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Farm and Home Research: 55-1

Lance Nixon

Marianne Stein

Utilizing and developing our resources to enhance quality of life

Farm & Home RESEARCH

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South Dakota State University · College of Agriculture & Biological Sciences · Agricultural Experiment Station

FLYING HIGH AND PREDICTING YIELD

STAR STUDENT VALUES HER RESEARCH EXPERIENCE

A MISSOURI RIVER SYNTHESIS—FROM HEADWATERS TO MOUTH

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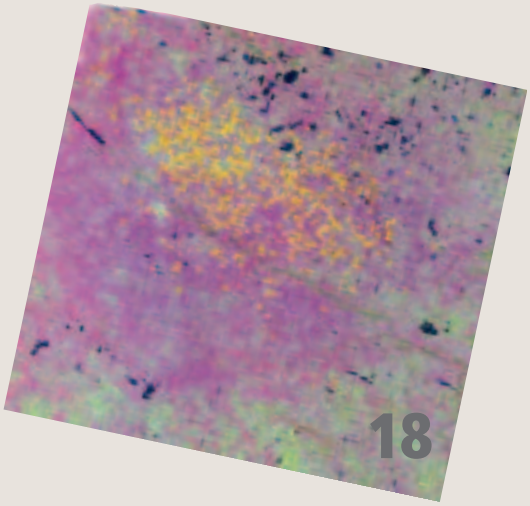

On the cover:

Two hundred years ago this summer the Corps of Discovery, better known as the Lewis & Clark Expedition, first touched the shores of what is now South Dakota. Only in today's reach of the Missouri River below Gavins Point Dam would they see any resemblance to the natural-running river they had learned to respect. The Missouri today is part shipping channel, part reservoir system, and a little free running river, and every section of it is claimed by interest groups. But it is a complete ecosystem, says Carter Johnson on page 6. It can't be looked at piecemeal." Cover photo courtesy of Chuck Berry SDSU Wildlife and Fisheries Department.

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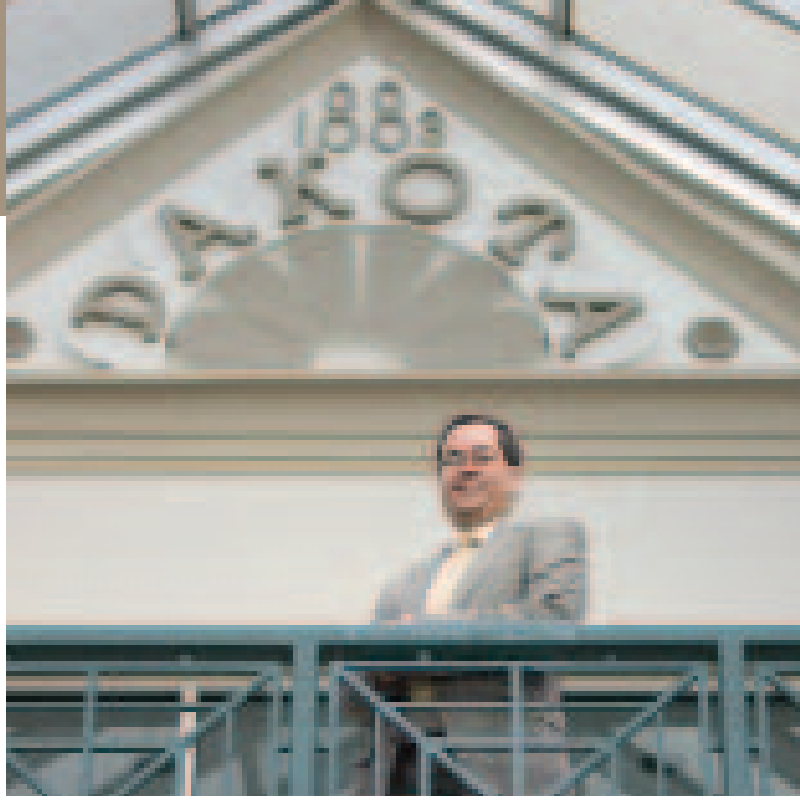
Director's comments

BY KEVIN KEPHART
Director, South Dakota Agricultural Experiment Station

TOOLS, old and new, help build our future



Kevin Kephart, AES director

Scientists of the South Dakota Agricultural Experiment Station are at work on ways to help producers harness next-generation technologies—such as satellite images—or make better use of old tools like the rain gauge and the thermometer. Those are among the ongoing topics we look at in this issue of *Farm & Home Research*.

Satellite images, or images shot from other platforms—an aircraft, a balloon, a kite, are now becoming fairly routine tools for scientists. Now we have gone beyond satellite imagery, into satellite-aided quantitative analysis that uses reflectance information gathered from these airborne platforms to help us determine whether a producer has, for example, high sugar concentration in his sugar beets or a certain protein level in his wheat field.

Reflectance data add an important source of information, but they are just one more tool in the kit that helps our scientists interpret the information they've gathered. Studies by Dan Humburg, Dave Clay, and Cheryl Reese will doubtless lead to more of this kind of work.

I envision a day when satellite-aided analysis will be of benefit to an individual producer. But it probably won't make sense for most producers to invest in the instrumentation needed to gather reflectance data about his crops.

Instead, I think the producer will contract out that information gathering to a company or a federal agency or university. Some may contract for flyovers with airplanes. Our South Dakota State University scientists have already ordered scans from U-2 high-altitude reconnaissance aircraft. Because digital images can be easily transported as electronic data, we're entering an age when producers can order an analysis via the Internet.

While we need to explore ways to use these next-generation tools, one important SDSU study suggests two old-fashioned tools found on virtually every farm or ranch—a thermometer and a rain gauge. They may be all that's needed to predict how much forage a pasture will yield in a given year. It sounds easy, but the science behind it is anything but simple.

Our range scientist, Sandy Smart, is working with a decades-old data set gathered by Tex Lewis and others. Dr. Lewis was a world-renowned range scientist in the Department of Animal and Range Sciences here at SDSU. He spent a great deal of time at the Cottonwood Range Research Station, looking at very long-term management impacts on the range. This included a thorough collection of weather data, because he understood that grasslands are a result of complex interactions between utilization, management, soils, and climatic conditions.

He collected data in the days of slide rules, mechanical calculators, and early mainframe computers with expensive operational costs. Sandy is analyzing this mountain of data inherited from Tex, using state-of the-art personal computers and statistical procedures. He hopes to fully understand these complex grassland interactions.

It's a unique situation. I can't think of anybody else who has a data set like this. Scientists: This project is a good example of how important it is to maintain your original data sets. They just may turn out to be very valuable for people who come after you.

Of course that's implicit in all our scientific research. Good scientists help build the future, but they lay the foundations for it on the past work of others—just as some important study decades in the future will be based on the work our SDSU scientists are doing now.◆

Two TOOLS tell a lot

How to predict pasture performance this season?
Hang up a rain gauge and a thermometer.

Decades of data from South Dakota State University's Cottonwood Range and Livestock Research Station, 11 miles west of Philip on Highway 14, may help ranchers sort out the connections between precipitation and temperature and pasture growth.

In the long run, Sandy Smart, SDSU range scientist, and his colleagues also hope to learn how light, moderate, and heavy stocking rates over the years affect gain per animal and return per acre.

Cottonwood, the nation's very first range research station, was established in 1909 by the South Dakota Agricultural Experiment Station and has been home to ongoing studies tracking forage production since 1942. The station also records weather data.

Tex Lewis, SDSU scientist, picked up on these studies in the the 1950s. It is largely his data—collected in some 30 notebooks—that Smart has been studying in a project that looks at long-term grazing effects on forage production, animal performance, and economic return.

In the wake of the 2002 drought, Smart turned to the decades of raw data from the Cottonwood station, looking for clues that could help South Dakota producers make management decisions. He presented his first findings at the 54th annual meeting of the Society for Range Management.

His suggestions on predicting forage production?

"You have two variables that can be easily measured on every ranch. You have a thermometer and can record when the nighttime temperature gets down below 30 degrees Fahrenheit. You have a rain gauge. With these two tools you can predict pasture forage production."

"MONITOR YOUR RAIN GAUGE if you have fair-condition pastures.

"If your pastures are in only fair condition, estimating forage production from the rain gauge is a little easier than if you have better pastures.

"For fair-condition pastures, the cumulative April, May, and June precipitation was the best predictor for current year's

Sandy Smart, SDSU range scientist

"You have a thermometer. ... You have a rain gauge. With these two tools you can predict pasture forage production."

—Sandy Smart
range scientist, SDSU

forage production," Smart continues.

That means that by the end of June, a producer can adjust stocking rates if necessary for the second half of the grazing season. The grazing season typically runs through October or into November in South Dakota.

Many producers already adjust stocking rates, Smart notes, but the study is valuable in that it establishes a clear cutoff mark for saying when South Dakota forages respond best to rainfall with increased production.

USE THE RAIN GAUGE and the thermometer together for pastures in good or excellent condition. Rainfall alone will not be the best predictor.

Smart found that April, May, and June precipitation and the last calendar day that the minimum temperature reached 30 degrees Fahrenheit (minus 1 Celsius) were the best combination.

"If you get a nighttime temperature that drops below 30 degrees in the middle of May, then the plants have to respond to handle that cold weather. They have used up energy that's not going to be there for growth."

He adds that precipitation alone does not correlate directly to forage production on pastures in good or excellent condition (typically pastures that have been lightly or moderately grazed) because such pastures have a greater mix of grasses and a more complex ecosystem.

Pastures that are in only fair condition often have been overgrazed, which eliminates many of the cool-season species over time, Smart says. Many times such pastures are made up of 90% or more warm-season grasses. That leaves a less complex system that is easier to understand.

WHAT THE COTTONWOOD NUMBERS suggest about forage production is eye-opening.

Lightly grazed pastures produced nearly a third more forage than heavily grazed pastures when normal April-June precipitation of 7.8 inches fell. Under such conditions, lightly grazed pastures produced 1,850 pounds of forage per acre, compared to 1,420 pounds per acre on moderately grazed pastures and 1,280 pounds per acre on heavily grazed pastures.

The difference is even more noticeable when April-June precipitation was below 75% of normal. Lightly grazed pastures still managed to produce 1,420 pounds of forage per acre, or what a moderately grazed pasture produced under normal rainfall conditions. In contrast, moderately grazed pastures under such drought conditions produced 1,030 pounds of forage per acre, while heavily grazed pastures yielded only 850 pounds per acre.

"It's clear from the data that a lighter stocking rate is better for the range." However, Smart adds that additional forage production alone may not be enough to convince ranchers to alter grazing patterns. But they might adjust stocking rate if data show they actually make more money—per acre or per animal—by stocking pastures more lightly.

Until he's finished his analysis of the Cottonwood data, Smart can't speculate about those numbers.

"I intend to develop average daily gain, gain per acre, and net return per acre. Once we've done that we'll be able to understand, given a certain stocking rate, what are the net returns. You'll be able to use that as a guide to recognize what changes you need to make."◆ —*Lance Nixon*

A Missouri River synthesis—
from headwaters to mouth

Days after the Lewis & Clark Corps of Discovery reached what is now South Dakota in 1804, some of the men catch nine catfish for supper. Five fish weigh an average hundred pounds each.

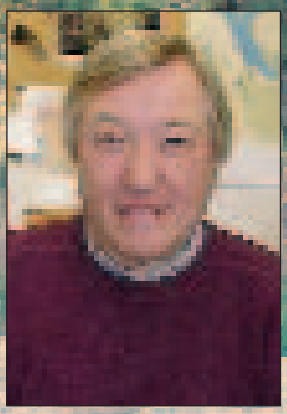
Four days later, on August 29, just below what is now Gavins Point Dam, John Ordway records, "we have plenty of fine fat Cat fish the most of the Time. … The Misouri river affords us pleanty of fish. …"

William Clark, on October 1 a few miles above the mouth of the Cheyenne River: "Sand bars are So noumerous, that it is impossible to discribe them, & think it unnecessary to mention them."

Two years later, coming back downriver in August and camped near the mouth of Spring Creek in Campbell County, Clark again: "I observe a great alteration in the Corrent course and appearance of this pt. of the Missouri. in places where there was Sand bars in the fall 1804 at this time the main Current passes, and where the current then passed is now a Sand bar. Sand bars which were then naked are now covered with willow Several feet high. the enteranc of Some of the Rivers & Creeks Changed."

THE REACH OF THE MISSOURI below Gavins Point Dam comes the closest in South Dakota to looking like the wild river of Lewis and Clark. The only free-running reach is above the large dams in Montana. Elsewhere, the multiple channels, oxbow lakes, islands, sand bars and dunes, and backwater areas along the river are just about gone.

Cottonwoods also were once "so noumerous" along the entire sweep of the 1804 river that they were rarely recorded



"We have traded a set of benefits the Missouri River offered us free of charge for a set we've had to pay for—and still are."

—Carter Johnson
ecology professor, SDSU

Missouri river photo courtesy of South Dakota Tourism.

by the explorers, who were the first to describe the tree for science. Today young trees are hard to find, since they only regenerate on sand bars after floods, which have been virtually eliminated by the dams.

Although the Lewis and Clark journals mention 31 species of fish, they apparently were only the ones the men caught and ate. Today there are 67 native fish species living along the mainstem of the river; 51 of them are listed as rare, uncommon, and/or decreasing across all or part of their ranges.

Nearly 3 million acres of natural habitat ("bluff to bluff" along the mainstem) have been altered through channelization, levee building, commercial development, farming, and other human activities.

And upstream states war with downstream states over distribution of the benefits the river still offers.

Carter Johnson, ecology professor in the Department of Horticulture, Forestry, Landscape and Parks at South Dakota State University, relates the history and future of the Missouri River as he summarizes the results of a National Research Council (NRC) project in which he participated. The group's major recommendation—adaptive management of the entire river system—was delivered to the agency that had requested the study, the Army Corps of Engineers. The Environmental Protection Agency had joined the Corps in funding the project.

"The initial reaction to the plan was positive—from the Corps, which has incorporated adaptive management into its

Missouri River Basin

environmental impact statement, and from a wide range of political and natural resource groups. They all saw the value in an unbiased, objective document that synthesized the entire river from headwaters to mouth.

"Everybody will have to give a little to help the system recover, but when it does, then everybody in the country—and the river, too—will be the better for it. Implementing adaptive management involves some risk, but what in life doesn't?"

"WE STARTED TRYING TO BEND THE RIVER to our will just 26 years after the Lewis and Clark expedition when Congress decided in 1832 that the Missouri needed 'improvement' for navigation.

"We have traded a set of benefits the Missouri River offered us free of charge for a set we've had to pay for—and still are. The river is continually degrading, by almost any ecological measure you use."

The lower river, from Sioux City on down, is little more than a shipping canal, Johnson says.

The Corps of Engineers has reported total commercial barge traffic at a record peak of 9.25 million tons in 1999. Excluding sand, gravel, and other riprapping and levee building materials, the total was 1.58 million tons.

The war between the states heats up over the comparison of alleged navigational benefits ($9 million a year) to recreational benefits ($85 million a year).

"That's a red herring," Johnson says. "You can't divide the river up into state segments if you want it to become healthy again. Ask the Missourian whether he wouldn't like a little fisheries and bird watching instead of barge watching. There are large population centers down there; they have a massive natural system in their backyards that is no longer useful to them as a recreational outlet. I find that very strange.

"Ask the upstream resident if he expects the river to only provide him with walleye and recreation. If the upstream fisherman values the river only for walleyes and the Missourian only for its barge traffic, the river will continue to slip away."

"There will be uncertainties, environmental changes we didn't foresee. With adaptive management, we take those happenings in stride and change our policies and strategies, in midstream, so to speak."

—Carter Johnson
ecology professor, SDSU

"If we manage the Missouri River through lawsuits, which is the way things are starting to go now, we're going to be in a heap of trouble. We can't afford to continue with piecemeal, uncoordinated approaches."

—Carter Johnson
ecology professor, SDSU

Johnson continues his list of free benefits from the frontier river: biomass fuels for new homes and steamboats ("generally, steamers had to stop about three times a day to load up on firewood"); wild game, timber ("wagon wheels, canoes, lumber for cabins"); clean air and water; medicines from plants ("aspirin comes from willow bark"); plant, animal, and bird species richness; maintenance of soil fertility through periodic flooding; and natural recharge of groundwater.

"We don't miss these things until they're gone or threatened," he says. "And it's hard to monetize them."

"When we began to manage the river, we lost many of those valuable original services although we traded for some new ones—flood control, recreation on the reservoirs, electric power."

PUBLIC OPINION IS BEGINNING to see the value of a more natural-running river, Johnson says.

"The Corps of Engineers, too, is becoming more 'green.' The Corps has always been very good at mechanics—building, turning valves, opening gates, and the like. They should always continue to regulate flow. But they see the river in decline. That's why they asked the NRC for help."

The NRC is not a government agency, but it was set up by President Lincoln as a way to provide the government with unbiased information about its policies and functions.

"The Corps always seems to attract controversy, just like a lightning rod. I think they felt they needed a little more science and a little less politics."

Johnson and 11 other nationally recognized specialists in ecology, biology, engineering, agriculture, and law were named to conduct a 2-year study of the river. "This was no bandaid approach. This was the first project in which non-stakeholders reported on the entire Missouri from its headwaters to its mouth.

"We met in river towns up and down the mainstem to ask the public how they used the river and what they thought needed to be done, if anything, to it. We heard from tribal members—who contributed most of the land that went under water in South Dakota, grain shippers, environmentalists, fishermen, and other folks, and we got a pretty good handle on what people thought."

ADAPTIVE MANAGEMENT IS THE CENTERPIECE of the committee's report.

"The river, even as tame as we've made it, is dynamic and changeable," Johnson says. "So there is no certainty that whatever steps we take will turn out as we expect. There will be surprises, environmental changes we didn't foresee. With adaptive management, we take those happenings in stride and change our policies and strategies, in midstream, so to speak. Adaptive management—and the river—are 'works in progress.'"

So who "manages" the river?

"Everybody who has a stake in it," Johnson says. Johnson and his fellow panel members suggest the formation of a group of stakeholders—Corps engineers, scientists, citizens up and down the river, the Department of Energy, Indian tribes, basin state committees, floodplain farmers, environmental and recreational groups, representatives of all people who have an interest in the river.

"Sure," he says, "since the 1800s, there have been committees and boards that have tried to manage the river. They failed because they only thought of their part of the river.

"The river is an ecosystem. It can't be looked at piecemeal."

Congress will have to play its part, he adds. The stakeholder group would define ecosystem improvements but Congress would provide the legislative authorities and fiscal resources to sustain adaptive management after a federal Missouri River Protection and and Recovery Act is passed.

"IF WE MANAGE THE MISSOURI RIVER through lawsuits, which is the way things are starting to go now, we're going to be in a heap of trouble. We can't afford to continue with piecemeal, uncoordinated approaches.

"We can be optimistic, however. We know so much more than we did 10 or 20 years ago. We want more than just economic return now. With the tools, the interest, and the cooperation we have now, we can better determine what the river needs to regain its health and provide all of us both tangible and intangible benefits. ◆ —*Mary Brashier*

The quotes from the Lewis and Clark expedition are taken from Gary Moulton, Lewis and Clark Journals, *University of Nebraska Press, 2003. The book by the Committee on Missouri River Ecosystem Science, for which Johnson was a contributing author, is* The Missouri River Ecosystem, exploring the prospects for recovery, *published in 2002 by the National Academy of Sciences. Go to http://www.nap.edu and type "Missouri River Ecosystem" in search box.*

Karissa Nielsen. SDSU senior in dairy production and manufacturing

Star student values her RESEARCH experience

Karissa Nielsen from Howard graduates with a bachelor's degree in dairy production and manufacturing in May 2004 with plenty of research experience to her credit.

A recipient of two undergraduate research awards, Nielsen conducted two separate independent-study projects during her senior year at South Dakota State University, both on how to maximize the use of byproducts in dairy production. Dave Henning, Alfred Chair of cheese chemistry and technology, served as her advisor.

In one study, Nielsen and Henning developed a value-added, edible product from the retentate that is a byproduct from M.O.O.M. production. Nielsen received a Griffith Undergraduate Research Award to conduct this project.

M.O.O.M is a carbonated drink made from milk by Dairilean, Inc., a Sioux Falls-based company working with the SDSU Dairy Science Department. M.O.O.M. is produced through ultrafiltration, a process whereby milk is filtered through a membrane that separates components of liquid according to molecular size.

"The ultrafiltration separates protein from lactose and minerals. The lactose and minerals are used in the M.O.O.M. drink, and my project was to work with the proteins," Nielsen said.

"Right now the retentate byproduct is just going to waste, and the idea was to develop a value-added product. We were hoping to make an acidified gel with a consistency like yogurt or pudding."

Nielsen used samples of skim milk, diluted skim milk, and retentate, adding transglutaminase, a food-grade enzyme, to one sample of each type. This was intended to cause the

casein (milk proteins) and the whey proteins to combine and produce a firmer curd.

Next, glucono-delta-lactose was added to each of the six samples as an acidifier for forming the gel. Glucono-delta-lactose is a commonly used compound in food production. When it hydrolyzes, it produces a gluconic acid very similar to lactic acid and lowers the pH, which releases calcium from the casein micelles in the milk, Henning explained. Casein micelles are aggregates of casein molecules and colloidal calcium phosphate that contain most of the calcium in milk.

"In the production of M.O.O.M., acid is already added, so some of that calcium has already been released. We thought the casein micelles might have been disrupted and that the retentate wouldn't act like regular skim milk."

However, all six products solidified into a gel. For the skim milk and skim milk dilution, liquid separated from the solid gel, but this was not the case for the retentate, which produced a firm, stable gel. The addition of transglutaminase did not appear to change gel consistency in any of the cases.

"Our results are very encouraging," Henning said. "Eventually we're hoping to create a healthy, snack-type product from the retentate. This product would be similar to yogurt but sweeter and less acidic. It would be somewhat like a pudding, but without the starch base. It would just be the milk product itself—and a healthy snack for children."

Bruce G. Schroder, president of Dairilean, Inc., expects to eventually manufacture and sell the product.

Schroder has been doing contract research with the SDSU Dairy Science Department since 1980, and he finds the interaction mutually benefiting. "It gives the students a lot of experience working on new research ideas, it allows me to work with the students and evaluate them, and it helps us move some research forward," he said.

The next step toward developing an edible product will be to add flavors and conduct sensory tests, Henning said.

RECOVERY OF WHEY PROTEIN in cottage cheese production was also studied by Nielsen and Henning. Nielsen received a Joseph E. Nelson Undergraduate Research Mentorship toward that project.

"When you make cottage cheese, you get curds and whey. The curds become the cheese, and the whey is a byproduct. So the more whey proteins you can include in the curd, the more you can increase the yield," Nielsen said.

"The whey proteins are not captured in the cottage cheese curd itself, because they are soluble at the pH of cottage cheese whey," Henning explained. "If we can retain more of the whey protein in the cheese, we can reduce the loss of a valuable nutrient. The product would also be more healthful, because whey proteins provide essential amino acids."

To bind the whey proteins, Nielsen and Henning again used transglutaminase enzyme, which is used with many different food products but not normally with cottage cheese.

"The idea was that transglutaminase could be used to hook up the casein with the whey proteins during manufacturing of cheese, so that when the whey is drained, some of the proteins will stay back with the curd," Henning said.

In three replicate trials, Nielsen and Henning used unfortified skim milk and direct-set cottage cheese to manufacture experimental cheese. Samples of the skim milk, whey, wash waters, and curd were collected and mass balance was measured in each.

All three trials resulted in more protein recovery in the experimental cheese compared with the control cheese, and each experimental vat contained less protein in the whey than the corresponding control.

The results were encouraging, though the magnitude of increase wasn't large, Henning said. "For a manufacturing plant that might make millions of pounds of cottage cheese a year, 2 to 3% can add up to a lot of dollars. However, there's also a cost to the enzyme, and we haven't done the economic calculations to see if the gain is worth the expense. We did the experiment to show whether or not we could easily get an effect using this procedure. And it looks like we can."

"... many of the things she learned here, such as how to approach a problem and how to apply the scientific method, will be useful in her future career."

—Dave Henning
associate professor of dairy science, SDSU

STELLAR RESEARCH RESULTS were not the main goal of Nielsen's projects, Henning points out, but rather that she gain a solid base in research methodology and technology.

"Karissa worked hard and learned a lot. I asked her to design an experiment and do the tests, and she did most of it on her own.

"Karissa received two scholarships because she is a great student. She has 130 credit hours of all A's and she still has time for extracurricular activities," Henning said. "I believe that many of the things she learned here, such as how to approach a problem and how to apply the scientific method, will be useful in her future career."

After graduation, Nielsen starts work as a quality control specialist for Rochester Cheese in Dalbo, Minn. She believes that her research projects at SDSU have prepared her well. "My job will be doing different analytical tests and making recipes, quite similar to what I've done here," she said.

"In our dairy science classes we learned a lot of analytical and technical skills and the research projects have allowed me to apply those skills. These projects have given me opportunity to use my problem solving skills, and I've also done several presentations, which has helped me with my public speaking skills. The SDSU research experience has really benefited me."◆

—Marianne Stein

'Nothing we can grow that will beat SUNFLOWER'

South Dakota is the second largest sunflower-producing state in the U.S. after North Dakota.

Sunflower is well suited for the climate in South Dakota and fits into a typical crop rotation. "It is quite drought tolerant and has a very deep root system. It is a good crop for the central and western part of the state," says South Dakota State University Plant Pathologist Marty Draper.

"In a rotation and as a cash crop, there's nothing we can grow that will beat sunflower," says Tim Pazour, a grower in Pukwana.

Tom Young, a producer from Onida, agrees. "Sunflower has become a major commodity in central South Dakota. In fact, Sully County has the most acres of sunflowers of any county in the nation. A common rotation around here is corn, sunflower, spring wheat, winter wheat."

Kathy Grady, SDSU oilseeds breeder

SEEDS FROM SUNFLOWER OILSEED VARIETIES are small and black, very high in oil concentration, and usually processed into oil and meal or used as bird feed. Most of the sunflower grown in South Dakota is the oil type. Seeds from confection varieties are black-and-white striped and usually roasted and eaten as snacks or used in other food products.

Kathy Grady, SDSU oilseeds breeder, uses traits such as yield, standability, and oil quality to develop new sunflower varieties. Producers grow hybrids, so Grady is breeding the germplasm sources, which are made available to seed companies as "parents" for the hybrids.

Grady also conducts annual yield trials in which she tests the performance of a large number of hybrids. Her results are available to the public in reports published by the South Dakota Cooperative Extension Service.

Much of her breeding research focuses on sunflower oil quality.

"Oil concentration and composition are emerging issues in sunflower breeding, as well as in other oil seed crops used for human consumption," she says.

Most vegetable oils must be hydrogenated for use in industrial food production; otherwise, the oil breaks down and becomes rancid or oxidized. Hydrogenation, however, produces trans fatty acids that are associated with a higher risk of coronary heart disease.

New varieties of sunflower with a higher proportion of oleic, monounsaturated fatty acids and a lower proportion of polyunsaturated fatty acids are being developed. This creates an oil that is healthier for human consumption and stable enough not to require hydrogenation. Sunflower hybrids—called NuSun™ hybrids—with these characteristics are already on the market, and Grady works to incorporate similar traits into her breeding program.

Grady's research also focuses on developing lines with disease or insect resistance, recently starting a project in cooperation with USDA Agricultural Research Service Northern Crop Science Lab in North Dakota to look at plant resistance to the red sunflower seed weevil, a serious pest in South Dakota and North Dakota.

The researchers have already found differences—from 8% to 55%—in infestation patterns of tested germplasm lines. Their next step will be to select the most resistant types and incorporate them into the breeding program.

A PEST THAT "CAN'T BE IGNORED," says Mike Catangui, SDSU Extension entomologist, is the pale-striped flea beetle. It is native to North America but until recently was not a problem in South Dakota because it had always fed mainly on weeds. However, during the past 2 years, it has been found on sunflower and more recently also on alfalfa and soybeans.

An attack from the pale-striped flea beetle can be devastating, Catangui says. "If the beetles attack early, when the seedlings are just sprouting from the ground, they can wipe out everything."

"If there's something out here we don't understand, we usually contact our local county educator or one of the Extension specialists."

—Tom Young
Onida producer

Seed treatment is one control option he finds effective. Seed treatment consists of an insecticide coated onto the seed. As the seed germinates, the chemical is absorbed into the plant and protects it while it is growing. This eliminates the need for scouting the fields and applying more expensive spray treatments later.

"The cost of seed treatment is about $5-6 per acre, and we found that it could increase yield by 120-348 pounds per acre, which is about $11-33 per acre, so it's economically feasible," Catangui says.

"It's an individual decision which type of control to use. If done right, seed treatment and spraying are both effective. Each has its advantages and disadvantages.

"You pay for seed treatment in advance, so if the insect doesn't show up you waste your money. Some farmers will prefer the flexibility to scout for insects and spray only if it is necessary."

Mike Catangui, Extension entomologist. Pale-striped flea beetle (insert) courtesy of Gerald Fauske, NDSU

SCLEROTINIA HEAD ROT is notable among other problems for sunflower. Sclerotinia is particularly damaging, because in addition to being infected through airborne spores, sunflower can pick up Sclerotinia through the roots, explains Draper, who conducts research on this and other diseases.

Sclerotinia occurs infrequently and is unpredictable, Draper says.

"In 1999 we had devastating head rot with 80-90% yield loss in some fields in northern counties. The next year we had none.

"The disease is strongly influenced by environmental conditions, such as moisture at the time of flowering, but it can still be very hard to predict and prevent, and it can't really be treated once it has appeared."

The best way to prevent the disease would be to plant resistant hybrids, but neither seed companies nor scientists have enough data to make firm recommendations yet, Draper says.

For the past few years, Draper has been testing hybrids for resistance and susceptibility to Sclerotinia head rot. He collaborates with a research group at an NDSU research station and the USDA sunflower pathologist in North Dakota. The scientists plant different hybrids and inoculate them with the disease.

"In 2003 our results were encouraging. We have some varieties that we use as our standards for resistance and susceptibility. And this year they did indeed show up on the opposite ends of the spectrum with everything else scattered in between."

But results haven't been reliable over several years, so there's more work to be done.

"Once we have 5 growing seasons of results, we should be able to assign some kind of rating to a hybrid, whether we are going to call it moderately resistant or moderately susceptible or truly resistant or truly susceptible."

Draper also looks at whether it is possible to protect the sunflower crop from Sclerotinia with fungicide treatment. Results so far have been erratic.

"We do have fungicides that we know are effective against this fungus, but on sunflower, so far, they have not produced reliable results. But we're keeping on and, hopefully, we will soon be able to make some recommendations."

Draper also conducts a portion of his research through the Sclerotinia Initiative, which is funded by the USDA-ARS. This national initiative focuses on Sclerotinia in five different commodity groups; pulse crops (chick peas, lentils), dry beans, canola, soybeans, and sunflowers. Draper's work includes chick peas, soybeans, and sunflowers.

WEED CONTROL POSES SPECIAL PROBLEMS in sunflower. Because the plant is itself a broadleaf, there is little opportunity to use post-emergence broadleaf products.

Leon Wrage, Extension weed specialist, tests different herbicide treatments in search of better options. That involves a combination of weed control, crop response, and carryover effect from previously used herbicides.

Kochia, foxtail, and redroot pigweed are major weeds in sunflower fields. "It's not uncommon to see fields that have a 400-500 pound reduction because of foxtail or kochia. In dry years, some fields have to be abandoned," Wrage says.

"In 2003, kochia was estimated to be in over 60% of the fields, foxtail in over half, and pigweed in nearly 40% of the fields."

Producer Young points out that Wrage's research into weed control for no-till producers is critically important.

"Many producers in central South Dakota are on the cutting edge of no-till," he says. "Wrage's research on weed control has been one of the reasons. Without the plots at research farms like Dakota Lakes," managed by Dwayne Beck, "where producers can see weed control in action, I don't think no-till practices would progress as fast as they have."

Wrage's 2003 field research program consisted of 16 different field tests in five locations across the state. Detailed results of these tests, including costs, rates, and application suggestions, are available in publications from the South Dakota Extension Service.

YOUNG BELIEVES that the work done by South Dakota Agricultural Experiment Station scientists and the South Dakota Extension Service is very helpful to growers.

"They are one of the first sources I and other producers turn to. If there's something out here we don't understand, we usually contact our local county educator or one of the Extension specialists. They might not have all the answers immediately, but they come up with some good suggestions.

"They have a good base of knowledge and that's what we need."

SDSU sunflower research is supported by funding from the National Sunflower Association and the South Dakota Oilseed Council.◆

—Marianne Stein

Leon Wrage, Extension weed specialist

Leon Wrage's recommendations for sunflower weed control:

- For no-till, use an early and a late burndown with a glyphosate product.
- If kochia is anticipated, use Spartan preplant, which provides excellent kochia control. It is the only option, because there are no post-emergence options for kochia.
- Foxtail can be controlled postemergence using sethoxydim or clethodim for about $7 to $9 per acre. In conventional till, incorporate trifluralin, ethalfluralin, or pendimethalin for foxtail and other grasses. They cost from $5.5 to $6.5 per acre, and they provide residual effect and control primarily grasses.
- Consider also the new Clearfield Production System for sunflower to control some broadleaf and grassy weeds. The Clearfield system consists of herbicide-tolerant sunflower hybrids that can be used with Beyond herbicide for post-emergence weed control. Hybrids in the Clearfield system are not transgenic; they are developed through traditional breeding methods.

BEAN POD MOTTLE
new, potentially serious disease

Now a virus has cropped up in South Dakota to bedevil soybean growers.

"Five years ago nobody had problems with viruses in soybeans in this state or in much of the Midwest," says Marie Langham, South Dakota State University plant pathologist who specializes in viral diseases. "This is a problem that has shown up over the past few years in the Upper Midwest."

SDSU scientists are trying to quantify how much yield soybean varieties lose when infected by bean pod mottle virus (BPMV).

Some varieties lost more than 50% of their potential yield in 2 years of research supported by the South Dakota Soybean Research and Promotion Council, the North Central Regional Soybean Program, the South Dakota Crop Improvement Association, and the South Dakota Agricultural Experiment Station. Other varieties in the study lost less than 20% of their potential yield.

Langham says the research can help soybean breeders at SDSU and elsewhere begin preparing varieties that are more resistant or tolerant to bean pod mottle before the disease has a chance to become really widespread.

South Dakota is fortunate in that bean pod mottle virus is the only viral disease of soybeans recorded so far in the state. Iowa, in contrast, already has four viral diseases in soybeans.

"As long as we have the vector, which is the bean leaf beetle, the problem is not going to go away," Langham says. "The long-term solution is to have resistant plants. Nobody knows how much resistance or tolerance there is for this virus in soybean. Our goal is to have an evaluation program and to do screening for the effects of the virus."

RESISTANCE TO BPMV has been a bigger issue for soybean breeders in the southern U.S. where the disease has been a problem for many years, says Roy Scott, SDSU soybean breeder.

"I don't think there's a lot of resistance in northern soybeans," Scott says. "Nobody's been working with it up here because it hasn't been a problem until recently."

Langham's research can be very valuable to northern breeders by helping develop the techniques for identifying resistance, Scott says.

Bean leaf beetle

"As long as we have the vector, which is the bean leaf beetle, the problem is not going to go away."

—Marie Langham
plant pathologist, SDSU

Some southern cultivars may have greater resistance to the disease, but Langham says such plant material is so different in maturity and other characteristics that it may be difficult to incorporate into northern soybean varieties.

Graduate research assistant Connie Cihlar works with Langham on this project. She's gathered two years of field data from test plots at the SDSU research farms at Brookings and Beresford. Now she's continuing her analysis in the laboratory to determine disease incidence by ELISA (Enzyme-Linked Immunosorbent Assay) testing. She's also trying to determine how the virus affects oil and protein concentration, and how much "mottling" or discoloration of seeds occurs.

"We're developing a scale for mottling based on a set of standards we've set up," Cihlar explained.

The virus causes discoloration or mottling of seeds by allowing what is called "bleeding of the hilum." The hilum is the place where the seed is attached to the soybean pod. The virus allows some color to be expressed in the seed coat, Langham explained.

Although so far the discoloration has not been an issue with commodity growers, Langham says she knows of one South Dakota grower who has lost sales to the organic soybean market because of mottling.

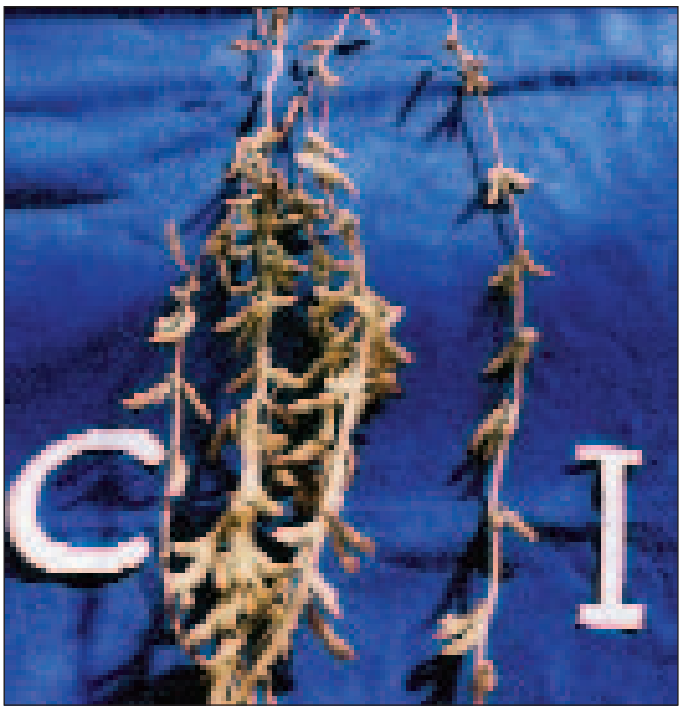
Cihlar adds that her study shows there are far fewer nodes and pods in soybeans severely infected with the virus. Fewer nodes mean there will be fewer branches on the soybean plant and, consequently, fewer pods and seeds. Plants in Langham and Cihlar's test plots that are heavily infected with the virus are shorter than healthy soybeans, and the canopy is less developed.

The disease is still relatively new to South Dakota. Langham says that's why the appearance of the leaves is sometimes mistakenly attributed to other causes such as herbicide damage.

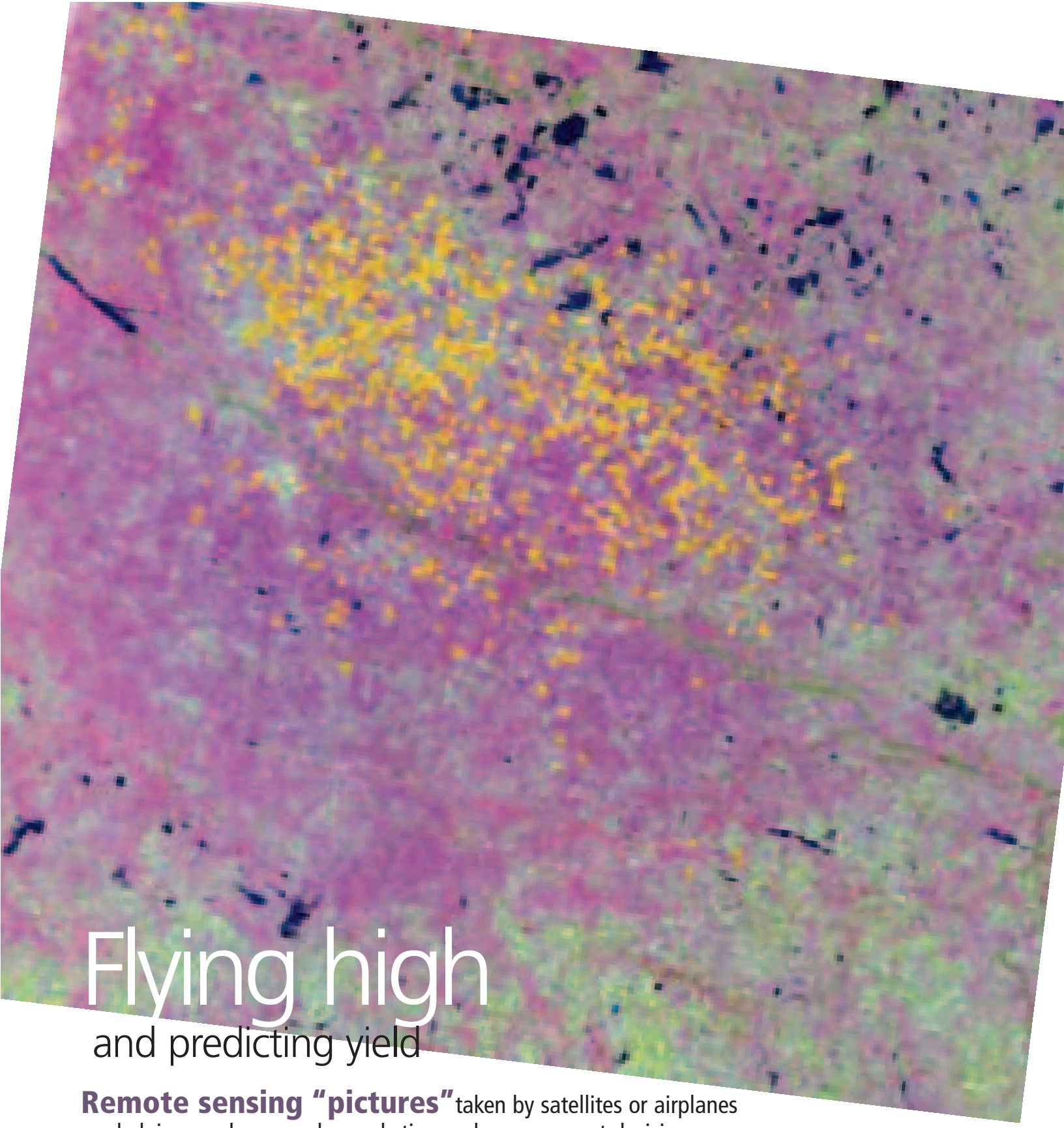
Scott, who chaired a study group about the virus at a soybean breeders meeting in St. Louis in February 2004, says breeders at six other universities are searching for resistance or tolerance to the virus—not only in soybeans but in wild plant species.

University of Wisconsin and Iowa State University breeders have not found complete resistance after evaluating 350 accessions in greenhouse trials. University of Nebraska researchers also found no resistance, but did find good levels of tolerance in some lines based on a lack of symptoms. "Tolerance," to plant breeders, means the ability of a plant to produce yields despite pressure from the disease.

At the University of Illinois, researchers are trying to identify resistance to the virus in *Glycine tomentella* and transfer the resistance to soybean. *G. tomentella* is a wild relative of the soybean.◆ —*Lance Nixon*



Soybean response to bean pod mottle: uninfected pods on left (C), virus-infected stem on right (I)



Flying high
and predicting yield

Remote sensing "pictures" taken by satellites or airplanes are helping producers make marketing and management decisions on the ground.

Remote sensing is measuring an object by a recording device not in contact with the object. In the context of precision farming, remote sensing often refers to measuring radiation reflected from crops or soil. This is what scientists mean when they speak of measuring "reflectance" of a given crop or field.

"Reflectance is a property of the material. Generally, any light that hits an object can either reflect back from the object,

"We have been able to explain 89% of the yield variability observed in 18 production fields between 2000 and 2003 using a simple equation based on crop reflectance and rainfall information."

—Dave Clay
plant scientist, SDSU

go through it, or be absorbed by it," explains Dan Humburg, South Dakota State University associate professor of agricultural and biosystems engineering. "The light collected by a satellite or a camera or an airborne platform is the portion that's reflected back."

Reflectance measurements change as a crop matures, because less bare soil is visible as the crop matures and because crop growth stages reflect light differently, Humburg adds. That means reflectance readings can help determine what is happening to the crop in a given area at a given time.

Ongoing SDSU precision-farming studies look at ways to use remote sensing to forecast corn yields, predict yield-limiting factors in wheat, and time the harvesting of sugarbeets.

YIELDS FROM ENTIRE CORNFIELDS may someday be estimated from satellite images. Dave Clay, SDSU plant scientist, is principal investigator on projects supported in part by the South Dakota Corn Utilization Council, National Aeronautics and Space Administration, USDA, U.S. Geological Survey through a project called SDView, and South Dakota Soybean Research and Promotion Council.

A goal of these projects is to develop remote sensing tools for identifying nitrogen and water stress in corn and soybean fields, Clay says. "We have been able to explain 89% of corn yield variability observed in 18 production fields between 2000 and 2003 using a simple equation based on crop reflectance and rainfall information," he says.

Clay stresses that in developing yield prediction equations, remote sensing images are only one information source. "We're not limiting ourselves to reflectance data. We're using available weather data as well. The weather data provide information about available water and energy.

"But the weather data doesn't take into account the type of tillage, rotation, or management the producer is using; the current status of the crop; when it was planted; or if it got hit by hail. That's what remote sensing adds to the equation."

Working with both sets of data can give producers a "pretty good estimate" of yields 2 or 3 months before harvest, he says. "If they have good yield estimates ahead of time, they can make better marketing decisions.

"In the future we plan to make tools such as this available on the Internet. We are also developing a remote-sensing library, SDView, where remote-sensing images are stored for future use. This library will be a Web-based system where users can download information for their own personal use," Clay says.

ANOTHER PRECISION-FARMING PROJECT identifies yield-limiting factors in wheat fields. Cheryl Reese, graduate research associate, works with Clay and Dwayne Beck, Dakota Lakes Research Farm manager, on the study funded by the South Dakota Wheat Commission.

Applying all the nitrogen to the wheat crop at planting results in lush vegetative growth with many tillers.

Given adequate fertilizer and water, most of the heads produced on these tillers can potentially fill with grain. The problem is that, in dry country such as western South Dakota, the wheat plant often runs out of water as the season progresses and can't produce enough carbohydrates to fill all heads.

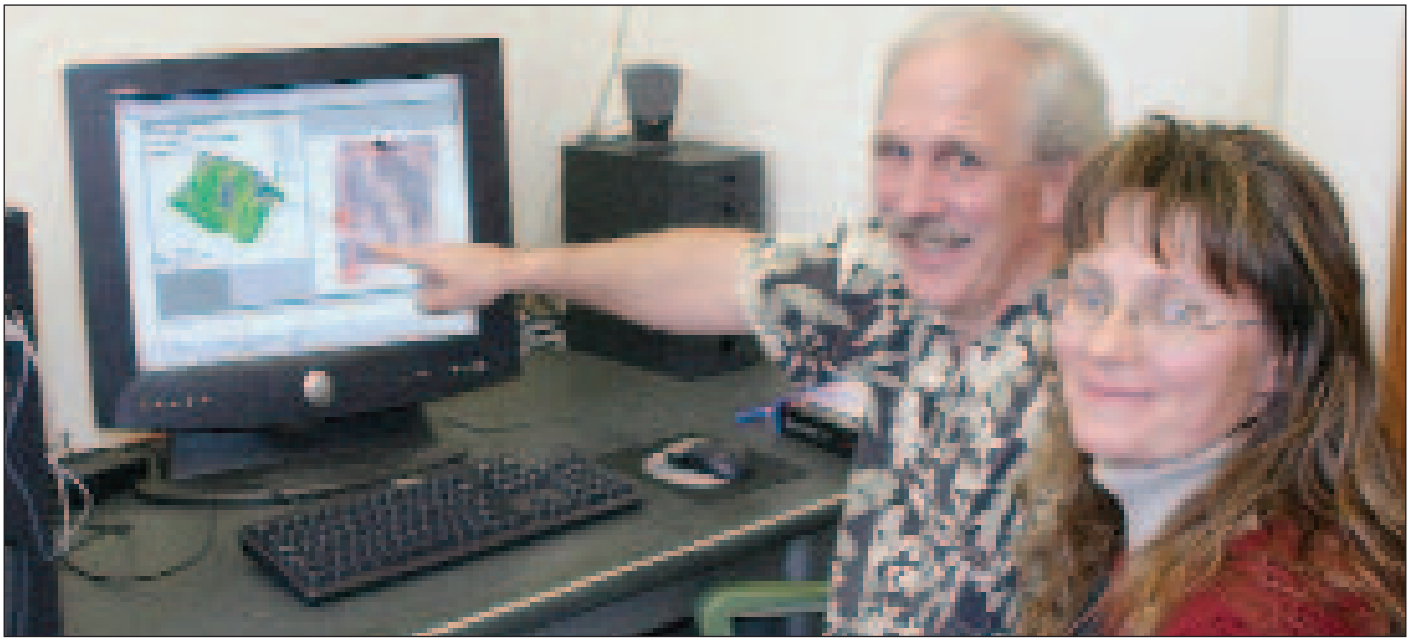
In addition, the thicker canopy may allow plant diseases a better chance to become established.

"From our study, we've seen that if a delayed application of nitrogen is put on at the five- to six-leaf stage under adequate moisture conditions, the wheat plant will produce only two or three tillers," Reese says. "Also, we observed that delaying the nitrogen application until the five- to six-leaf stage results in less vegetative growth and less lodging."

Reese notes that the delayed application method can save on fertilizer costs in dry years. If it's clear the crop isn't going to mature, the grower can decide not to apply nitrogen.

Reese conducted the experiment under irrigation at Dakota Lakes Research Farm and will repeat it under dryland and irrigation conditions.

Remote sensing is being used to predict grain quality and yield in wheat. From imagery collected by cameras mounted on airplanes and by hand-held radiometers, the researchers are analyzing whether the combination of remote sensing and



Dave Clay, SDSU plant scientist, and Cheryl Reese, graduate research associate

weather data can be used to predict grain quality and/or identify yield-limiting conditions in spring wheat.

DOES WHEAT QUALITY VARY when nitrogen is selectively applied at different points in the growing season? The South Dakota Wheat Commission is doing additional tests on the wheat from this study to find that answer.

"We hope we can show that the quality maintains itself within that management system," says Randy Englund, executive director of the South Dakota Wheat Commission. "Maybe some aspects of this kind of management would even increase quality."

Englund adds that it's too soon to draw conclusions because the study has only one year of data about quality so far. More will be coming.

SUGARBEETS MAY NOT BE A MAJOR South Dakota crop, but Humburg has targeted them for a closer look.

He uses data about sugarbeet quality that is gathered routinely by the Southern Minnesota Beet Sugar Cooperative of Renville, Minn. This becomes one source of information to help target the time when fields are ripe for harvest. He's also using remote-sensing images shot from satellites.

The idea, Humburg explains, is to cross-reference the data about beet quality in specific fields—data gathered routinely from samples taken as farmers bring sugarbeets in to stations where the beets are piled until processing—with the remote-sensing data. His aim is a model for monitoring sugar content in fields before the beets are dug.

He's able to pinpoint where specific fields are on satellite images with the help of global-positioning coordinates from each field as recorded by the cooperative.

SUGAR CONCENTRATION IS DRIVEN by a change that takes place in the plant when it runs out of nitrogen, Humburg says.

"Knowing when that occurs would help the sugarbeet cooperatives do a better job," Humburg explains.

"Could we predict sugar concentration of the root by looking at the canopy with some form of remote sensing, whether it's airborne images or satellite imaging? It seems we can.

"At least under controlled circumstances, we've been able to demonstrate that there is a change in the beet canopy color in the latter part of the growing season that can be associated with sugar concentration at harvest."

The problem for the cooperative is that not all fields reach high sugar concentration at the same time.

"Some of the fields have adequate sugar levels, some have very low sugar levels. So, when the cooperative wants to start processing, some fields are ready and their beets are profitable for turning into sugar, and some are a losing proposition. But it's not practical to sample every field to find out which fields have high sugar and which fields have low sugar.

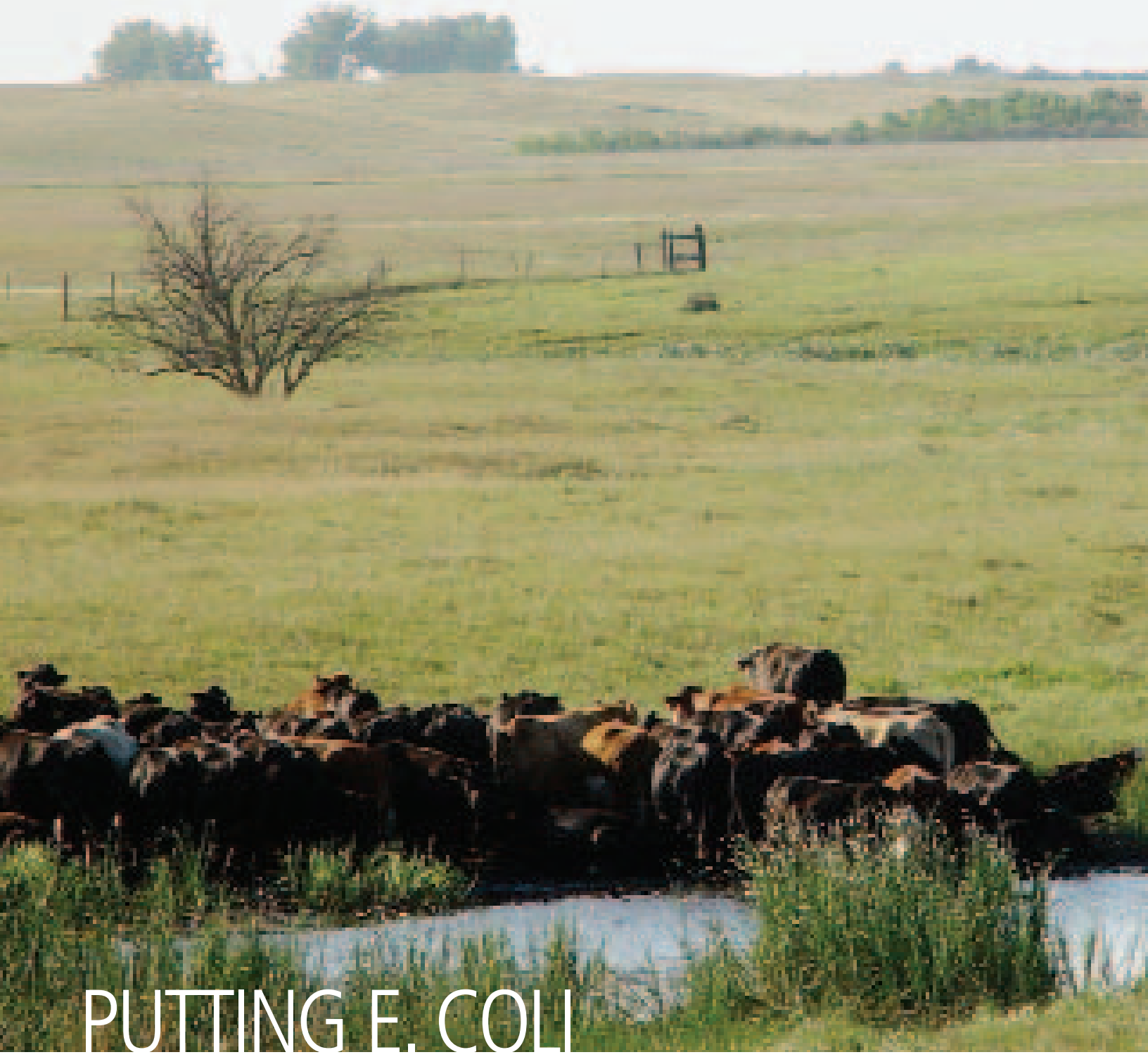
"If you had a method that could rank the fields in the cooperative's growing area and tell them which are probably the highest-sugar-content fields, they could probably do a planned harvest of fields that were good quality while they allowed other fields to mature."

Ideally, Humburg says, a sugarbeet will exhaust its supply of nitrogen at some point in early August. That causes the plant to make a physiological change and stop or slow its production of new leaf growth so that it can redirect energy to produce sugar.

The resulting nitrogen stress causes a yellowing of the sugarbeet leaf that is visible to humans. Humburg adds there is also a change that takes place in the Near Infrared Reflectance of the leaf that can be detected on remote-sensing images.

"The potential is there to develop a model from their own data that would allow the cooperative to apply that model to the new satellite data before the next year's harvest."◆

—Lance Nixon



PUTTING E. COLI to good use

Fecal matter from animals and humans can—and does—end up in lakes, streams, and even the groundwater, carrying with it many disease-causing agents. It is easy to identify the presence of fecal contamination but much more difficult to determine where it originated.

Knowing the origin would greatly improve chances of successful water quality management. "If you can identify the source of pollution, you can target specific management practices to reduce bacterial contamination in the water," says Nels H. Troelstrup, Jr., associate professor of biology/microbiology at South Dakota State University.

A research project to identify sources of fecal contamination in water bodies was conducted by Erick Jorgenson, graduate student in biology at SDSU, Troelstrup, and Bruce Bleakley, professor of biology/microbiology.

The research was based on a technique called Antibiotic Resistance Analysis (ARA), developed primarily at the

"...benign *E. coli* strains have their uses: They can signal the presence of disease-causing organisms."

—Bruce Bleakley
professor of biology/microbiology. SDSU

University of South Florida. With this technique, scientists isolate *E. coli* bacteria from animal and human feces and look for patterns of resistance to antibiotics for each *E. coli* strain.

E. coli found in water samples can then be compared to this database of resistance patterns and the possible source of contamination identified.

"The *E. coli* that you'd find in the gut of a cow would be different from the type you'd find in the gut of a horse or a person. In order to find out where the bacteria came from, you need to know what strains of *E. coli* from different species look like," Troelstrup explains.

***E. COLI* BACTERIA ARE ALWAYS PRESENT** in the intestines of warmblooded animals; thus they function as indicators of fecal contamination.

"Where there is *E. coli*, there is feces," says Bleakley. "*E. coli* is not naturally a water or soil organism; it originates in the gut of a warmblooded mammal or a bird. It is a fecal pollution indicator."

E. coli bacteria are usually not harmful—though a few strains such as *E. coli* 0157:H7 can be deadly. These benign *E. coli* strains have their uses: They can signal the presence of disease-causing organisms.

"There are a lot of pathogens transmitted by the fecal-oral route, including those causing polio, cholera, typhoid, and salmonellosis. When *E. coli* is in the water, these pathogens may be there also," Bleakley says.

In addition, *E. coli* is easy to work with in the laboratory. It is easy to grow, and a lot is known about it, so it is a natural choice as an indicator organism.

The rationale behind ARA is the following: When humans and animals are exposed to antibiotics, bacteria in their guts develop resistance to those antibiotics.

Since different species are exposed to different types and amounts of antibiotics in their foods and from medication, their gut bacteria will show different levels of antibiotic resistance. Studying the antibiotic resistance patterns of *E. coli* isolates can help the scientists identify the host in which the bacteria developed.

"Each species has what we call an antibiotic resistance profile. It's like a fingerprint of antibiotic resistance," Troelstrup says.

EVEN WITHIN SPECIES, there are regional differences, because animals are exposed to different conditions depending on where they live. Jorgensen says, "we can't just develop one national database and use that everywhere. It has to be done locally.

"Our study is the first to look at an entire state. Most other projects have just covered watersheds. We are examining ecoregions—geographical areas that have their own distinctive climate, vegetation, animals, soil, water, and land use. This is the first study of its kind that looks at ecoregions within a state and compares differences between close regions."

Jorgenson, Troelstrup, and Bleakley are developing a database of antibiotic resistance profiles for source animals within each ecoregion in South Dakota. Such a database can be used by the South Dakota Department of Environment and Natural Resources (DENR) to monitor water quality and specifically target contamination sources.

The DENR funded the project and has been instrumental in deciding which animals and ecoregions to study.

"They wanted us to look at the major farm animals—beef and dairy cattle, horses, sheep, turkeys, and chickens," says Jorgenson.

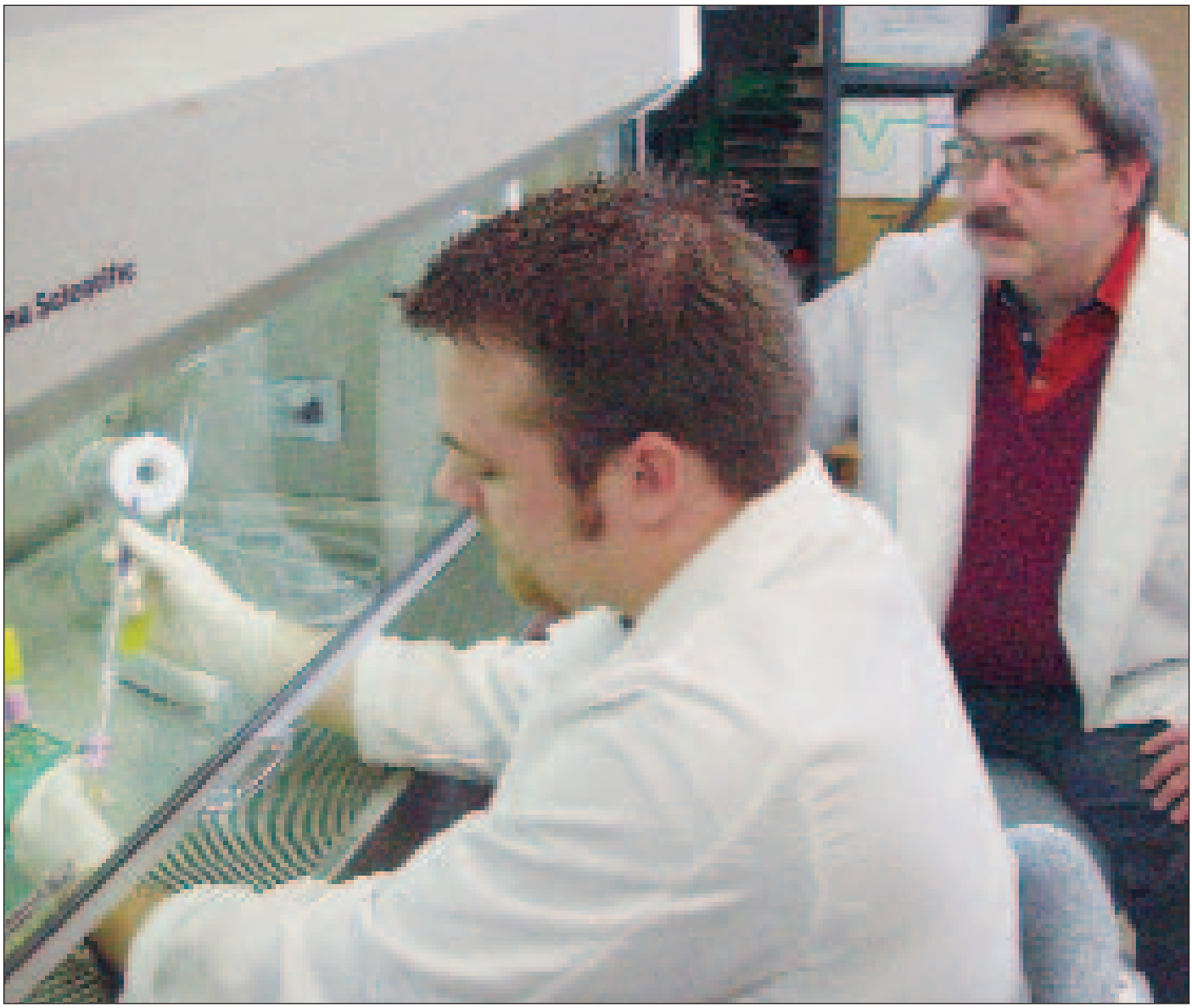
"We also decided to include cats and dogs, as well as human samples from wastewater facilities. We looked at four different ecoregions, two in the eastern and two in the western parts of the state."

The scientists collected 100 isolates per animal per ecoregion, resulting in a database of more than 3,000 samples.

IT WAS JORGENSON'S JOB to collect fecal samples. He went to country fairs to get a concentration of animals, so he wouldn't have to visit hundreds of different farms, and he went to animal shelters for samples from dogs and cats.

Back in the lab, the *E. coli* had to be isolated from the sample. "We'd streak it onto ChromAgar. That's a light yellow agar growth medium, and *E. coli* colonies turn blue on it, while other things turn red or white, so it's really nice to work with.

"Once we had a blue colony, we inoculated it with EC-MUG broth and viewed it under a UV light. If it fluoresced, we knew it was positive for *E. coli*. Of course we ran a control and a negative control also."



Erick Jorgenson, graduate student, and Bruce Bleakley, SDSU professor of biology/microbiology

When the *E. coli* was isolated, the samples were sent to University of South Florida for antibiotic-resistance testing. "Their lab specializes in this technique, so it was meaningful and affordable to send it out for analysis," says Bleakley. "They tested each bacterial isolate for resistance to about 15 different common antibiotics and set up a profile. The data were sent back to SDSU for statistical analysis."

When the DENR received additional funding from the U.S. Environmental Protection Agency, the decision was made to expand the project to two other methods of *E. coli* tracking: pulsed-field gel electrophoresis (PFGE) and ribotyping. The PFGE was done by the South Dakota Department of Health in Pierre, and ribotyping was done at the University of Washington in Seattle.

This meant that each bacterial sample was grown in triplicate and sent to three different labs, enabling the scientists to compare the results from different methods. A fourth copy of each sample was kept in the SDSU laboratory.

WHEN THE PROJECT IS COMPLETED in Summer 2004, the scientists will be able to provide the DENR with a comprehensive database of antibiotic resistance profiles from eight different kinds of animals plus humans.

The DENR will then be able to take water samples, isolate *E. coli* bacteria, match them against the database to determine the source of the contamination, and consequently target management practices specifically to the particular problem, whether it be a wastewater facility or a farm operation.

"Let's say we look at a watershed with a stream flowing through it, and we identify that there is degradation caused by fecal coliform bacteria originating from two or three main sources," Troelstrup explains.

"Based on those results, the DENR can suggest best management practices that landowners can implement on their property to reduce fecal coliform bacteria in the stream channel."◆ *—Marianne Stein*

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