

## NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION

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### Tim Faller

- Develop support for the concept of a major biomass conversion initiative and describe how NDSU can be a force in its development.

## AGRIBUSINESS AND APPLIED ECONOMICS

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### Dwight Aakre

- Study biofuel's impact on agriculture; ethanol industry expansion, statistics and projected growth; and Impacts, economics and risks of an expanded ethanol industry.

### Cole Gustafson

- Develop crop insurance provisions for biofuel crops. Many potential biofuel crops are not insurable. Existing crops are insured for yield, but oil/starch is the more insurable trait. Biofuel crops may have unique agronomic characteristics (e.g., drought tolerance, different harvest period) requiring insurance program modification.
- Investigate technical feasibility and logistics of using field pea fractions in North Dakota ethanol plants by determining economic feasibility of North Dakota farmers increasing pea production, including assessment of agronomic and economic risk/returns, and accessing synergies of vertically integrating pea fractionation with existing and potential ethanol production activities in North Dakota.
- Develop risk management strategies for biofuel producers to minimize income variability and sustain operations in rural communities.
- Develop Extension educational program for renewable energy that includes newsreleases, workshops, and webcasts for biofuels and wind energy.
- Evaluate the financial impact of the North Dakota's ethanol production incentive, including alternative designs that provide more support in environment of higher price volatility and lower public sector cost.
- Investigate financial viability of sugarbeet to biofuel industry in North Dakota. Funding for this project was obtained from ND Commerce Department's APUC program and a dozen public/private sponsors across the region. A preliminary feasibility study shows upwards of 30 percent return on investment.

### Nancy Hodur

- Develop and commercialize technologies to produce materials and fuels from biomass feedstocks.

### Won Koo

- A spatial equilibrium model is developed to determine the optimal location and size of biomass processing plants in North Dakota. Water availability is an important constraint in the model.
- Another project examines the impact recent federal ethanol mandates have on the U.S. agricultural sector, especially corn and soybeans. Alternative scenarios of farming technology will be considered.

### F. Larry Leistritz

- Develop and commercialize technologies to produce materials and fuels from biomass feedstocks through the NDSU/MBI Biomaterials Program. Initial efforts have focused on commercializing technology to produce a biomass nanocomposite material as a substitute for fiberglass and petroleum-based composites. Wheat straw is a preferred feedstock for a biorefinery because it has a higher content of both cellulose and lignin than alternative feedstocks.
- Estimate production, harvest and transportation costs and supply prices for switchgrass and other energy crops as part of the Central Grasslands Research Extension Center feedstock project.
- Determine potential contribution to the North Dakota economy if livestock enterprises were developed to use byproduct feed from an ethanol plant. Economic impacts were estimated for a 20,000-head capacity beef finishing lot and for a 5,000-cow dairy.

- Evaluate the impact of the Conservation Reserve Program on local economies in North Dakota. The study included an extensive survey of CRP landowners and interviews with a cross section of community leaders in six multicounty study areas.

#### **Bill Wilson**

- Serve as director of the NDSU Oilseed Development Center of Excellence. Its goal is to increase North Dakota's competitiveness in production and processing of specialty oils and biodiesel. The center is a multidisciplinary team of research efforts to evaluate canola varieties, test new lines and develop new technologies in the production of canola biodiesel and bioproducts. Canola biodiesel plants are under construction in North Dakota, increasing the immediate local impacts of the center's research. Improved NDSU Pilot Plant laboratory technology is focusing on new and innovative uses for canola meal and bioproducts from producing biodiesel, including construction materials, adhesives and thermoplastics and the development of epoxy and other resins from canola oil for plastic composites.
- Conduct research in areas including risk analysis, strategy, Intellectual property, feasibility studies, logistics and commodity marketing.
- Participate in the USDA's Current Research Information System project to assess economic changes in trade arrangements, bioterrorism threats and renewable fuels requirements on the U.S. grain and oilseed sector.

## **AGRIBUSINESS AND BIOSYSTEMS ENGINEERING**

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#### **Ken Hellevang**

- Serve on the North Dakota Biomass Energy Task Force. The North Dakota Department of Commerce selected the North Dakota State University Extension Service through a grant proposal process to convene a task force of representatives from agencies and organizations associated with or interested in biomass for energy in North Dakota. The task force's mission was to complete the following objectives:
  - a) Review biomass energy activities, development and potential in North Dakota
  - b) Examine current state policies/programs related to biomass development
  - c) Propose action items to promote biomass as an energy source, including possible legislation for the 2007 legislative session.
- Participate with other Agricultural and Biosystems Engineering/NDSU Extension Service faculty in the North Dakota Renewable Energy Partnership (NDREP). The NDREP promotes ethanol, biodiesel, wind and biomass energy production in North Dakota through development and expansion of markets for renewable energy and through support of state and federal legislation enhancing the industry. The coalition grew out of "A Vision for the Future," the state's first renewable energy summit. The North Dakota Department of Agriculture, North Dakota Department of Commerce, North Dakota Corn Utilization Council, North Dakota Soybean Growers Association and University of North Dakota Energy and Environmental Research Center organized the 2003 conference.
- Co-author an Extension publication titled "Fuel Cost Comparison Chart," AE-1015, which provides North Dakota residents with an easy way to compare the heating cost of various fuels, including some biomass fuels. It also provides information on the energy content in British thermal units per pound of the biomass products.
- Work with Agricultural and Biosystems Engineering/NDSU Extension Service faculty to obtain funding for several years from the North Dakota Department of Commerce's Division of Community Service as part of the State Energy Program to deliver energy-related information and education to North Dakota residents.

#### **Vern Hofman**

- Test green canola for quality for the production of biodiesel and to determine harvesting practices.
- Serve on the North Dakota Biomass Energy Task Force to review biomass energy activities, development and potential in North Dakota.
- Work on developing a hydrogen- and diesel fuel-operated tractor.

#### **John Nowatzki**

- Present educational sessions on biofuels production and uses.
- Coordinate biodiesel seminars for NDSU county Extension faculty.

#### **Suranjan Panigrahi**

- Participate in the USDA's Current Research Information System project on science and engineering for a biobased industry: development and evaluation of field-scale sensors for rapid characterization of feedstock.

#### **Scott Pryor**

- Produce ethanol from Conservation Reserve Program biomass and other lignocellulosic materials. Aims are to 1) characterize mixed-grass biomass from CRP lands to determine ideal mixtures for optimal fermentable sugar production, 2) determine the effect of mixed feedstocks on biomass pretreatment processes, and 3) develop rapid methods for biomass characterization in the laboratory and in the field. Collaborators: Mario Biondini (Range Science), Dennis Wiesenborn (ABEN), Suranjan Panigrahi (ABEN)
- Study the interaction of dilute acid pretreatment conditions on enzymatic hydrolysis of switchgrass and other biomass feedstocks using several commercial enzyme systems. We will determine if the current methods of quantifying enzymatic activity are a fair means of evaluation under different processing conditions. Collaborators: Nurun Nahar (ABEN)
- Study the utilization of canola meal and canola proteins for industrial bioproducts and economic viability for higher value uses, e.g., adhesives, polymers and polymer matrix composites from canola proteins. Collaborators: Chad Ulven (mechanical Engineering), Dennis Wiesenborn (ABEN), Sam Chang (Cereal and Food Science)
- Study the use of sugarbeet pulp for ethanol production. Enzymatic hydrolysis is being used to generate several fermentable sugar streams. Processing conditions will be altered to maximize ethanol yields and ethanol concentrations in the final fermentation. Collaborators: American Crystal Sugar Company (Moorhead, MN)
- Study the economic and technical feasibility of using irrigated sugarbeets in east-central ND for ethanol production. Collaborators: Cole Gustafson (Agribusiness), and Heartland Renewable Energy (Muscatine, IA)
- Study the impact of encapsulating some or all of the enzymes required for complete cellulose hydrolysis in nanoscale membranes with adjustable pores. Project aims include enhanced enzyme stability and recovery, and reduced inhibition. Collaborators: Andriy Voronov (Polymers and Coatings) and Clarkson University.
- Study the impact of Ammonia Fiber Expansion (AFEX) biomass pretreatment coupled with densification on hydrolysis and fermentation of perennial grasses. Collaborators: South Dakota State University, South Dakota School of Mines and Technology, Michigan State University, Federal Machine (Fargo, ND)

#### **Dennis Wiesenborn/Darrin Haagenson/Rachel Brudvik**

- Develop new products from vegetable oils and oilseed coproducts, such as resins from canola oil that can be used to manufacture composite materials, and conduct product analysis.
- Evaluate biodiesel technology and feedstock, such as use of dry refining methods.
- Develop new methods for high-throughput evaluation of new canola varieties for biodiesel and coproduct use, such as through use of spectroscopic methods.
- Conduct engineering analysis of processes, such as fractionation of field peas for ethanol feedstock.

## **ANIMAL SCIENCES**

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#### **Joel Caton**

- Evaluate nutrient and non-nutrient compounds associated with coproducts.
- Evaluate composition of coproducts, coproducts as sources of nutrients for livestock feed and value-added uses of coproducts as part of an active, collaborative research and Extension effort in byproduct/coproduct use for livestock diets.

#### **Greg Lardy**

- Conduct research on feeding various ethanol byproducts to cattle to determine appropriate feeding levels and optimum usage.
- Investigate the effects of thiamin as a means of reducing the incidence of sulfur related toxicities when feeding high levels of distillers coproducts.
- Investigate the use of condensed distillers solubles as a supplement for low quality forages.

## **CEREAL AND FOOD SCIENCES (SCHOOL OF FOOD SYSTEMS)**

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#### **Sam Chang**

- Analyze physical and chemical characteristics of byproduct biopolymers, such as proteins and carbohydrates, for industrial uses.
- Convert valuable byproducts to foods.

#### **Clifford Hall**

- Develop uses for coproducts from biofuels production. Develop methods for utilization of byproducts from ethanol, including CO<sub>2</sub> pigments and proteins.

## **PLANT PATHOLOGY**

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#### **Luis del Rio**

- Study the epidemiology and management of diseases affecting canola production.
- Generate and evaluate germplasm with resistance to diseases affecting canola production.

## **PLANT SCIENCES**

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#### **Darrin Haagenson**

- Ensure analysis can be done on large amounts of canola trial seed (testing oil content) efficiently.

#### **Burton Johnson**

- Research sunflower, alternative and new crops. Research will continue to be directed to identify production practices that will improve crop agronomic and economic yield and thus net returns to the producer. Crops evaluated in this endeavor include traditional, alternative and new biomass, grain and oil-producing crops that would have direct utilization in biofuel and other applications.

#### **Chiwon Lee**

- Work on biomass to heat greenhouses. This includes working with a group in the Turtle Mountains.

#### **Marcelo Melani**

- Conduct research in plant breeding and genetics.
- Develop canola germplasm with enhanced value for bi-diesel production.

#### **Dwain Meyer**

- Research forage production and physiology.
- Study biomass production of switchgrass and other forage-related plants.

## **RANGE SCIENCE PROGRAM (SCHOOL OF NATURAL RESOURCE SCIENCES)**

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#### **Mario Biondini**

- Develop restoration techniques and management strategies to optimize biomass production for ethanol while maintaining the USDA Conservation Reserve Program objectives. This involves concentrating on the following question: What species combinations, minimum levels of species diversity and harvest periodicity are required to generate sustainable and economically viable biomass output for ethanol production, to maintain plant community stability, minimize invasion by exotic species and maximize C sequestration
- Construct a user-oriented model for the planning and ecological assessments of CRP-ethanol projects across a variety of climatic and soils conditions.

#### **Kevin Sedivec**

- Study growth patterns, biomass and nutritional quality, including acid detergent fiber and neutral detergent fiber, of 36 cool- and warm-season perennial grass cultivars in North and South Dakota.

## **SOIL SCIENCE (SCHOOL OF NATURAL RESOURCE MANAGEMENT)**

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**Adnan Akyuz**

- Conduct research on meteorology, local climatology and agricultural microclimatology.
- Conduct environmental monitoring.
- Study bioresponse to weather and climate variables, environmental measurement techniques and alternative renewable energy (wind and solar) potentials in North Dakota.

**Larry Cihacek**

- Study terrestrial carbon (carbon dioxide) sequestration on Conservation Reserve Program land, specifically the relationship between age of restored grasslands and changes in stored soil carbon (C). Changes are being compared with current cropland and undisturbed native grassland. Models are being developed relating age of grass stand with soil C.
- Research terrestrial C (carbon dioxide) sequestration in cropping systems management, specifically evaluate changes in soil C sequestration due to changes in conversion of grassland to cropland and cropland to grassland under conventional and no-till tillage management and grazed and ungrazed grassland management.
- Participate in a USDA Current Research Information System project on carbon sequestration and storage on eroded landscapes. This includes evaluation of processes on landscapes that offset changes in soil C on a landscape continuum from uplands to wetland periphery under both cropland and grassland management in the northern Great Plains.

**Tom DeSutter**

- Study the impacts of biofuels on soil quality.
- Determine how soil quality is influenced by the harvesting of both grain and biomass for ethanol production when monoculture rotations (corn-corn) are used.

## VETERINARY AND MICROBIOLOGICAL SCIENCES

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**Charlene Wolf-Hall**

- Study the utilization of soybean coproducts in mushroom production. The goal is to evaluate the role of variations in soybean meal as a substrate for specialty mushroom growth. The hull is the best substrate for producing oyster mushrooms.
- Conduct research in industrial and food microbiology, with emphasis on microorganisms that affect quality and safety of bioproducts.

## CENTER FOR COMMUNITY VITALITY, INSTITUTE FOR BUSINESS AND INDUSTRY DEVELOPMENT

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**Kathy Tweeten**

- Serve on the North Dakota Biomass Energy Task Force to review biomass energy activities, development and potential in North Dakota.

## CIVIL ENGINEERING

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**Eakalak Khan**

- Study the biodegradation of waste.
- Investigate the utilization of biomass, such as yard waste compost, cattail fiber, and rice husk, for removing inorganic and organic contaminants such as polynuclear aromatic hydrocarbons and heavy metals from water (Biosorption).
- Study the use of biotechnologies, such as bioaugmentation and cell entrapment, for removing hydrocarbons and pesticide from subsurface water.
- Investigate the bioconversion of agricultural waste, such as sugarcane mill wastewater and manure, to energy (ethanol and biogas).

**Wei Lin**

- Work on biomass to heat greenhouses. This includes working with a group in the Turtle Mountains.

## COATINGS AND POLYMERIC

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### Stuart Croll (chair)

- Study biowaste materials as a source of useful chemicals.
- Conduct analytical materials characterization.
- Model materials structure and properties.

### Dean Webster

- Study how to use biowaste and biomass as raw materials for polymers and resins for high performance coatings.

## ELECTRICAL AND COMPUTING ENGINEERING

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### Dan Ewert (chair)

- Work on developing a hydrogen- and diesel fuel-operated tractor.

## MECHANICAL ENGINEERING

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### Alan Kallmeyer

- Work on developing a hydrogen- and diesel fuel-operated tractor.

### Zakaria Mahmud

- Work on developing a hydrogen- and diesel fuel-operated tractor.

### Robert Pieri

- Work on developing a hydrogen- and diesel fuel-operated tractor.

### Michael Stewart

- Work on developing a hydrogen- and diesel fuel-operated tractor.

### Chad Ulven

- Study the utilization of canola meal and canola proteins for industrial bioproducts and economic viability for higher-value uses, e.g., adhesives, polymers and polymer matrix composites from canola proteins.
- Study the utilization of flax fiber in the production of natural fiber reinforced polymer matrix composites for primary and secondary structural applications.

## NORTHERN CROPS INSTITUTE

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### Kim Koch

- Develop biofuel coproducts into efficient livestock feedstuffs as part of an active, cooperative research and outreach effort involving corn-ethanol coproduct (and other regional coproducts), coproduct nutrient content and value generation.

### Mehmet Tulbek

- Evaluate biofuel coproducts (canola meal, glycerin, soybean meal, dried distillers grains with solubles) in extruded food and feed products.
- Screen regional soybean and canola varieties as a feedstock for the biodiesel industry.

## UPPER GREAT PLAINS TRANSPORT

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### Alan Dybing

- Study transportation infrastructure impacts.
- Estimate the highway impacts of a proposed ethanol facility at Spiritwood, N.D. The study focuses on modal shift from long-haul rail shipments to short truck shipments to the facility.

## RESEARCH EXTENSION CENTERS

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### Carrington REC

#### Blaine Schatz, director

- Evaluate traditional and alternative crops that have potential as an oil or starch based feedstock for bio-fuel production.

#### Ezra Aberle

- Evaluate production and management of perennial grass species to enhance the supply and quality of biomass for cellulosic ethanol.

#### Vern Anderson

- Lead extensive investigations in the utilization of bio-fuel processing co-products for beef diets and assisting to expand the livestock industry associated with diverse co-products.
- Conduct research to determine co-product value, appropriate methods of utilization and opportunities to formulate and commercialize with other feedstuffs.

#### Walt Albus

- Researches refinement of corn production systems (e.g., continuous corn, strip-till, nitrogen strategies, residue removal rates) to address the increased demands upon the regions corn production capabilities.

#### Paul Hendrickson

- Evaluate production techniques of corn and other crops with bio-fuel potential to enhance and refine practices that lead to greater productivity and sustainable production.

#### Steve Zwinger

- Evaluate annual forages and alternative species and production systems for forage and biomass production potential.

### CENTRAL GRASSLANDS REC (STREETER)

#### Paul Nyren, director

- Research production practices for growing switchgrass as a biomass fuel crop (five-year project started in 2001). This included producing a paper titled "Costs of producing switchgrass on farmers' fields in the Great Plains."
- Work with biochemists to evaluate new bacterium for extracting ethanol from cellulosic materials.
- Work with engineers to set up a pilot biomass briquetting plant to evaluate its potential use in small-scale installations that would be located throughout North Dakota.
- Evaluate perennial herbaceous biomass crops for ethanol. This is being conducted on five sites: Hettinger REC, Williston REC, North Central REC, Carrington REC and Central Grasslands REC. This study has the following objectives: determine the biomass yield and select chemical composition of perennial herbaceous crops at several locations throughout central and western North Dakota, determine the optimum harvest dates for maximum biomass yield and maintenance of the stands, compare annual and biennial harvest on total biomass yield and maintenance of the stands, evaluate carbon sequestration and storage of the various perennial crops and evaluate the economic feasibility of the various perennial herbaceous energy crops with competing crops in the surrounding area.

### DICKINSON REC

#### Kris Ringwall, director

- See Biondini research project summary (Animal and Range Sciences).

### HETTINGER REC

#### Christopher Schauer, director

- Conduct research on the use of ethanol coproducts in lamb and cattle finishing rations. Recommendations for the maximum safe level of inclusion of ethanol coproducts in lamb and cattle rations are especially useful in these time periods.

- Study the effect of land management changes (converting CRP lands to barley/corn production, grazing and haying) on pheasant and upland bird population dynamics.

#### **Eric Eriksmoen**

- Participate in a multiyear, statewide project evaluating switchgrass production as an alternative source of biomass for ethanol production.
- Research grain production and physiology.
- Conduct research in conjunction with the Main Station on the development of drought-tolerant corn to meet the growing need for corn production.

### **LANGDON REC**

#### **Randy Mehlhoff, director**

- Evaluate canola seed quality with different levels of green seed for use as a biofuel (diesel alternative).
- Conduct research that takes collected seed from two harvest methods (swathing and straight cutting) at three different timings (designed to obtain green seed levels of <2 percent, 8 percent to 10 percent and 10 percent to 20 percent) from two cultivars. Results are yielding green seed that are determining differences in the quality of biodiesel fuel among treatments.
- Participate in work to begin in 2007 to support the NDSU canola breeding effort through the NDSU Oilseed Development Center of Excellence for canola biodiesel development. Initial work will focus on developing high oil content canola varieties.

### **NORTH CENTRAL REC (MINOT)**

#### **Jay Fisher, director**

- Hydrogen electrolyzer: Wind generated electricity is passed through water in a large scale hydrogen electrolyzer separating off the hydrogen which is used to fuel three pickup trucks and one diesel tractor. The project began in 2006.

#### **Mark Halvorson**

- Participate in a multiyear, statewide perennial herbaceous biomass production evaluation for cellulosic ethanol production. Total biomass yield and stand maintenance are being compared between annual and biennial harvest dates. Ultimately carbon sequestration and economic feasibility comparisons with competing crops for this region will be reported. Foundation seed production of four native grass species are annually inspected and produced on a field scale basis.

#### **Shana Pederson**

- Breed and develop pulse crops for expanding markets worldwide and identify product end use utilization. Beneficial nitrogen fixing pulse crop species such as chickpea, field pea, and lentil grown in rotation with commonly grown crops lowers input costs associated with subsequent fertility needs of producers and are known to break disease cycles. Efficient use of these legume crops are environmentally friendly, and attributes of the rotational benefits are being researched.

#### **Angela Sebelius**

- Designated as a field testing and greenhouse evaluation location for biofuel development, the NCREC has worked closely and in concert with the Oilseed Development Centers of Excellence initiative since 2006. Conduct research and genetic development of highly adapted canola lines for both high oil and high seed yield characteristics for biodiesel production. One thousand F3 derived F4 breeding lines were screened at Minot, and 40 advance yield trial entries were evaluated at Minot and Rugby in 2008. Evaluations of many additional oilseed crops such as juncea, camelina, crambe, and field pennycress are ongoing and include fatty acid compositions which are being quantified for potential usefulness in the agricultural renewable energy industry.

#### **Gary Willoughby**

- An 80 horsepower tractor has been operated on 100 percent canola biodiesel since 2004 with no negative effects to either engine performance or mechanical wear.

### **WILLISTON REC**

#### **Jerry Bergman, director**

- Breed and develop value-added safflower products (high oleic/low saturate safflower oil and high linoleic/low saturate oils) for expanding market potentials in biofuel biolubricants, cosmetics and pharmaceuticals, and as a value-added feed supplement for livestock, in cooperation with the Montana State University Eastern Agricultural Research Center.

- Evaluate oilseed crops produced for vegetable oil-based biodiesel/biolubricant/biobased product industries cooperatively with the Montana State University Eastern Agricultural Research Center. Oleic safflower lines having up to 87 percent oleic oil and greater than 95 percent gamma tocopherol with increased oxidation stability have been developed.
- Develop high oleic, high gamma tocopherol safflower varieties for use in biofuel/biobased products and assessment of vegetable oil for biodiesel yield and quality. Biodiesel will be produced utilizing a university research and development biodiesel production system and evaluated for fuel related properties.
- Study perennial grasses and Conservation Reserve Program mixtures for cellulosic ethanol on a dryland and irrigated site at Nesson Valley 23 miles northeast of Williston, N.D., to identify most productive perennial herbaceous crops in western North Dakota and eastern Montana (MonDak region) for cellulosic ethanol.

#### **Chet Hill**

- Working with local group to build an ethanol plant
- Coordinate tours of biofuels facilities to educated extension field staff
- Give presentations on general ethanol production and production of oilseed crops
- Serve on the North Dakota Biomass Energy Task Force

## **ACADEMICS**

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#### **Tom Bon**

- ABEN 263: Biological Materials Processing — coursework on physical characteristics of biodiesel.

#### **Scott Pryor**

- ABEN 499/696: Biofuels — interdisciplinary course that brings together NDSU expertise in areas such as economics (Cole Gustafson), transportation (Mark Lofgren and Mark Berwick), agronomics (Burton Johnson), farm management (Dwight Aakre), coproduct utilization (Greg Lardy) and conversion technologies (Dennis Wiesenborn and Scott Pryor) to provide students with a broad background of the complex issues and opportunities for the biofuels industry.

#### **Paul Schwarz**

- MICRO/CFS 454/654: Bioprocessing — the use of microorganisms and enzymes for processing agricultural materials into industrial products, including foods, biofuels and antimicrobials. Prerequisite: MICR 202L, CHEM 260 or graduate standing.
- CFS 765: 765 Advanced Cereal and Food Chemistry - physiochemical, structural, functional analysis of cereal and food carbohydrates and enzymes. Biochemical aspects of these components also will be presented.

#### **Charlene Wolf-Hall**

- MICRO/CFS 454/654: Bioprocessing — the use of microorganisms and enzymes for processing agricultural materials into industrial products, including foods, biofuels and antimicrobials. Prerequisite: MICR 202L, CHEM 260 or graduate standing.