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AE Staff Paper AE95003 **March 1995**

VALUE OF AGRICULTURAL AND RELATED RESEARCH, TEACHING, AND EXTENSION AT NORTH DAKOTA STATE UNIVERSITY[1]

By

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Value of Agricultural and Related Research, Teaching, and Extension at North Dakota State University

The return from money spent on agricultural and related research ranges from 35 to 50 percent. These returns often are masked by the general research and technology diffusion and adoption process, which can take 30 years, or longer, to occur. This is partly why a majority of agricultural research is financed by public funds. Another reason is because private individuals cannot capture a sufficient proportion of economic gains associated with research results. The possible beneficiaries are far removed from the research. Beneficiaries of agricultural and related research are consumers, taxpayers, governments, producers, processors, distributors/retailers, landlords/tenants, management/labor/unemployed, retired/infirm, service providers (i.e., teachers, advisers, technicians), and even researchers.

The purpose of agricultural research is to produce outputs (knowledge, methods, products) that provide society with potential power to change agricultural systems in ways that are expected to **improve the welfare of all individuals in society**. The benefits to agricultural and related research accrue in three areas: (1) economic **growth** (i.e., quantity, quality, availability), (2) economic **security** (i.e., health and safety, food sources safety, and conservation), and (3) social **equity** (i.e., wealth distribution, employment, and individual rights). Getting to the point of felt public impact of research takes time and considerable human and physical capital.

The people, infrastructure, and social institutions that support research are essential in the process. Figure 1 illustrates this process and how public sector research is organized. People, infrastructure, and the social institution are the base upon which basic and applied research stand. However, only a small portion of the effort that goes into basic and applied research is readily visible to the general public via teaching on campus and extension across the state. It is from this visible portion that ultimately economic growth and security, and social equity are enhanced.

Agricultural research, teaching, and extension are necessary to increase the absolute amount of economic activity in the ag sector, which is responsible for 62 percent of nongovernmental basic sector activity in North Dakota, and to maintain that activity (Figure 2). One-fourth of productivity growth in production agriculture is due to public sector research investments and one-fourth to extension and education investments. The remaining growth comes from private sector activities. An even stronger case could be made for the roles of research, teaching, and extension in maintaining the (growing) baseline of productivity.

The ultimate goal of NDSU agricultural research, teaching, and extension is to enhance the well-being of North Dakotans. North Dakota's ag research capacity is spread across a dozen or so academic departments/disciplines on the NDSU campus, at the main Experiment Station, and at nine branch research centers. Research is disseminated by the extension service network.

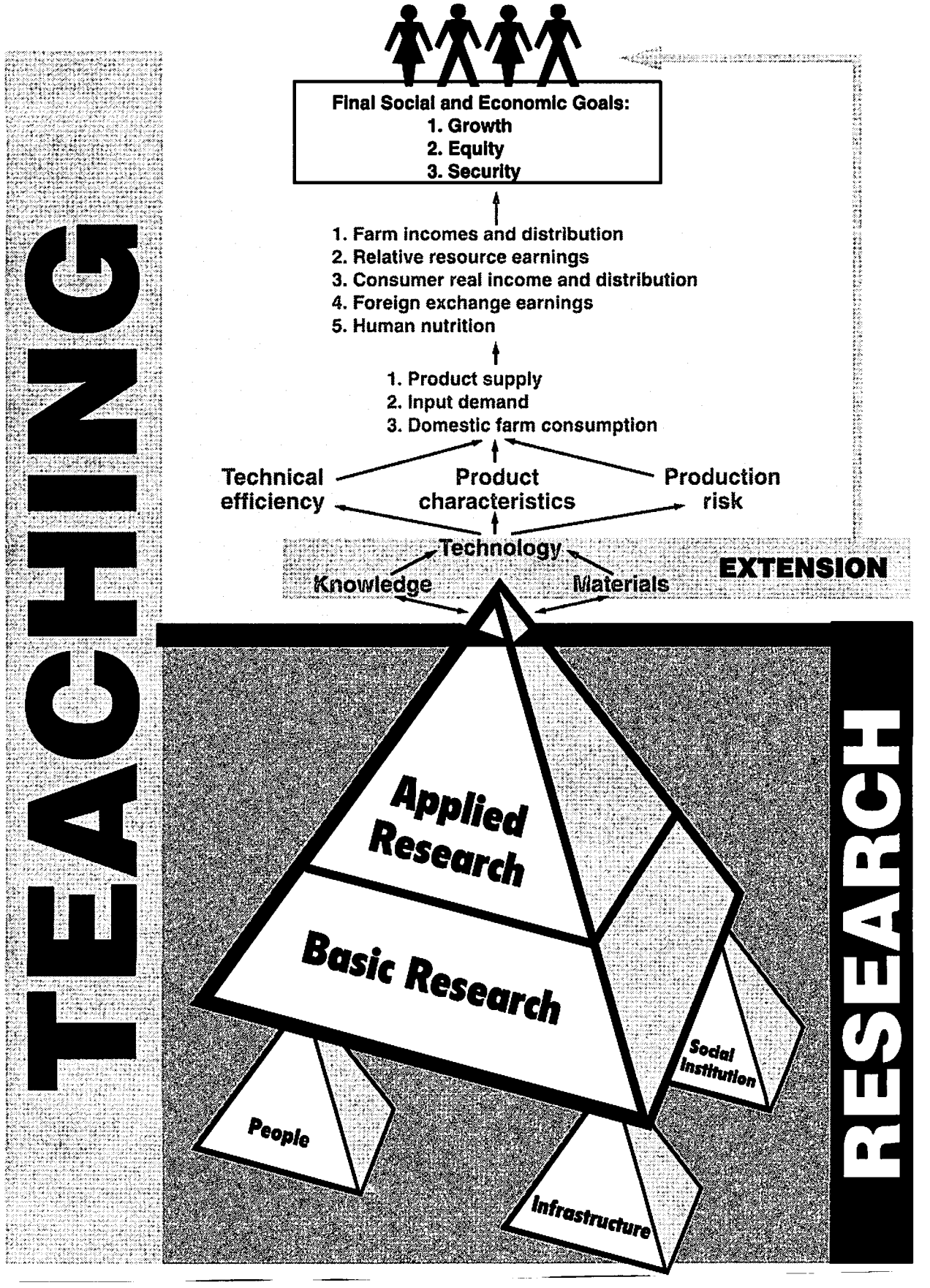

Figure 1. How Teaching, Research, and Extension Relate to Social and Economic Goals

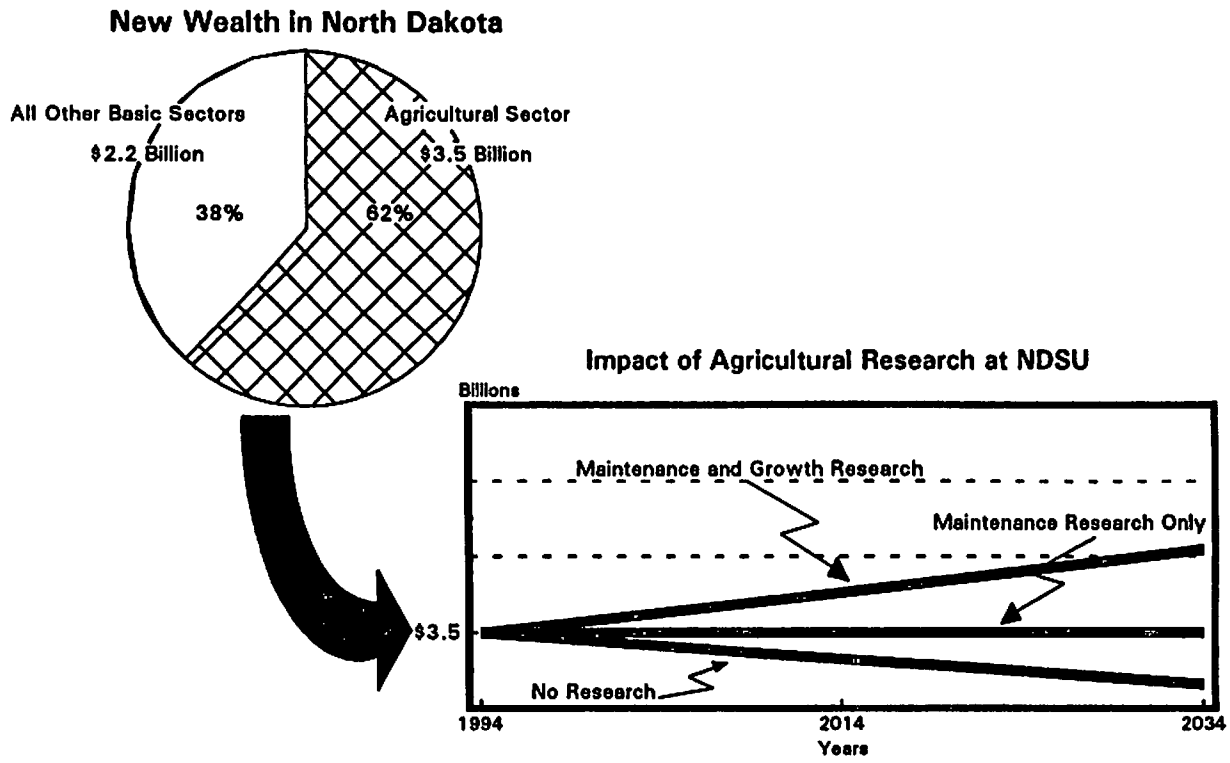

Figure 2. How Agricultural Research at NDSU Affects the North Dakota Economy.

Many do not appreciate the connection between an increase in personal income, or wellbeing, in the state and research into the most basic properties of soil or about how fungi grow. But the connection is solid; personal incomes in North Dakota would not be what they are today without NDSU's research output. Likewise, in order to maintain existing well-being or to enhance it in the future requires maintenance of NDSU's research capacity.

The basic research capacity of NDSU continually provides necessary scientific building blocks so that applied research can effectively respond to real-world problems of today and the future. Thus, the benefits-(payoffs to the state)-of basic research are the capacity to do meaningful applied research. Applied research, in turn, has little value unless its results are transferred to and implemented by ultimate users. This technology transfer is the role of extension. Extension transfers knowledge and technology applicable to North Dakota that has been developed at NDSU and at other institutions (Figure 1). Thus, while basic research and extension are crucial to the ultimate usefulness of applied research, applied research outputs are the visible tip of the benefits iceberg.

Value of Agricultural Degree Programs at NDSU

Teaching is a key to the overall research program (Figure 1) and in producing graduates who add value to the state's agricultural sector. The incremental salary earned by employees with college degrees is a partial estimate of "value added" to their job performance that emanates from their experience at NDSU. The College of Agriculture graduates about 140 B.S. students, 35 M.S. students, and 14 Ph.D. students each year (Appendix A). People with

B.S. degrees in agriculture can expect to earn an additional $6,000 annually. If one-half of NDSU's graduates from the College of Agriculture work and live in North Dakota after graduation, another $420,000 of value will be added to the state's economy per year. The "value-added" contributions by all employed NDSU College of Agriculture graduates from the last seven years who likely work in the state is $2.9 million annually.

Value of Extension Programs at NDSU

Extension disseminates research products from the university to the ultimate user (Figure 1). While extension does not produce research results, those results would not be consumed by end users without extension.

Nature and Value of Agricultural and Related Research at NDSU

Agricultural research at NDSU ranges from that done to respond to producers' immediate questions to that done to enhance knowledge. Both types and everything in-between enhance the well-being of the citizens of the state. Ag research builds on itself and on research of other disciplines.

Examples of recent research findings and expectations for ongoing research help to illustrate NDSU agriculture's role in the state's economic development. Each unit in agriculture was asked to identify from one to three specific outcomes that contribute/d to one of the final social and economic goals (Figure 1).

Examples of Research Results and Ongoing Efforts

Agricultural Engineering

Nitrogen management research has shown an average of 28 percent could be saved by using best management practices (BMP). If just 25 percent of the state's producers implemented NDSU-recommended BMPs for nitrogen management, the total annual savings would exceed $2.0 million.

Research on irrigation management has demonstrated water savings of about 35 percent could be achieved using NDSU-recommended BMPs. These savings translate to (1) more water available for other uses and (2) reduced annual pumping costs of approximately $10/acre or a total of $1.1 million if 50 percent of the state's irrigators adopted BMPs. Other advantages of reduced water used include minimized losses of agrichemicals to ground and surface waters, conservation of water resources, and reduced soil erosion.

Plant Sciences

A hard red winter (HRW) wheat breeding project was initiated at NDSU in 1969 to develop improved varieties of HRW wheat for North Dakota. Three varieties **'Roughrider'** (1975), **'Agassiz'** (1983), and **'Seward'** (1987) have been released and now account for nearly 85 percent of winter wheat grown in the state. These varieties yield about 13 percent higher than varieties they replaced. A ten-year average of 300,000 acres of HRW wheat, represents

an increase in gross returns to North Dakota agriculture of approximately $2.4 million annually.

Entomology

Research on insect control has identified a pest management strategy called *trap cropping*, which can reduce pesticide application by as much as 90 percent without decreasing crop protection. If this practice was applied to 60 percent of the sunflower acreage in North Dakota that is treated with pesticides, producers could reduce chemical costs approximately $3.6 million annually.

Experiment station and extension faculty conducted efficiency research on horn fly control via insecticide-impregnated ear tags on cattle. Calves with ear tags gained more weight than those that were not tagged. If one out of four North Dakota cattle ranchers were to adopt this procedure based on NDSU recommendations, there would be a potential benefit of $4.2 million annually.

Soil Science

The Yield Goal/Nutrient Sufficiency approach to fertilizer use has improved efficiency of crop production and minimized environmental impacts by identifying precise amounts of nutrients necessary to achieve the yield goal. Through cooperation with soil testing labs throughout North Dakota, which are largely staffed by NDSU graduates, soil scientists can minimize amount of fertilizer applied. This research has the potential to reduce fertilizer expense to growers by as much as $420 million annually. If 25 percent of growers used the Yield Goal/Nutrient Sufficiency approach, a cost savings of $105 million annually would be realized. This would improve net income to growers and reduce environmental impacts of fertilizer application.

A sugarbeet planter testing program tests seeding equipment for malfunctions. By repairing or replacing defective equipment or calibrating new planters, sugarbeet farmers could improve emergence. The estimated value of this program would be an additional $8,000 in production revenue to each farmer.

Ridge tilling practices for sugarbeets, sunflowers, and soybeans have reduced wind erosion of topsoil. Reduced wind erosion can improve yields by as much as 20 percent in some areas. Further benefits of ridge tilling for sugarbeets include improve germination rates. This can increase yields up to one ton per acre, which amounts to $46 per acre of additional revenue from production. If 25 percent of North Dakota's sugarbeet acreage was tilled in this fashion, an additional $2.25 million in revenue would be generated.

Agricultural Experiment Stations

Several projects at the Mandan Land Reclamation Research Center have identified procedures that have reduced costs to North Dakota's lignite industry.

- → Ripping or chiseling topsoil on reclaimed land was determined to have no impact on wheat yield. If this practice were discontinued North Dakota's lignite industry could save between $50 and $100 per reclaimed acre.
- → Grading reclaimed land that is required by law has been found to restrict the infiltration of water. Modifications to these regulations could save the lignite industry $100,000 to $200,000 annually.
- → It has been determined that no difference in yield between prime and nonprime soils exists, thus eliminating the need for maintaining them separately. This would save $100,000 to $200,000 for the lignite industry annually.

The Central Grasslands Research Center (CGRC) has helped Conservation Reserve Program (CRP) participants in North Dakota to identify economical uses of land being removed from the program. Using the state's 3 million CRP acres for grazing versus returning them to crops could achieve an added value of $25 per acre or $75 million in total to producers annually.

An economic study of retaining calves produced in North Dakota to their finishing weights was conducted at the CGRC. Results show an average value-added return of $50 per head for retained cattle. While retained ownership marketing may not be feasible for all North Dakota livestock operations, if 25 percent of producers could adapt their management systems for retention, the additional value would total $6 million annually.

Agricultural Economics

Over the past ten years, weaning weights of North Dakota produced calves have increased by approximately 10 pounds per calf. Some of this increase was directly related to research and consultation provided by NDSU agricultural economists through the Integrated Resource Management (IRM) program. If just 20 percent of the increase were attributed to IRM efforts and if 25 percent of the ranchers used IRM, revenue to the North Dakota cattle industry would have increased by $150,000 in 1993 alone.

Animal and Range Sciences

Research on feed additives could lead to BMPs of MER, which could lead to a 15 percent reduction in daily feed costs. Daily feed costs reductions of $0.12 per animal less the cost of additives (about $0.01/animal) could save as much as $780,000 in production cost per year.

These examples are a small fraction of all applicable research results, yet they represent an annual contribution of over $202 million to the state's economy. Many other examples of

"value-adding" research outputs are provided in Appendix B, but are not quantified in dollar terms.

If the quantified examples represent 10 percent of everything useful produced by NDSU agriculture the potential total annual contribution of NDSU's ag research, teaching, and extension would be over $2 billion. However, because of adoption rates (often far less than 100 percent), time lags in adoption, and market forces this potential if difficult to attain.

APPENDIX A

Number of Degrees Awarded to NDSU College of Agriculture Graduates								
Major	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**Total**
Ag Economics	60	55	52	37	37	31	31	303
Ag Extension	6	4	3	1	4	2	1	21
Ag Systems	6	10	10	13	11	7	13	70
Animal and Range	25	38	28	31	26	24	28	200
Biotechnology	4	1	2	3	1	4	2	17
Crop and Weed	8	20	29	9	12	16	18	112
Entomology	1	0	1	1	0	0	0	3
Food Science	0	5	3	5	6	5	4	28
General Ag	7	10	16	5	11	4	2	55
Vet Tech	13	14	2	6	8	10	14	67
Horticulture	4	2	6	6	7	4	9	38
Microbiology	2	2	0	4	2	2	2	14
Plant Pathology	1	0	0	1	0	1	0	3
Soil Science	2	3	3	4	3	5	0	20
Total	139	164	155	126	128	115	124	951
Advanced Degrees								
Master of Science	45	49	42	36	41	23	21	257
Phd	18	12	8	10	14	9	14	85
Total	63	61	50	46	55	32	35	349
TOTAL DEGREES	202	225	205	172	183	147	159	1,293

Annual Average Number of Degrees Awarded	
Bachelor's of Science	136
Master of Science and Phd.	49
Combined Total	185

APPENDIX B

Agricultural Engineering

- Studies are in progress to develop irrigation BMPs for potatoes and specialty crops that will reduce costs and minimize environmental impacts.

- An inexpensive end-gate sampling device was developed which provides samples as representative as the official FGIS approved sampler. The new device is low cost (about $12 vs. $80) and is easier to operate. Inaccurate sampling can result in substantial financial loss since all quality and grade determinations are made with samples collected.

- Research is underway to determine optimum harvest moisture content needed to maintain quality. Effects of storage and processing on the end quality of edible beans will also be evaluated. A process to use machine vision to determine bean quality is being developed to eliminate the subjective nature of manual quality evaluation.

- Research on value-added processing which may help North Dakota farmers to improve their competitive position in processed food industries includes extraction and processing of natural red food colorant from purple-hulled sunflowers, development of alternative uses for potato starch such as starch noodles for oriental markets, design of computer imaging and decision support systems for improved frozen French fry processing, devising processing system for deheating mustard seed for improved marketability.

- Alternative energy research involving the combination of vegetable oil and diesel fuel is designed to reduce airborne pollutants while at the same time creating a value-added use for North Dakota agricultural products.

- Tests on soil compaction of rubber tires versus rubber track tractors is being conducted to determine the impact of compaction on crop yields.

- Development of standards for replacing hazardous power takeoff (PTO) applications with hydraulic motor drives will improve safety in some dangerous agricultural power systems.

- Analyzing electrostatic chemical spray technology to identify potential reductions in over-spray which may have hazardous environmental impacts.

- Grain drying and storage educational programs have helped to maintain and protect quality of North Dakota grain in storage. More than 4,000 copies of "Natural Air/Low Temperature Crop Drying" were distributed in one year alone. Individual assistance was provided to more than 600 people during telephone inquiries, and 62 educational presentations were made across the state. Information has also been disseminated through news releases, radio programs, electronic mail networks, and satellite networks.

- Applied research information and educational programs that assist North Dakota producers with implementation of new production practices include row crop planter accuracy inspections, depth control for small grain planting equipment, stripper headers for small grain harvest, and residue management during tillage.

- Publications on Farmstead Assessment have assisted farmers and ranchers analyze how they impact surrounding water quality.

- Pesticide use and groundwater vulnerability instruction is presented annually to about 1,000 commercial applicators and through a slide/tape program to individual applicators on a countywide basis.

- The *AgrAbility in Dakota* program helps physically disabled farmers to remain in production agriculture by locating and obtaining handicap-assistive equipment.

Plant Science

- Study of wild oat control in wheat production has reduced incidence and infection from 90 percent of fields in 1973 to less than 50 percent of fields in 1993.

- Oat breeding at NDSU has resulted in the development of **'Pierce'** (1983), **'Steele'** (1984), **'Jerry'**, **'Whitestone'**, and **'Paul'** (1994). These varieties have improved test weight, increased protein content and yield, and strengthened resistance to disease of North Dakota's oat crop.

- Leafy spurge infestation costs the state nearly $100 million in lost business activity annually. This noxious weed can be controlled with herbicides, but chemicals are expensive and cannot be used in many areas adjacent to trees and water. Ongoing weed science research has determined that biological control methods may complement and even enhance chemical control of leafy spurge.

- Identification of alternative crop varieties that can adapt to the North Dakota climate will provide important economic opportunities to the state's producers. Examples of past successful research in this area includes sunflowers, dry edible beans, and crambe. Several additional crops have been identified as having industrial and pharmaceutical uses.

- North Dakota's potato crop has been increasing in importance. Of the acreage grown, 30 to 40 percent are varieties that have been introduced by NDSU scientists.

- Ongoing research has indicated that more frequent and smaller applications of herbicides to sugarbeets are most efficient. The increase in costs incurred by producers for the additional applications is offset by the decrease in expenditures for fewer herbicide chemicals.

- Research into the use of flax seed oil to improve blood lipids and/or cholesterol levels in humans may increase flax production in North Dakota. Flax would likely increase by 1 million acres.

Entomology

- Perform annual evaluations of new pesticides to identify which ones may provide effective and economical control of pests which threaten North Dakota crops.

- Ongoing research continues to develop knowledge that will allow North Dakota to diversify its agricultural base into new crops.

- NDSU annually entomologists conduct research that will ultimately lead to new pest management strategies in North Dakota. This research encompasses methods of reducing insecticide resistance and identifying of pest resistant crop varieties and methods for reducing pesticide volume and non-chemical control of pests.

- In cooperation with the USDA, the North Dakota Department of Agriculture, and the North Dakota Association of Weed Control Officers, department specialists have distributed of 3 million insects for biological control of leafy spurge.

- A program developed to manage sugarbeet root maggots has resulted in significant cost savings to growers. Recommendations for planter modifications, types and amounts of insecticides, and methods of application (e.g., post emergence) have helped growers to manage the insect more effectively.

- Entomology "outreach" efforts include programs for K through 12th grade students to introduce them to "science through the use of insects in the classroom." Also, department faculty have assisted students in developing ideas and interests for science fair topics that include insects.

Plant Pathology

- Plant pathology research at NDSU focuses on disease problems that affect agricultural crops within the state, such as root rots, head blights, foliar diseases, stem rust, leaf rust and viruses of cereal crops, sunflowers, dry edible beans, potatoes, sugarbeets, flax, soybeans, and urban forestry and shelterbelts.

- Extension plant pathologists help growers to apply research results toward controlling plant diseases. The State Plant Diagnostic Laboratory identifies plant diseases and other plant health problems for farmers and urban gardeners. The Seed Health Testing Laboratory identifies seed borne pathogens which help to prevent future disease problems.

- Root rot diseases in spring wheat and barley, although not epidemic like scab diseases, reduce North Dakota crops by as much as 25 million bushels annually. Each year, NDSU plant pathologists screen 35 to 40 spring wheat and 25 to 30 durum varieties for root rot resistance. In addition to providing information to plant breeders for development of disease-resistent varieties, results from these tests are provided to extension staff so they may better advise producers.

- Extension plant pathologists were proactive in organizing and participating in a task force gathered to respond to concerns about scab, vomitoxin, and septoria in the 1993 wheat crop. This task force provided information on harvesting, marketing, feeding, and milling options for the problem wheat.

- Potato pathologists worked closely in 1993 and 1994 with potato processing companies on ring rot disease in North Dakota grown potatoes. This work helped processors to avoid further losses caused by the disease. Thus, North Dakota's potato production industry will remain an important contributor to the nation's potato supply.

- Control of Sclerotinia or white mold is necessary for healthy sunflower and other row crop production in North Dakota. Epidemiology research at NDSU has identified important factors associated with the development of this disease, such as the amount of fungus in the soil. These results have been developed into integrated disease control programs that growers and crop consultants use.

- Continuing and planned research on the effects and management techniques of Ash Yellows, a disease that causes serious damage to green ash trees, will impact agriforestry and urban forestry plantings.

- Plant pathologists have found brown leaf spot disease on dry edible beans in North Dakota. The disease has not caused serious yield problems; but, if left unchecked, it has the potential to cause damage. In cooperation with county extension agents and the North Dakota Agricultural Weather Network (NDAWN--developed by NDSU Soil Science Dept.), plant pathologists have begun to track the disease and the weather conditions that favor its development. By remaining proactive, they hope to avoid any loss of production to the state.

Soil Science

- Preliminary greenhouse experiments have suggested that co-application of soluble sulfur with phosphorus products can benefit short-term uptake of phosphorus by wheat. Future research will apply this knowledge to field tests on maximizing first-year recovery of added phosphorus.

- Ongoing and proposed research involving the North Dakota Agricultural Weather Network (NDAWN) includes establishing of a nationwide agricultural weather system for use in agriclimatology, compilation and documentation of meteorological variables, development of weather-driven disease models, analyzing risk of frost with early and late plantings of soybeans, and archiving soil temperature data for future crop production studies.

- The goal of soil science research at NDSU is to aid production agriculture by obtaining information about soil performance. Areas of emphasis include efficient fertilizer use, improved fertilizers, fate of applied nutrients, and soil testing to provide accurate nutrient recommendations.

Agricultural Experiment Stations

- Research on the seasonality of sheep production conducted at the Hettinger Research/Extension Center has increased fall lambing from 30 percent to 80 percent of ewes. This project could have major impact on sheep production in North Dakota since fall lambing matches available labor and market times better than traditional spring lambing strategies. Fall lambing also fits better into biological leafy spurge control efforts.

- The effects of land reclamation on water redistribution have been studied at the Mandan Land Reclamation Research Center. A mathematical factor has been calculated to estimate water take-up of reclaimed lands. This *topofactor* is being used to further investigate the crop production attributes of reclaimed lands.

- Nesting success of waterfowl on CRP lands in Stutsman and Ward Counties was studied by the Central Grasslands Research Center at Streeter. It was determined that nest densities were higher than previously believed.

Cereal Science Department

- The cereal science department at NDSU (1 of 2 in the nation) was instrumental in organizing the Northern Crops Institute (NCI). The NCI has as its mission the research, teaching, and promotion of the benefits of North Dakota grown crops. The NCI trains trade teams from around the world about how to use North Dakota products in their home countries and does groundbreaking research into new and improved uses for North Dakota products.

- Quality research in the cereal science labs helps producers and processors to determine what specific traits of North Dakota grain and seed crops are important to the processing of different kinds of foods. By providing this necessary conduit between producers and

processors, the cereal science labs have helped producers remain competitive in the market.

Veterinary and Microbiological Sciences

- Veterinary research at NDSU has identified the strain Hemophilus parasuis (HP) which is virulent to swine. As a result, a vaccine can be developed to protect against this disease.

- Through a cooperative effort with the U.S. Biological survey, NDSU veterinary scientists have identified skunks as the primary vector of rabies. Each year, skunks can be traced to transmitting rabies to cattle, horses, and pets, creating a dangerous situation that could result in human contact with the disease. Ongoing research will help to explain rabies behavior in skunks and why this animal seems to be so prone to carrying the disease.

Agricultural Economics

- International trade research at NDSU is evaluating sources of competitiveness of hard red spring wheat and durum in major import markets, such Japan, South Korea, China, and Russia. Analysis of different trade policies and import demand conditions will bring to light export strategies for North Dakota wheat producers.

- Research on opportunities for exporting "value-added" wheat products will evaluate public and private strategies for expanding exports. This project has identified and quantified market opportunities within the wheat value chain.

- Extension agricultural economists are an economic information source for North Dakota's agribusinesses, farmers and ranchers, and county agents (who request information on behalf of other citizens). A request may trigger a research project that provides information about a problem that many people throughout the state face. In this instance, a formal and widely publicized research report may result.

Animal and Range Sciences

- To help lessen the animosity between agriculturalists and environmentalists, animal and range scientists have conducted research that has demonstrated means of producing wildlife on grazing land that equals production on wildlife habitat areas.

- Leafy spurge results in nearly $100 million in forgone business volumes in North Dakota. Research on the biocontrol of leafy spurge has provided information to lessen the expansion and the economic impact of the noxious weed.

- While the promoters of *escape proteins* as feed for cattle contend that it is a nutrient requirement, research has demonstrated it is only necessary for dairy cows. If adopted, these findings would reduce production costs for other cattle ranchers and producers.

- Swine research involves ways to enhance carcass value and to reduce production costs. In addition, swine nutrient research may lead to expanded markets for waxy corn and hull-less oats.