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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 · ...cultural Experiment Station

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Marie-Laure Sauer, doctoral student in plant science, is working in the lab of Roy Scott, SDSU soybean breeder. Sauer is searching for soybean varieties containing oils low in saturated fat and trans fat. Once these lines are identified, they will be incorporated into Scott's breeding program to develop low-linolenic varieties adapted specifically to the South Dakota environment.

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Director's comments

BY KEVIN KEPHART
Director, South Dakota Agricultural Experiment Station

Kevin Kephart

We connect to the land and care for it

In South Dakota, we take pride in how we're connected to the land. We have abundant natural resources, we enjoy a high-quality environment, and we're rich in wildlife. It seems especially fitting to me that this issue of *Farm & Home Research* presents several articles on the broad spectrum of issues that reflect what South Dakotans care about.

We look at research into fully domesticated species such as beef, corn, and soybeans. We delve into studies that help manage wild species such as Canada geese and prairie dogs. And we discuss research projects that deal with bison, a species somewhere in the middle—not fully domesticated but being raised for meat now on the Northern Plains where it once roamed free.

With domesticated species, new uses for plants and animals or new methods of raising them generate new needs for research. Scientists at the South Dakota Agricultural Experiment Station are investigating the health properties of soybean oil, for example. They're also looking at ways to raise corn in greenhouses using aeroponic technology. That means that instead of growing in soil, roots are exposed so that a system can spray them with nutrients at regular intervals. Eventually, corn in such isolated settings can be used to grow the next generation of medicines, antibodies, and industrial enzymes.

Scientists here at SDSU are also helping refine the diets of beef cattle in feedlot settings, with the hope of reducing the potential environmental impacts of livestock production. And SDSU research is helping state agencies regulate how producers manage the manure that comes from animal feeding operations, large and small, in a way that reduces risk to the environment.

Research on wild species is more difficult because we have less control over the setting and the subjects. There have been studies before that say how much forage prairie dogs consume, for example. But SDSU research is looking at the bigger picture by also assessing how much prairie dogs clip around their burrows to keep their fields of vision clear. The information we glean from such studies can affect ranchers' decisions on stocking rate, and could help refine management policies concerning prairie dogs.

South Dakota manages a population of giant Canada geese for the benefit of hunters and others who love wildlife. It's a remarkable success story, since South Dakota went from having virtually no giant Canada geese some decades ago to having about 109,000 birds now in the spring breeding population.

SDSU's wildlife research makes a difference. It lets us know where the geese are in the state, and when they come and go. All that can make it easier for wildlife managers to better manage that population. Incidentally, that's research that benefits agricultural producers as well as hunters and wildlife enthusiasts. Inevitably, wildlife do consume some of what producers grow. But a well-managed wildlife population—when wildlife managers have accurate information that allows them to set hunting seasons and limits appropriately, for example—will hopefully result in less damage in farmers' fields.

Finally, this issue looks at some of the bison research being done by young Native American researchers, many of them working toward advanced degrees in the sciences through the SDSU Prairie Ph.D. program. Their projects consider not only the bison, but also how bison affect and interact with water, soil, grass, and wildlife. They're also exploring the role bison meat can have in human nutrition when traditional Native American foods are included in the diet.

We have tremendous wealth in our agricultural enterprises, natural resources, and wildlife base. We'll need this full spectrum to be successful in the future, and we'll continue to need science to help us manage this bounty of the Northern Plains. u

LAGOON AND FIELD:
manure regulations designed for safety

Allen Jones,
SDSU civil engineer

As South Dakota wrestles with issues associated with its expanding livestock industries, South Dakota State University scientists are doing their part to see that manure lagoons are designed properly and operated safely.

Jim Gerwing, Extension soils specialist, and Ron Gelderman, plant science professor, shared a major award in 2004 with Jeff Hemenway, conservation agronomist for the South Dakota Natural Resources Conservation Service, for helping develop such producer guidelines.

The three won the Environmental Protection Agency's Environmental Achievement Award for putting together a nutrient management standard for nitrogen and phosphorus in manure.

Meanwhile, Allen Jones, assistant professor of civil engineering at SDSU, is preparing a publication that summarizes factors to consider when designing and building a lagoon.

Jones worked for 15 years as a consulting engineer in earth and environmental technologies and occasionally serves as an expert witness in court cases where environmental engineering expertise is required.

THE SOIL SCIENTIST AND THE ENGINEER, Gerwing and Jones, take similar stances on the safety of nutrient regulations and the safety of lagoon systems: The standards are safe, if followed.

"If lagoons are constructed and maintained properly, they address a lot of the issues that people are talking about out there. Notice the word 'properly' in there," Jones says.

"If lagoons are constructed and maintained properly, they address a lot of the issues that people are talking about out there."

—Allen Jones,
SDSU civil engineer

Jones says there are very specific design methodologies that engineers use to select a good site for a lagoon. Then the lagoon is built to contain the manure for a set period of days plus any runoff from a major rainfall event.

Many states including South Dakota require compacted soil (clay) liners be installed in the bottom and sides of lagoons during construction, while some states require liners made of synthetic materials. South Dakota mandates that the clay liners be 18 inches thick.

Jones adds that, from an engineering point of view, additional factors—site soil conditions, type of animal waste, waste depth, and construction techniques, to name a few—may dictate an even thicker liner.

Some states also require monitoring wells near the lagoon to be sure that nutrients from the facility are not seeping into groundwater. In South Dakota, monitoring wells are required when lagoons are located above shallow aquifers.

Jones adds that engineers also take into consideration what kind of manure is going to be kept in the lagoon.

"There's a design procedure that you go through based on the liquid that you're putting in for containment. You want what's called a target permeability in the liner. Nutrient-enriched manure, liquid manure, flows quite a bit differently than water does. So what people have done lately is look at what these nitrogen and phosphorus compounds do to the liner and how that might either impede or actually amplify flow through the liner."

Clay liners are made by putting the clay down layer after layer and packing it after each new layer so that the air spaces and pores between soil particles are nearly eliminated, giving the water no place to go.

"There is no such thing as an impermeable material—even clay soils have permeability. The reality is, however, that the permeabilities are so low that it takes a long time for water or some other liquid material to flow through a 2-foot-thick clay liner."

Many factors control the rate at which leakage occurs, and those factors need to be considered in the design, construction, and maintenance, Jones says.

MAINTENANCE AND EMPTYING OF LAGOONS present other challenges. There is always the possibility that an operator or contractor hired to empty or clean out lagoon solids may damage the lagoon liner. Mixing methods prior to pumping as well as mechanical cleaning of the lagoon with a dredge or a backhoe might accidentally gouge some of the clay liner.

"If, every time you go in there to take the solids out of the lagoon, you take out a couple inches of the liner this year, a couple inches next year—after 5 or 10 years your liner could be gone," Jones says.

"You're really banking on proper maintenance so don't compromise the integrity of your liner. As soon as you compromise the integrity of your liner, all design bets are off."

Because the level of the liquid in lagoons fluctuates, the sides of the lagoon may experience some cracking over time from being wet and then dry, and from alternately freezing and thawing.

In theory, farmers could completely drain their lagoon every few years and take a core sample of the liner to make sure they still have the required design thickness. But in practice that's very difficult to do, since a livestock operation is always producing waste that needs to be stored somewhere.

GETTING THE MANURE FROM A LAGOON to the field is different than in the old days, when the manure that a farmer scraped out of a barn each day had roughly the same concentration of nutrients, Gerwing says.

Lagoons are typically mixed or stirred before being emptied, but even then the manure will often vary in concentration of nutrients according to whether it's the first third, the middle third, or the final third of the lagoon that the farmer is emptying. A good producer will have to make several recalculations during the process of emptying a lagoon to make sure he's not putting on too much or too little for crop needs, Gerwing says.

South Dakota's geography and climate build in advantages for producers that make it easier to manage nitrogen in manure.

"I think the regulations for nitrogen—if they're strictly followed—are really adequate," Gerwing said. "States in the west, like South Dakota, actually have an easier time coming up with

"I think the regulations for nitrogen—if they're strictly followed—are really adequate."

—Jim Gerwing,
SDSU soil scientist

a good set of nitrogen regulations that will minimize nitrate pollution of the aquifers. The reason is that we are drier, and we have the nitrate soil test that predicts very closely how much fertilizer N or additional N is needed for crop growth."

Soil nitrate tests aren't as valid farther east because rainfall is more abundant and quickly leaches the nitrate downward through soil and potentially into groundwater.

SOUTH DAKOTA NITROGEN regulations are straightforward.

"The rules simply say you have to sample for nitrate nitrogen, and use the fertilizer recommendations from South Dakota State University.

"You also have to sample the manure so you know how much nitrogen is in the manure and then adjust the manure rate so that, at the end of the season, there will be very little left over, just like we would suggest for fertilizer N," says Gerwing.

Commercial haulers in South Dakota have noted that before regulations some large-scale farmers were applying 10,000 gallons of hog manure an acre per year—enough to provide 500 pounds or more of nitrogen per acre.

A crop of corn needs only 100 to 140 pounds of nitrogen an acre.

"Clearly in some cases, more nitrogen was being applied than needed," says Gerwing.

Even after nitrogen regulations arrived, there were no requirements about monitoring phosphorus, as there are now when concentrated animal feeding operations apply manure to cropland. Phosphorus does not directly threaten human health as nitrogen in groundwater can. But phosphorus can cause algae blooms if it gets into waterways, depleting oxygen reserves and causing die-offs of aquatic life.

"In most manures there are two to three times, up to as much as 10 times, more phosphorus than nitrogen relative to what crops need for any given year," Gerwing says.

"If you put enough manure out there, carefully using the right rate to meet the nitrogen needs of the crop, you'll put out, as a general rule, at least two, if not three or four or more times, the amount of phosphorus that crops need. Therefore, even when you're following the regulations for nitrogen, soil test levels for phosphorus will continue to increase. If no rules or regulations were made for phosphorus, phosphorus soil test levels would go sky high."

The added phosphorus rules allow producers to follow nitrogen rate recommendations to a certain point. Then producers have to monitor manure applications so they don't raise the phosphorus levels any higher.

But Gerwing says that for South Dakota soils, that threshold—usually 50 parts per million of phosphorus—will take years to reach for most careful operators who follow regulations.

"Really, in South Dakota, two-thirds of our soils actually are low or medium in phosphorus soil test levels, so we could have a lot of land that could use a lot of manure. If you're starting on new land that hasn't had manure in the past, depending upon how much nitrogen is applied, it could take 20 or more years before you get to the level where you'd have to start restricting phosphorus applications."

Gerwing adds that manure from different kinds of concentrated animal feeding operations also varies in concentration of phosphorus.

Manure from dairies and the hog operations supplies two or three times more phosphorus than needed. Manure from large commercial feedlots can supply up to eight or 10 times more phosphorus than is needed.

"That's simply because a lot of the nitrogen is lost to the atmosphere in the lot, concentrating the phosphorus in the manure. So those operations will run up against that phosphorus limit earlier," Gerwing said.

Ongoing work at SDSU and other land-grant institutions continues to help producers better manage the nutrients in livestock manure.u —*Lance Nixon*

FEEDLOT NITROGEN:
feeding too much crude protein?

Robbi Pritchard, SDSU beef nutritionist

South Dakota State University research may help feedlot operators fine-tune beef cattle diets to put less nitrogen into animal waste.

Robbi Pritchard, beef nutritionist, explains that one issue driving the research is the fact that area producers increasingly want to feed distillers grains, co-product of the many ethanol plants in South Dakota and neighboring states. Inclusion of distillers grains can result in very high crude protein diets.

The problem, Pritchard says, is that the accepted nutritional requirement equations say distillers grains, which are high in crude protein, don't have enough of what ruminant nutritionists call DIP crude protein fraction available to feed the microbes in the rumen that help the animal to ferment the feed it eats. DIP stands for degradable intake protein.

"When we feed distillers grains, the equations say that using distillers grain as the sole source of crude protein doesn't provide enough ammonia for the rumen microbes. So we add urea to the diet to feed those microbes, because they ferment the feed and generate the energy," Pritchard says.

The result is diets containing excess crude protein. Inevitably that worsens the feedlot nitrogen balance, Pritchard adds.

"We have several experiments now that say that's a waste because all of the excess nitrogen that comes out of this system ends up either in urine or in the feces, most of it in the urine. A high percentage of urine nitrogen ends up degrading into ammonia and heading for the atmosphere."

"If you want to reduce the amount of nitrogen that cattle excrete, you have to reduce the amount of nitrogen that they're fed."

—Robbi Pritchard,
SDSU beef nutritionist

IN A RECENT EXPERIMENT, Pritchard included distillers grains in all the diets. In one of those diets he added no urea. He added increasing amounts of urea to the other diets as the source of the additional crude protein the equations call for.

"We went from zero, to some, to more urea. But when we looked at performance, there was absolutely no difference in average daily gain, no difference in growth efficiency," Pritchard says.

Pritchard believes distillers grains already have enough crude protein to meet the animal's needs without the additional crude protein the equations call for. But the industry still typically adds crude protein because that is what the National Research Council model suggests is necessary. The NRC's published nutrient requirements for domestic species are the generally accepted reference point from which animal-feeding industries work.

"I fit in the camp with a small handful of people who think we just feed too much crude protein, and we put too much confidence in the NRC predictions," Pritchard says. "The problem is that there isn't a big enough body of data to convince the commercial feeder."

Feedlot waste: preventing nitrogen escape

How much nitrogen from feedlot cattle consuming distillers grains diets stays in the form of organic nitrogen that can be applied to fields instead of escaping into the air as ammonia gas?

It's an important question, says Kent Tjardes, South Dakota State University Extension beef feedlot specialist. His work to find the answer is funded by the South Dakota Corn Utilization Council.

Tjardes says distillers grains, the co-product of ethanol production, is becoming increasingly popular as a feed source, especially in seasons or situations where it might be a more economical energy source than corn. Distillers grains has much higher crude protein concentrations than corn, so it takes less distillers grains to meet the crude protein (nitrogen) requirement of beef cattle, he says.

All the excess nitrogen that the cattle cannot use passes through the animals into the waste stream.

Tjardes says if nitrogen that escapes from feedlots is in the form of ammonia gas, it can be a problem for two reasons—it causes odor, and it eventually comes back down to earth again in rainfall, ending up as unwanted nutrients in streams and waterways.

"We know that the nitrogen excretion is going to be higher when feeding higher levels of distillers grains," Tjardes says. "But if it stays in the manure, it's more beneficial because you can control where it's going. If it stays in the manure, you can apply it to the fields."

Tjardes' experiment uses a control diet in which cattle are fed no distillers grains or varying levels of dried distillers grains with solubles: 15, 25, and 35% DDGS.

The cattle are fed in earthen pens, 12 animals per pen and 16 pens in all, resulting in four pens per treatment. The soil was sampled before the experiment and again at the end of the 100-day feeding trial.

Tjardes knows how much nitrogen is in the feed the animals eat and can calculate how much nitrogen the animals use for their weight gain. He can also calculate how much nitrogen is in the manure by measuring the volume and sampling the nitrogen in the manure.

Somewhat more difficult is finding out how much nitrogen is in the runoff from the pens—a calculation he makes by actually sampling runoff and then calculating the volume of runoff from the pens given the rainfall events during the feeding trial.

In addition to the outdoor trial, Tjardes also has cattle on a metabolism study inside a building. Those animals are fed different levels of dried distillers grains with solubles, and the wastes are collected to determine exactly how much nitrogen is in the urine and feces from the different diets. The metabolism study can help Tjardes better understand what's happening in the outdoor pens.

In the end, Tjardes says, the SDSU experiment can help supply livestock producers with best management practices, and perhaps help regulators fine-tune the way they manage feedlots.

The results will be coming later in 2005, Tjardes says.

TO GET AN IDEA of the magnitude of the problem, Pritchard suggests doing the math for a single operation.

"Let's say we feed a steer a diet that's 12% crude protein, and he eats 20 pounds of that diet on a dry basis. He's eating 2.4 pounds of crude protein. That protein is only 16% nitrogen, so the steer ate 0.384 pounds of nitrogen. He's only going to keep 10% of that in his body, which means he's going to excrete 0.35 pounds of nitrogen a day.

"You can see what happens if you have 5,000 head of cattle on feed. That's almost a ton of nitrogen per day."

Nutritionists had hoped that, with their more sophisticated knowledge of how cattle use nitrogen, they could increase the percentage of nitrogen that the animal retains in the body. But that hasn't worked.

"If you want to reduce the amount of nitrogen that cattle excrete, you have to reduce the amount of nitrogen that they're fed," Pritchard says.

Pritchard adds that the research is clear that not having enough crude protein in the diet will hurt animal performance. And he says studies have so far found nothing superior to a blend of urea and soybean meal as a way to deliver that crude protein in corn-based diets—essentially what beef producers in the region have been using for two decades or more.

"Those are the crude protein sources, when used in the right blend, that can allow us to minimize crude protein intake without sacrificing cattle performance," he adds.

Why that blend remains so effective hasn't been clearly defined yet. But Pritchard speculates that as protein from soybean meal is degraded in the rumen, there are peptide fractions that stimulate the bacteria to perform better than they do on just the ammonia that is normally generated.

More experiments in the future with distillers grains and other sources of crude protein will help scientists better understand what happens to nitrogen in feedlot settings, Pritchard says. His current work was funded through the South Dakota Experient Station and the Beef Nutrition Program.u

—Lance Nixon

Nitrogen efficiency: a balance between animal performance and environment

Learning how efficiently feedlot beef cattle use nitrogen can add clarity to discussions of concentrated animal feeding operations, or CAFOs, says Robbi Pritchard, South Dakota State University beef nutritionist.

Although the total amount of nitrogen a CAFO loses to the environment can be considerable, a large feedlot operation may be producing beef efficiently and releasing less nitrogen into the environment per unit of food produced than a less efficient operation of any scale, he says.

"There are dispersion issues that are important, but we need to think about food production as well. We need to ask how much nitrogen is contributed to the environment relative to how much food is produced.

"You can have somebody with 100 head or 5,000 head of cattle doing it very badly. Per pound of beef that gets to the grocery store, either operation is dumping a lot of excess nitrogen into the environment. But only the larger feedlot is regulated."

Pritchard adds that a diet that appears to be efficient from the standpoint of requiring less nitrogen may be inefficient in terms of how much feed animals on that diet require. In one study, Pritchard calculated nitrogen intake per 100 pounds of live weight gain in the cattle for cattle on a 13% crude protein—typical for the feedlot industry today—and on diets as low as 11% crude protein.

Significantly less nitrogen was required per 100 pounds of live weight gain on the low crude protein diet: 9.89 pounds compared to 11.33 pounds.

"We were a lot more nitrogen-efficient, we were getting less nitrogen loss to the environment per unit of beef," Pritchard says.

"But here's the rub: On the low crude protein diet, there was less nitrogen required per unit of beef produced but significantly more feed required per pound of gain. If you lower the crude protein content of the diet so that there isn't as much nitrogen wasted from the system, eventually you'll start to compromise animal performance.

"The optimum, from an environmental and economic standpoint, is going to be where we have nitrogen intake as low as possible before animal performance is affected. What we have to do is find that balance that will work for cattle and for environment."

CONFINED CORN:
first step in pharming

Neil Reese, SDSU biologist, and
Michelle Hays, agronomy major

Tomorrow's transgenic crops will be "biopharmaceuticals," say those who envision plants that produce, among other things, vaccines, medical proteins, antibodies, and industrial enzymes.

Their crop of choice to produce some of these biopharmaceuticals is corn.

Corn is popular with biotechnology companies because the companies have developed the skills to manipulate its genome and because corn can produce large amounts of designer proteins in the kernels. Proponents of the technology say that production of biopharmaceuticals from renewable resources such as corn would be cheaper and the response to public need would be faster than building or enlarging a manufacturing facility.

The USDA has initiated stringent measures to prevent plant-made pharmaceuticals (PMPs) from comingling with crops grown for food, feed, and fiber, says Kevin Kephart, director of the South Dakota Agricultural Experiment Station.

"APHIS [Animal and Plant Health Inspection Service] reviews all plans for seed production, timing of pollination, harvest, shipment, and the storage and use of equipment before permitting a PMP field trial," Kephart says. "And the corn will never outgrow the oversight. If a PMP corn becomes commercially available, it will still be under regulation by the USDA, every step of the way to actual user.

"The operative word is 'isolation,'" Kephart adds, "That is both spatial isolation and temporal separation. Corn would appear to present an isolation problem because its pollen is known to drift beyond the field in which it is planted. However, an updated 2003 guideline stipulates that no conventional corn can be grown within one mile of a field test that involves open-pollinated pharmaceutical corn. If the PMPs are detasseled or the tassels are bagged, the spatial requirement is reduced to a half mile.

"In addition, the PMP corn must be planted either 28 days before or 28 days after planting or harvesting of any other corn

"The whole idea was to grow corn that can be genetically modified to produce high-value pharmaceuticals and other biochemicals."

—Neil Reese,
SDSU biologist

growing within a half mile of the test plot. That further reduces the possibility of pollen drift to non-test fields during the period of fertilization."

In 2002, the last year for which data has been released, APHIS granted 20 permits for 34 field sites for a total of 130 acres. None was in South Dakota. Iowa and Nebraska were the closest states with PMP permits.

PMP corn holds the possibility of a lucrative niche market for a few corn producers in South Dakota. The corn would command a high price for its designer compounds.

Confinement—separation from food and feed corn— could be overcome if the corn were truly confined, in a greenhouse.

NOT JUST ANY GREENHOUSE.

"We were asked by the South Dakota Corn Utilization Council [CUC] if growing corn under controlled indoor conditions, following APHIS regulations and FDA good manufacturing practices, could be done and if we could work out the production kinks," says Neil Reese, South Dakota State University biologist. "We said we'd try, and the CUC funded the project. The corn we used had no inserted genes that could be termed pharmaceutical."

He enlisted Michelle Hays, agronomy major from Volga. All she had to do was figure out how to grow corn under glass—and without soil—in a self-contained greenhouse.

The greenhouse was a BL3, Biosecurity Level 3, on the SDSU campus, with an air lock. "After I entered the first door, I couldn't open the next one for 5 minutes, because in that time the air recirculated and filtered out any pollen that would have escaped from inside the room or entered from the outside," Hayes explains.

"The water was recycled, and at the end of the experiment it was autoclaved before it left the greenhouse. All of the plant material was also autoclaved at the end."

There was no soil to sterilize.

"The plants were suspended in chambers where the entire root system was exposed to air at all times. At timed intervals the roots were sprayed with water that contained a nutrient solution," Hayes explains. "We picked aeroponics instead of hydroponics because there was less water to sterilize at the end of the experiment."

She started the corn from seed, and 82 days later the plants had completed pollination.

"I turned the system off to allow the corn to dry down after 105 days and harvested at 135 days."

The rapid and complete adaptation of the corn to this procedure led to the biggest problem Hayes and Reese faced.

"Give corn everything it wants and it goes to town," Hayes says. "Corn never did too well in hydroponics—when roots are totally submerged in water—but in aeroponics the roots appeared strong, healthy, and much more numerous."

With extra root surface to absorb the nutrients, the corn grew at an average rate of 9 inches per week. By the time the leaves were rubbing the underside of the greenhouse roof, Hayes and Reese had run out of lighting options.

Iron chlorosis was another problem. Hayes solved that by experimenting with various forms of chelated iron and the leaves lost their striped appearance almost overnight. If they continue the project, she says she would like to optimize the air temperatures in the greenhouse.

COMMERCIALLY AVAILABLE AEROPONICS UNITS are designed primarily for the horticultural trade, and the equipment was not well suited for corn.

"The plants pushed the equipment to its limits. I'm sure we could grow them faster, harvest in a shorter period of time, and increase potential for profit if the units were modified," Hays says.

"We had a couple of crop failures because pumps went out or spray controllers didn't function, but when things got ironed out and the first tassels appeared on our first complete crop, we were pretty happy scientists."

Next time, "I'd like to have these units built locally and tailor made for corn and other agronomic species. The framework would need to be sturdier to hold the plants better, and the pumps and nozzles and piping should be available from a local supplier. I always had to order parts from Colorado.

Reese has plans, also.

" This project is finished. We turned the data over to the Experiment Station for inclusion in the July report to the Corn Utilization Council.

"The whole idea was to grow corn that can be genetically modified to produce high-value pharmaceuticals and other biochemicals. If we grew the corn in a greenhouse, one big enough to produce an economical crop—but given the value of biopharmaceutical corn it wouldn't have to be exceptionally big—we could use the excess carbon dioxide plants need that was generated in the next-door ethanol plant."

"The CUC recognized the advantage of utilizing the carbon dioxide and steam given off in ethanol production to increase profitability of the ethanol plants. The biggest cost in running a greenhouse in South Dakota is heating it. An associated greenhouse could convert corn, steam, and carbon dioxide into valuable biopharmaceuticals and be another source of income for farmer cooperatives or corporations running the ethanol plants."

Meanwhile, Hayes says that "both Dr. Reese and I were impressed with many aspects of the aeroponics method for growing plants and we feel that this is the best method for continuing research in this area."u —*Mary Brashier*

SOYBEAN OILS:
'to your health'

Marie-Laure Sauer, doctoral student in plant science

Vegetable oil composition has become a focus of attention in the food industry and among health-conscious consumers after the FDA reported that trans fatty acids, found in most oils used for industrial cooking, are related to coronary heart disease.

At South Dakota State University, Roy Scott, soybean breeder, and Marie-Laure Sauer, doctoral student in plant science, are identifying soybean varieties that yield oils with more healthful properties. Scott and Sauer have developed a technique to select soybean breeding lines by identifying genes that carry the desired traits for oil composition.

"Right now markets are cropping up for value-added traits such as a specific fatty acid composition," Scott says. "There are premiums attached to marketing those varieties, mostly driven by the health concerns that people have about vegetable oils.

"New soybean lines that are low in saturated fat and trans fat will produce oils more competitive against other oils such as canola or sunflower oil."

SOYBEAN AND OTHER VEGETABLE OILS consist of fatty acids – primarily linolenic and linoleic acids, which are both polyunsaturated; oleic acid, which is monounsaturated; and some saturated fatty acids. Typically, although there are exceptions, fats from plants are unsaturated, and fats from animals are saturated.

Unsaturated fats are considered healthier than saturated fats and have been widely used in the food industry for decades. However, a polyunsaturated acid oxidizes quickly and doesn't store well, so to make the oil stable enough for use in commercial food production, it must be partially hydrogenated. That process creates trans fatty acids, or trans fat, which has been linked to high levels of LDL ("bad") cholesterol and increased risk of coronary heart disease. The FDA has established new regulations, taking effect January 1, 2006, that will require manufacturers to list the amount of trans fat separately on food labels.

The most important factor in creating a vegetable oil that does not require hydrogenation is the level of linolenic, polyunsaturated acid. Oil from traditional soybean varieties

"New soybean lines that are low in saturated fat and trans fat will produce oils more competitive against ... canola or sunflower oil."

—Roy Scott,
SDSU soybean breeder

contains linolenic acid levels around 15%. To avoid hydrogenation, linolenic acid in the oil must be reduced to less than 3%. A high level of oleic, monounsaturated acid also helps keep the oil stable.

One way to develop soybean oil with a different oil composition is to identify plants with specific fatty acid compositions and use these plants in a breeding program. Scott and Sauer do this by looking for molecular genetic markers in DNA from soybean plants in order to locate the traits of interest—primarily low linolenic and high oleic acid content.


Roy Scott, SDSU soybean breeder

"Molecular markers enable us to follow the traits in the different steps of the breeding program. With this approach, we can focus on the genes present in the plant without having to extract the oil and look at the fatty acid profile," Sauer explains.

Through such genetic identification, plants with the desired oil composition can be selected for incorporation in Scott's soybean breeding program.

The scientists know the DNA sequence involving the linolenic acid genes. With the laboratory techniques of Polymerase Chain Reaction (PCR) and gel electrophoresis they can search for that sequence. When they find it, they can look for the presence or absence of the marker that identifies the relevant genes.

"We extract the DNA from the plant, look at whether the marker is there or not, and then we can predict which plants are going to be low linolenic and which ones are not," Sauer says.

At least three genes in the soybean plant's DNA are involved in controlling the linolenic acid content, but one of these genes is thought to be the most important. That's the one Sauer and other researchers primarily focus on in their selection.

"The overall goal of this research is to find a way to evaluate the fatty acid profile of large numbers of lines at an economical cost," Scott says. "Marie is developing a method that uses a molecular approach. We can handle more DNA in the lab than actual plant materials out in the field, and there's no need to grind large amounts of material. If we can refine the lab procedure, it will be more cost-effective and probably faster, because we can automate the system more easily."

Sauer and Scott have been able to identify soybean lines with a linolenic acid content between 2 and 4%. They have recently begun incorporating germplasm from varieties developed at Iowa State University with linolenic acid content in the 1% range.

"We're also trying to combine the low linolenic with mid-oleic acid. A higher level of oleic acid is healthier and helps to enhance the stability," Scott says. "We hope to develop mid-oleic soybeans with oleic acid content around 40-50%. We're also trying to reduce the level of saturated fat to below 7%."

ONCE THE LINES WITH THE PREFERRED genetic traits have been identified, the traits need to be incorporated into Scott's soybean breeding program to develop varieties that are optimal for South Dakota producers.

"We need to combine oil composition with other traits," Scott says. "We also want high yield and disease resistance, and we want to keep protein at a reasonable level while modifying the fatty acid content."

Low linolenic soybean varieties have been developed in other parts of the U.S., but varieties must be adapted specifically to South Dakota, because climate also influences oil composition.

"Fatty acid composition does fluctuate with environment. We have to test our varieties in South Dakota to see how much fluctuation there is and use that information to guide how well we can produce oils with those traits that we are developing. We grow the varieties across several different environments in South Dakota and test the fatty acid profiles after harvest.

"As it gets colder and more marginal in South Dakota, it might be difficult to produce soybeans that will maintain the low saturated fat and low linolenic traits. But we believe through genetic work we can develop such varieties."

Scott says it will take up to 5 years before he is ready to release soybeans varieties with improved fatty acid profiles that are adapted to South Dakota.

"We'll use varieties that are already adapted to South Dakota and high yielding in this area. In some cases we're trying to backcross the new traits, so that we keep existing varieties, only with the improved fatty acid profile. In other cases we are developing completely new varieties by crossing existing South Dakota varieties with the low-linolenic varieties," he says.

Scott and Sauer's research is funded by soybean check-off dollars through the Better Bean Initiative, a regional project involving several universities. The project has received additional funding from the South Dakota Soybean Research and Promotion Council, the South Dakota Crop Improvement Association, the Foundation Seed Stock Division, and the SDSU Agricultural Experiment Station.u —*Marianne Stein*

GIANT CANADAS: frequent fliers

Overheard the first day of September.

"Got shells, your license? Let's go get us some geese."

No, these hunters aren't jumping the gun. If they're in the right county in eastern South Dakota, they're participating in an early fall Canada goose hunting season.

Early September Canada goose seasons began in 1996; they target only resident giant Canada geese. In the last 4 years the average annual harvest has been 41,500 Canadas during the early season. That has been good hunting, say some South Dakotans. It draws down the total fall harvest of resident geese, say others. The geese flee the prime hunting locations once the guns start banging, they contend.

The fact is that no one, hunters, game officials, or biologists, knew exactly if or where or when the resident geese move during summer and fall. Is it in response to the early season, feed availability, or are many of them already out of the state by September 1?

We need that answer, says Bob Anderson, graduate student working with Chuck Dieter, associate professor in the SDSU Biology/Microbiology Department. "If we are going to really manage our resident Canada geese for their benefit and for hunter success, we have to understand where and when these geese come and go."

THE BIRDS IN QUESTION, the giants, are members of a subspecies of Canada geese that has come back from oblivion.

While Canada geese are the most widely distributed bird species in North America, by 1900 the giant Canadas, which nested in the northern prairie states, were believed to have been driven to the verge of extinction by unlimited gathering of eggs and year-round hunting of adults by settlers. By the 1950s, it was assumed the subspecies was gone.

However, small flocks managed to hang on at a few national wildlife refuges (NWR) and other places in northern prairie states. Modern farming was creating abundant foods for the birds, who also liked the open sight lines that go with cultivated fields and who had developed a taste for corn grain and wheat in the fall after their spring and summer diet of grasses and forbs.

Restoration efforts in South Dakota began during the 1960s. The state's Game, Fish and Parks Department (GF&P), working with sportsmen, farmers, ranchers, and the U.S. Fish & Wildlife Service, began releasing 7- to 8-week-old goslings from a captive goose flock, formerly decoy geese, at Sand Lake NWR and from a cooperating Faulk County farmer into suit-

Bob Anderson, SDSU graduate student

able wetlands. To aid in the restoration, hunters in the different release areas agreed to a 5-year closure on all Canada goose hunting; the reason is that most Canadas will not nest until 3 years old and the newcomers needed to be protected until they reached reproductive age.

When releases ended in 1998, well over 12,000 goslings had been set free.

"We went from basically no giant Canadas in South Dakota to what we have today," says Spencer Vaa, senior waterfowl biologist for the GF&P. Give or take a few, we have approximately 109,000 birds in the spring breeding population."

For some farmers, that is too much of a good thing.

By the 1990s, depending on their locations, some soybean, corn, and wheat fields were seeing significant damage. In response, the GF&P launched a damage control program for these areas. The gun is the main way to control Canada goose populations, but there are other tricks to employ, and GF&P tried them all—electric fences, special food plots, vegetation barriers, scare devices, and special management on state and federal wildlife areas.

"Geese don't like to walk through tall grass. That's why they're so fond of golf courses. Planting a buffer strip of switchgrass or other tall grass around a private slough works well to limit goose entry to crop fields. Opening up shoreline areas on state game production areas also works well at coaxing the geese onto public land, land which is purchased for wildlife propagation and public hunting," says Vaa.

Ultimately, the best control of goose numbers is hunting, he adds. "There's not much else that can cause goose mortality if they have good habitat. If you don't harvest them the populations will keep going up until they crash.

"We were the first state in the Central Flyway in 1996 to open an early Canada goose season that specifically targeted resident giant Canadas. They're the only geese here at that time of year. Small Canada geese generally don't come down until the first part of October."

"If we are going to really manage our resident Canada geese ... we have to understand where and when these geese come and go."

—Bob Anderson,
SDSU biology graduate student

The regular Canada goose hunting season opens on the Saturday closest to September 24. In zones of the state with early fall giant Canada goose seasons, hunting starts on September 1 with a daily bag limit of five and may run up to the beginning of the regular season.

"These early hunts have proven to be very effective at harvesting resident Canada geese, averaging about 40,000 annually. The total Canada goose harvest in South Dakota is approximately 130,000 annually," Vaa adds.

NOW COMPLAINTS OF A DIFFERENT nature surfaced. Some hunters told GF&P there didn't seem to be as many Canada geese around in September as they'd seen in the summer. They suspected the early season was causing the resident geese to move out of the open hunting areas.

Anderson began tailing the geese in 2000. Enlisting the help of GF&P crews, he roamed seven counties (Brookings, Lake, Codington, Clark, Hamlin, Kingsbury, and Day), setting nets and driving the geese in, capturing adults during the molting period, which usually runs from June 20 to July 15 when the birds are flightless, and attaching collars and leg bands. Adults molt their primary wing feathers at about the same time their young are growing theirs. The parents regain flight status about the same time the young birds are ready to take off.

By the end of the project Anderson and his crew had attached 3,840 leg bands, 153 VHF (very high frequency) collars, and 43 satellite collars over 4 years.

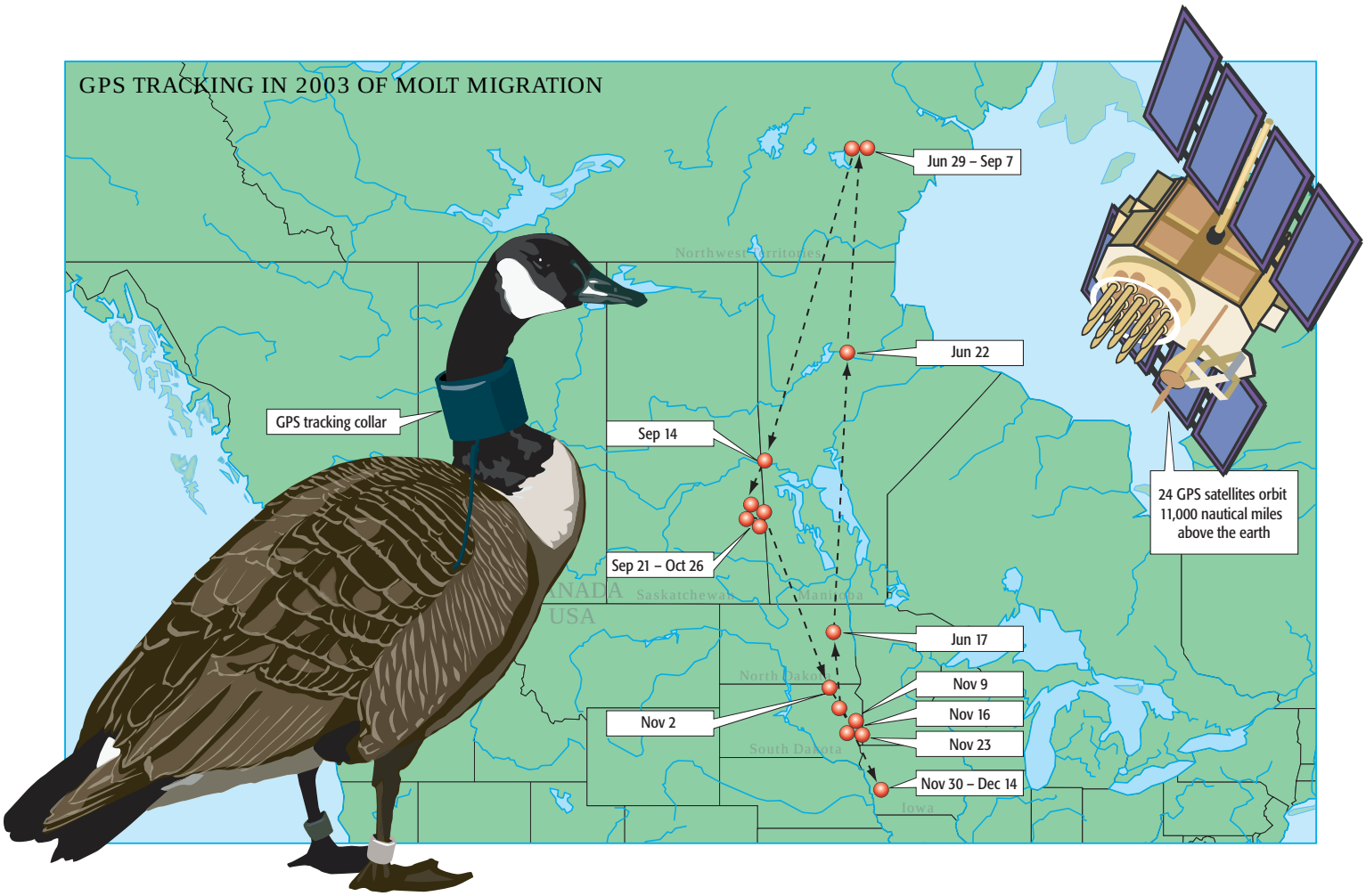
GIANT CANADAS IN SOUTH DAKOTA may be residents, but given the chance, they like to travel, he found. Almost half (46%) of the collared geese made trips of significant distances (25 miles or more), starting around August 10, before they ultimately migrated south for the winter.

Nearly half (45%) of those trips occurred in August before the special hunting seasons. Another 45% moved out during the first week of the September season, "probably because of hunting pressure," says Anderson. After the first week of the season, geese moved much less.

"The greatest distance I documented was by a satellite collared goose from near East Oakwood to just north of Rugby, N.D. Many geese moved up to along the South Dakota-North Dakota line." Most giants (56%) went north or northwest, often more than 60 miles.

Since the trips can't be attributed entirely to hunting pressure, what motivates the geese to fly?

That's still a puzzle. Perhaps, Vaa suggests, they're looking for food, for more small grains. "There's not a whole lot to eat around here in late July and early August."



ANOTHER PUZZLE IS THE MOLT MIGRATION.

"If the geese have families, they stay home," says Anderson. "Subadults, non-breeding adults, failed breeders, even a few successful breeders who lost their broods early—they tend to make molt migrations. It's north.

"Most times we don't notice, unless we look skyward sometime around May 15 to June 25 and see geese flying north. In fact, no one had even known giant Canadas were molt migrating out of the state until the summer of 2003."

Each spring Anderson says, 68% of non-nesting and failed breeders "disappeared" during late May and early June.

"I flew all of eastern South Dakota and southeastern North Dakota each June searching for these missing geese and was only able to locate four, two on Bitter Lake and two on Sand Lake Refuge."

He got a hint of where they were going from a well-traveled goose.

He had found three geese incubating their nests at a site where GF&P planned to drill eggs because of local crop depredation problems. He gave the females satellite collars and waited. One bird eventually lifted off and molt migrated in June to the Northwest Territories, 1,281 miles away as the goose flies. The Brookings County resident returned to South Dakota at the beginning of November.

"It looks like failed or non-breeders migrate to areas north of South Dakota. The many leg bands recovered in Manitoba, Saskatchewan, and North Dakota would tend to back this up."

ARE THERE AS MANY GIANT CANADAS around South Dakota in September during early hunting season as there are earlier in the summer? Probably not; almost half have left their home breeding grounds for northern South Dakota and southern North Dakota, but we also probably have geese from down south that have moved up here for molt migration, says Anderson.

Of the South Dakota birds Anderson tracked, 38% of molt migrants returned to their breeding grounds by the hunting seasons.

Are there enough giant Canadas to justify an early hunting season? Yes, says Vaa. "The average spring population for the last 7 years was 124,800 birds and in the most recent 3 years has been 109,000 birds. Our management plan calls for 60,000 birds. A dip in 2002 could be due to some difference in how the survey was conducted, to drought, or to something else. That's why we use a 3-year average in our reporting.

"For the most part, people like having these big geese around. We have an effective damage control plan in place, we continue to work at creating and restoring wetlands that provide the necessary habitat to sustain healthy goose populations, and we have both early and regular hunting seasons, which is the primary way to keep populations under control. If the population should drop below 60,000, for example, we will close the early season until they rebuild."

Anderson's project was supported by federal Pittman-Robertson funds, the South Dakota GF&P, and the South Dakota Agricultural Experiment Station.u —*Mary Brashier*

PRAIRIE DOGS:

adjust your cattle stocking rate

Prairie dogs stir up strong emotions and heated arguments. Ranchers claim they destroy valuable rangeland. Environmentalists say that prairie dogs are a critical component of the prairie ecosystem.

New research from South Dakota State University sheds light on one important aspect of the issue. A group of scientists conducted a study to determine to what extent prairie dogs affect rangeland in South Dakota. And their conclusion is that the impact is considerable.

"Each acre on a prairie dog town provides only half the forage for cattle that a similar acre off the town would provide," says Pat Johnson, professor of range science. "Ranchers need to take this into account when they determine stocking rates on pastures with prairie dog towns."

Johnson was lead scientist on the study. Much of the research was conducted by graduate student Matt Stoltenberg as part of his master's thesis research. Also contributing were Alexander Smart, assistant professor of range science, and Lan Xu, assistant professor of biology. The research received funding from the North Central Region Sustainable Agriculture Research and Education Program and the USDA Higher Education Tribal Colleges Research Grants Program.

"PRIOR TO OUR STUDY, no one had measured how much vegetation prairie dogs remove. How much of the forage that disappears are prairie dogs responsible for, and how much is removed by cattle?" Johnson says.

Other studies had looked at how much prairie dogs eat, Johnson says. But that's not an accurate measure for how much forage they remove, because prairie dogs clip vegetation around their towns so they can watch for predators.

"What they eat is only a small part of what they remove,"

Johnson says. "Based on the data collection we did, we estimate that prairie dogs eat only about 5 to 10% of what they destroy. The rest is clipping."

The research team worked in cooperation with Sinte Gleska University to collect data from mixed grass prairie rangeland sites at the Rosebud Indian Reservation, about 25 miles west of Mission.

Vegetation samples were collected from three pastures during the summers of 2002 and 2003. Data were collected during two periods each year: late spring (June) and mid-summer (July) to sample both cool- and warm-season species common to the region.

Two sites were selected for data collection on each pasture. One was on a prairie dog town, and the other site was near the town but had no prairie dog activity. Sites were selected based on similarity of soils, because soil type strongly affects vegetation.

The researchers used three types of plots: plots open to grazing by both prairie dogs and cattle; plots fenced to exclude cattle but allow use by prairie dogs; and plots covered by cages that excluded both cattle and prairie dogs. Vegetation samples were collected from each plot and analyzed for quantity of vegetation and species composition.

"This methodology allowed us to find out how much cattle and prairie dogs each were removing. We could look at the total amount of forage removed and the amount of forage removed by prairie dogs. By subtraction, we could also find out how much was removed by cattle," Smart says.

ABOUT 75% OF THE FORAGE REMOVAL from prairie dog towns can be attributed to prairie dog activity and 25% to cattle, the scientists learned. "We also estimate that cattle get twice as much forage per acre from sites without prairie dog towns compared to sites with towns," Johnson says.

Prairie dogs not only remove available forage; their activity also affects the plant species composition on town sites.

"We evaluated biomass per plant species and looked at the contribution of each species to the total biomass," Johnson says. "We found that grasses dominate both on- and off town sites, but the kinds of grasses were different.

Matt Stoltenberg, SDSU graduate student

"Constant clipping shifts the vegetation toward annual species and forbs, which change considerably from year to year, and which are not necessarily favored by cattle."

The study clearly shows that prairie dogs affect pastures. The results underscore that it is important for ranchers to take prairie dog activity into consideration when planning their stocking rates, Smart says.

"Competitive use from prairie dogs reduces the forage supply. If the rancher plans on having a certain number of animal unit days to provide for the cattle, that number needs to be adjusted. On the prairie dog town, the amount of animal unit days is reduced to half. If you don't make adjustments to the stocking rate, the utilization level on the rest of the pasture will be higher than expected."

Smart says that long-term research at SDSU has shown that when forage utilization goes above 50%, it can change the plant species composition towards less desirable species.

Prairie dog facts

Prairie dogs are small, stout ground squirrels that live in underground burrows, collectively called "towns." There are five species of prairie dogs. Two, the Utah prairie dog and the Mexican prairie dog, are currently listed under the Endangered Species Act. The black-tailed prairie dog, the species in South Dakota, was suggested for inclusion in the Endangered Species Act by the National Wildlife Foundation in 1998. The prairie dog population was believed to have greatly diminished over the past century due to diseases and poisoning.

However, in August 2004, the U.S. Fish and Wildlife Service removed the black-tailed prairie dog as a candidate for endangered species listing, after new estimates of a population of around 18.5 million prairie dogs covering an area of about 1.8 million acres in the U.S.

Environmentalists remain concerned about the prairie dog population, mainly because of the species' role in the prairie ecosystem. Many predators depend on the prairie dog for food. The black-footed ferret preys almost exclusively on prairie dogs and relies on prairie dog burrows for habitat. The ferret is endangered and lives only in a few small populations in the wild, including the Conata Basin in the Buffalo Gap National Grasslands in southwestern South Dakota.

The black-tailed prairie dog is estimated to occupy about 400,000 acres in South Dakota. Its population has expanded in the last 5 years, when poisoning control has been limited. Dry conditions have also favored the expansion of prairie dog towns, because drought limits plant growth and makes it easier for prairie dogs to escape predators.

In October 2004, the state of South Dakota implemented a prairie dog poisoning program on the Buffalo Gap National Grasslands. Following criticism from conservation groups, the original poisoning plan was reduced to cover about 5,000 acres of national grassland. In addition, 13,000 acres of adjacent private land have been treated.

"... cattle get twice as much forage per acre from sites without prairie dog towns compared to sites with towns."

—PAT JOHNSON,
SDSU RANGE SCIENTIST

"If you're already stocking for 50% utilization of the whole pasture, and a quarter of that pasture is prairie dog town, the cattle are only getting half of what they should on that area. Utilization on the remaining pasture may increase 5 or 10%, and you risk changing the species composition because of overgrazing."

In addition, overgrazing will actually help the prairie dogs expand their towns, because they have to expend less energy clipping the grass to avoid predators, Smart says.

Keeping a lighter stocking rate might limit or shrink the prairie dog towns, because the dogs need to work harder to keep the grass low, says Smart. "This is especially important in dry years, because drought also helps the prairie dogs by limiting vegetation growth."

Ranchers need to evaluate how to make adjustments in the stocking rate to avoid overgrazing and prevent the prairie dogs from expanding. But there's a cost to maintaining a lighter stocking rate, so economic calculations must be made to determine the most efficient utilization of the pasture.

For the past 5 years, poisoning and other control measures have been limited while prairie dogs were considered for inclusion in the Endangered Species Act. In August 2004, the prairie dog was removed from consideration, and poisoning programs have been resumed. However, poisoning is costly, and in many cases new prairie dogs quickly move into the existing burrows. Johnson says that the SDSU data can also be used to calculate a rate of compensation for ranchers who are willing to accommodate prairie dogs on their land, in case public policy or environmental organizations should favor such compensation.u —*Marianne Stein*

Prairie dog economics

Based on the findings by Johnson and her colleagues, it is possible to calculate the economic value of the pasture loss caused by prairie dogs, says Martin Beutler, professor of economics and director of SDSU's West River Ag Center. He provides the following sample calculations.

A typical stocking rate for cattle on non-prairie dog sites in Johnson's study is 0.33 animal unit months (AUM) per acre. (One AUM indicates one month's forage for a cow and calf.) On prairie dog town sites, the combined usage of cattle and prairie dogs was about 0.63 AUMs; prairie dogs were responsible for 0.48 AUMs, while cattle consumed 0.15 AUMs.

The value of an AUM in western South Dakota during the study was approximately $21.35. That means cattle grazing on land without prairie dog towns consumed forage valued at $7.00 per acre. On land with prairie dog towns, the prairie dogs removed forage valued at $10.20 per acre, while forage value per acre consumed by cattle was $3.20, for a total cost of $13.45 per acre.

Given that areas with prairie dog towns were grazed at 0.63 AUMs per acre (by cattle and prairie dogs combined) compared with a grazing rate of 0.33 AUMs on land without prairie dog towns, the land with prairie dogs was overgrazed at a rate of 0.3 AUMs. There are an estimated 400,000 acres of prairie dog towns on South Dakota rangeland, so total overgrazing amounts to 120,000 AUMs. Using the $21.35 per AUM rate in the study, that's a value of 2.6 million dollars in lost forage per year in South Dakota.

Beutler also calculated what the loss would mean for an individual rancher.

Suppose you have a ranch with 12,120 acres of pasture. Given a 10-month grazing season and a stocking rate of 0.33 AUMs, this would supply 4,000 AUMs and support 400 head of cattle per year.

If prairie dogs have towns on 5% of the land, 606 acres would be affected. Those acres would normally provide 606 x 0.33 = 200 AUMs, but because of prairie dog activity, the land only provides 606 x 0.15 = 91 AUMs for the cattle, which is a loss of 109 AUMs. If the cost of leasing or renting additional land for those AUMs is $21.35, that would cost the rancher $2,327 per year, or $5.82 per head. If additional grazing is not available for leasing or renting, additional hay would have to be purchased to compensate for the loss of grazing AUMs. Assuming the cost of hay is $70 per ton and that it takes approximately 780 pounds of forage to replace each AUM, the additional cost to the livestock operation would be $2,976 or $7.44 per head.

If the ranch had prairie dog towns on 20% of the land, 2,424 acres would be affected. Those would normally provide 2,424 x 0.33 = 800 AUMs, but with prairie dog towns, they will provide only 2,424 x 0.15 = 364 AUMs for cattle; that is, a loss of 436 AUMs. The cost of leasing additional AUMs would be 436 x $21.35 = $9,309 per year; $23.27 per head. If the rancher cannot lease or rent land and needs to purchase additional hay at $70/ton, the additional forage cost would be $11,904 or $29.76 per head.

BISON RESEARCH:
in collaboration with tribal scientists

Bison are an integral part of traditional Lakota/Dakota culture, and bison production is a popular source of income for Native American tribes and individuals in South Dakota.

The state now claims the title for most bison produced in the nation with 40,168 head in 2002. That's 17% of the nation's total, and far above no. 2, North Dakota, which produced 30,856 head of bison in 2002.

Bison production is the focus of several USDA-funded research projects at South Dakota State University, many of them conducted in cooperation with tribal colleges and agencies.

Some of the projects take place through the Prairie Ph.D. program—a unique program that provides opportunities for tribal faculty and tribal agency employees to earn master's and doctoral degrees in the agricultural and biological sciences at SDSU while remaining in their local communities. Classes are taught via the Internet and interactive television and in short, intensive courses on the SDSU campus.

"Our bison research projects take a holistic approach," says Diane Rickerl, plant science professor and one of the SDSU faculty coordinators for the Prairie Ph.D. program. "We're looking at the entire ecological system from soil, water, plants, and wildlife to human nutrition, marketing, and legislative aspects."

THE LONG-TERM IMPACT OF BISON production on soil and plants is one of Rickerl's own projects, conducted with Joe French, a master's student in the Prairie Ph.D. program.

"We have selected four different test sites," Rickerl explains. "At each site, we're looking at steep gradients at different positions including near the top, at the bottom, and in the middle. At the mid slope range, we also have exclosures where the animals can't graze.

"We collect soil and plant data to look at the influence of bison grazing on the natural resources of the landscape. We take samples for total plant production and nutrient value for the animal, as well as soil characteristics such as fertility, organic matter, and carbon content. The purpose is to begin a database, documenting natural resource conditions over time.

"When an animal is slaughtered, we harvest a bone sample and analyze the stable carbon isotope ratio. We have an ancient bone sample with which we can compare the new data. Stable carbon isotope data tell us something about what the animal was eating, so we get an idea of what the range used to be like and how it is different today."

Trudy Ecoffey, department chair of Ag and Natural Resources at Oglala Lakota College, is a doctoral student in the Prairie Ph.D. program. Her USDA-funded research project, conducted with Ken Higgins, professor of wildlife and fisheries sciences at SDSU, focuses on vegetation and fire ecology at the Pine Ridge Reservation.

"We're studying how fast grass recovers after a wildfire. We're looking at buffalo pastures as well as other habitats such as ponderosa pine areas," Ecoffey explains.

Ecoffey says that several bison-related projects are ongoing at Oglala Lakota College. "We're not doing any testing on the animals themselves; we're looking at what's going on around them with the water, soil, grass, and birds. We're comparing bison to cattle, to find out what the differences are."

The college recently acquired its own herd of buffalo, currently 35 adult animals and about 15 calves. Several Native American families on the Pine Ridge reservation raise buffalo, and the Oglala Sioux Tribe owns a buffalo herd, Ecoffey says.

"We're looking at the entire ecological system from soil, water, plants, and wildlife to human nutrition, marketing, and legislative aspects. "

—Diane Rickerl,
SDSU plant scientist

Trudy Ecoffey, left, department chair of Ag and Natural Resources at Oglala Lakota College

BISON PRODUCTION IS POPULAR with Native Americans, partially because bison play an important role in Lakota culture, says Kent Jensen, assistant professor of wildlife and fisheries sciences at SDSU, who advises three Prairie Ph.D. projects related to bison.

"Traditionally, Lakota lifestyle was centered around the buffalo—movement patterns, food, clothing, tepees, and so forth. There's a strong interest from a cultural standpoint and from a health standpoint in trying to get back to making a living on bison," Jensen says. "Many tribes, including the Cheyenne River Sioux, Oglala Sioux, Pine Ridge, Rosebud Sioux, and Lower Brule have their own bison herd."

South Dakota land is uniquely suited for buffalo production, Jensen says. In recent years, drought and other factors have threatened the cattle industry. People were looking to diversify, and bison might be a way to do that, Jensen believes.

"Bison are actually more efficient at converting grass than cows are. Bison are also easier to raise than cattle; they are adapted to the environment and aren't bothered by deep snow or hot weather."

BURROWING OWLS ARE PART of one of Jensen's research projects focusing on the impact of bison production on the wildlife around the pastures. Conducted with Joanna Murray, wildlife biologist at the Cheyenne River Sioux Tribe Game, Fish and Parks Department and funded by the tribe, the study deals with the population of the little owls on the Cheyenne River Sioux Reservation.

"We want to find out if burrowing owl density is different in areas grazed by buffalo versus areas grazed by cattle," Murray says. "Burrowing owls are small owls that live in prairie dog colonies and nest underground. They are not endangered, but they are a species of concern. Not a lot is known about their population on the reservation, so the study is helping to shed light on that."

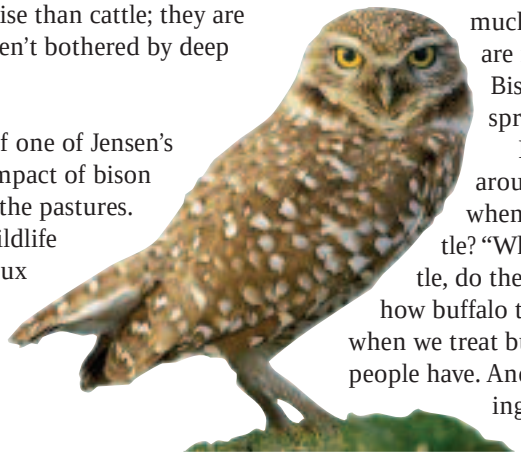
Murray selected nine different prairie dog towns: three each in areas grazed by buffalo, cattle, and ungrazed. "We counted the number of adult owls that we saw. We're also looking at other aspects such as prairie dog density and size of the prairie dog town," Murray says.

Another project, conducted by Jensen and graduate student Kris Marvill, focuses on the population of upland nesting birds in grasslands. Jensen and Marvill compare bird populations on cattle-grazed vs. bison-grazed and burned vs. unburned pastures. "We're looking at the effect of grazing as well as the effect of naturally occurring prairie fires on bird populations," Jensen says.

Jensen is also working on a project with graduate student Heather Hatfield, looking at wildlife use of natural seeps and springs on the Pine Ridge Reservation in bison grazed vs. cattle grazed pastures.

ALL OF THESE PROJECTS are in the early stages of data collection, and no results are available yet. But Jensen says it's not unlikely that some differences between bison and cattle grazed pastures will emerge.

"Anecdotal evidence indicates that bison are easier on grasslands than cattle are," Jensen says. "They tend to distribute their grazing more evenly, while cattle tend to hit some areas very hard and not touch other areas. Cattle tend to stay concentrated where the water is, whereas bison are much less dependent upon free-standing water and are more evenly spread out over a landscape. Bison are less hard on the natural seeps and springs."



However, bison would traditionally move around from area to area. What happens today when bison are kept in a confined area, just like cattle? "When we pen buffalo up and treat them like cattle, do they act like cattle? Is there a difference between how buffalo treat the land and how cattle treat the land when we treat buffalo like cattle? Those are questions a lot of people have. And that's what we're trying to find out by studying the habitats," Jensen says.u

—Marianne Stein

BISON MEAT:
low in fat and calories

Kibbe Conti, nutrition consultant

Traditional Native American foods, prepared in the "old way," has met 21st century nutrition analysis.

The results of the study, conducted at South Dakota State University, showed that bison meat can be an important ingredient in a healthy diet.

Padu Krishnan, professor of food science at SDSU, was principal investigator in a study of the nutritional value of traditional Native American foods. He was assisted by Suzanne Parker Stluka, who graduated in May 2004 with a bachelor's degree in nutrition and food science, and Mary Lynn Gengler, a senior microbiologist.

This project comparing the nutrition content of 16 traditional, Native American foods to contemporary foods was part of a USDA National Research Initiative Competitive Program (NRICGP) seed grant. Stluka received an SDSU EPSCoR Undergraduate Scholarship stipend to work on the project.

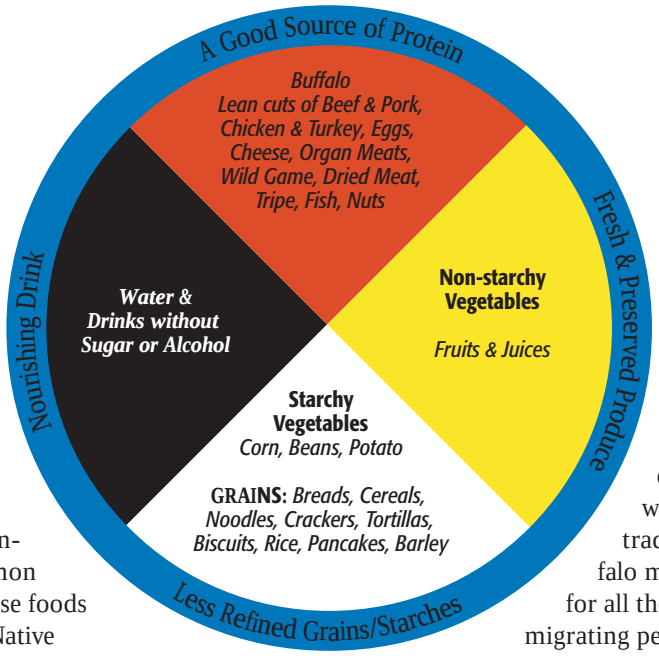
The Native American foods were prepared by members of the Sisseton Wahpeton Oyate using traditional ingredients and recipes. The foods were condensed and analyzed by Stluka and Gengler and data were compared to similar common contemporary foods. In almost all cases, the traditional foods turned out to be healthier than the contemporary diet. Results of the study showed, for example, that buffalo meat is lower in fat and calories and has a higher mineral content than beef (Table 1).

Table 1. Comparisons between traditional Native American foods and their contemporary counterparts.

Food Product	Calories (KCal/100g)	Fat (g/100g)	Protein (g/100g)
Traditional Native American Bean Soup	68.0	1.2	3.9
Contemporary Bean Soup	66.1	2.45	3.5
Buffalo Roast	141.7	2.9	26.9
Beef Roast	191.0	8.6	28.4

"... traditional Native American recipes we tested were generally healthier in relation to selected nutrients such as fat content, total calories, and sodium content, compared to contemporary recipes that use common ingredients."

—Padu Krishnan, SDSU food scientist



"Our study indicated that the traditional Native American recipes we tested were generally healthier in relation to selected nutrients such as fat content, total calories, and sodium content, compared to contemporary recipes that use common ingredients," Krishnan said. "These foods may provide healthy choices in Native American diets when they are prepared in traditional ways."

DIETARY PRACTICES AMONG Native American tribes are the interests of Kibbe Conti, a master's student in the Prairie Ph.D. program, and Kendra Kattelmann, associate professor of food science. Conti is a registered dietitian and consultant.

Much of her research and consulting efforts focus on educating Native Americans on the health benefits of eating in a way that reflects traditional food patterns.

"Many Native Americans living on reservations eat highly processed food and diabetes is epidemic," Conti says.

Conti has developed a dietary model based on the Native American medicine wheel. The model, which can be adapted to the specific situation of each tribe, depicts the development from a traditional diet to a contemporary diet and outlines suggestions to integrate traditional foods to regain balance and health (see illustration above).

Conti worked with dialysis patients on the Pine Ridge Reservation. "About 30% of the patients were malnourished, defined as having below normal protein levels in their blood. This is to some degree an effect of being on dialysis, because it affects their appetites. The challenge was to get their protein levels up by giving them protein-rich food that they would enjoy," she says.

"I gave the patients four ounces of buffalo wasna or dried buffalo weekly. Wasna (or pemmican) is a traditional snack made from dried buffalo meat and dried fruit. It was a staple for all the Plains Indians, because as a migrating people they had to eat on the go. It's an energy-dense food they would use to sustain them; it's very tasty and very protein-rich."

Conti says that patients in the study enjoyed the wasna, and it also produced noticeable health benefits. "It's a comfort food, something their grandmothers made for them when they were children. After the patients had consumed it for several months, we could see protein levels improving, and the malnutrition rate dropped to 20%," Conti says.

CONTI AND KATTELMANN ARE now teaching healthy nutrition education at the Cheyenne River Reservation. The scientists have recruited 114 adults with type 2 diabetes and are leading them through a 6-month educational program. The project is funded by a grant from the National Institute of Health.

"We call it the Four Winds Nutrition Project. It is culturally appropriate nutrition intervention," Conti says. "We use nutrition materials that are culturally based. We also use 'talking circles,' where people discuss food issues in a group setting."

The researchers will test blood sugar levels to measure any improvement in diabetes control and compare results to a control group who receives no nutrition education until after the study is completed. u —*Marianne Stein*

SOUTH DAKOTA STATE UNIVERSITY
College of Agriculture and Biological Sciences
Agricultural Experiment Station
Brookings, SD 57007
Kevin Kephart, Director

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