to the sugarbeet root maggot. Preliminary findings suggest additive root protection results from combining the two control strategies. A new federally registered and commercially produced strain (F-52) of this fungus has been demonstrated as having high virulence to the root maggot. One year of testing produced very encouraging results. Under moderate root maggot infestations, the integrated system of the fungus and cover crops (oat or rye) provided protection from root maggot feeding injury and allowed for comparable sugar and root tonnage yields as conventional chemical insecticide programs.

Impact: The sugarbeet root maggot is the most serious insect pest of sugarbeet in the Red River Valley of North Dakota and Minnesota. It is also a major pest in over 2/3 of the sugarbeet-producing acres of the United States. Sugarbeet producers in the north central and western United States have relied on the same chemical insecticide mode of action for controlling this pest. The threat of insecticide resistance development in these populations is a major concern, and alternative control strategies are needed. Grower adoption of alternative root maggot

management tools would allow for less use of conventional nerve poison insecticides for control of this insect, thus potentially causing less harm to the environment and to non-target organisms.

Canola Insect Pest Trapping Network was conducted in the major canola growing areas of North Dakota for the past eight years. Pheromone traps are used to monitor for two insect pests of canola: Bertha armyworm and Diamondback moth. Trap data provides growers, Ag consultants, field researchers, and county extension agents/specialists with an "early" risk warning system of when these insect pests are active and their population levels. A total of 12 trap sites in 9 counties in North Dakota and 3 sites in northwestern Minnesota were monitored. Overall, the average bertha armyworm moth per trap day was about 35% lower than the averages in 2004, and populations did not need to be controlled in the 2005 canola crop. Diamondback moth arrived in higher densities and earlier than 2004. Severe larval feeding injury was observed in seedling canola fields in the north central region of North Dakota. The above average rainfall during June throughout most of North Dakota drowned larvae of the first generation and reduced populations.

Impact: The trapping network was a very useful monitoring tool and as a result, the majority of canola fields did not require any insecticide spraying.

The Extension statewide IPM pest survey has evolved into a more comprehensive program for obtaining crop and pest information. The survey was limited to five crops for 2005. A total of 1,917 fields were visited from late May until the end of August. Information from these surveys is summarized in geo-referenced maps for use in newsletters, reports, and web information. The maps summarizing the sampling data were used to graphically illustrate where pest problems were developing in the region. Crops include wheat, barley, soybean, sunflower, and canola. Pests of regulatory importance are also recorded to assist detection efforts of the State Department of Agriculture and USDA APHIS, such cereal leaf beetle.

Impact: The pest surveys have provided valuable information about current crop and pest situations as they develop in the region. With the survey information, extension specialists have been able to develop programming needs to address the issues that were being faced by agriculture in a proactive fashion rather than after the fact. The proactive programming provides the tools to make timely management decisions that produce economic return during the current production season. In addition, researchers get a heads up on pest activity and where research should be focused.

U.S. Department of Agriculture
Cooperative State Research, Education and Extension Service
Supplement to the Annual Report of Accomplishments and Results
Multistate Extension Activities and Integrated Activities

Institution: NDSU

State: North Dakota

Check one:

__ Multistate Extension Activities
__ Integrated Activities (Hatch Act Funds)
X Integrated Activities (Smith-Lever Act Funds)

Title of Planned Program/Activity	Actual Expenditures FY 2005
Renewable Resources	2,000
Beef Education	19,000
Entomology Education	15,500
Total:	36,500

Check one:

__ Multistate Extension Activities
X Integrated Activities (Hatch Act Funds)
__ Integrated Activities (Smith-Lever Act Funds)

Title of Planned Program/Activity	Actual Expenditures FY 2005
Renewable Resources	20,000
Beef Research	14,500
Entomology Research	6,500
Total:	41,000

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